



PC87307/PC97307 Plug and Play Compatible and PC97 Compliant SuperI/O

Highlights

General Description

The PC87307/PC97307 (VUL) are functionally identical parts that offer a single-chip solution to the most commonly used ISA, EISA and MicroChannel® peripherals. This fully Plug and Play (PnP) compatible chip incorporates a Floppy Disk Controller (FDC), a Keyboard and mouse Controller (KBC), a Real-Time Clock (RTC), two fast full function UARTs, Infrared (IR) support, a full IEEE 1284 parallel port, three general purpose chip select signals that can be programmed for game port control, and a separate configuration register set for each module. It also provides support for power management (including a WATCHDOG timer) and standard PC-AT address decoding for on-chip functions.

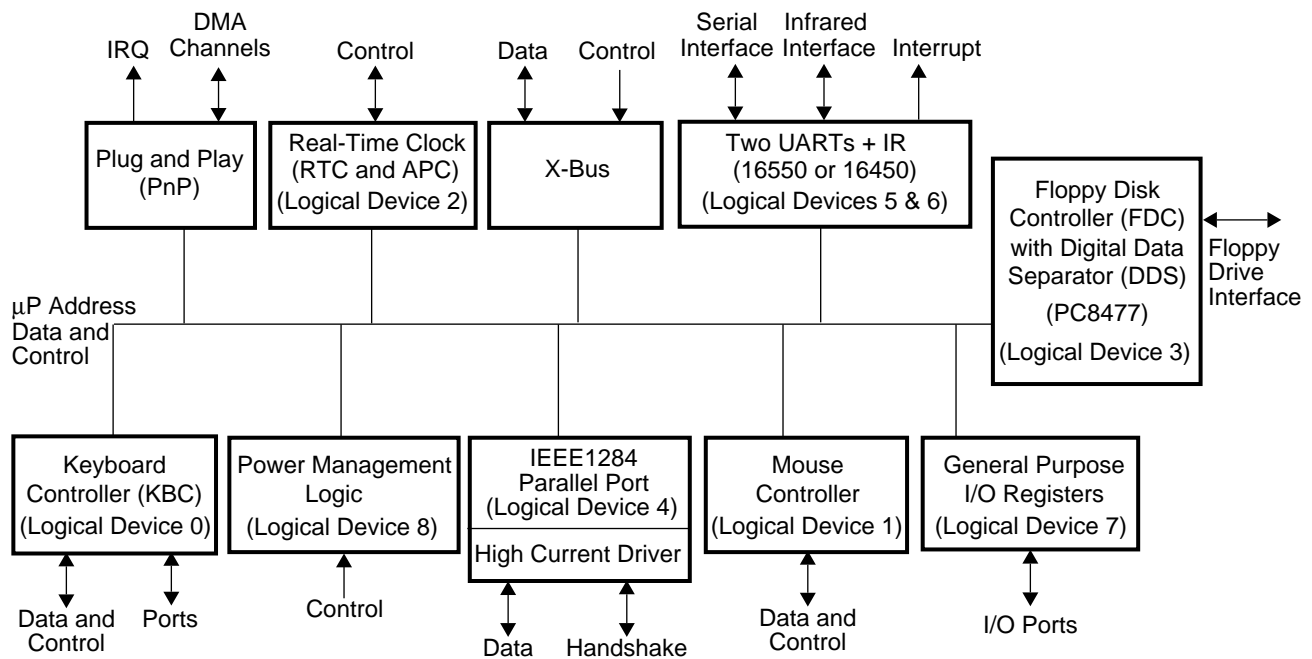
The Plug and Play (PnP) support in the device conforms to the "Plug and Play ISA Specification" Version 1.0a, May 5, 1994.

The Infrared (IR) interface complies with the IrDA 1.0 SIR and SHARP-IR standards, and supports all four basic protocols for Consumer-IR (TV-Remote) circuitry (RC-5, RC-5 extended, RECS80 and NEC).

Features

- 100% compatible with Plug and Play requirements specified in the "Plug and Play ISA Specification", ISA, EISA, and MicroChannel architectures
- Meets PC97 requirements

Block Diagram



TRI-STATE® is a registered trademark of National Semiconductor Corporation. IBM®, MicroChannel®, PC-AT® and PS/2® are registered trademarks of International Business Machines Corporation. Microsoft® and Windows® are registered trademarks of Microsoft Corporation.

- A special Plug and Play (PnP) module that includes:
 - Flexible IRQs, DMAs and base addresses that meet the Plug and Play requirements specified by Microsoft® in their 1995 hardware design guide for Windows® and Plug and Play ISA Revision 1.0A
 - Plug and Play ISA mode (with isolation mechanism – Wait for Key state)
 - Motherboard Plug and Play mode
- A Floppy Disk Controller (FDC) that provides:
 - A modifiable address that is referenced by a 16-bit programmable register
 - Software compatibility with the PC8477, which contains a superset of the floppy disk controller functions in the μ DP8473, the NEC μ PD765A and the N82077
 - 13 IRQ channel options
 - Four 8-bit DMA channel options
 - 16-byte FIFO
 - Burst and non-burst modes
 - A high-performance, internal, digital data separator that does not require any external filter components
 - Support for standard 5.25" and 3.5" floppy disk drives
 - Automatic media sense support
 - Perpendicular recording drive support
 - Three-mode Floppy Disk Drive (FDD) support
 - Full support for the IBM Tape Drive Register (TDR) implementation of AT and PS/2 drive types
- A Keyboard and mouse Controller (KBC) with:
 - A modifiable address that is referenced by a 16-bit programmable register, reported as a fixed address in resource data
 - 13 IRQ options for the keyboard controller
 - 13 IRQ options for the mouse controller
 - An 8-bit microcontroller
 - Software compatibility with the 8042AH and PC87911 microcontrollers
 - 2 KB of custom-designed program ROM
 - 256 bytes of RAM for data
 - Five programmable dedicated open drain I/O lines for keyboard controller applications
 - Asynchronous access to two data registers and one status register during normal operation
 - Support for both interrupt and polling
 - 93 instructions
 - An 8-bit timer/counter
 - Support for binary and BCD arithmetic
 - Operation at 8 MHz, 12 MHz or 16 MHz (programmable option)
 - Can be customized using the PC87323VUL, which includes a RAM-based KBC, as a development platform for keyboard controller code
- A Real-Time Clock (RTC) that has:
 - A modifiable address that is referenced by a 16-bit programmable register
 - 13 IRQ options, with programmable polarity
 - DS1287, MC146818 and PC87911 compatibility
 - 242 bytes of battery backed up CMOS RAM in two banks
 - Selective lock mechanism for the RTC RAM
 - Battery backed up century calendar in days, days of the week, months and years, with automatic leap-year adjustment
 - Battery backed-up time of day in seconds, minutes and hours that allows a 12 or 24 hour format and adjustments for daylight savings time
 - BCD or binary format for time keeping
 - Three different maskable interrupt flags:
 - Periodic interrupts - At intervals from 122 msec to 500 msec
 - Time-of-day alarm - At intervals from once per second to once per day
 - Updated Ended Interrupt - Once per second upon completion of update
 - Separate battery pin, 2.4 V operation that includes an internal UL protection resistor
 - 2 μ A maximum power consumption during power down
 - Double-buffer time registers
- An Advanced Power supply Control (APC) that controls the main power supply to the system, using open-drain output, as follows:

Power turned on when:

 - The RTC reaches a pre-determined date and time.
 - A high to low transition occurs on the \overline{RI} input signals of the UARTs.
 - A ring pulse or pulse train is detected on the \overline{RING} input signal.
 - A SWITCH input signal indicates a Switch On event

Powered turned off when:

 - A SWITCH input signal indicates a Switch Off event
 - A Fail-safe event occurs (power-save mode detected but the system is hung up).
 - Software turns power off.
- Two UARTs that provide:
 - Software compatibility with the 16550A and the 16450
 - A modifiable address that is referenced by a 16-bit programmable register
 - 13 IRQ channel options
 - Shadow register support for write-only bits
 - Four 8-bit DMA options for the UART with Infrared support (UART2)
- An enhanced UART and Infrared (IR) interface on the UART2 that supports:
 - UART data rates up to 1.5 Mbaud
 - IrDA 1.0 SIR
 - ASK-IR option of SHARP-IR
 - DASK-IR option of SHARP-IR
 - Consumer-IR (TV-Remote) circuitry
 - A Plug and Play compatible external transceiver
- A bidirectional parallel port that includes:
 - A modifiable address that is referenced by a 16-bit programmable register

- Software or hardware control
- 13 IRQ channel options
- Four 8-bit DMA channel options
- Demand mode DMA support
- An Enhanced Parallel Port (EPP) that is compatible with the new version EPP 1.9, and is IEEE1284 compliant
- An Enhanced Parallel Port (EPP) that also supports version EPP 1.7 of the Xircom specification.
- Support for an Enhanced Parallel Port (EPP) as mode 4 of the Extended Capabilities Port (ECP)
- An Extended Capabilities Port (ECP) that is IEEE 1284 compliant, including level 2
- Selection of internal pull-up or pull-down resistor for Paper End (PE) pin
- Reduction of PCI bus utilization by supporting a demand DMA mode mechanism and a DMA fairness mechanism
- A protection circuit that prevents damage to the parallel port when a printer connected to it powers up or is operated at high voltages
- Output buffers that can sink and source 14 mA
- Three general purpose pins for three separate programmable chip select signals, as follows:
 - Can be programmed for game port control
 - The Chip Select 0 ($\overline{CS0}$) signal produces open drain output and is powered by the V_{CCH}
 - The Chip Select 1 ($\overline{CS1}$) and 2 ($\overline{CS2}$) signals have push-pull buffers and are powered by the main V_{DD}
 - Decoding of chip select signals depends on the address and the Address Enable (\overline{AEN}) signals, and can be qualified using the Read (\overline{RD}) and Write (\overline{WR}) signals.
- 16 single-bit General Purpose I/O ports (GPIO):
 - Modifiable addresses that are referenced by a 16-bit programmable register
 - Programmable direction for each signal (input or output) with configuration lock
- Programmable drive type for each output pin (open-drain or push-pull) with configuration lock
- Programmable option for internal pull-up resistor on each input pin with configuration lock
- A back-drive protection circuit
- An X-bus data buffer that connects the 8-bit X data bus to the ISA data bus
- Clock source options:
 - Source is a 32.768 KHz crystal - an internal frequency multiplier generates all the required internal frequencies.
 - Source may be either a 48 MHz or 24 MHz clock input signal.
- Enhanced Power Management (PM), including:
 - Special configuration registers for power down
 - WATCHDOG timer for power-saving strategies
 - Reduced current leakage from pins
 - Low-power CMOS technology
 - Ability to shut off clocks to all modules
- General features include:
 - All accesses to the SuperI/O chip activate a Zero Wait State (\overline{ZWS}) signal, except for accesses to the Enhanced Parallel Port (EPP) and to configuration registers
 - Access to all configuration registers is through an Index and a Data register, which can be relocated within the ISA I/O address space
 - 160-pin Plastic Quad Flatpack (PQFP) package

Basic Configuration

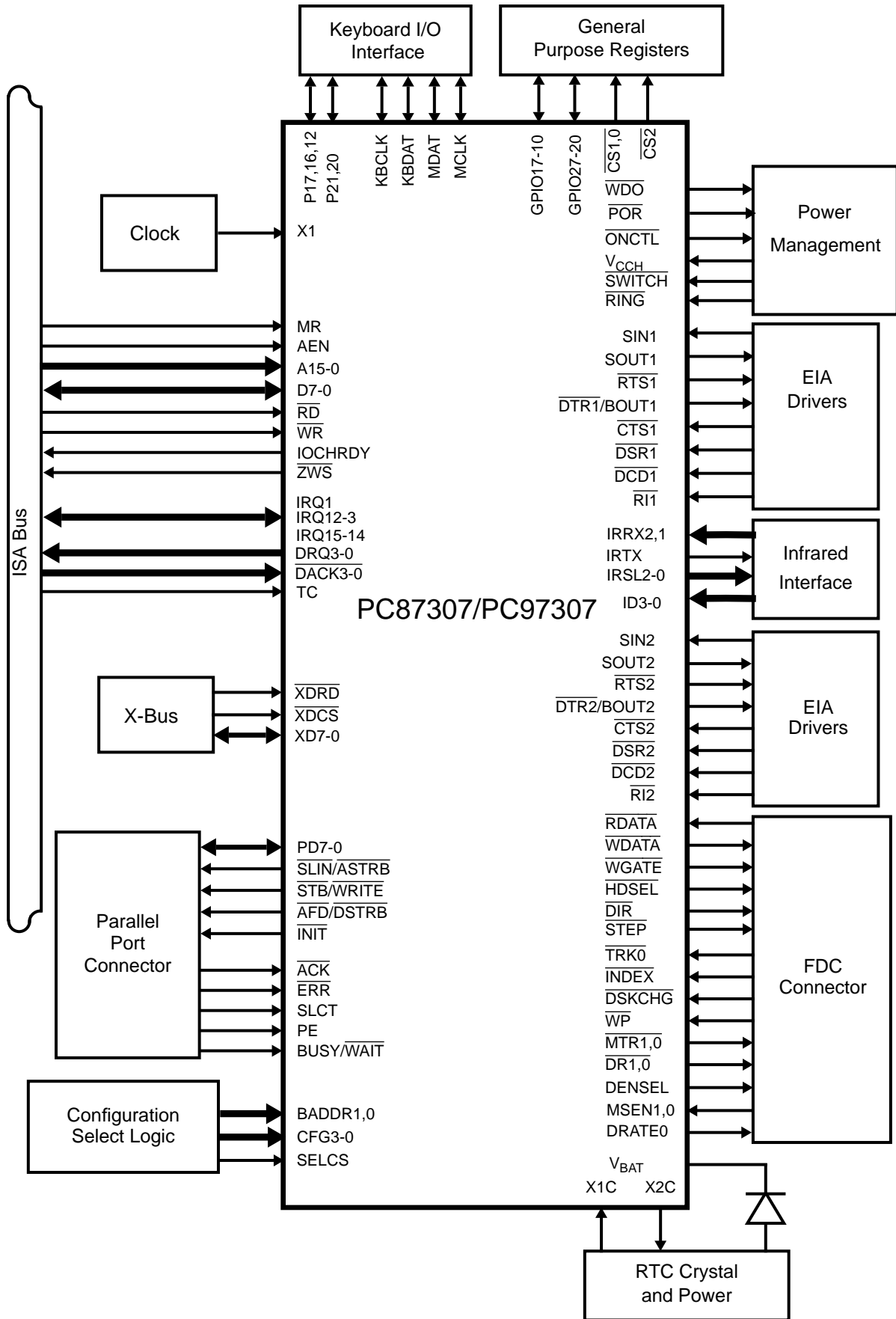


Table of Contents

Highlights	1
1.0 Signal/Pin Connection and Description	
1.1 CONNECTION DIAGRAM	14
1.2 SIGNAL/PIN DESCRIPTIONS	15
2.0 Configuration	
2.1 HARDWARE CONFIGURATION	24
2.1.1 Wake Up Options	24
2.1.2 The Index and Data Register Pair	24
2.1.3 The Strap Pins	25
2.2 SOFTWARE CONFIGURATION	25
2.2.1 Accessing the Configuration Registers	25
2.2.2 Address Decoding	25
2.3 THE CONFIGURATION REGISTERS	26
2.3.1 Standard Plug and Play (PnP) Register Definitions	27
2.3.2 Configuration Register Summary	30
2.4 CARD CONTROL REGISTERS	34
2.4.1 SID Register (In PC87307)	34
2.4.2 SID Register (In PC97307)	34
2.4.3 SuperI/O Configuration 1 Register, Index 21h	34
2.4.4 SuperI/O Configuration 2 Register, Index 22h	35
2.4.5 Programmable Chip Select Configuration Index Register, Index 23h	35
2.4.6 Programmable Chip Select Configuration Data Register, Index 24h	36
2.4.7 SRID Register (In PC97307 only)	36
2.5 KBC CONFIGURATION REGISTER (LOGICAL DEVICE 0)	36
2.5.1 SuperI/O KBC Configuration Register, Index F0h	36
2.6 FDC CONFIGURATION REGISTERS (LOGICAL DEVICE 3)	36
2.6.1 SuperI/O FDC Configuration Register, Index F0h	36
2.6.2 Drive ID Register, Index F1h	37
2.7 PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 4)	37
2.7.1 SuperI/O Parallel Port Configuration Register, Index F0h	37
2.8 UART2 AND INFRARED CONFIGURATION REGISTER (LOGICAL DEVICE 5)	38
2.8.1 SuperI/O UART2 Configuration Register, Index F0h	38
2.9 UART1 CONFIGURATION REGISTER (LOGICAL DEVICE 6)	38
2.9.1 SuperI/O UART1 Configuration Register, Index F0h	38
2.10 PROGRAMMABLE CHIP SELECT CONFIGURATION REGISTERS	39
2.10.1 $\overline{CS0}$ Base Address MSB, Second Level Index 00h	39
2.10.2 $\overline{CS0}$ Base Address LSB Register, Second Level Index 01h	39
2.10.3 $\overline{CS0}$ Configuration Register, Second Level Index 02h	39
2.10.4 Reserved, Second Level Index 03h	39
2.10.5 $\overline{CS1}$ Base Address MSB Register, Second Level Index 04h	40
2.10.6 $\overline{CS1}$ Base Address LSB Register, Second Level Index 05h	40

2.10.7	$\overline{CS1}$ Configuration Register, Second Level Index 06h	40
2.10.8	Reserved, Second Level Index 07h	40
2.10.9	$\overline{CS2}$ Base Address MSB Register, Second Level Index 08h	40
2.10.10	$\overline{CS2}$ Base Address LSB Register, Second Level Index 09h	40
2.10.11	$\overline{CS2}$ Configuration Register, Second Level Index 0Ah	40
2.10.12	Reserved, Second Level Indexes 0Bh-0Fh	40
2.10.13	Not Accessible, Second Level Indexes 10h-FFh	40
2.11	CARD CONTROL REGISTER BITMAPS	41
3.0	Keyboard (and Mouse) Controller (KBC) (Logical Devices 0 and 1)	
3.1	SYSTEM ARCHITECTURE	43
3.2	FUNCTIONAL OVERVIEW	44
3.3	DEVICE CONFIGURATION	44
3.3.1	I/O Address Space	44
3.3.2	Interrupt Request Signals	44
3.3.3	KBC Clock	45
3.3.4	Timer or Event Counter	46
3.4	EXTERNAL I/O INTERFACES	46
3.4.1	Keyboard and Mouse Interface	46
3.4.2	General Purpose I/O Signals	46
3.5	INTERNAL KBC - PC87307/PC97307 INTERFACE	47
3.5.1	The KBC DBBOUT Register, Offset 60h, Read Only	47
3.5.2	The KBC DBBIN Register, Offset 60h (F1 Clear) or 64h (F1 Set), Write Only	47
3.5.3	The KBC STATUS Register, Offset 64h, Read Only	48
3.6	INSTRUCTION TIMING	48
4.0	Real-Time Clock (RTC) and Advanced Power Control (APC) (Logical Device 2)	
4.1	RTC OPERATION OVERVIEW	49
4.1.1	RTC Hardware and Functional Description	49
4.1.2	Timekeeping	50
4.1.3	Power Supply	51
4.1.4	Interrupt Handling	52
4.2	THE RTC REGISTERS	52
4.2.1	RTC Control Register A (CRA), Index 0Ah	52
4.2.2	RTC Control Register B (CRB), Index 0Bh	54
4.2.3	RTC Control Register C (CRC), Index 0Ch	54
4.2.4	RTC Control Register D (CRD), Index 0Dh	55
4.3	APC OVERVIEW	55
4.3.1	User Selectable Parameters	55
4.3.2	System Power States	56
4.3.3	System Power Switching Logic	56
4.4	DETAILED FUNCTIONAL DESCRIPTION	58
4.4.1	The \overline{ONCTL} Signal	58
4.4.2	Entering Power States	58
4.4.3	System Power-Up and Power-Off Activation Event Description	59

4.5	APC REGISTERS	60
4.5.1	APC Control Register 1 (APCR1), Index 40h	60
4.5.2	APC Control Register 2 (APCR2), Index 41h	61
4.5.3	APC Status Register (APSR), Index 42h	61
4.5.4	RAM Lock Register (RLR), Index 47h	62
4.6	RTC AND APC REGISTER BITMAPS	62
4.6.1	RTC Register Bitmaps	62
4.6.2	APC Register Bitmaps	63
4.7	REGISTER BANK TABLES	64
5.0	The Digital Floppy Disk Controller (FDC) (Logical Device 3)	
5.1	FDC FUNCTIONS	66
5.1.1	Microprocessor Interface	66
5.1.2	System Operation Modes	66
5.2	DATA TRANSFER	67
5.2.1	Data Rates	67
5.2.2	The Data Separator	67
5.2.3	Perpendicular Recording Mode Support	68
5.2.4	Data Rate Selection	68
5.2.5	Write Precompensation	69
5.2.6	FDC Low-Power Mode Logic	69
5.2.7	Reset	69
5.3	THE REGISTERS OF THE FDC	70
5.3.1	Status Register A (SRA), Offset 00h	70
5.3.2	Status Register B (SRB), Offset 01h	71
5.3.3	Digital Output Register (DOR), Offset 02h	71
5.3.4	Tape Drive Register (TDR), Offset 03h	73
5.3.5	Main Status Register (MSR), Offset 04h, Read Operations	74
5.3.6	Data Rate Select Register (DSR), Offset 04h, Write Operations	75
5.3.7	Data Register (FIFO), Offset 05h	76
5.3.8	Digital Input Register (DIR), Offset 07h, Read Operations	77
5.3.9	Configuration Control Register (CCR), Offset 07h, Write Operations	78
5.4	THE PHASES OF FDC COMMANDS	78
5.4.1	Command Phase	78
5.4.2	Execution Phase	78
5.4.3	Result Phase	80
5.4.4	Idle Phase	80
5.4.5	Drive Polling Phase	80
5.5	THE RESULT PHASE STATUS REGISTERS	81
5.5.1	Result Phase Status Register 0 (ST0)	81
5.5.2	Result Phase Status Register 1 (ST1)	81
5.5.3	Result Phase Status Register 2 (ST2)	82
5.5.4	Result Phase Status Register 3 (ST3)	83
5.6	FDC REGISTER BITMAPS	84
5.6.1	FDC Standard Register Bitmaps	84

5.6.2	FDC Result Phase Status Register Bitmaps	85
5.7	THE FDC COMMAND SET	86
5.7.1	Abbreviations Used in FDC Commands	87
5.7.2	The CONFIGURE Command	88
5.7.3	The DUMPREG Command	88
5.7.4	The FORMAT TRACK Command	89
5.7.5	The INVALID Command	92
5.7.6	The LOCK Command	92
5.7.7	The MODE Command	92
5.7.8	The NSC Command	94
5.7.9	The PERPENDICULAR MODE Command	94
5.7.10	The READ DATA Command	96
5.7.11	The READ DELETED DATA Command	98
5.7.12	The READ ID Command	99
5.7.13	The READ A TRACK Command	100
5.7.14	The RECALIBRATE Command	100
5.7.15	The RELATIVE SEEK Command	101
5.7.16	The SCAN EQUAL, the SCAN LOW OR EQUAL and the SCAN HIGH OR EQUAL Commands	101
5.7.17	The SEEK Command	102
5.7.18	The SENSE DRIVE STATUS Command	103
5.7.19	The SENSE INTERRUPT Command	103
5.7.20	The SET TRACK Command	104
5.7.21	The SPECIFY Command	105
5.7.22	The VERIFY Command	106
5.7.23	The VERSION Command	108
5.7.24	The WRITE DATA Command	108
5.7.25	The WRITE DELETED DATA Command	109
5.8	EXAMPLE OF A FOUR-DRIVE CIRCUIT USING THE PC87307/PC97307	110
6.0	Parallel Port (Logical Device 4)	
6.1	PARALLEL PORT CONFIGURATION	111
6.1.1	Parallel Port Operation Modes	111
6.1.2	Configuring Operation Modes	111
6.1.3	Output Pin Protection	111
6.2	STANDARD PARALLEL PORT (SPP) MODES	111
6.2.1	Standard Parallel Port (SPP) Modes Register Set	112
6.2.2	SPP Data Register (DTR), Offset 00h	112
6.2.3	Status Register (STR), Offset 01h	113
6.2.4	SPP Control Register (CTR), Offset 02h	114
6.3	ENHANCED PARALLEL PORT (EPP) MODES	115
6.3.1	Enhanced Parallel Port (EPP) Register Set	115
6.3.2	SPP or EPP Data Register (DTR), Offset 00h	115
6.3.3	SPP or EPP Status Register (STR), Offset 01h	115
6.3.4	SPP or EPP Control Register (CTR), Offset 02h	116
6.3.5	EPP Address Register (ADDR), Offset 03h	116
6.3.6	EPP Data Register 0 (DATA0), Offset 04h	116

6.3.7	EPP Data Register 1 (DATA1), Offset 05h	116
6.3.8	EPP Data Register 2 (DATA2), Offset 06h	116
6.3.9	EPP Data Register 3 (DATA3), Offset 07h	117
6.3.10	EPP Mode Transfer Operations	117
6.3.11	EPP 1.7 and 1.9 Zero Wait State Data Write and Read Operations	118
6.4	EXTENDED CAPABILITIES PARALLEL PORT (ECP)	119
6.4.1	ECP Modes	119
6.4.2	Software Operation	119
6.4.3	Hardware Operation	119
6.5	ECP MODE REGISTERS	120
6.5.1	Accessing the ECP Registers	120
6.5.2	Second Level Offsets	120
6.5.3	ECP Data Register (DATAR), Bits 7-5 of ECR = 000 or 001, Offset 000h	121
6.5.4	ECP Address FIFO (AFIFO) Register, Bits 7-5 of ECR = 011, Offset 000h	121
6.5.5	ECP Status Register (DSR), Offset 001h	121
6.5.6	ECP Control Register (DCR), Offset 002h	122
6.5.7	Parallel Port Data FIFO (CFIFO) Register, Bits 7-5 of ECR = 010, Offset 400h	122
6.5.8	ECP Data FIFO (DFIFO) Register, Bits 7-5 of ECR = 011, Offset 400h	122
6.5.9	Test FIFO (TFIFO) Register, Bits 7-5 of ECR = 110, Offset 400h	123
6.5.10	Configuration Register A (CNFGA), Bits 7-5 of ECR = 111, Offset 400h	123
6.5.11	Configuration Register B (CNFGB), Bits 7-5 of ECR = 111, Offset 401h	123
6.5.12	Extended Control Register (ECR), Offset 402h	124
6.5.13	ECP Extended Index Register (EIR), Offset 403h	125
6.5.14	ECP Extended Data Register (EDR), Offset 404h	126
6.5.15	ECP Extended Auxiliary Status Register (EAR), Offset 405h	126
6.5.16	Control0, Second Level Offset 00h	126
6.5.17	Control2, Second Level Offset 02h	126
6.5.18	Control4, Second Level Offset 04h	127
6.5.19	PP Confg0, Second Level Offset 05h	127
6.6	DETAILED ECP MODE DESCRIPTIONS	128
6.6.1	Software Controlled Data Transfer (Modes 000 and 001)	128
6.6.2	Automatic Data Transfer (Modes 010 and 011)	128
6.6.3	Automatic Address and Data Transfers (Mode 100)	130
6.6.4	FIFO Test Access (Mode 110)	130
6.6.5	Configuration Registers Access (Mode 111)	130
6.6.6	Interrupt Generation	130
6.7	PARALLEL PORT REGISTER BITMAPS	131
6.7.1	EPP Modes Parallel Port Register Bitmaps	131
6.7.2	ECP Modes Parallel Port Register Bitmaps	132
6.8	PARALLEL PORT PIN/SIGNAL LIST	134
7.0	UART1 and UART2 (with IR) (Logical Devices 5 and 6)	
7.1	FEATURES	135
7.2	FUNCTIONAL MODES OVERVIEW	135
7.2.1	UART Modes: 16450 or 16550, and Extended	135
7.2.2	Sharp-IR, IrDA SIR Infrared Modes	135

Table of Contents

7.2.3	Consumer IR Mode	135
7.3	REGISTER BANK OVERVIEW	136
7.4	UART MODES – DETAILED DESCRIPTION	136
7.4.1	16450 or 16550 UART Mode	137
7.4.2	Extended UART Mode	137
7.5	SHARP-IR MODE – DETAILED DESCRIPTION	138
7.6	SIR MODE – DETAILED DESCRIPTION	138
7.7	CONSUMER-IR MODE – DETAILED DESCRIPTION	138
7.7.1	Consumer-IR Transmission	138
7.7.2	Consumer-IR Reception	138
7.8	FIFO TIME-OUTS	139
7.8.1	UART, SIR or Sharp-IR Mode Time-Out Conditions	139
7.8.2	Consumer-IR Mode Time-Out Conditions	139
7.8.3	Transmission Deferral	139
7.9	AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE	140
7.10	OPTICAL TRANSCEIVER INTERFACE	140
7.11	BANK 0 – GLOBAL CONTROL AND STATUS REGISTERS	140
7.11.1	Receiver Data Port (RXD) or the Transmitter Data Port (TXD), Bank 0, Offset 00h ..	141
7.11.2	Interrupt Enable Register (IER), Bank 0, Offset 01h	141
7.11.3	Event Identification Register (EIR), Bank 0, Offset 02h	143
7.11.4	FIFO Control Register (FCR), Bank 0, Offset 02h	145
7.11.5	Link Control Register (LCR), Bank 0, Offset 03h, and Bank Selection Register (BSR), All Banks, Offset 03h	145
7.11.6	Bank Selection Register (BSR), All Banks, Offset 03h	147
7.11.7	Modem/Mode Control Register (MCR), Bank 0, Offset 04h	147
7.11.8	Link Status Register (LSR), Bank 0, Offset 05h	148
7.11.9	Modem Status Register (MSR), Bank 0, Offset 06h	149
7.11.10	Scratchpad Register (SPR), Bank 0, Offset 07h	150
7.11.11	Auxiliary Status and Control Register (ASCR), Bank 0, Offset 07h	150
7.11.12	Legacy Baud Generator Divisor Ports (LBGD(L) and LBGD(H)), Bank 1, Offsets 00h and 01h	151
7.11.13	Link Control Register (LCR) and Bank Select Register (BSR), Bank 1, Offset 03h ..	152
7.12	BANK 2 – EXTENDED CONTROL AND STATUS REGISTERS	152
7.12.1	Baud Generator Divisor Ports, LSB (BGD(L)) and MSB (BGD(H)), Bank 2, Offsets 00h and 01h	152
7.12.2	Extended Control Register 1 (EXCR1), Bank 2, Offset 02h	154
7.12.3	Link Control Register (LCR) and Bank Select Register (BSR), Bank 2, Offset 03h ..	155
7.12.4	Extended Control and Status Register 2 (EXCR2), Bank 2, Offset 04h	155
7.12.5	Reserved Register, Bank 2, Offset 05h	155
7.12.6	TX_FIFO Current Level Register (TXFLV), Bank 2, Offset 06h	155
7.12.7	RX_FIFO Current Level Register (RXFLV), IrDA or Consumer-IR Modes, Bank 2, Offset 07h	156
7.13	BANK 3 – MODULE REVISION ID AND SHADOW REGISTERS	156
7.13.1	Module Revision ID Register (MRID), Bank 3, Offset 00h	156
7.13.2	Shadow of Link Control Register (SH_LCR), Bank 3, Offset 01h	157

7.13.3	Shadow of FIFO Control Register (SH_FCR), Bank 3, Offset 02h	157
7.13.4	Link Control Register (LCR) and Bank Select Register (BSR), Bank 3, Offset 03h ..	157
7.14	BANK 4 – IR MODE SETUP REGISTER	157
7.14.1	Reserved Registers, Bank 4, Offsets 00h and 01h	157
7.14.2	Infrared Control Register 1 (IRCR1), Bank 4, Offset 02h	157
7.14.3	Link Control Register (LCR) and Bank Select Register (BSR), Bank 4, Offset 03h ..	158
7.14.4	Reserved Registers, Bank 4, Offsets 04h -07h	158
7.15	BANK 5 – INFRARED CONTROL REGISTERS	158
7.15.1	Reserved Registers, Bank 5, Offsets 00h -02h	158
7.15.2	(LCR/BSR) Register, Bank 5, Offset 03h	158
7.15.3	Infrared Control Register 2 (IRCR2), Bank 5, Offset 04h	158
7.15.4	Reserved Registers, Bank 5, Offsets 05h -07h	158
7.16	BANK 6 – INFRARED PHYSICAL LAYER CONFIGURATION REGISTERS	159
7.16.1	Infrared Control Register 3 (IRCR3), Bank 6, Offset 00h	159
7.16.2	Reserved Register, Bank 6, Offset 01h	159
7.16.3	SIR Pulse Width Register (SIR_PW), Bank 6, Offset 02h	159
7.16.4	Link Control Register (LCR) and Bank Select Register (BSR), Bank 6, Offset 03h ..	159
7.16.5	Reserved Registers, Bank 6, Offsets 04h-07h	159
7.17	BANK 7 – CONSUMER-IR AND OPTICAL TRANSCEIVER CONFIGURATION REGISTERS	159
7.17.1	Infrared Receiver Demodulator Control Register (IRRXDC), Bank 7, Offset 0	160
7.17.2	Infrared Transmitter Modulator Control Register (IRTXMC), Bank 7, Offset 01h	160
7.17.3	Consumer-IR Configuration Register (RCCFG), Bank 7, Offset 02h	163
7.17.4	Link Control/Bank Select Registers (LCR/BSR), Bank 7, Offset 03h	163
7.17.5	Infrared Interface Configuration Register 1 (IRCFG1), Bank 7, Offset 04h	163
7.17.6	Reserved Register, Bank 7, Offset 05h	164
7.17.7	Infrared Interface Configuration 3 Register (IRCFG3), Bank 7, Offset 06h	164
7.17.8	Infrared Interface Configuration Register 4 (IRCFG4), Bank 7, Offset 07h	164
7.18	UART2 REGISTER WITH FAST IR REGISTER BITMAPS	165
8.0	General Purpose Input and Output (GPIO) Ports (Logical Device 7) and Chip Select Output Signals	
8.1	GENERAL PURPOSE INPUT AND OUTPUT (GPIO) PORTS	170
8.2	PROGRAMMABLE CHIP SELECT OUTPUT SIGNALS	171
9.0	Power Management (Logical Device 8)	
9.1	POWER MANAGEMENT OPTIONS	172
9.1.1	Configuration Options	172
9.1.2	The WATCHDOG Feature	172
9.2	THE POWER MANAGEMENT REGISTERS	172
9.2.1	Power Management Index Register, Base Address + 00h	172
9.2.2	Power Management Data Register, Base Address + 01h	173
9.2.3	Function Enable Register 1 (FER1), Index 00h	173
9.2.4	Function Enable Register 2 (FER2), Index 01h	173
9.2.5	Power Management Control 1 Register (PMC1), Index 02h	174
9.2.6	Power Management Control 2 Register (PMC2), Index 03h	174

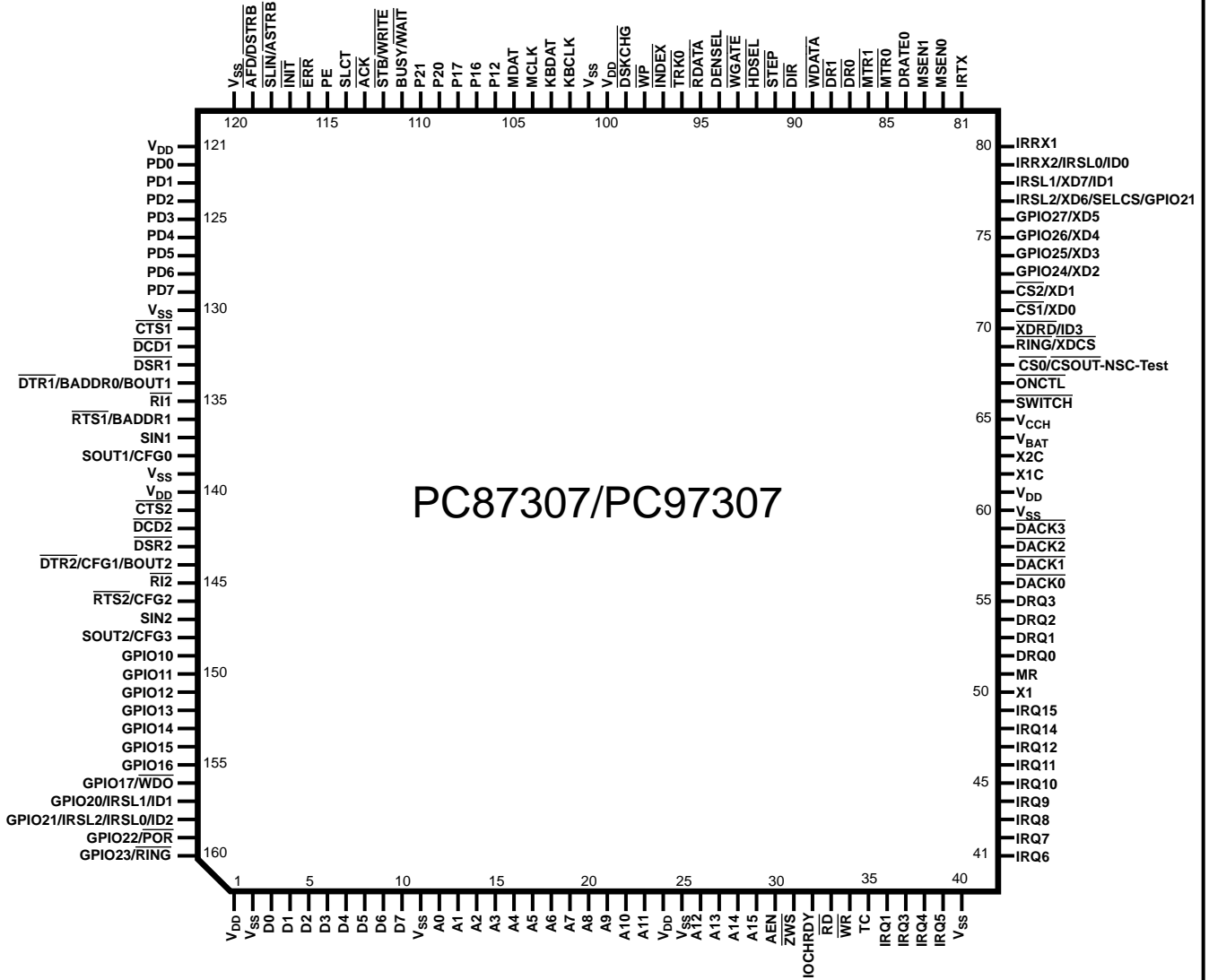
9.2.7	Power Management Control 3 Register (PMC3), Index 04h	175
9.2.8	Watchdog Time-Out (WDTO) Register, Index 05h	175
9.2.9	WATCHDOG Configuration Register (WDCF), Index 06h	175
9.2.10	WATCHDOG Status Register (WDST), Index 07h	176
9.3	POWER MANAGEMENT REGISTER BITMAPS	177
10.0	X-Bus Data Buffer	
10.1	FUNCTIONAL OVERVIEW	179
10.2	MAPPING	179
11.0	The Internal Clock	
11.1	THE CLOCK SOURCE	180
11.2	THE INTERNAL ON-CHIP CLOCK MULTIPLIER	180
11.3	SPECIFICATIONS	180
12.0	Interrupt and DMA Mapping	
12.1	IRQ MAPPING	181
12.2	DMA MAPPING	181
13.0	Device Description	
13.1	GENERAL DC ELECTRICAL CHARACTERISTICS	182
13.1.1	Recommended Operating Conditions	182
13.1.2	Absolute Maximum Ratings	182
13.1.3	Capacitance	182
13.1.4	Power Consumption Under Recommended Operating Conditions	183
13.2	DC CHARACTERISTICS OF PINS, BY GROUP	183
13.2.1	Group 1	183
13.2.2	Group 2	184
13.2.3	Group 3	184
13.2.4	Group 4	184
13.2.5	Group 5	185
13.2.6	Group 6	185
13.2.7	Group 7	185
13.2.8	Group 8	186
13.2.9	Group 9	186
13.2.10	Group 10	187
13.2.11	Group 11	187
13.2.12	Group 12	188
13.2.13	Group 13	188
13.2.14	Group 14	189
13.2.15	Group 15	189
13.2.16	Group 16	189
13.2.17	Group 17	190
13.2.18	Group 18	190
13.2.19	Group 19	190

Table of Contents

13.2.20	Group 20	190
13.2.21	Group 21	190
13.2.22	Group 22	191
13.2.23	Group 23	191
13.3	AC ELECTRICAL CHARACTERISTICS	191
13.3.1	AC Test Conditions $T_A = 0\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$, $V_{DD} = 5.0\text{ V} \pm 10\%$	191
13.3.2	Clock Timing	192
13.3.3	Microprocessor Interface Timing	193
13.3.4	Baud Output Timing	195
13.3.5	Transmitter Timing	196
13.3.6	Receiver Timing	197
13.3.7	UART, Sharp-IR and Consumer-IR Timing	199
13.3.8	SIR Timing	200
13.3.9	IRSLn Write Timing	200
13.3.10	Modem Control Timing	201
13.3.11	DMA Timing	202
13.3.12	Reset Timing	204
13.3.13	Write Data Timing	204
13.3.14	Drive Control Timing	205
13.3.15	Read Data Timing	205
13.3.16	Parallel Port Timing	206
13.3.17	Enhanced Parallel Port 1.7 Timing	207
13.3.18	Enhanced Parallel Port 1.9 Timing	208
13.3.19	Extended Capabilities Port (ECP) Timing	209
13.3.20	GPIO Write Timing	210
13.3.21	RTC Timing	210
13.3.22	APC Timing	211
13.3.23	Chip Select Timing	212

1.0 Signal/Pin Connection and Description

1.1 CONNECTION DIAGRAM



PlasticQuad Flatpack (PQFP), EIAJ
 Order Number PC87307VUL/PC97307VUL
 See NS Package Number VUL160A

1.2 SIGNAL/PIN DESCRIPTIONS

Table 1-1 lists the signals of the part in alphabetical order and shows the pin(s) associated with each. Table 1-2 on page 23 lists the X-Bus Data Buffer (XDB) signals that are multiplexed and Table 1-3 on page 23 lists the pins that have strap functions during reset.

The Module column indicates the functional module that is associated with these pins. In this column, the System label indicates internal functions that are common to more than one module.

The I/O and Group # column describes whether the pin is an input, output, or bidirectional pin (marked as Input, Output or I/O, respectively). This column also specifies the DC characteristics group to which this pin belongs. See Section 13.2 on page 183 for details.

Refer to the glossary for an explanation of abbreviations and terms used in this table, and throughout this document. Use the Table of Contents to find more information about each register.

TABLE 1-1. Signal/Pin Description Table

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
A15-0	29-26, 23-12	ISA-Bus	Input Group 1	ISA-Bus Address – A15-0 are used for address decoding on any access except DMA accesses, on the condition that the AEN signal is low. See Address Decoding in Section 2.2.2 on page 25.
$\overline{\text{ACK}}$	113	Parallel Port	Input Group 3	Acknowledge – This input signal is pulsed low by the printer to indicate that it has received data from the parallel port. It is pulled up by an internal nominal 25 K Ω pull-up resistor.
$\overline{\text{AFD}}$	119	Parallel Port	I/O Group 13	Automatic Feed – When this signal is low the printer should automatically feed a line after printing each line. This pin is in TRI-STATE after a 0 is loaded into the corresponding control register bit. An external 4.7 K Ω pull-up resistor should be attached to this pin. For Input mode see bit 5 in “Control0, Second Level Offset 00h” on page 126. This signal is multiplexed with $\overline{\text{DSTRB}}$. See Table 6-12 on page 134 for more information.
AEN	30	ISA-Bus	Input Group 1	DMA Address Enable – This input signal disables function selection via A15-0 when it is high. Access during DMA transfer is not affected by this signal.
$\overline{\text{ASTRB}}$	118	Parallel Port	Output Group 1	Address Strobe (EPP) – This signal is used in EPP mode as an address strobe. It is active low. This signal is multiplexed with $\overline{\text{SLIN}}$. See Table 6-12 on page 134 for more information.
BADDR1,0	136, 134	Configuration	Input Group 5	Base Address Strap Pins 0 and 1 – These pins determine the base addresses of the Index and Data registers, the value of the Plug and Play ISA Serial Identifier and the configuration state immediately after reset. These pins are pulled down by internal 30 K Ω resistors. External 10 K Ω pull-up resistors to V_{DD} should be employed. BADDR1 is multiplexed with $\overline{\text{RTS1}}$. BADDR0 is multiplexed with $\overline{\text{DTR1}}$ and $\overline{\text{BOUT1}}$. See Table 2-2 on page 25 and Section 2.1 on page 24.
BOUT2,1	144, 134	UART1, UART2	Output Group 17	Baud Output – This multi-function pin provides the associated serial channel Baud Rate generator output signal if test mode is selected, i.e., bit 7 of the EXCR1 register is set. (See Section “Bit 7 - Baud Generator Test (BTEST)” on page 155.) After Master Reset this pin provides the SOUT function. BOUT2 is multiplexed with $\overline{\text{DTR2}}$ and $\overline{\text{CFG1}}$. BOUT1 is multiplexed with $\overline{\text{DTR1}}$ and $\overline{\text{BADDR0}}$.
BUSY	111	Parallel Port	Input Group 2	Busy – This pin is set high by the printer when it cannot accept another character. It is internally connected to a nominal 25 K Ω pull-down resistor. This signal is multiplexed with $\overline{\text{WAIT}}$. See Table 6-12 on page 134 for more information.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
CFG3-0	148, 146, 144, 138	Configuration	Input Group 5	Configuration Strap Pins 3-0 – These pins determine the default configuration upon power up. These pins are pulled down by internal 30 K Ω resistors. External 10 K Ω pull-up resistors to V _{DD} should be employed. CFG3 is multiplexed with SOUT2. CFG2 is multiplexed with $\overline{\text{RTS2}}$. CFG1 is multiplexed with $\overline{\text{DTR2}}$ and $\overline{\text{BOUT2}}$. CFG0 is multiplexed with SOUT1. See Table 2-2 on page 25 and Section 2.1 on page 24 for more information.
$\overline{\text{CS0}}$	68	General Purpose	Output Group 21	Programmable Chip Select – $\overline{\text{CS0}}$, $\overline{\text{CS1}}$ and $\overline{\text{CS2}}$ are programmable chip select and/or latch enable and/or output enable signals that have many uses, for example, as game ports or for I/O port expansion. The decoded address and the assertion conditions are configured via the chip configuration registers. See Section 2.3 on page 26. $\overline{\text{CS0}}$ is an open-drain pin that is in TRI-STATE unless V _{DD} is applied. $\overline{\text{CS2}}$ is multiplexed with $\overline{\text{XD1}}$, $\overline{\text{CS1}}$ is multiplexed with $\overline{\text{XD0}}$, and $\overline{\text{CS0}}$ is multiplexed with $\overline{\text{CSOUT-NSC-Test}}$.
$\overline{\text{CS2,1}}$	72, 71	General Purpose	I/O Group 9	
$\overline{\text{CSOUT-NSC-Test}}$	68	NSC use	Output Group 21	Chip Select Read Output, NSC-Test – National Semiconductor test output. This is an open-drain output signal. This signal is multiplexed with $\overline{\text{CS0}}$.
$\overline{\text{CTS,1}}$	141, 131	UART1, UART2	Input Group 1	UART1 and UART2 Clear to Send – When low, these signals indicate that the modem or other data transfer device is ready to exchange data. The $\overline{\text{CTS}}$ signal is a modem status input signal whose condition the CPU can test by reading bit 4 (CTS) of the Modem Status Register (MSR) for the appropriate serial channel. Bit 4 is the complement of the CTS signal. Bit 0 (DCTS) of MSR indicates whether the $\overline{\text{CTS}}$ input signal has changed state since the previous reading of MSR. $\overline{\text{CTS}}$ has no effect on the transmitter. Whenever the DCTS bit of the MSR is set, an interrupt is generated if modem status interrupts are enabled.
D7-0	10-3	ISA-Bus	I/O Group 8	ISA-Bus Data – Bidirectional data lines to the microprocessor. D0 is the LSB and D7 is the MSB. These signals have 24 mA (sink) buffered outputs.
$\overline{\text{DACK3-0}}$	59-56	ISA-Bus	Input Group 1	DMA Acknowledge 0,1,2 and 3 – These active low input signals acknowledge a request for DMA services and enable the IOWR and IORD input signals during a DMA transfer. These DMA signals can be mapped to the following logical devices: FDC, UART1, UART2 or parallel port.
$\overline{\text{DCD,1}}$	142, 132	UART1, UART2	Input Group 1	UART1 and UART2 Data Carrier Detected – When low, this signal indicates that the modem or other data transfer device has detected the data carrier. The $\overline{\text{DCD}}$ signal is a modem status input signal whose condition the CPU can test by reading bit 7 (DCD) of the Modem Status Register (MSR) for the appropriate serial channel. Bit 7 is the complement of the DCD signal. Bit 3 (DDCD) of the MSR indicates whether the $\overline{\text{DCD}}$ input signal has changed state since the previous reading of MSR. Whenever the DDCCD bit of the MSR is set, an interrupt is generated if modem status interrupts are enabled.
DENSEL	94	FDC	Output Group 16	Density Select (FDC) – Indicates that a high FDC density data rate (500 Kbps or 1 Mbps) or a low density data rate (250 or 300 Kbps) is selected. DENSELs polarity is controlled by bit 5 of the SuperI/O FDC Configuration register as described in Section 2.6.1 on page 36.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
$\overline{\text{DIR}}$	90	FDC	Output Group 16	Direction (FDC) – This output signal determines the direction of the Floppy Disk Drive (FDD) head movement (active = step in, inactive = step out) during a seek operation. During reads or writes, DIR is inactive.
$\overline{\text{DR1,0}}$	88, 87	FDC	Output Group 16	Drive Select 0 and 1 (FDC) – These active low output signals are the decoded drive select output signals. DR0 and DR1 are controlled by Digital Output Register (DOR) bits 0 and 1. They are encoded with information to control four FDDs when bit 7 of the SuperI/O FDC Configuration register is 1, as described in Section 2.6.1 on page 36. See MTR0,1 for more information.
DRATE0	84	FDC	Output Group 20	Data Rate 0 (FDC) – This output signal reflects the value of bit 0 of the Configuration Control Register (CCR) or the Data Rate Select Register (DSR), whichever was written to last. Output from the pin is totem-pole buffered (6 mA sink, 6 mA source).
DRQ3-0	55-52	ISA-Bus	Output Group 18	DMA Request 0, 1, 2 and 3 – These active high output signals inform the DMA controller that a data transfer is needed. These DMA signals can be mapped to the following logical devices: Floppy Disk Controller (FDC), UART1, UART2 or parallel port.
$\overline{\text{DSKCHG}}$	99	FDC	Input Group 1	Disk Change (FDC) – This input signal indicates whether or not the drive door has been opened. The state of this pin is available from the Digital Input Register (DIR). This pin can also be configured as the RGATE data separator diagnostic input signal via the MODE command. See the MODE command in Section 5.7.7 starting on page 92.
$\overline{\text{DSR2,1}}$	143, 133	UART1, UART2	Input Group 1	Data Set Ready – When low, this signal indicates that the data transfer device, e.g., modem, is ready to establish a communications link. The $\overline{\text{DSR}}$ signal is a modem status input signal whose condition the CPU can test by reading bit 5 (DSR) of the Modem Status Register (MSR) for the appropriate channel. Bit 5 is the complement of the $\overline{\text{DSR}}$ signal. Bit 1 (DDSR) of the MSR indicates whether the $\overline{\text{DSR}}$ input signal has changed state since the previous reading of the MSR. Whenever the DDSR bit of the MSR is set, an interrupt is generated if modem status interrupts are enabled.
$\overline{\text{DSTRB}}$	119	Parallel Port	Output Group 23	Data Strobe (EPP) – This signal is used in EPP mode as a data strobe. It is active low. $\overline{\text{DSTRB}}$ is multiplexed with $\overline{\text{AFD}}$. See Table 6-12 on page 134 for more information.
$\overline{\text{DTR2,1}}$	144, 134	UART1, UART2	Output Group 17	Data Terminal Ready – When low, this output signal indicates to the modem or other data transfer device that the UART1 or UART2 is ready to establish a communications link. The $\overline{\text{DTR}}$ signal can be set active low by programming bit 0 (DTR) of the Modem Control Register (MCR) to high (1). A Master Reset (MR) deactivates this signal high, and loopback operation holds this signal inactive. $\overline{\text{DTR2}}$ is multiplexed with CFG1 and BOUT2. $\overline{\text{DTR1}}$ is multiplexed with BADDR0 and BOUT1.
$\overline{\text{ERR}}$	116	Parallel Port	Input Group 3	Error – This input signal is set active low by the printer when it has detected an error. This pin is internally connected to a nominal 25 K Ω pull-up resistor.
GPIO17-10	156-149	General Purpose	I/O Group 10	General Purpose I/O Signals 17-10 – General purpose I/O signals of I/O Port 1. GPIO17 is multiplexed with $\overline{\text{WDO}}$.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
GPIO20 GPIO21 GPIO22 GPIO23 GPIO27-24	157 77, 158 159 160 76-73	General Purpose	I/O Group 10	General Purpose I/O Signals 27-20 – General purpose I/O port 2 signals. GPIO27-24 are multiplexed with XD5-2, respectively. GPIO23 is multiplexed with $\overline{\text{RING}}$. GPIO22 is multiplexed with $\overline{\text{POR}}$. GPIO21 is multiplexed on pin 158 with IRSL2, IRSL0 and on pin 77 with IRSL2, SELCS and XD6. See “SuperI/O Configuration 2 Register, Index 22h” on page 35. GPIO20 is multiplexed with IRSL1.
$\overline{\text{HDSEL}}$	92	FDC	Output Group 16	Head Select – This output signal determines which side of the FDD is accessed. Active low selects side 1, inactive selects side 0.
ID0 ID1 ID2 ID3	79 78 or 157 158 70	UART2	Input Group 1	Identification – These ID signals identify the infrared transceiver for Plug and Play support. These pins are read after reset. ID0 is multiplexed on pin 79 with IRRX2 and IRSL0. ID1 is multiplexed on pin 78 with IRSL1 and XD7, or on pin 157 with GPIO20 and IRSL1. ID2 is multiplexed on pin 158 with GPIO21, IRSL2 and IRSL0. ID3 is multiplexed on pin 70 with $\overline{\text{XDRD}}$. See Table 1-2 on page 23 for more information.
$\overline{\text{INDEX}}$	97	FDC	Input Group 1	Index – This input signal indicates the beginning of an FDD track.
$\overline{\text{INIT}}$	117	Parallel Port	I/O Group 13	Initialize – When this signal is active low, it causes the printer to be initialized. This signal is in TRI-STATE after a 1 is loaded into the corresponding control register bit. An external 4.7 K Ω pull-up resistor should be employed.
IOCHRDY	32	ISA-Bus	Output Group 22	I/O Channel Ready – This is the I/O channel ready open drain output signal. When IOCHRDY is driven low, the EPP extends the host cycle.
IRQ1 IRQ5-3 IRQ12-6 IRQ15,14	36 39-37 47-41 49,48	ISA-Bus	I/O Group 15	Interrupt Requests 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 15 – IRQ polarity and push-pull or open-drain output selection is software configurable by the logical device mapped to the IRQ line. Keyboard Controller (KBC) or Mouse interrupts can be configured by the Interrupt Request Type Select 0 register (index 71h) as either edge or level. The parallel port interrupt is either edge or level, according to the operation mode (default edge, configured by the SuperI/O Parallel Port Configuration register at index F0h).
IRRX2,1	79, 80	UART2 (SIR)	Input Group 1	Infrared Reception 1 and 2 – Infrared serial input data. IRRX2 is multiplexed with IRSL0 and ID0. See Table 1-2 on page 23 for more information.
IRSL0 IRSL1 IRSL2	79 or 158 78 or 157 77 or 158 79, 78, 77 158, 157	UART2 (SIR)	Output Group 17 Group 10	Infrared Control Signals 0, 1 and 2 – These signals control the Infrared analog front end. The pins on which these signals are driven is determined by the SuperI/O Configuration 2 register (index 22h). See Section 2.4.4 on page 35. IRSL0 or ID0/IRRX2 on pin 79 is determined by UART2 bit 5 of the IRCFG4 register (See page 165). IRSL0 is multiplexed on pin 79 with IRRX2 and ID0, or on pin 158 with GPIO21, IRSL2 and ID2. IRSL1 is multiplexed on pin 78 with XD7 and ID1, or on pin 157 with GPIO20 and ID1. IRSL2 is multiplexed on pin 77 with XD6, SELCS and GPIO21, or on pin 158 with GPIO21, IRSL0 and ID2.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
IRTX	81	UART2 (SIR)	Output Group 19	Infrared Transmit – Infrared serial output data.
KBCLK	102	KBC	I/O Group 11	Keyboard Clock – This I/O pin transfers the keyboard clock between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to the internal TO signal of the KBC.
KBDAT	103	KBC	I/O Group 11	Keyboard Data – This I/O pin transfers the keyboard data between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's P10.
MCLK	104	KBC	I/O Group 11	Mouse Clock – This I/O pin transfers the mouse clock between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's T1.
MDAT	105	KBC	I/O Group 11	Mouse Data – This I/O pin transfers the mouse data between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's P11.
MR	51	ISA-Bus	Input Group 1	Master Reset – An active high MR input signal resets the controller to the idle state, and resets all disk interface output signals to their inactive states. MR also clears the DOR, DSR and CCR registers, and resets the MODE command, CONFIGURE command, and LOCK command parameters to their default values. MR does not affect the SPECIFY command parameters. MR sets the configuration registers to their selected default values.
MSEN1,0	83, 82	FDC	Input Group 4	Media Sense – These input pins are used for media sensing when bit 6 of the SuperI/O FDC Configuration register (at index F0h) is 1. See Section 2.6.1 on page 36. Each pin has a 40 K Ω internal pull-up resistor.
$\overline{\text{MTR1,0}}$	86, 85	FDC	Output Group 16	Motor Select 1,0 – These motor enable lines for drives 0 and 1 are controlled by bits D7-4 of the Digital Output Register (DOR). They are output signals that are active when they are low. They are encoded with information to control four FDDs when bit 7 of the SuperI/O FDC Configuration register is set, as described in Section 2.6.1 on page 36. See DR1,0.
$\overline{\text{ONCTL}}$	67	APC	Output Group 23	On/Off Control for the RTC's Advanced Power Control (APC) – This signal indicates to the main power supply that power should be turned on. ONCTL is an open-drain output signal that is powered by V _{CCH} .
P17,16 P12	108, 107 106	KBC	I/O Group 12	I/O Port – KBC quasi-bidirectional port for general purpose input and output.
P21,20	110, 109	KBC	I/O Group 12	I/O Port – KBC open-drain signals for general purpose input and output. These signals are controlled by KBC firmware.
PD7-0	129-122	Parallel Port	I/O Group 14	Parallel Port Data – These bidirectional signals transfer data to and from the peripheral data bus and the appropriate parallel port data register. These signals have a high current drive capability. See "GENERAL DC ELECTRICAL CHARACTERISTICS" on page 182.
PE	115	Parallel Port	Input Group 2	Paper End – This input signal is set high by the printer when it is out of paper. This pin has an internal nominal 25 K Ω pull-up or pull-down resistor that is selected by bit 2 of the PP Config0 register (second level offset 05h) of the parallel port.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
POR	159	APC	Output Group 21	Power Off Request – This signal becomes active when an APC Switch Off event occurs, regardless of the fail-safe delay. Selection of edge or level for POR is via the APCR1 register of the APC. Selection of an output buffer is via GPIO22 output buffer control bits (in the Port 2 Output Type and Port 2 Pull-up Control registers described in Table 8-1 on page 170). See Section 4.3 on page 55. This signal is multiplexed with GPIO22.
RD	33	ISA-Bus	Input Group 1	I/O Read – An active low RD input signal indicates that the microprocessor has read data.
RDATA	95	FDC	Input Group 1	Read Data – This input signal holds raw serial data read from the Floppy Disk Drive (FDD).
RI2,1	145, 135	UART1, APC	Input Group 7	Ring Indicators (Modem) – When low, this signal indicates that a telephone ring signal has been received by the modem. The CPU can test the status of the RI modem status input signal by reading bit 6 (RI) of the Modem Status Register (MSR) for the appropriate serial channel. Bit 6 is the complement of the RI signal. Bit 2 (TERI) of the MSR indicates whether the RI input signal has changed from low to high since the previous reading of the MSR. When the TERI bit of the MSR is set, an interrupt is generated if modem status interrupts are enabled. When enabled, a high to low transition on RI1 or RI2 activates the ONCTL pin. The RI1 and RI2 pins each have a schmitt-trigger input buffer.
RING	69 or 160	APC	Input Group 7	Ring Indicator (APC) – Detection of an active low RING pulse or pulse train activates the ONCTL signal. The APC's APCR2 register determines which pin the RING signal uses. The pins have a schmitt-trigger input buffer. RING is multiplexed on pin 69 with XDCS and on pin 160 with GPIO23.
RTS2,1	146, 136	UART1, UART2	Output Group 17	Request to Send – When low, these output signals indicate to the modem or other data transfer device that the corresponding UART1 or UART2 is ready to exchange data. The RTS signal can be set active low by programming bit 1 (RTS) of the Modem Control Register (MCR) to a high level. A Master Reset (MR) sets RTS to inactive high. Loopback operation holds it inactive. RTS2 is multiplexed with CFG2. RTS1 is multiplexed with BADDR1.
SELCS	77	Configuration	Input Group 4	Select CSOUT – During reset, this signal is sampled into bit 1 of the SuperI/O Configuration 1 register (index 21h). A 40 KΩ internal pull-up resistor (or a 10 KΩ external pull-down resistor for National Semiconductor testing) controls this pin during reset. Do not pull this signal low during reset. This signal is multiplexed with GPIO21, IRSL2 and XD6.
SIN2,1	147, 137	UART1, UART2	Input Group 1	Serial Input – This input signal receives composite serial data from the communications link (peripheral device, modem or other data transfer device.)
SLCT	114	Parallel Port	Input Group 2	Select – This input signal is set active high by the printer when the printer is selected. This pin is internally connected to a nominal 25 KΩ pull-down resistor.
SLIN	118	Parallel Port	I/O Group 13	Select Input – When this signal is active low it selects the printer. This signal is in TRI-STATE after a 0 is loaded into the corresponding control register bit. An external 4.7 KΩ pull-up resistor should be used. This signal is multiplexed with ASTRB.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
SOUT2,1	148, 138	UART1, UART2	Output Group 17	Serial Output – This output signal sends composite serial data to the communications link (peripheral device, modem or other data transfer device). The SOUT2,1 signals are set active high after a Master Reset (MR). SOUT2 is multiplexed with CFG3. SOUT1 is multiplexed with CFG0.
$\overline{\text{STB}}$	112	Parallel Port	I/O Group 13	Data Strobe – This output signal indicates to the printer that valid data is available at the printer port. This signal is in TRI-STATE after a 0 is loaded into the corresponding control register bit. An external 4.7 K Ω pull-up resistor should be employed. This signal is multiplexed with $\overline{\text{WRITE}}$.
$\overline{\text{STEP}}$	91	FDC	Output Group 16	Step – This output signal issues pulses to the disk drive at a software programmable rate to move the head during a seek operation.
$\overline{\text{SWITCH}}$	66	APC	Input Group 7	Switch On/Off – Indicates a request to the APC to switch the power on or off. When V_{DD} does not exist, a high to low transition on this signal indicates a Switch On request. When V_{DD} exists, a high to low transition on this pin indicates a Switch Off request. The pin has an internal pull-up of 1 M Ω (nominal), a schmitt-trigger input buffer and debounce protection of at least 16 msec.
TC	35	ISA-Bus	Input Group 1	DMA Terminal Count – The DMA controller issues TC to indicate the termination of a DMA transfer. TC is accepted only when a DACK signal is active. TC is active high in PC-AT mode, and active low in PS/2 mode.
$\overline{\text{TRK0}}$	96	FDC	Input Group 1	Track 0 – This input signal indicates to the controller that the head of the selected floppy disk drive is at track 0.
V_{BAT}	64	RTC and APC	Input	Battery Power Supply – Power signal from the battery to the Real-Time Clock (RTC) or for Advanced Power Control (APC) when V_{CCH} is less than V_{BAT} (by at least 0.5 V). V_{BAT} includes a UL protection resistor.
V_{CCH}	65	RTC and APC	Input	V_{CC} Help Power Supply – This signal provides power to the RTC or APC when V_{CCH} is higher than V_{BAT} (by at least 0.5 V).
V_{DD}	1, 24, 61, 100, 121, 140	Power Supply	Input	Main 5 V Power Supply – This signal is the 5 V supply voltage for the digital circuitry.
V_{SS}	2, 11, 25, 40, 60, 101, 120, 130, 139	Power Supply	Output	Ground – This signal provides the ground for the digital circuitry.
$\overline{\text{WAIT}}$	111	Parallel Port	Input Group 2	Wait – In EPP mode, the parallel port device uses this signal to extend its access cycle. $\overline{\text{WAIT}}$ is active low. It is internally connected to a nominal 25 K Ω pull-down resistor. This signal is multiplexed with BUSY. See Table 6-12 on page 134 for more information.
$\overline{\text{WDATA}}$	89	FDC	Output Group 16	Write Data (FDC) – This output signal holds the write precompensated serial data that is written to the selected floppy disk drive. Precompensation is software selectable.
$\overline{\text{WDO}}$	156	Power Management	Output Group 10	WATCHDOG Out – This output pin becomes low when a WATCHDOG time-out occurs. See “The WATCHDOG Feature” on page 172. This pin is configured by bit 6 of the SuperI/O Configuration Register 2. This signal is multiplexed with GPIO17.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
$\overline{\text{WGATE}}$	93	FDC	Output Group 16	Write Gate (FDC) – This output signal enables the write circuitry of the selected disk drive. $\overline{\text{WGATE}}$ is designed to prevent glitches during power up and power down. This prevents writing to the disk when power is cycled.
$\overline{\text{WP}}$	98	FDC	Input Group 1	Write Protected – This input signal indicates that the disk in the selected drive is write protected.
$\overline{\text{WR}}$	34	ISA-Bus	Input Group 1	I/O Write – $\overline{\text{WR}}$ is an active low input signal that indicates a write operation from the microprocessor to the controller.
$\overline{\text{WRITE}}$	112	Parallel Port	Output Group 23	Write Strobe – In EPP mode, this active low signal is a write strobe. This signal is multiplexed with $\overline{\text{STB}}$. See Table 6-12 on page 134 for more information.
X1	50	Clock	Input Group 6	Clock In – A TTL or CMOS compatible 24 MHz or 48 MHz clock. See Chapter 11.
X1C	62	RTC	Input	Crystal 1 Slow – Input signal to the internal Real-Time Clock (RTC) crystal oscillator amplifier.
X2C	63	RTC	Output	Crystal 2 Slow – Output signal from the internal Real-Time Clock (RTC) crystal oscillator amplifier.
XD7,6, XD1,0	78, 77 72, 71	X-Bus	I/O Group 9	X-Bus Data – These bidirectional signals hold the data in the X Data Buffer (XDB). XD7 is multiplexed with IRSL1 and ID1. XD6 is multiplexed with IRSL2, SELCS and GPIO21. XD5-2 are multiplexed with GPIO27-24, respectively. XD1,0 are multiplexed with CS2,1 respectively. See Table 1-2 on page 23.
XD5-2	76-73	X-Bus	I/O Group 10	
$\overline{\text{XDCS}}$	69	X-Bus	Input Group 7	X-Bus Data Buffer (XDB) Chip Select – This signal enables and disables the bidirectional XD7-0 data buffer signals. This signal is multiplexed with $\overline{\text{RING}}$. See Table 1-2 on page 23.
$\overline{\text{XDRD}}$	70	X-Bus	Input Group 1	X-Bus Data Buffer (XDB) Read Command – This signal controls the direction of the bidirectional XD7-0 data buffer signals. This signal is multiplexed with ID3. See Table 1-2 on page 23.
$\overline{\text{ZWS}}$	31	ISA-Bus	Output Group 22	Zero Wait State – When this open-drain output signal is activated (driven low), it indicates that the access time can be shortened, i.e., zero wait states. $\overline{\text{ZWS}}$ is never activated (driven low) on access to SuperI/O chip configuration registers (including during the Isolation state) or on access to the parallel port in SPP or EPP 1.9 mode. $\overline{\text{ZWS}}$ is always activated (driven low) on access to the parallel port in ECP mode. Assertion of $\overline{\text{ZWS}}$ on access to a parallel port in EPP 1.7 mode is controlled by bit 3 of the Control2 register (at second level offset 02h) of the parallel port (accessed by the Index and Data registers at base+403h and base+404h). See page 127. Bit 0 of the SuperI/O Configuration 1 register (at index 21h) controls assertion of $\overline{\text{ZWS}}$ on access to any other addresses of the part. See page 35.

In Table 1-2, unselected (XDB or alternate function) input signals are internally blocked high.

TABLE 1-2. Multiplexed X-Bus Data Buffer (XDB) Pins

Pin	X-Bus Data Buffer (XDB) Bit 4 of SuperI/O Configuration Register 1 = 1	I/O	Alternate Function Bit 4 of SuperI/O Configuration 1 Register = 0	I/O
69	$\overline{\text{XDCS}}$	Input	$\overline{\text{RING}}$	Input
70	$\overline{\text{XDRD}}$	Input	ID3	Input
71	XD0	I/O	$\overline{\text{CS1}}$	Output
72	XD1	I/O	$\overline{\text{CS2}}$	Output
73	XD2	I/O	GPIO24	I/O
73	XD3	I/O	GPIO25	I/O
75	XD4	I/O	GPIO26	I/O
76	XD5	I/O	GPIO27	I/O
77	XD6/SELCS	I/O	IRSL2/SELCS/GPIO21	I/O
78	XD7	I/O	IRSL1/ID1	I/O

TABLE 1-3. Pins with a Strap Function During Reset

Strap Pins	Pin	Symbols
BADDR1,0	134	$\overline{\text{DTR1}}$ /BADDR0/BOU1
	136	$\overline{\text{RTS1}}$ /BADDR1
CFG3-0	138	SOUT1/CFG0
	144	$\overline{\text{DTR2}}$ /CFG1/BOU2
	146	$\overline{\text{RTS2}}$ /CFG2
	148	SOUT2/CFG3
SELCS	77	IRSL2/XD6/SELCS/GPIO21

2.0 Configuration

The part is partially configured by hardware, during reset. The configuration can also be changed by software, by changing the values of the configuration registers.

The configuration registers are accessed using an Index register and a Data register. During reset, hardware strapping options define the addresses of the configuration registers. See Section 2.1.2.

After the Index and Data register pair have determined the addresses of the configuration registers, the addresses of the Index and Data registers can be changed within the ISA I/O address space, and a 16-bit programmable register controls references to their addresses and to the addresses of the other registers.

This chapter describes the hardware and software configuration processes. For each, it describes configuration of the Index and Data register pair first. See Sections 2.1 and 2.2.

Section 2.3 starting on page 26 presents an overview of the configuration registers of the part and describes each in detail.

2.1 HARDWARE CONFIGURATION

The part supports two Plug and Play (PnP) configuration modes that determine the status of register addresses upon wake up from a hardware reset, Full PnP ISA mode and PnP Motherboard mode.

2.1.1 Wake Up Options

During reset, strapping options on the BADDR0 and BADDR1 pins determine one of the following modes.

- Full Plug and Play ISA mode – System wakes up in Wait for Key state.

Index and Data register addresses are as defined by Microsoft and Intel in the *“Plug and Play ISA Specification, Version 1.0a, May 5, 1994.”*

- Plug and Play Motherboard mode – system wakes up in Config state.

The BIOS configures the part. Index and Data register addresses are different from the addresses of the PnP Index and Data registers. Configuration registers can be accessed as if the serial isolation procedure had already been done, and the part is selected.

The BIOS may switch the addresses of the Index and Data registers to the PnP ISA addresses of the Index and Data registers, by using software to modify the base address bits of the SuperI/O Configuration 2 register (at Index 22h). See Section 2.4.4

2.1.2 The Index and Data Register Pair

During reset, a hardware strapping option on the BADDR0 and BADDR1 pins defines an address for the Index and Data Register pair. This prevents contention between the registers for I/O address space.

Table 2-1 shows the base addresses for the Index and Data registers that hardware sets for each combination of values of the Base Address strap pins (BADDR0 and BADDR1). You can access and change the content of the configuration registers at any time, as long as the base addresses of the Index and Data registers are defined.

When BADDR1 is low (0), the PnP protocol defines the addresses of the Index and Data register, and the system wakes up from reset in the Wait for Key state.

When BADDR1 is high (1), the addresses of the Index and Data register are according to Table 2-1, and the system wakes up from reset in the Config state.

This configures the part with default values, automatically, without software intervention. After reset, use software as described in Section 2.2 to modify the selected base address of the Index and Data register pair, and the defaults for configuration registers.

The Plug and Play soft reset has no effect on the logical devices, except for the effect of the Activate registers (index 30h) in each logical device.

The part can wake up with the FDC, the KBC and the RTC either active (enabled) or inactive (disabled). The clock multiplier, if configured via CFG3,2 strap pins, wakes up enabled. The other logical devices wake up inactive (disabled).

TABLE 2-1. Base Addresses

BADDR1	BADDR0	Address		Configuration Type
		Index Register	Data Register	
0	x	0279h Write Only	Write: 0A79h Read: RD_DATA Port	Full PnP ISA Mode Wake up in Wait for Key state
1	0	015Ch Read/Write	015Dh Read/Write	PnP Motherboard Mode Wake up in Config state
1	1	002Eh Read/Write	002Fh Read/Write	PnP Motherboard Mode Wake up in Config state

2.1.3 The Strap Pins

TABLE 2-2. Strap Pins

Pin	Reset Configuration	Affected
CFG0	0 - FDC, KBC and RTC wake up inactive. 1 - FDC, KBC and RTC wake up active.	Bit 0 of Activate registers (index 30h) of logical devices 0,2 and 3.
CFG1	0 - No X-Bus Data Buffer. (See XDB pins multiplexing in Table 1-2.) 1 - X-Bus Data Buffer (XDB) enabled.	Bit 4 of SuperI/O Configuration 1 register (index 21h).
CFG3,2	00 - Clock source is 24 MHz fed via X1 pin. 01 - Reserved for \overline{CSOUT} -NSC-Test fed via X1 pin. 10 - Clock source is 48 MHz fed via X1 pin. 11 - Clock source is 32.768 KHz with on-chip clock multiplier.	Bits 2-0 of PMC2 register of Power Management (logical device 8) CFG2 affects bits 0 and 2. CFG3 affects bit 1.
BADDR1,0	00 - Full PnP ISA, Wake in Wait For Key state. Index PnP ISA. 01 - Full PnP ISA, Wake in Wait For Key state. Index PnP ISA. 10 - PnP Motherboard, Wake in Config state. Index 015Ch. 11 - PnP Motherboard, Wake in Config state. Index 002Eh.	Bits 1 and 0 of SuperI/O Configuration 2 register (index 22h)
SELCS	0 - \overline{CSOUT} -NSC-test on $\overline{CS0}$ pin. 1 - $\overline{CS0}$ on $\overline{CS0}$ pin.	Bit 1 of SuperI/O Configuration 1 register (index 21h).

2.2 SOFTWARE CONFIGURATION

2.2.1 Accessing the Configuration Registers

Only two system I/O addresses are required to access any of the configuration registers. The Index and Data register pair is used to access registers for all read and write operations.

In a write operation, the target configuration register is identified, based on a value that is loaded into the Index register. Then, the data to be written into the configuration register is transferred via the Data register.

Similarly, for a read operation, first the source configuration register is identified, based on a value that is loaded into the Index register. Then, the data to be read is transferred via the Data register.

Reading the Index register returns the last value loaded into the Index register. Reading the Data register returns the data in the configuration register pointed to by the Index register.

If, during reset, the Base Address 1 (BADDR1) signal is low (0), the Index and Data registers are not accessible immediately after reset. As a result, all configuration registers of the part are also not accessible at this time. To access these registers, apply the PnP ISA protocol.

If during reset, the Base Address 1 (BADDR1) signal is high (1), all configuration registers are accessible immediately after reset.

It is up to the configuration software to guarantee no conflicts between the registers of the active (enabled) logical devices, between IRQ signals and between DMA channels. If conflicts of this type occur, the results are unpredictable.

To maintain compatibility with other SuperI/O's, the value of reserved bits may not be altered. Use read-modify-write.

2.2.2 Address Decoding

In full Plug and Play mode, the addresses of the Index and Data registers that access the configuration registers are decoded using pins A11-0, according to the ISA Plug and Play specification.

In Plug and Play Motherboard mode, the addresses of the Index and Data registers that access the configuration registers are decoded using pins A15-1. Pin A0 distinguishes between these two registers.

KBC and mouse register addresses are decoded using pins A1,0 and A15-3. Pin A2 distinguishes between the device registers.

RTC/APC and Power Management (PM) register addresses are decoded using pins A15-1. PM has only five registers and only responds to accesses to those registers.

FDC, UART, and GPIO register addresses are decoded using pins A15-3.

Parallel Port (PP) modes determine which pins are used for register addresses. In SPP mode, 14 pins are used to decode Parallel Port (PP) base addresses. In ECP and EPP modes, 13 address pins are used. Table 2-3 shows which address pins are used in each mode.

TABLE 2-3. Address Pins Used for Parallel Port

PP Mode	Pins Used to Decode Base Address	Pins Used to Distinguish Registers
SPP	A15-2	A1,0
ECP	A9-2 and A15-11	A1,0 and A10
EPP	A15-3	A2-0

TABLE 2-4. Parallel Port Address Range Allocation

Parallel Port Mode	SuperI/O Parallel Port Configuration Register Bits	Decoded Range ^a
	7 6 5 4	
SPP	0 0 x x	Three registers, from base to base + 02h
EPP (Non ECP Mode 4)	0 1 x x	Eight registers, from base to base + 07h
ECP, No Mode 4, No Internal Configuration	1 0 0 0	Six registers, from base to base + 02h and from base + 400h to base + 402h
ECP with Mode 4, No Internal Configuration	1 1 1 0	11 registers, from base to base + 07h and from base + 400h to base + 402h
ECP with Mode 4, Configuration within Parallel Port	1 0 0 1 or 1 1 1 1	16 registers, from base to base + 07h and from base + 400h to base + 407h

a. The SuperI/O processor does not decode the Parallel Port outside this range.

2.3 THE CONFIGURATION REGISTERS

The configuration registers control the setup of the part. Their major functions are to:

- Identify the chip
- Enable major functions (such as, the Keyboard Controller (KBC) for the keyboard and the mouse, the Real-Time Clock (RTC), including Advanced Power Control (APC), the Floppy Disc Controller (FDC), UARTs, parallel and general purpose ports, power management and pin functionality)
- Define the I/O addresses of these functions
- Define the status of these functions upon reset

Section 2.3.2 summarizes information for each register of each function. In addition, the following non-standard, or card control registers are described in detail in Section 2.4, starting on page 34.

- Card Control Registers
 - SuperI/O Configuration 1 Register (SIOC1)
 - SuperI/O Configuration 2 Register (SIOC2)
 - Programmable Chip Select Configuration Index Register
 - Programmable Chip Select Configuration Data Register
- KBC Configuration Register (Logical Device 0)
 - SuperI/O KBC Configuration Register
- FDC Configuration Registers (Logical Device 3)
 - SuperI/O FDC Configuration Register
 - Drive ID Register

- Parallel Port Configuration Register (Logical Device 4)
 - SuperI/O Parallel Port Configuration Register
- UART2 and Infrared Configuration Register (Logical Device 5)
 - SuperI/O UART2 Configuration Register
- UART1 Configuration Register (Logical Device 6)
 - SuperI/O UART1 Configuration Register
- Programmable Chip Select Configuration Registers
 - $\overline{CS0}$ Base Address MSB Register
 - $\overline{CS0}$ Base Address LSB Register
 - $\overline{CS0}$ Configuration Register
 - $\overline{CS1}$ Base Address MSB Register
 - $\overline{CS1}$ Base Address LSB Register
 - $\overline{CS1}$ Configuration Register
 - $\overline{CS2}$ Base Address MSB Register
 - $\overline{CS2}$ Base Address LSB Register
 - $\overline{CS2}$ Configuration Register

2.3.1 Standard Plug and Play (PnP) Register Definitions

Tables 2-5 through 2-10 describe the standard Plug and Play registers. For more detailed information on these registers, refer the "Plug and Play ISA Specification, Version 1.0a, May 5, 1994."

TABLE 2-5. PnP Standard Control Registers

Index	Name	Definition
00h	Set RD_DATA Port	Writing to this location modifies the address of the port used for reading from the Plug and Play ISA cards. Data bits 7-0 are loaded into I/O read port address bits 9-2. Reads from this register are ignored. Bits 1 and 0 are fixed at the value 11.
01h	Serial Isolation	Reading this register causes a Plug and Play card in the Isolation state to compare one bit of the ID of the board. This register is read only.
02h	Config Control	This register is write-only. The values are not sticky, that is, hardware automatically clears the bits and there is no need for software to do so. Bit 0 - Reset Writing this bit resets all logical devices and restores the contents of configuration registers to their power-up (default) values. In addition, all the logical devices of the card enter their default state and the CSN is preserved. Bit 1 - Return to the Wait for Key state. Writing this bit puts all cards in the Wait for Key state, with all CSNs preserved and logical devices not affected. Bit 2 - Reset CSN to 0. Writing this bit causes every card to reset its CSN to zero.
03h	Wake[CSN]	A write to this port causes all cards that have a CSN that matches the write data in bits 7-0 to go from the Sleep state to either the Isolation state, if the write data for this command is zero, or the Config state, if the write data is not zero. It also resets the pointer to the byte-serial device. This register is write-only.
04h	Resource Data	This address holds the next byte of resource information. The Status register must be polled until bit 0 of this register is set to 1 before this register can be read. This register is read-only.
005	Status	When bit 0 of this register is set to 1, the next data byte is available for reading from the Resource Data register. This register is read-only.
06h	Card Select Number (CSN)	Writing to this port assigns a CSN to a card. The CSN is a value uniquely assigned to each ISA card after the serial identification process so that each card may be individually selected during a Wake[CSN] command. This register is read/write.
07h	Logical Device Number	This register selects the current logical device. All reads and writes of memory, I/O, interrupt and DMA configuration information access the registers of the logical device written here. In addition, the I/O Range Check and Activate commands operate only on the selected logical device.
20h - 2Fh	Card Level, Vendor Defined	Vendor defined registers.

TABLE 2-6. PnP Logical Device Control Registers

Index	Name	Definition
0030h	Activate	<p>For each logical device there is one Activate register that controls whether or not the logical device is active on the ISA bus.</p> <p>This is a read/write register.</p> <p>Before a logical device is activated, I/O Range Check must be disabled.</p> <p>Bit 0 - Logical Device Activation Control 0 - Do not activate the logical device. 1 - Activate the logical device.</p> <p>Bits 7-1 - Reserved These bits are reserved and return 0 on reads.</p>
0031h	I/O Range Check	<p>This register is used to perform a conflict check on the I/O port range programmed for use by a logical device.</p> <p>This register is read/write.</p> <p>Bit 0 - I/O Range Check control 0 - The logical device drives 00AAh. 1 - The logical device responds to I/O reads of the logical device's assigned I/O range with a 0055h when I/O Range Check is enabled.</p> <p>Bit 1 - Enable I/O Range Check 0 - I/O Range Check is disabled. 1 - I/O Range Check is enabled. (I/O Range Check is valid only when the logical device is inactive).</p> <p>Bits 7-2 - Reserved These bits are reserved and return 0 on reads.</p>

TABLE 2-7. PnP I/O Space Configuration Registers

Index	Name	Definition
60h	I/O Port Base Address Bits (15-8) Descriptor 0	Read/write value indicating the selected I/O lower limit address bits 15-8 for I/O descriptor 0.
61h	I/O Port Base Address Bits (7-0) Descriptor 0	Read/write value indicating the selected I/O lower limit address bits 7-0 for I/O descriptor 0.
62h	I/O Port Base Address Bits (15-8) Descriptor 1	Read/write value indicating the selected I/O lower limit address bits 15-8 for I/O descriptor 1.
63h	I/O Port Base Address Bits (7-0) Descriptor 1	Read/write value indicating the selected I/O lower limit address bits 7-0 for I/O descriptor 1.

TABLE 2-8. PnP Interrupt Configuration Registers

Index	Name	Definition
70h	Interrupt Request Level Select 0	Read/write value indicating selected interrupt level. Bits3-0 select the interrupt level used for interrupt 0. A value of 1 selects IRQL 1, a value of 15 selects IRQL 15. IRQL 0 is not a valid interrupt selection and (represents no interrupt selection).
71h	Interrupt Request Type Select 0	Read/write value that indicates the type and level of the interrupt request level selected in the previous register. If a card supports only one type of interrupt, this register may be read-only. Bit 0 - Type of the interrupt request selected in the previous register. 0 - Edge 1 - Level Bit1 - Level of the interrupt request selected in the previous register. (see also "IRQ Mapping" on page 181). 0 - Low polarity (implies open-drain output with strong pull-up for a short time, followed by weak pull-up). 1 - High polarity (implies push-pull output).

TABLE 2-9. PnP DMA Configuration Registers

Index	Name	Definition
74h	DMA Channel Select 0	Read/write value indicating selected DMA channel for DMA 0. Bits 2-0 select the DMA channel for DMA 0. A value of 0 selects DMA channel 0; a value of 7 selects DMA channel 7. Selecting DMA channel 4, the cascade channel, indicates that no DMA channel is active.
75h	DMA Channel Select 1	Read/write value indicating selected DMA channel for DMA 1 Bits 2-0 select the DMA channel for DMA 1. A value of 0 selects DMA channel 0; a value of 7 selects DMA channel 7. Selecting DMA channel 4, the cascade channel, indicates that no DMA channel is active.

TABLE 2-10. PnP Logical Device Configuration Registers

Index	Name	Definition
F0h-FEh	Logical Device Configuration Vendor Defined	Vendor defined.

2.3.2 Configuration Register Summary

The tables in this section specify the Index, type (read/write), reset value and configuration register or action that controls each register associated with each function. When the reset value is not fixed, the table indicates what controls the value or points to another section that provides this information.

Soft Reset is related to a Reset executed by utilizing the Reset Bit (Bit 0) of the Config Control Register. (See Table 2-5 on page 27.)

TABLE 2-11. Card Configuration Registers

Index	Type	Hard Reset	Soft Reset	Configuration Register or Action
00h	W	00h	PnP ISA	Set RD_DATA Port.
01h	R			Serial Isolation.
02h	W	PnP ISA	PnP ISA	Configuration Control.
03h	W	00h	PnP ISA	Wake[CSN].
04h	R			Resource Data.
05h	R			Status.
06h	R/W	00h	PnP ISA	Card Select Number (CSN).
07h	R/W	00h	PnP ISA	Logical Device Number.
20h	R	See section 2.4.1 and 2.4.2 on page 34.		SID Register.
21h	R/W	See Section 2.4.3 on page 34.	No Effect	SuperI/O Configuration 1 Register.
22h	R/W	See Section 2.4.4 on page 35.	No Effect	SuperI/O Configuration 2 Register.
23h	R/W	See Section 2.4.5 on page 35.	No Effect	Programmable Chip Select Configuration Index Register.
24h	R/W	See Section 2.4.6 on page 36.	No Effect	Programmable Chip Select Configuration Data Register.
27h	R	See Section 2.4.7 on page 36.		SRID Register (in pc97307 only).

TABLE 2-12. KBC Configuration Registers for Keyboard - Logical Device 0

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h or 01h See CFG0, Section 2.1.3.	00h or 01h See CFG0, Section 2.1.3.	Activate. See also FER1 of power management device (logical device 8).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	00h	00h	Data Base Address MSB Register.
61h	R/W	60h	60h	Data Base Address LSB Register. Bit 2 (for A2) is read only, 0.
62h	R/W	00h	00h	Command Base Address MSB Register.
63h	R/W	64	64h	Command Base Address LSB. Bit 2 (for A2) is read only, 1.
70h	R/W	01h	01h	KBC Interrupt (KBC IRQ1 pin) Select.
71h	R/W	02h	02h	KBC Interrupt Type. Bits 1,0 are read/write; other bits, read only.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.
F0h	R/W	See Section 2.5.1 on page 36.	No Effect	SuperI/O KBC Configuration Register.

TABLE 2-13. KBC Configuration Registers for Mouse - Logical Device 1

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. When mouse of the KBC mouse is inactive, the IRQ selected by the Mouse Interrupt Select register (index 70h) is not asserted. This register has no effect on host KBC commands handling the PS/2 mouse.
70h	R/W	0Ch	0Ch	Mouse Interrupt (KBC IRQ12 pin) Select.
71h	R/W	02h	02h	Mouse Interrupt Type. Bits 1,0 are read/write; other bits are read only.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

TABLE 2-14. RTC and APC Configuration Registers - Logical Device 2

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h or 01h See CFG0 in Section 2.1.3.	00h or 01h See CFG0 in Section 2.1.3.	Activate. The APC of the RTC is not affected by bit 0. See also FER1 of logical device 8.
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	00h	00h	Base Address MSB Register.
61h	R/W	70h	70h	Base Address LSB Register. Bit 0 (for A0) is read only, 0.
70h	R/W	08h	08h	Interrupt Select.
71h	R/W	00h	00h	Interrupt Type. Bit 1 is read/write, other bits are read only.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

TABLE 2-15. FDC Configuration Registers - Logical Device 3

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h or 01h See CFG0 in Section 2.1.3.	00h or 01h See CFG0 in Section 2.1.3.	Activate. See also FER1 of logical device 8.
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	03h	03h	Base Address MSB Register.
61h	R/W	F2h	F2h	Base Address LSB Register. Bits 2 and 0 (for A2 and A0) are read only, 0,0.
70h	R/W	06h	06h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is read/write; other bits are read only.
74h	R/W	02h	02h	DMA Channel Select.
75h	R	04h	04h	Report no DMA assignment.
F0h	R/W	See Section 2.6.1 on page 36.	No Effect	SuperI/O FDC Configuration Register.
F1h	R/W	See Section 2.6.2 on page 37.	No Effect	Drive ID Register.

TABLE 2-16. Parallel Port Configuration Registers - Logical Device 4

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. See also FER1 of the power management device (logical device 8).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	02h	02h	Base Address MSB register. Bits 7-2 (for A15-10) are read only, 000000b.
61h	R/W	78h	78h	Base Address LSB register. Bits 1,0 (for A1,0) are read only, 00b. See Section 2.2.2 on page 25.
70h	R/W	07h	07h	Interrupt Select.
71h	R/W	00h	00h	Interrupt Type. Bit 0 is read only. It reflects the interrupt type dictated by the Parallel Port operation mode and configured by the SuperI/O Parallel Port Configuration register. This bit is set to 1 (level interrupt) in Extended Mode and cleared (edge interrupt) in all other modes. Bit 1 is a read/write bit. Bits 7-2 are read only.
74h	R/W	04h	04h	DMA Channel Select.
75h	R	04h	04h	Report no DMA assignment.
F0h	R/W	See Section 2.7 on page 37.	No Effect	SuperI/O Parallel Port Configuration register.

TABLE 2-17. UART2 and Infrared Configuration Registers - Logical Device 5

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00	Activate. See also FER1 of the power management device (logical device 8).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	02h	02h	Base Address MSB register.
61h	R/W	F8h	F8h	Base Address LSB register. Bit 2-0 (for A2-0) are read only, 000b.
70h	R/W	03h	03h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is R/W; other bits are read only.
74h	R/W	04h	04h	DMA Channel Select 0 (RX_DMA).
75h	R/W	04h	04h	DMA Channel Select 1 (TX_DMA).
F0h	R/W	See Section 2.8 on page 38.	No Effect	SuperI/O UART2 Configuration register.

TABLE 2-18. UART1 Configuration Registers - Logical Device 6

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. See also FER1 of the power management device (logical device 8).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	03h	03h	Base Address MSB Register.
61h	R/W	F8h	F8h	Base Address LSB Register. Bits 2-0 (for A2-0) are read only as 000b.
70h	R/W	04h	04h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is read/write. Other bits are read only.
74h	R	04h	04h	Report no DMA Assignment.
75h	R	04h	04h	Report no DMA Assignment.
F0h	R/W	See Section 2.9.1 on page 38.	No Effect	SuperI/O UART 1 Configuration register.

TABLE 2-19. GPIO Ports Configuration Registers - Logical Device 7

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. See also FER2 of the power management device (logical device 8).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	00h	00h	Base Address MSB Register.
61h	R/W	00h	00h	Base Address LSB Register. Bit 2-0 (for A2-0) are read only: 000b.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

TABLE 2-20. Power Management Configuration Registers - Logical Device 8

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00	00	Activate. When bit 0 is cleared, the registers of this logical device are not accessible. The registers are maintained.
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	00h	00h	Base Address Most Significant Byte.
61h	R/W	00h	00h	Base Address LSB Register. Bit 0 (for A) is read only: 0.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

2.4 CARD CONTROL REGISTERS

This section describes the registers at first level indexes in the range 20h - 2Fh.

2.4.1 SID Register (In PC87307)

This read-only register holds the revision and chip identity number of the chip. The PC87307VUL is identified by the value C0h in this register.

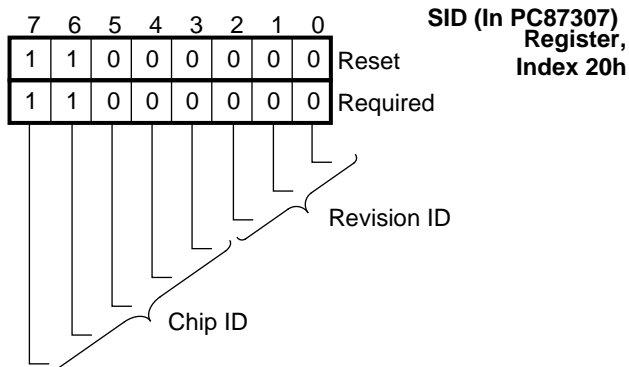


FIGURE 2-1. SID Register Bitmap (In PC87307)

2.4.2 SID Register (In PC97307)

This read-only register holds the identity number of the chip. The PC97307VUL is identified by the value CFh in this register.

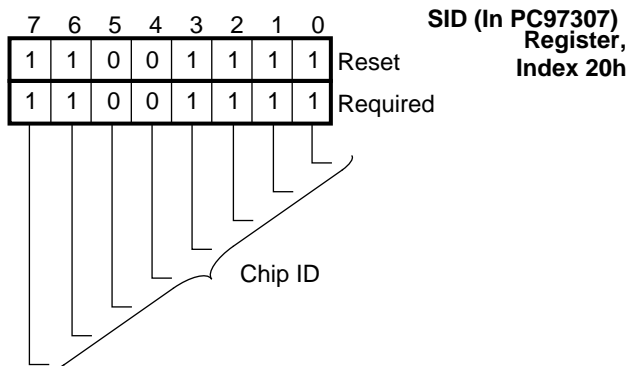


FIGURE 2-2. SID Register Bitmap (In PC97307)

2.4.3 SuperI/O Configuration 1 Register, Index 21h

This register can be read or written. It is reset by hardware to 04h, 06h, 14h or 16h. See SELCS and the CFG1 strap pin in Table 2-2 on page 25.

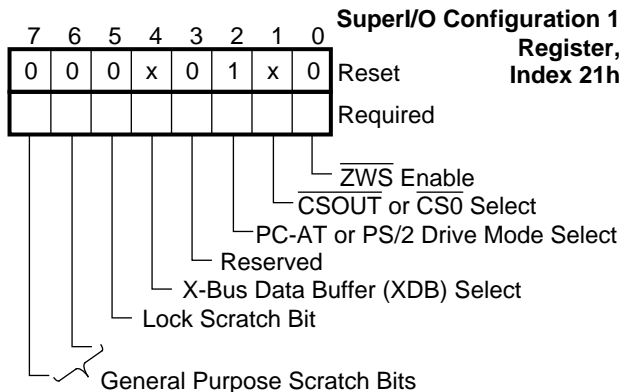


FIGURE 2-3. SuperI/O Configuration 1 Register Bitmap

Bit 0 - \overline{ZWS} Enable

This bit controls assertion of \overline{ZWS} on any host SuperI/O chip access, except for configuration registers access (including Serial Isolation register) and except for Parallel Port access.

For \overline{ZWS} assertion on host-EPP access, see Section 6.5.17 on page 126.

- 0 - \overline{ZWS} is not asserted.
- 1 - \overline{ZWS} is asserted.

Bit 1 - \overline{CSOUT} -NSC-test or $\overline{CS0}$ Pin Select

This bit is initialized with SELCS strap value.

- 0 - \overline{CSOUT} -NSC-test on $\overline{CS0}$ pin.
- 1 - $\overline{CS0}$.

Bit 2 - PC-AT or PS/2 Drive Mode Select

- 0 - PS/2 drive mode.
- 1 - PC-AT drive mode. (Default)

Bit 3 - Reserved

Reserved.

Bit 4 - X-Bus Data Buffer (XDB) Select

Select X-bus buffer on the XDB pins. This read only bit is initialized with the CFG1 strap value. See also Chapter 10 on page 179.

- 0 - No XDB buffer. XDB pins have alternate function, see Table 1-2 on page 23.
- 1 - XDB enabled.

Bit 5 - Lock Scratch Bit

This bit controls bits 7 and 6 of this register. Once this bit is set to 1 by software, it can be cleared to 0 only by a hardware reset.

- 0 - Bits 7 and 6 of this register are read/write bits.
- 1 - Bits 7 and 6 of this register are read only bits.

Bits 7,6 - General Purpose Scratch Bits

When bit 5 is set to 1, these bits are read only. After reset they can be read or written. Once changed to read-only, they can be changed back to be read/write bits only by a hardware reset.

2.4.4 SuperI/O Configuration 2 Register, Index 22h

This read/write register is reset by hardware to 00h-03h. See BADDR1,0 strap pins in Section 2.1.3.

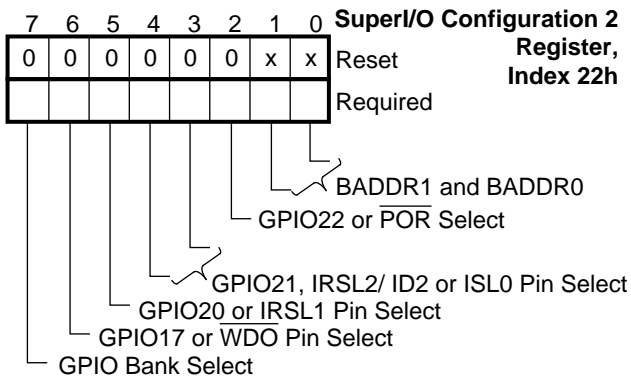


FIGURE 2-4. SuperI/O Configuration 2 Register Bitmap

Bits 1,0 - BADDR1 and BADDR0

Initialized on reset by BADDR1 and BADDR0 strap pins (BADDR0 on bit 0). These bits select the addresses of the configuration Index and Data registers and the Plug and Play ISA Serial Identifier. See Tables 2-1 and 2-2.

Bit 2 - GPIO22 or \overline{POR} Pin Select

The output buffer of this pin is selected by Port 2 Output Type and Port 2 Pull-up Control registers.

- 0 - The pin is GPIO22.
- 1 - The pin is \overline{POR} .

Bits 4,3 - GPIO21, IRSL2/ID2 or IRSL0 Pin Select

The output buffer of this pin is selected by Port 2 Output Type and Port 2 Pull-up Control registers as shown in Table 2-21.

TABLE 2-21. Signal Assignment for Pins 158 and 77

Bit 4 3	Pin 158	Pin 77 when Bit 4 of SuperI/O Config 1 Register = 0
0 0	GPIO21	IRSL2/SELCS
0 1	IRSL2/ID2	GPIO21/SELCS
1 0	IRSL0	IRSL2/SELCS
1 1	Reserved	IRSL2/SELCS

Bit 5 - GPIO20, IRSL1 or ID1 Pin Select

The output buffer of this pin is selected by Port 2 Output Type and Port 2 Pull-up Control registers.

- 0 - The pin is GPIO20.
- 1 - The pin is IRSL1/ID1.

Bit 6 - GPIO17 or \overline{WDO} Pin Select

This bit determines whether GPIO17 or \overline{WDO} is routed to pin 156 when bit 7 of the Port 1 Direction register at offset 01h of logical device 7 is set to 1. See Section 8.1 on page 170.

The output buffer of this pin is selected by Port 2 Output Type and Port 2 Pull-up Control registers.

- 0 - GPIO17 uses the pin. (Default)
- 1 - \overline{WDO} uses the pin.

Bit 7 - GPIO Bank Select

This bit selects the active register bank of GPIO registers.

- 0 - Bank 0 is selected. (Default)
- 1 - Bank 1 is selected.

2.4.5 Programmable Chip Select Configuration Index Register, Index 23h

This read/write register is reset by hardware to 00h. It indicates the index of one of the Programmable Chip Select (CS0, CS1 or CS2) configuration registers described in Section 2.10.

The data in the indicated register is in the Programmable Chip Select Configuration Data register at index 24h.

Bits 7 through 4 are read only and return 0000 when read.

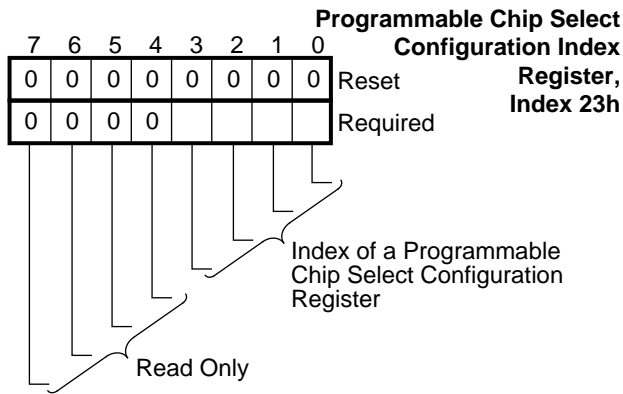


FIGURE 2-5. Programmable Chip Select Configuration Index Register Bitmap

2.4.6 Programmable Chip Select Configuration Data Register, Index 24h

This read/write register contains the data in the Programmable Chip Select Configuration register (see Section 2.10) indicated by the Programmable Chip Select Configuration Index register at index 23h.

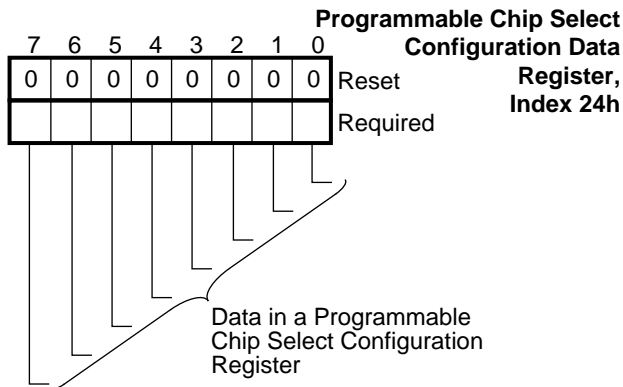


FIGURE 2-6. Programmable Chip Select Configuration Data Register Bitmap

2.4.7 SRID Register (In PC97307 only)

This read-only register contains the identity number of the chip revision. SRID is incremented on each tapeout.

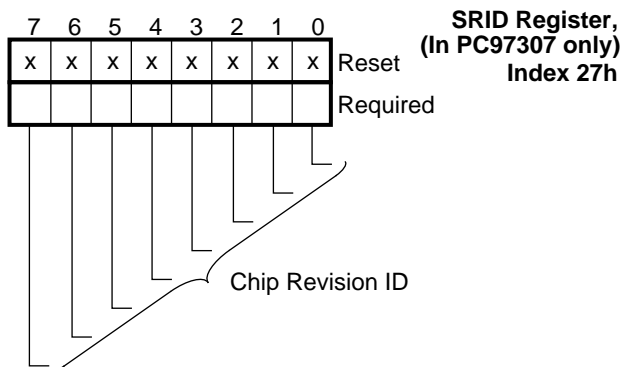


FIGURE 2-7. SRID Register Bitmap

2.5 KBC CONFIGURATION REGISTER (LOGICAL DEVICE 0)

2.5.1 SuperI/O KBC Configuration Register, Index F0h

This read/write register is reset by hardware to 40h.

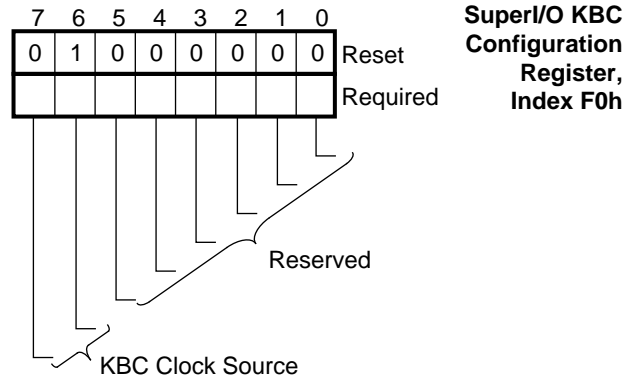


FIGURE 2-8. SuperI/O KBC Configuration Register Bitmap

Bits 5-0 - Reserved

Reserved.

Bits 7,6 - KBC Clock Source

Bit 6 is the LSB. The clock source can be changed only when the KBC is inactive (disabled).

00 - 8 MHz

01 - 12 MHz

10 - 16 MHz. Undefined results when these bits are 10 and the clock source for the chip is 24 MHz on X1.

11 - Reserved.

2.6 FDC CONFIGURATION REGISTERS (LOGICAL DEVICE 3)

2.6.1 SuperI/O FDC Configuration Register, Index F0h

This read/write register is reset by hardware to 20h.

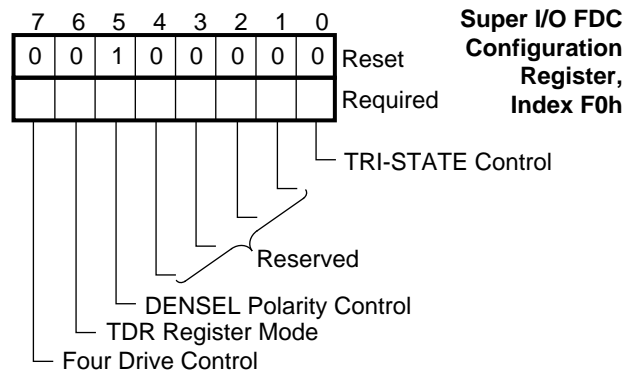


FIGURE 2-9. SuperI/O FDC Configuration Register Bitmap

Bit 0 - TRI-STATE Control

When set, this bit causes the FDC pins to be in TRI-STATE (except the IRQ and DMA pins) when the FDC is inactive (disabled).

This bit is ORed with a bit of PMC1 register of logical device 8.

- 0 - FDC pins are not put in TRI-STATE.
- 1 - FDC pins are put in TRI-STATE.

Bits 4-1 - Reserved

Reserved.

Bit 5 - DENSEL Polarity Control

- 0 - DENSEL is active low for 500 Kbps or 1 Mbps data rates.
- 1 - DENSEL is active high for 500 Kbps or 1 Mbps data rates. (Default)

Bit 6 - TDR Register Mode

- 0 - AT Compatible TDR mode (bits 7 through 2 of TDR are not driven).
- 1 - Enhanced TDR mode (bits 7 through 2 of TDR are driven on TDR read).

Bit 7 - Four Drive Encode

- 0 - Two floppy drives are directly controlled by $\overline{DR1-0}$, $\overline{MTR1-0}$.
- 1 - Four floppy drives are controlled with the aid of an external decoder.

2.6.2 Drive ID Register, Index F1h

This read/write register is reset by hardware to 00h. These bits control bits 5 and 4 of the enhanced TDR register.

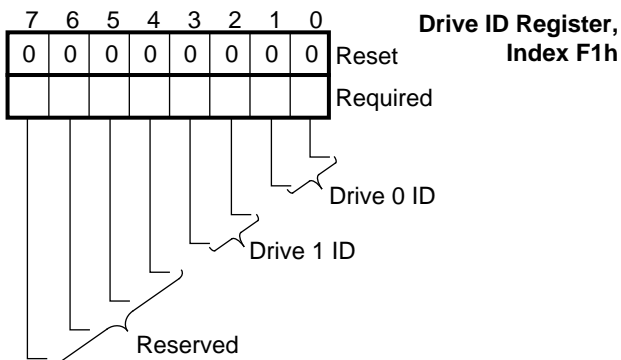


FIGURE 2-10. Drive ID Register Bitmap

Bits 1,0 - Drive 0 ID

These bits are reflected on bits 5 and 4, respectively, of the Tape Drive Register (TDR) of the FDC when drive 0 is accessed. See Section 5.3.4 on page 73.

Bits 3,2 - Drive 1 ID

These bits are reflected on bits 5 and 4, respectively, of the TDR register of the FDC when drive 1 is accessed. See Section 5.3.4 on page 73.

Bits 7-4 - Reserved

These bits are reserved.

2.7 PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 4)

2.7.1 SuperI/O Parallel Port Configuration Register, Index F0h

This read/write register is reset by hardware to F2h. For normal operation and to maintain compatibility with future chips, do not change bits 7 through 4.

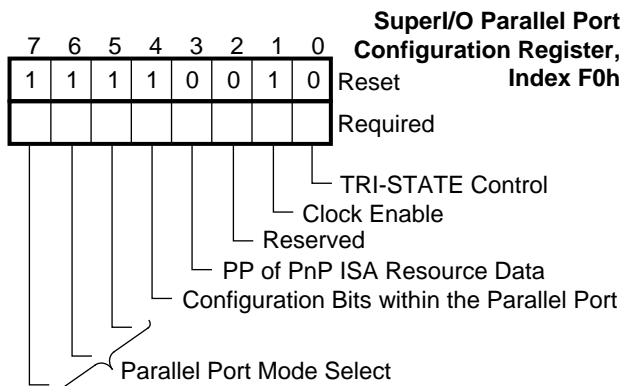


FIGURE 2-11. SuperI/O Parallel Port Configuration Register Bitmap

Bit 0 - TRI-STATE Control

When set, this bit causes the parallel port pins to be in TRI-STATE (except IRQ and DMA pins) when the parallel port is inactive (disabled). This bit is ORed with a bit of the PMC1 register of logical device 8.

Bit 1 - Clock Enable

0 - Parallel port clock disabled.

ECP modes and EPP time-out are not functional when the logical device is active. Registers are maintained.

1 - Parallel port clock enabled.

All operation modes are functional when the logical device is active. This bit is ANDed with a bit of the PMC3 register of the power management device (logical device 8).

Bit 2 - Reserved

This bit is reserved.

Bit 3 - Reported Parallel Port of PnP ISA Resource Data

Report to the ISA PnP Resource Data the device identification.

0 - ECP device.

1 - SPP device.

Bit 4 - Configuration Bits within the Parallel Port

0 - The registers at base (address) + 403h, base + 404h and base + 405h are not accessible (reads and writes are ignored).

1 - When ECP is selected by bits 7 through 5, the registers at base (address) + 403h, base + 404h and base + 405h are accessible.

This option supports run-time configuration within the Parallel Port address space. An 8-byte (and 1024-byte) aligned base address is required to access these registers. See Chapter 6 on page 111 for details.

Bit 7-5 - Parallel Port Mode Select

Bit 5 is the LSB.

Selection of EPP 1.7 or 1.9 in ECP mode 4 is controlled by bit 4 of the Control2 configuration register of the parallel port at offset 02h. See Section 6.5.17 on page 126.

000 - SPP Compatible mode. PD7-0 are always output signals.

001 - SPP Extended mode. PD7-0 direction controlled by software.

010 - EPP 1.7 mode.

011 - EPP 1.9 mode.

100 - IEEE1284 mode (IEEE1284 register set), with no support for EPP mode.

101 - Reserved.

110 - Reserved.

111 - IEEE1284 mode (IEEE1284 register set), with EPP mode selectable as mode 4.

2.8 UART2 AND INFRARED CONFIGURATION REGISTER (LOGICAL DEVICE 5)

2.8.1 SuperI/O UART2 Configuration Register, Index F0h

This read/write register is reset by hardware to 02h.

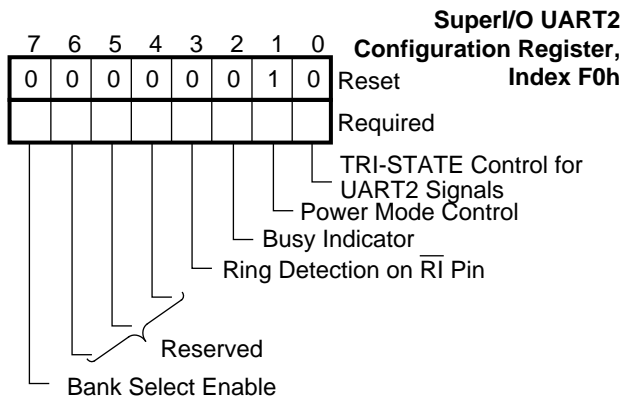


FIGURE 2-12. SuperI/O UART2 Configuration Register Bitmap

Bit 0 - TRI-STATE Control for UART signals

This bit controls the TRI-STATE status of UART signals (except IRQ and DMA signals) when the UART is inactive (disabled). This bit is ORed with a bit of the PMC1 register of the power management device (logical device 8).

0 - Signals not in TRI-STATE.

1 - Signals in TRI-STATE.

Bit 1 - Power Mode Control

0 - Low power mode.

UART Clock disabled. UART output signals are set to their default state. The RI input signal can be programmed to generate an interrupt. Registers are maintained.

1 - Normal power mode.

UART clock enabled. The UART is functional when the logical device is active. This bit is ANDed with a bit of the PMC3 register of the power management device (logical device 8)

Bit 2 - Busy Indicator

This read-only bit can be used by power management software to decide when to power down the logical device. This bit is also accessed via the PMC3 register of the power management device (logical device 8).

0 - No transfer in progress.

1 - Transfer in progress.

Bit 3 - Ring Detection on RI Pin

0 - The UART RI input signal uses the RI pin.

1 - The UART RI input signal is the RING detection signal on the RING pin. RING pin is selected by the APCR2 register of the Advanced Power Control (APC) module.

Bits 6-4 - Reserved

These bits are reserved.

Bit 7 - Bank Select Enable

Enables bank switching. If this bit is cleared, all attempts to access the extended registers are ignored.

2.9 UART1 CONFIGURATION REGISTER (LOGICAL DEVICE 6)

2.9.1 SuperI/O UART1 Configuration Register, Index F0h

This read/write register is reset by hardware to 02h. Its bits function like the bits in the SuperI/O UART2 Configuration register.

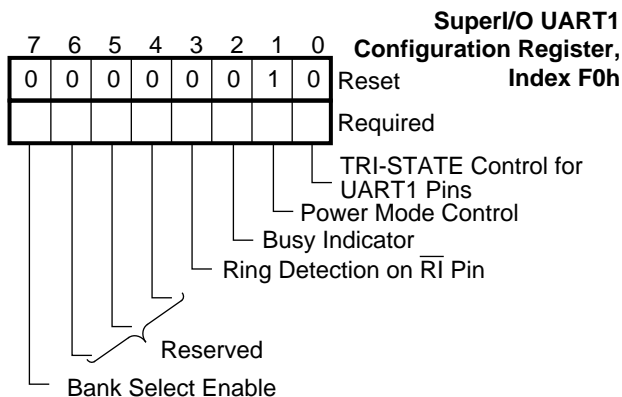


FIGURE 2-13. SuperI/O UART1 Configuration Register Bitmap

2.10 PROGRAMMABLE CHIP SELECT CONFIGURATION REGISTERS

The chip select configuration registers are accessed using two index levels. The first index level accesses the Programmable Chip Select Index register at 23h. See Section 2.4.5 on page 35. The second index level accesses a specific chip select configuration register as shown in Table 2-22.

See also, "Programmable Chip Select Output Signals" on page 171 and the description of each signal in Table 1-1 on page 15.

TABLE 2-22. The Programmable Chip Select Configuration Registers

Second Level Index	Register Name	Type	Reset
00h	$\overline{\text{CS0}}$ Base Address MSB Register	R/W	00h
01h	$\overline{\text{CS0}}$ Base Address LSB Register	R/W	00h
02h	$\overline{\text{CS0}}$ Configuration Register	R/W	00h
03h	Reserved	-	-
04h	$\overline{\text{CS1}}$ Base Address MSB Register	R/W	00h
05h	$\overline{\text{CS1}}$ Base Address LSB Register	R/W	00h
06h	$\overline{\text{CS1}}$ Configuration Register	R/W	00h
07h	Reserved	-	-
08h	$\overline{\text{CS2}}$ Base Address MSB Register	R/W	00h
09h	$\overline{\text{CS2}}$ Base Address LSB Register	R/W	00h
0Ah	$\overline{\text{CS2}}$ Configuration Register	R/W	00h
0Bh-0Fh	Reserved	-	-
10h-FFh	Not Accessible	-	-

2.10.1 $\overline{\text{CS0}}$ Base Address MSB, Second Level Index 00h

This read/write register is reset by hardware to 00h. Same as Plug and Play ISA base address register at index 60h. See Table 2-7 on page 28.

2.10.2 $\overline{\text{CS0}}$ Base Address LSB Register, Second Level Index 01h

This read/write register is reset by hardware to 00h. It is the same as the Plug and Play ISA base address register at index 61h. See Table 2-7 on page 28.

2.10.3 $\overline{\text{CS0}}$ Configuration Register, Second Level Index 02h

This read/write register is reset by hardware to 00h. It controls activation of the $\overline{\text{CS0}}$ signal upon an address match, when AEN is inactive (low) and the non-masked address pins match the corresponding base address bits.

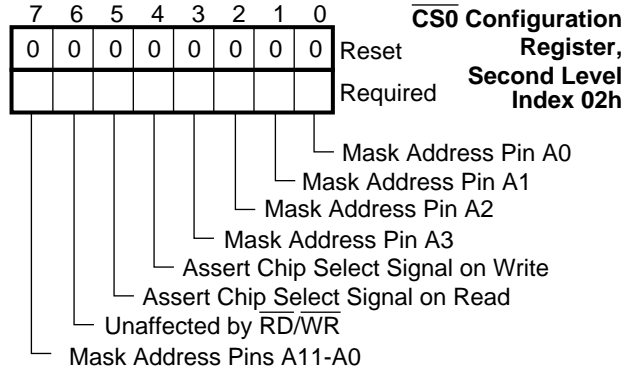


FIGURE 2-14. $\overline{\text{CS0}}$ Configuration Register Bitmap

Bit 0 - Mask Address Pin A0

- 0 - A0 is decoded.
- 1 - A0 is not decoded; it is ignored.

Bit 1 - Mask Address Pin A1

- 0 - A1 is decoded.
- 1 - A1 is not decoded (ignored).

Bit 2 - Mask Address Pin A2

- 0 - A2 is decoded.
- 1 - A2 is not decoded; it is ignored.

Bit 3 - Mask Address Pin A3

- 0 - A3 is decoded.
- 1 - A3 is not decoded; it is ignored.

Bit 4 - Assert Chip Select Signal on Write

- 0 - Chip select not asserted on address match and when $\overline{\text{WR}}$ is active (low).
- 1 - Chip select asserted on address match and when $\overline{\text{WR}}$ is active (low).

Bit 5 - Assert Chip Select Signal on Read

- 0 - Chip select not asserted on address match and when $\overline{\text{RD}}$ is active (low).
- 1 - Chip select asserted on address match and when $\overline{\text{RD}}$ is active (low).

Bit 6 - Unaffected by $\overline{\text{RD}}/\overline{\text{WR}}$

- Bits 5 and 4 are ignored when this bit is set.
- 0 - Chip select asserted on address match, qualified by $\overline{\text{RD}}$ or $\overline{\text{WR}}$ pin state and contents of bits 5 and 4.
- 1 - Chip select asserted on address match, regardless of $\overline{\text{RD}}$ or $\overline{\text{WR}}$ pin state and regardless of contents of bits 5 and 4.

Bit 7 - Mask Address Pins A11-A0

- 0 - A11-A0 are decoded.
- 1 - A11-A0 are not decoded; they are ignored.

2.10.4 Reserved, Second Level Index 03h

Attempts to access this register produce undefined results.

2.10.5 $\overline{CS1}$ Base Address MSB Register, Second Level Index 04h

This read/write register is reset by hardware to 00h. Same as Plug and Play ISA base address register at index 60h. See Table 2-7 on page 28.

2.10.6 $\overline{CS1}$ Base Address LSB Register, Second Level Index 05h

This read/write register is reset by hardware to 00h. Same as Plug and Play ISA base address register at index 61h. See Table 2-7 on page 28.

2.10.7 $\overline{CS1}$ Configuration Register, Second Level Index 06h

This read/write register is reset by hardware to 00h. It functions like the $\overline{CS0}$ Configuration Register described in Section 2.10.3.

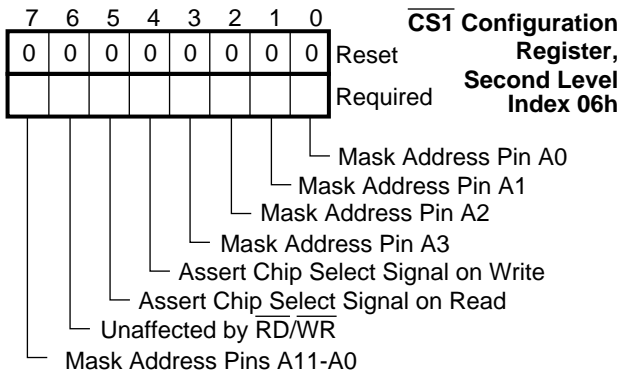


FIGURE 2-15. $\overline{CS1}$ Configuration Register Bitmap

2.10.8 Reserved, Second Level Index 07h

Attempts to access this register produce undefined results.

2.10.9 $\overline{CS2}$ Base Address MSB Register, Second Level Index 08h

This read/write register is reset by hardware to 00h. It functions like the Plug and Play ISA base address register at index 60h. See Table 2-7 on page 28.

2.10.10 $\overline{CS2}$ Base Address LSB Register, Second Level Index 09h

This read/write register is reset by hardware to 00h. It functions like the Plug and Play ISA base address register at index 61h. See Table 2-7 on page 28.

2.10.11 $\overline{CS2}$ Configuration Register, Second Level Index 0Ah

This read/write register is reset by hardware to 00h. It functions like the $\overline{CS0}$ Configuration register.

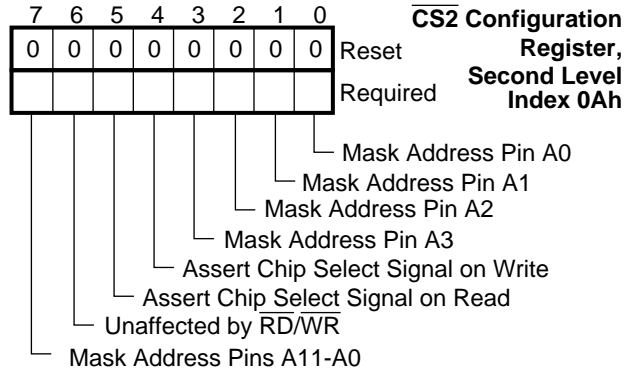


FIGURE 2-16. $\overline{CS2}$ Configuration Register Bitmap

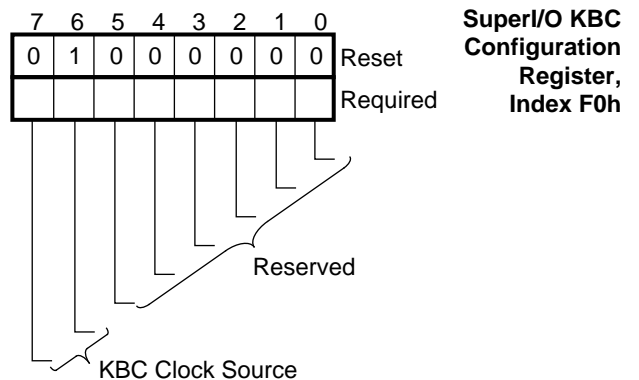
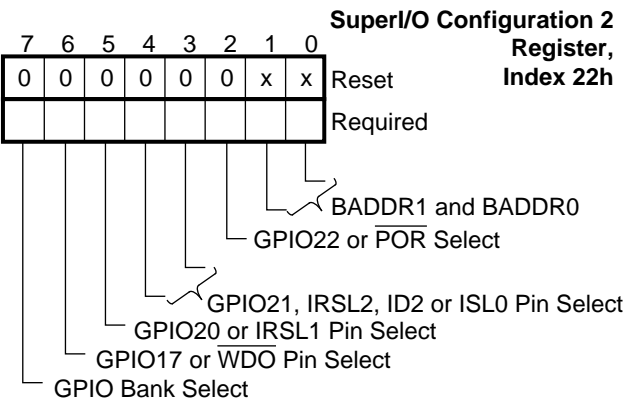
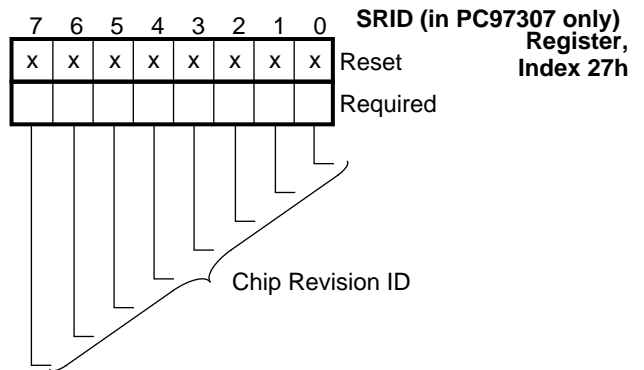
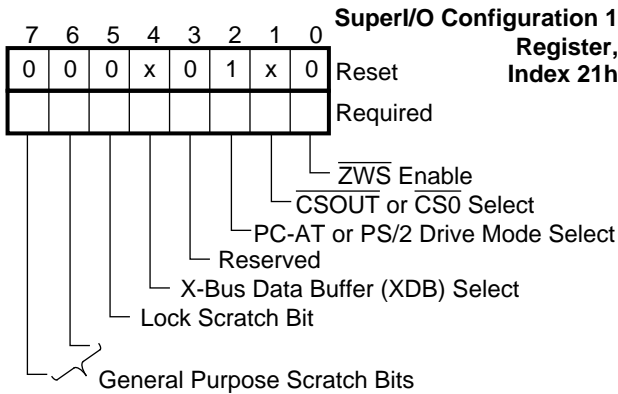
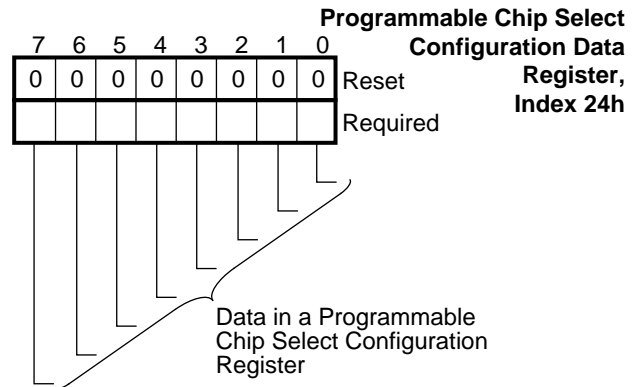
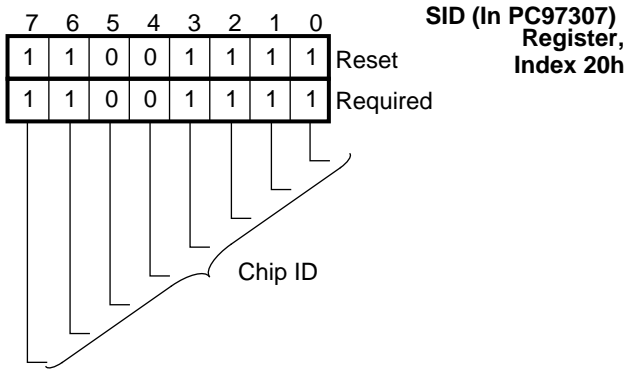
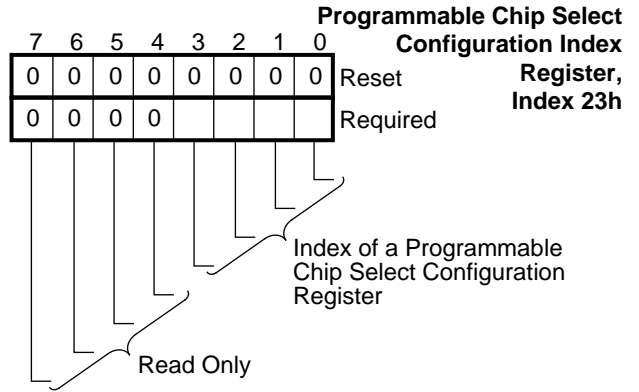
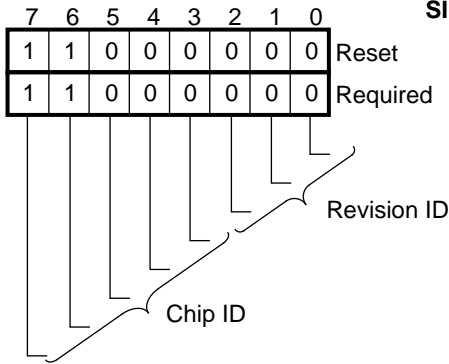
2.10.12 Reserved, Second Level Indexes 0Bh-0Fh

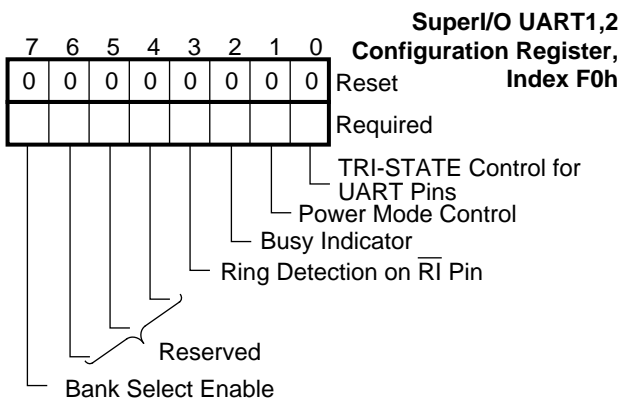
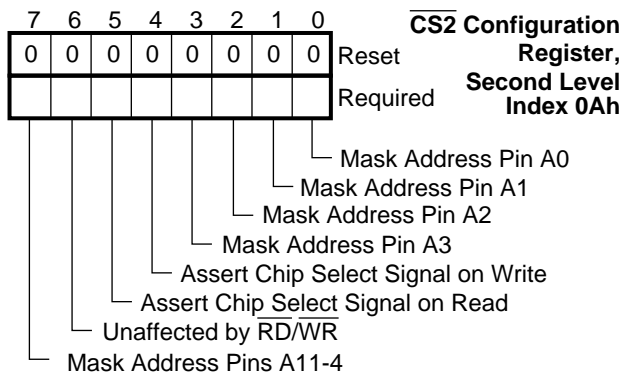
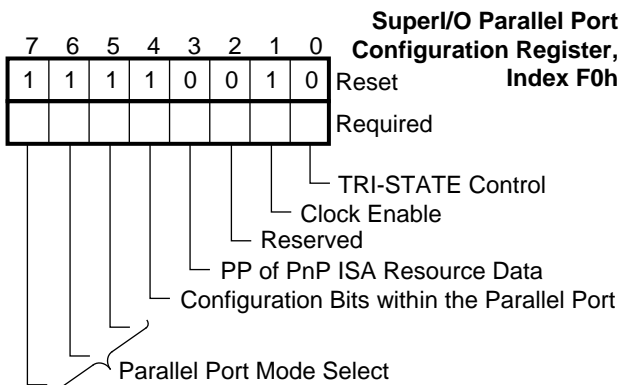
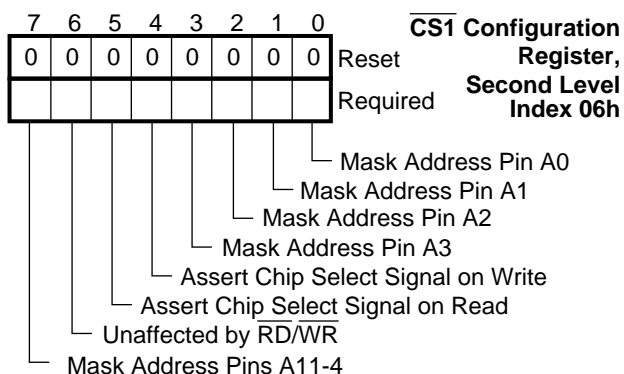
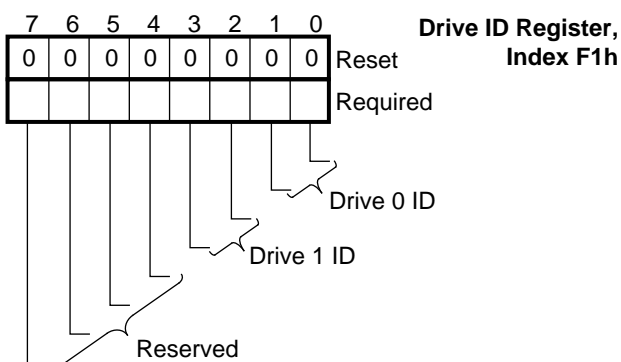
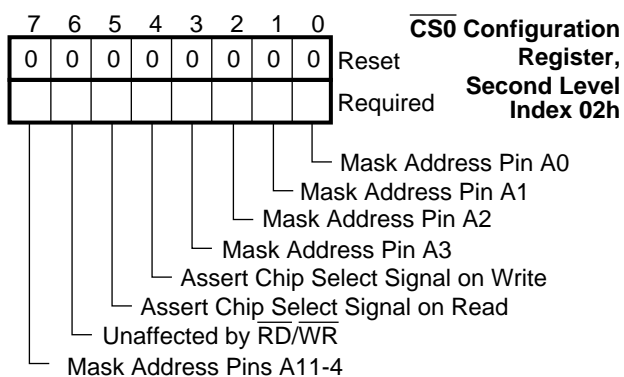
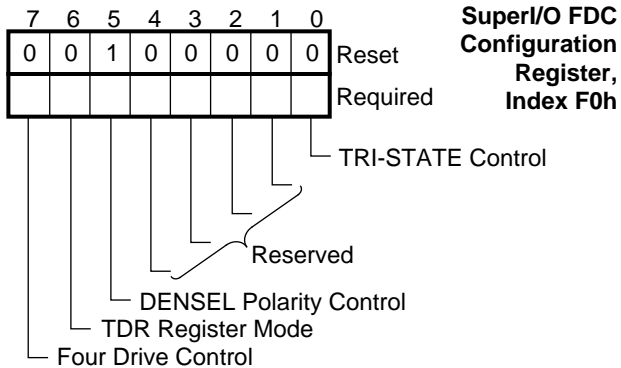
Attempts to access these registers produce undefined results.

2.10.13 Not Accessible, Second Level Indexes 10h-FFh

Not accessible because bits 7-4 of the Index register are 0.

2.11 CARD CONTROL REGISTER BITMAPS





3.0 Keyboard (and Mouse) Controller (KBC) (Logical Devices 0 and 1)

The Keyboard Controller (KBC) is a functionally independent programmable device controller. It is implemented physically as a single hardware module on the part multi-I/O chip and houses two separate logical devices: a keyboard controller and a mouse controller.

The KBC accepts user input from the keyboard or mouse, and transfers this input to the host PC via the common PC87307/PC97307-PC interface.

The KBC is functionally equivalent to the industry standard 8042A keyboard controller, which may serve as a detailed technical reference for the KBC.

The KBC is delivered preprogrammed with customer-supplied code. KBC firmware code is identical to 8042 code, and to code of the keyboard controller of the PC87323VUL chip. The PC87323VUL is recommended as a development platform for the KBC since it uses identical code and includes an internal program RAM that enables software development

3.1 SYSTEM ARCHITECTURE

The KBC is a general purpose microcontroller, with an 8-bit internal data bus. See Figure 3-1. It includes the following functional blocks:

Serial Open-Collector Drivers: Four open-collector bi-directional serial lines enable serial data exchange with the external devices (keyboard and mouse) using the PS/2 protocol.

Program ROM: 2 Kbytes of ROM store program machine code in non-erasable memory. The code is copied to this ROM during manufacture, from customer-supplied code.

Data RAM: 256 bytes of Data RAM enables run-time internal data storage, and includes an 8-level stack and 16 8-bit registers.

Timer/Counter: An internal 8-bit timer/counter can count external events or pre-divided system clock pulses. An internal time-out interrupt may be generated by this device.

I/O Ports: Two 8-bit ports (Port 1 and Port 2) serve various I/O functions. Some are for general purpose use, others are utilized by the KBC firmware as shown in Figure 3-1.

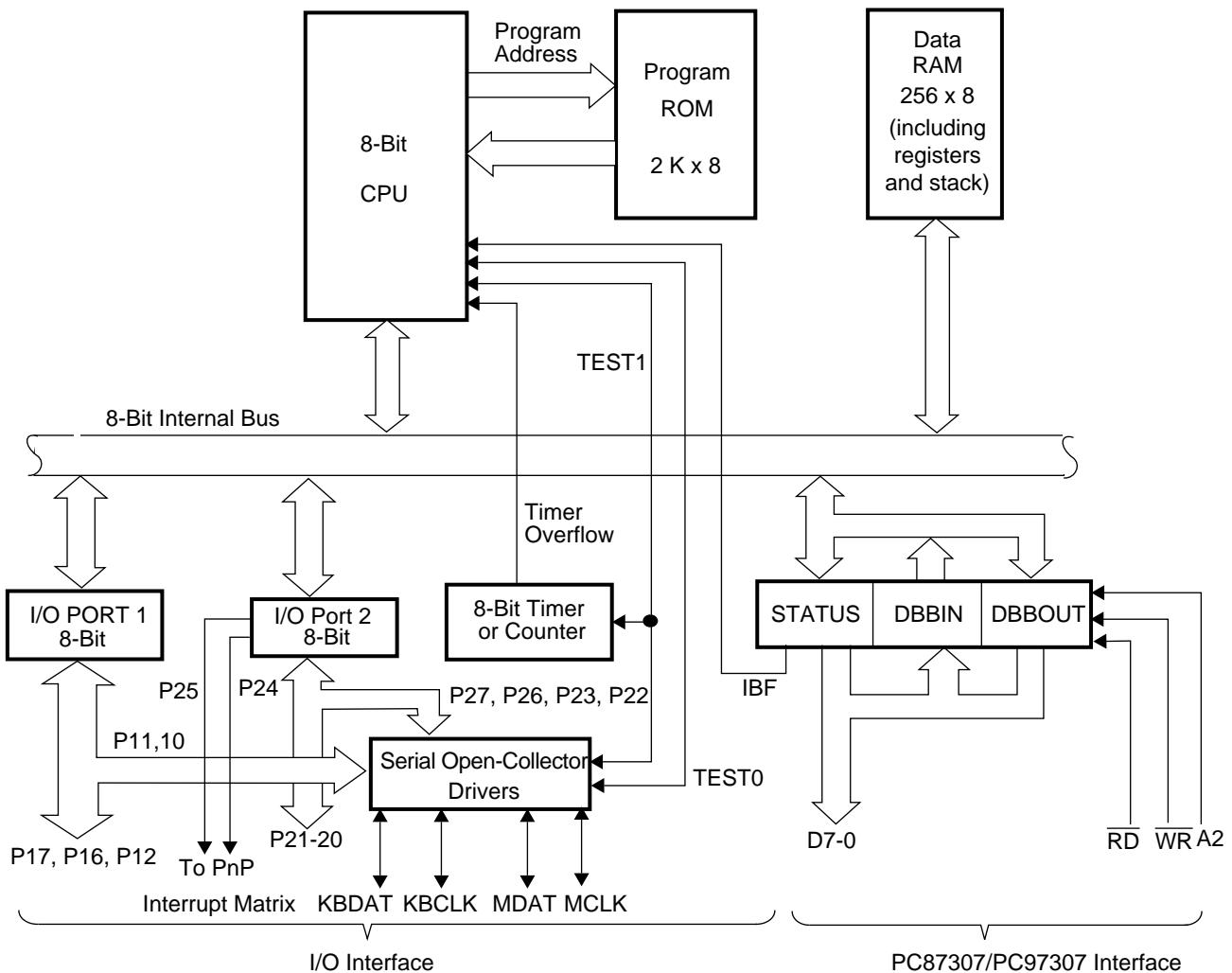


FIGURE 3-1. KBC System Functional Block Diagram

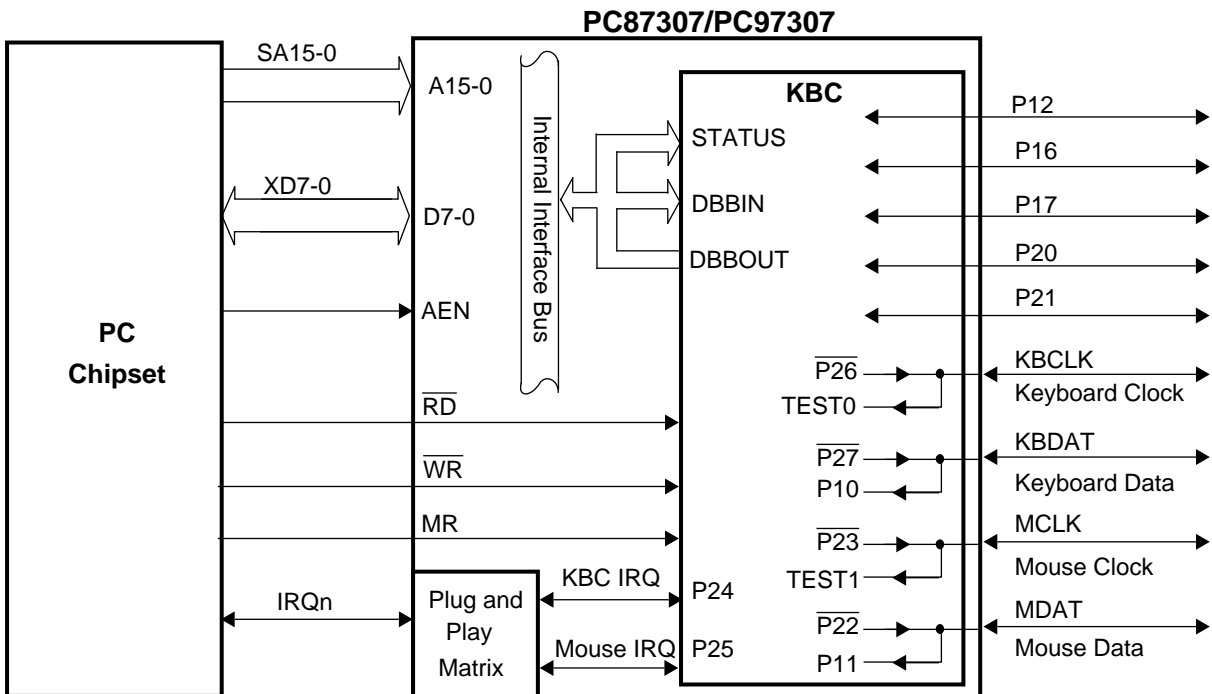


FIGURE 3-2. System Interfaces

3.2 FUNCTIONAL OVERVIEW

The KBC supports two external devices — a keyboard and a mouse. Each device communicates with the KBC via two bidirectional serial signals. Five additional external general-purpose I/O signals are provided.

KBC operation involves three signal interfaces:

- External I/O interface
- Internal KBC - PC87307/PC97307 interface
- PC87307/PC97307 - PC chip set interface.

These system interfaces are shown in Figure 3-2.

The KBC uses two data registers (for input and output) and a status register to communicate with the part central system. Data exchange between these units may be based on programmed I/O or interrupt-driven.

The KBC has two internal interrupts: the Input Buffer Full (IBF) interrupt and Timer Overflow interrupt (see Figure 3-1). These two interrupts can be independently enabled or disabled by KBC firmware. Both are disabled by a hard reset. These two interrupts only affect the execution flow of the KBC firmware, and have no connection with the external interrupts requested by this logical device.

The KBC can generate two external interrupt requests. These request signals are controlled by the KBC firmware which generates them by manipulating I/O port signals. See Section 3.3.2.

The part supports the KBC and handles interactions with the PC chip set. In addition to data transfer, these interactions include KBC configuration, activation and status monitoring. The part interconnects with the host via one interface that is shared by all chip devices

The KBC clock is generated from the main clock of the chip, which may come from an external clock source or from the internal frequency multiplier. (See Sections 3.3 and 3-4.) The KBC clock rate is configured by the SuperI/O (SIO) Configuration Registers.

3.3 DEVICE CONFIGURATION

The KBC hardware contains two logical devices—the KBC (logical device 0) and the mouse (logical device 1).

3.3.1 I/O Address Space

The KBC has two I/O addresses and one IRQ line (KBC IRQ) and can operate without the companion mouse.

The mouse cannot operate without the KBC device. It has one IRQ line (mouse IRQ) but has no I/O address. It utilizes the KBC I/O addresses.

3.3.2 Interrupt Request Signals

The KBC IRQ and Mouse IRQ interrupt request signals are identical to (or functions of) the P24 and P25 signals of the 8042. These interrupt request signals are routed internally to the Plug and Play interrupt Matrix and may be routed to user-programmable IRQ pins. Each logical device is independently controlled.

The Interrupt Select registers (index 70h for each logical device) select the IRQ pin to which the corresponding interrupt request is routed. The interrupt may also be disabled by not routing its request signal to any IRQ pin.

Bit 0 of the Interrupt Type registers (index 71h for each logical device) determines whether the interrupts are passed (bit 0 = 0) or latched (bit 0 = 1). If bit 0 = 0, interrupt request signals (P24 and P25) are passed directly to the selected IRQ pin. If bit 0 = 1, interrupt request signals that become active are latched on their rising edge, and held until read from the KBC output buffer (port 60h).

Figure 3-3 illustrates the internal interrupt request logic.

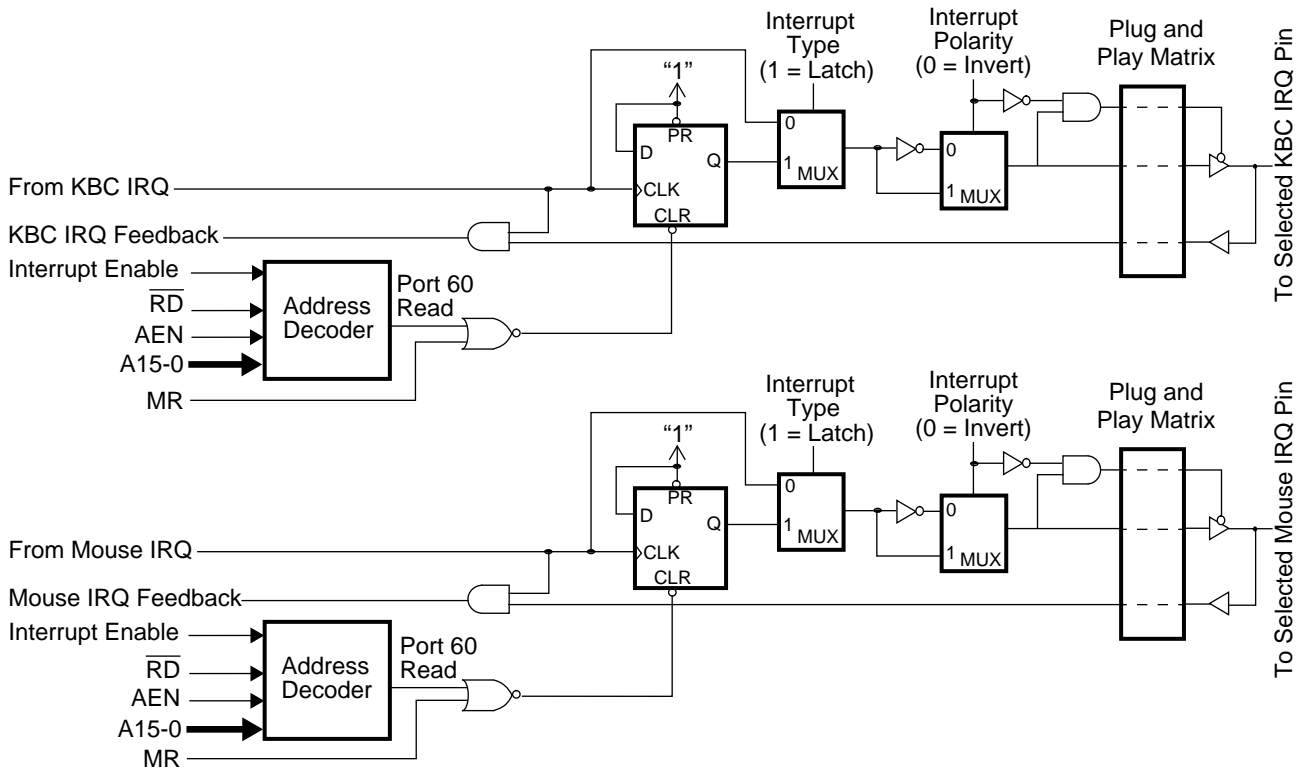


FIGURE 3-3. Interrupt Request Logic

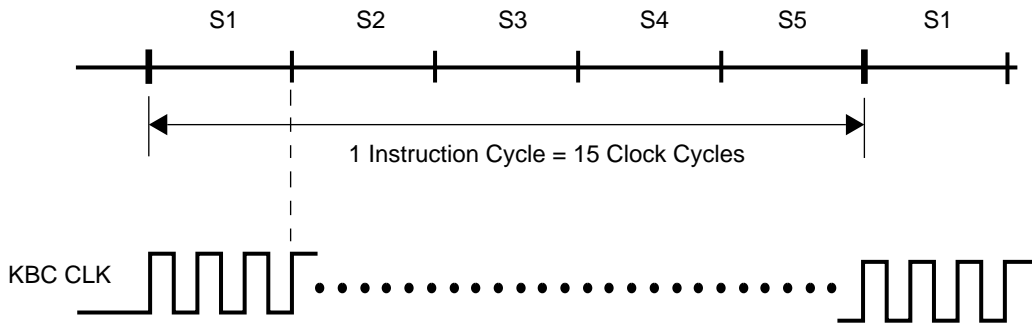


FIGURE 3-4. Instruction Timing

Note:

The EN FLAGS command (used for routing OBF and IBF onto P24 and P25 in the 8042) causes unpredictable results and should not be issued.

3.3.3 KBC Clock

The KBC clock frequency is selected by the SuperI/O KBC Configuration Register at index F0h of logical device 0 to be either 8, 12 or 16 MHz. 16 MHz is not available when the clock source on pin X1 is 24 MHz. This clock is generated from a 32.768 KHz crystal connected to pins X1C and X2C, or from either a 24 MHz or a 48 MHz clock input at pin X1. See "SuperI/O KBC Configuration Register, Index F0h" on page 36, Figures 3-4 and 3-5. The clock source and frequency may only be changed when the KBC is disabled.

For details regarding the configuration of each device, refer to Tables 2-12 and 2-13 starting on page 30.

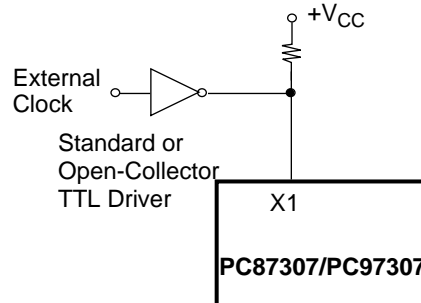


FIGURE 3-5. External Clock Connection

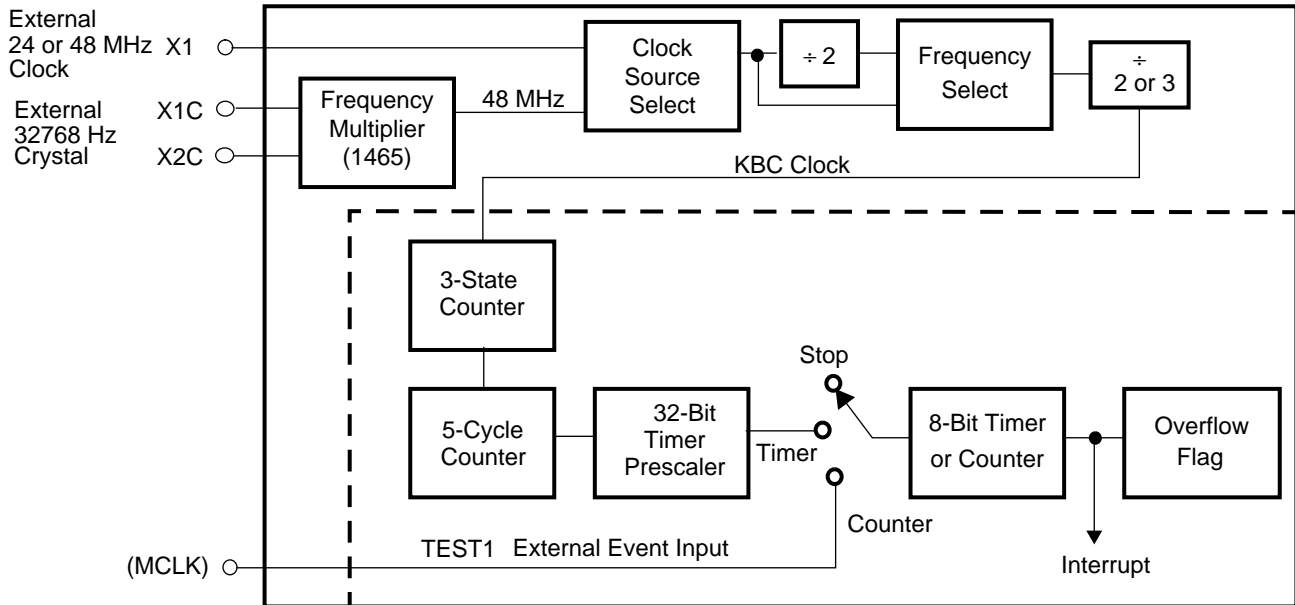


FIGURE 3-6. Timing Generation and Timer Circuit

3.3.4 Timer or Event Counter

The keyboard controller includes an 8-bit counter, which can be used as a timer or an event counter, as selected by the firmware.

Timer Operation

When the internal clock is chosen as the counter input, the counter functions as a timer. The clock fed to the timer consists of the KBC instruction cycle clock, divided by 32. (See Figures 3-4 and 3-6.) The divisor is reset only by a hardware reset or when the timer is started by an STRT T instruction.

The timer counts up from a programmable initial value and sets an overflow flag when it overflows. This flag may be tested, or may be set up to generate an overflow interrupt.

Refer to the 8042 or PC87323VUL instruction set for details.

Event Counter Operation

When the clock input of the counter is switched to the external input (MCLK), it becomes an event counter. The falling edge of the signal on the MCLK pin causes the counter to increment. Timer Overflow Flag and Timer interrupt operate as in the timer mode.

3.4 EXTERNAL I/O INTERFACES

The PC chipset interfaces with the part as illustrated in Figure 3-2 on page 44.

All data transactions between the KBC and the PC chipset are handled by the part.

The part decodes all I/O device chip-select functions from the address bus. The KBC chip-select codes are, traditionally, 60h or 64h, as described in Table 3-1. (These addresses are user-programmable.)

The external interface includes two sets of signals: the keyboard and mouse interface signals, and the general-purpose I/O signals.

3.4.1 Keyboard and Mouse Interface

Four serial I/O signals interface with the external keyboard and mouse. These signals are driven by open-collector drivers with signals derived from two I/O ports residing on the internal bus. Each output can drive 16 mA, making them suitable for driving the keyboard and mouse cables. The signals are named KBCLK, KBDAT, MCLK and MDAT, and they are the logical complements of P26, P27, P23 and P22, respectively.

TEST0 and TEST1 are dedicated test pins, internally connected to KBCLK and MCLK, respectively, as shown in Figures 3-1 and 3-2. These pins may be used as logical conditions for conditional jump instructions, which directly check the logical levels at the pins.

KBDAT and MDAT are connected to pins P10 and P11, respectively.

MCLK also provides input to the event counter.

3.4.2 General Purpose I/O Signals

The P12, P16, P17, P20 and P21 general purpose I/O signals interface to two I/O ports (port1 and port2). P12, P16 and P17 are mapped to port 1 and P20 and P21 are mapped to port 2.

P12, P16 and P17 are driven by quasi-bidirectional drivers. (See Figure 3-7.) These signals are called quasi-bidirectional because the output buffer cannot be turned off (even when the I/O signal is used for input).

During output, a 1 written to output is strongly pulled up for the duration of a (short) write pulse, and thereafter maintained by a high impedance "weak" active pull-up (implemented by a degenerated transistor employed as a switchable pull-up resistor). A series resistor to those port lines used for input is recommended to limit the surge current during the strong pull-up. See Figure 3-8.

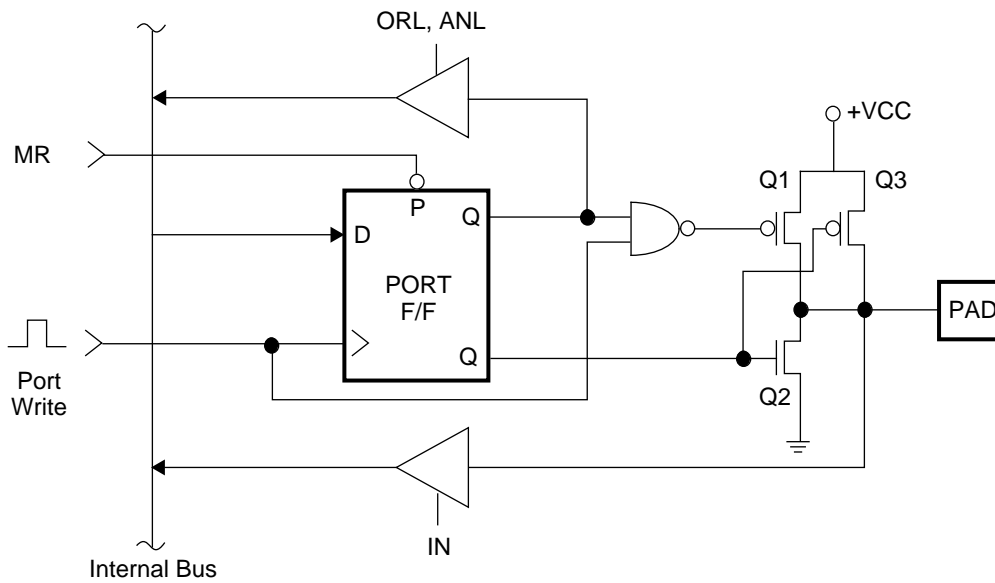


FIGURE 3-7. Quasi-Bidirectional Driver

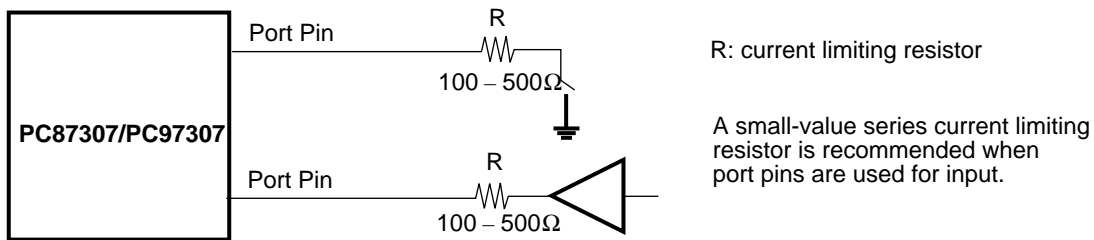


FIGURE 3-8. Current Limiting Resistor

If a 1 is asserted, an externally applied signal may pull down the output. Therefore, input from this quasi-bidirectional circuit can be correctly read if preceded by a 1 written to output.

P20 and P21 are driven by open-drain drivers.

When the KBC is reset, all port data bits are initialized to 1.

3.5 INTERNAL KBC - PC87307/PC97307 INTERFACE

The KBC interfaces internally with the part via three registers: an input (DBBIN), output (DBBOUT) and status (STATUS) register. See Figure 3-1 on page 43 and Table 3-1.

TABLE 3-1. System Interface Operations

\overline{RD}	\overline{WR}	Default Addresses	Operation
0	1	60h	Read DBBOUT
1	0	60h	Write DBBIN, F1 Clear (Data)
0	1	64h	Read STATUS
1	0	64h	Write DBBIN, F1 Set (Command)

Table 3-1 illustrates the use of address line A2 to differentiate between data and commands. The device is selected by chip identification of default address 60h (when A2 is 0) or 64h (when A2 is 1). After reset, these addresses can be changed by software.

3.5.1 The KBC DBBOUT Register, Offset 60h, Read Only

The DBBOUT register transfers data from the keyboard controller to the part. It is written to by the keyboard controller and read by the part for transfer to the PC. The PC may be notified of the need to read data from the KBC by an interrupt request or by polling the Output Buffer Full (OBF) bit (bit 0 of the KBC STATUS register described in Section 3.5.3 on page 48).

3.5.2 The KBC DBBIN Register, Offset 60h (F1 Clear) or 64h (F1 Set), Write Only

The DBBIN register transfers data from the part system to the keyboard controller. (This transaction is transparent to the user, who should program the device as if direct access to the registers were in effect.)

When data is received in this manner, an Input Buffer Full (IBF) internal interrupt may be generated in the KBC, to deal with this data. Alternatively, reception of data in this manner can be detected by the KBC polling the Input Buffer Full bit (IBF, bit 1 of the KBC STATUS register).

3.5.3 The KBC STATUS Register, Offset 64h, Read Only

The STATUS register holds information regarding the system interface status. Figure 3-9 shows the bit definition of this register. This register is controlled by the KBC firmware and hardware, and is read-only for the system.

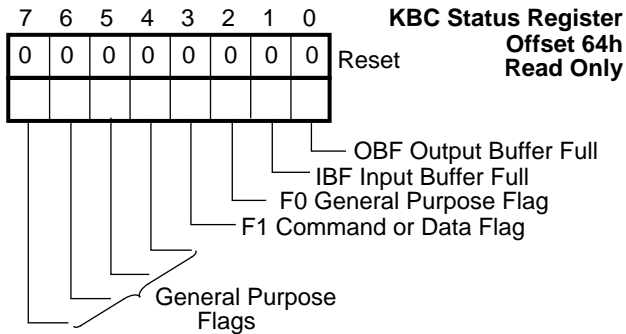


FIGURE 3-9. KBC STATUS Register Bitmap

Bit 0 - OBF, Output Buffer Full

A 1 indicates that data has been written into the DB-BOUT register by the KBC. It is cleared by a system read operation from DBBOUT.

Bit 1 - IBF, Input Buffer Full

When a write operation is performed by the host system, this bit is set to 1, which may be set up to trigger the IBF interrupt. Upon executing an IN A, DBB instruction, it is cleared.

Bit 2 - F0, General Purpose Flag

A general purpose flag that can be cleared or toggled by the keyboard controller firmware.

Bit 3 - F1, Command/Data Flag

This flag holds the state of address line A2 while a write operation is performed by the host system. It distinguishes between commands and data from the host system. In this device, a write with A2 = 1 (hence F1 = 1) is defined as a command, and A2 = 0 (hence F1 = 0) is data.

Bits 7-4, General Purpose Flags

These flags may be modified by KBC firmware.

3.6 INSTRUCTION TIMING

The KBC clock is first divided by 3 to generate the state timing, then by 5 to generate the instruction timing. Thus each instruction cycle consists of five states and 15 clock cycles.

Most keyboard controller instructions require only one instruction cycle, while some require two cycles. Refer to the 8042 or PC87323VUL instruction set for details.

4.0 Real-Time Clock (RTC) and Advanced Power Control (APC) (Logical Device 2)

The RTC logical device contains two major functions: the Real-Time Clock (RTC) and Advanced Power Control (APC).

The RTC is a timekeeping module that supplies a time-of-day clock and a multi-century calendar in various formats. It provides alarm facilities and three programmable timer interrupts. It continues valid timekeeping and maintains RAM contents during power down by utilizing external battery backup.

Additional features of the RTC include Advanced Power Control (APC), a century timekeeping storage byte, full Plug and Play support, additional battery-backed RAM and RAM lock schemes, and additional power management options.

The APC function adds the ability of automatic PC system power-up in response to external events. This enables efficient use of the PC system in applications such as voice answering machines or fax receivers, which are typically powered up at all times.

The APC also enables a controlled power-down sequence when switched off by the user. The APC function does not replace the power management abilities of various modules—it adds power management ability to the PC host system.

RTC software is compatible with the DS1287 and MC146818 clock chips. (The only difference is that Port 70 is read/write in this module, and is write-only in the DS1287 and MC146818.)

Battery-Backed Register Banks and RAM

The RTC and APC module has three battery-backed register banks. Two are used by the logical units themselves. The host system uses the third for general purpose battery-backed storage.

Battery-backup power enables information retention during system power down.

The banks are:

- Bank 0 - General Purpose Register Bank
- Bank 1 - RTC Register Bank
- Bank 2 - APC Register Bank

The memory maps and register content for each of the three banks is illustrated in Section 4.7 on page 64.

The lower 64-byte locations of the three banks are shared. The first 14 bytes store time and alarm data and contain control registers. The next 50 bytes are general purpose memory.

The upper 64 bytes of bank addresses are utilized as follows:

- Bank 0 supplies an additional 64 bytes of memory backed RAM.
- Bank 1 uses the upper 64 bytes for functions specific to the RTC activity and for addressing Upper RAM.
- Bank 2 uses the upper 64 bytes for functions specific to the APC activity.

Registers with reserved bits should be written in “Read-Modify-Write” method.

RTC Control Register A (CRA) selects the active bank according to the value of bits 6-4 (DV2-0). (See Table 4-3 on page 53.)

All register locations within the device are accessed by the RTC Index and Data registers (at base address and base address+1). The Index register points to the register location being accessed, and the Data register contains the data to be transferred to or from the location. An additional 128 bytes of battery-backed RAM (also called upper RAM) may be accessed via a second level address. The second level uses the upper RAM Index register at index 50h of bank 1 and the upper RAM Data register at index 53h of bank 1.

Access to the three register banks and RAM may be locked. For details see “RAM Lock Register (RLR), Index 47h” on page 62.

4.1 RTC OPERATION OVERVIEW

The control registers listed in Table 4-1 control all RTC operation. These registers appear in all the RTC register banks. See Section 4.7 on page 64.

TABLE 4-1. RTC Control Registers

Index	Name	Description
0Ah	CRA	RTC Control Register A
0Bh	CRB	RTC Control Register B
0Ch	CRC	RTC Control Register C
0Dh	CRD	RTC Control Register D

RTC configuration registers within the part store the settings for all interface, configuration and power management options. These registers are described in detail in Section 2.3 on page 26.

The RTC employs an external crystal connected to an internal oscillator circuit or an optional external clock input, as the basic clock for timekeeping.

Local battery-backed RAM serves as storage for all timekeeping functions.

4.1.1 RTC Hardware and Functional Description

Bus Interface

The RTC function is initially mapped to the default I/O locations at indexes 70h (Index) and 71h (data) within the part. These locations may be reassigned, in compliance with the Plug and Play requirements. See Section 2.2 on page 25.

External Clock and Timing Generation

The RTC can use one of the following timekeeping input clock options:

- A 32768 Hz crystal connected externally at the X1C and X2C pins completes an oscillator circuit and generates the 32768 Hz input clock. (See “Oscillator Internal and External Circuitry” on page 50.)

- An external clock may be connected to pin X1C.

The time generation function divides the 32.768 KHz by 2^{15} to derive a 1 Hz signal which serves as the input for time-keeping functions. Bits 6-4 of RTC Control Register A (CRA) control the activity and location of the divider chain in memory. Bits 3-0 of the CRA register select one of fifteen taps from the divider chain to be used as a periodic interrupt. See Section "RTC Control Register A (CRA), Index 0Ah" on page 52 for a description of divider configurations and rate selections.

The divider chain is reset to 0 by bits 6-4 of the CRA register. An update occurs 500 msec after the divider chain is activated by setting normal operational mode (bits 6-4 of CRA = 010). The periodic flag becomes active one half of the programmed period after the divider chain is activated.

Figure 4-1 illustrates the internal and external circuitry that comprise the oscillator.

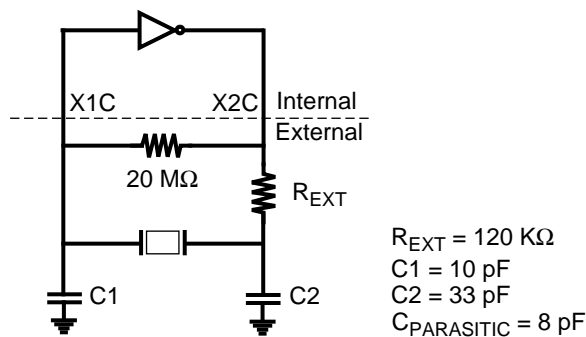


FIGURE 4-1. Oscillator Internal and External Circuitry

This oscillator is active under normal power or during power down. It stops only in the event of a power failure with the oscillator disabled (see "Oscillator Activity" on page 52), or when battery backup power drops below two volts.

If oscillator input is from an external source, input should be driven rail to rail and should have a nominal 50% duty cycle. In this case, oscillator output X2C should be disabled.

External capacitor values should be chosen to provide the manufacturer's specified load capacitance for the crystal when combined with the parasitic capacitance of the trace, socket, and package, which can vary from 0 to 8 pF. The rule of thumb in choosing these capacitors is:

$$C_L = (C1 * C2) \div (C1 + C2) + C_{PARASITIC}$$

$$C2 > C1$$

C1 can be trimmed to achieve precisely 32768.0 Hz after insertion.

Start-up time for this oscillator may vary from two to seven seconds due to the high Q of the crystal. The parameters below describe the crystal requirements:

Parallel, resonant, tuning fork (N cut) or XY bar
 $Q \geq 35000$

Load Capacitance (C_L) 9 to 13 pF

Accuracy and temperature coefficients are user defined.

4.1.2 Timekeeping

Time is kept in BCD or binary format as determined by bit 2 (DM) of Control Register B (CRB). Either 12 or 24 hour representation for the hours can be maintained as determined by bit 1 of CRB. When changing formats, the time registers must be re-initialized to the corresponding data format.

Daylight savings time and leap year exceptions are handled by the timekeeping function. When bit 0 (the Daylight Saving Enable bit, DSE) of CRB is set to 1, time advances from 1:59:59 AM to 3:00:00 on the first Sunday in April, and changes from 1:59:59 to 1:00:00 on the last Sunday of October. In leap years, February is extended to 29 days.

Updating

Timekeeping is performed by hardware, which updates a pre-programmed time value once per second. The pre-programmed time values are written by the user to the following locations:

The values for seconds, minutes, hours, day of week, date of month, month and year are located in the common storage area in all three memory banks (See Table 4-6 on page 64). The century value is located in Bank 1 (See Table 4-8 on page 65).

Users must ensure that reading or writing to the time storage locations does not coincide with a system update of these locations, which would cause invalid and unpredictable results.

There are several ways to avoid this contention. Four options follow:

Method 1 - Set the SET bit (bit 7 of the CRB register) to 1.

This takes a "snapshot" of the internal time registers and loads it into the user copy. If user copy registers have been updated, the user copy updates the internal registers when the SET bit goes from 1 to 0. This mechanism enables loading new time parameters into the RTC.

Method 2 - Access after detection of an Update-Ended interrupt.

This implies that an update has just completed and there are 999 msec remaining until the next occurrence.

Method 3 - Poll Update-In-Progress (UIP) (bit 7 in Control Register A).

The update occurs 244 μ sec after the update-in-progress bit goes high. Therefore if a 0 is read, there is a minimum of 244 μ s in which the time is guaranteed to remain stable.

Method 4 - Use a periodic interrupt to determine if an update cycle is in progress.

The periodic interrupt is first set to a desired period. Periodic interrupt appearance then indicates there is a period of (Period of periodic interrupt \div 2 + 244 μ sec) remaining until another update occurs.

Alarms

The timekeeping function may generate an alarm when the current time reaches a stored alarm time. After each RTC time update, the seconds, minutes, and hours storage locations are compared with the seconds, minutes and hours in the alarm storage locations. If equal, the alarm flag is set in Control Register C (CRC). If the Alarm Interrupt Enable (AIE) bit is set in Control Register B (CRB), then setting the Alarm Flag (AF) in CRC generates the IRQ internal interrupt request (IRQ = 0).

Any alarm location, i.e., seconds, minutes or hours, may be set to a "Don't Care" state by setting bits 7,6 to 11. (This value is unused for either BCD or binary time codes.) This results in periodic alarm activation at an increased rate whose period is that of the Don't Care location, e.g., if the hours location is set to 11, the alarm will be activated every hour.

The seconds, minutes and hours alarm registers are shared with the wake-up function.

4.1.3 Power Supply

The host PC and part power is supplied by the system power supply voltage, V_{DD} .

Figure 4-2 shows the power supplies of the part.

A stand-by voltage (V_{CCH}) from the external AC power supply powers the RTC and APC under normal conditions. The V_{DD} voltage reaches the RTC/APC as a sense signal, to determine the presence or absence of a valid V_{DD} supply.

A battery backup voltage V_{BAT} maintains RTC/APC timekeeping and backup memory storage when the V_{CCH} voltage is absent, due to power failure or disconnection of the external AC input power supply.

The APC function produces the \overline{ONCTL} signal, which controls the V_{DD} power supply voltage. (See Section 4.4.1 on page 58.)

To ensure proper operation, a 500 mV differential is needed between V_{CCH} and V_{BAT} .

Figure 4-3 represents a typical battery configuration. No external diode is required to meet the UL standard, due to the internal serial resistor.

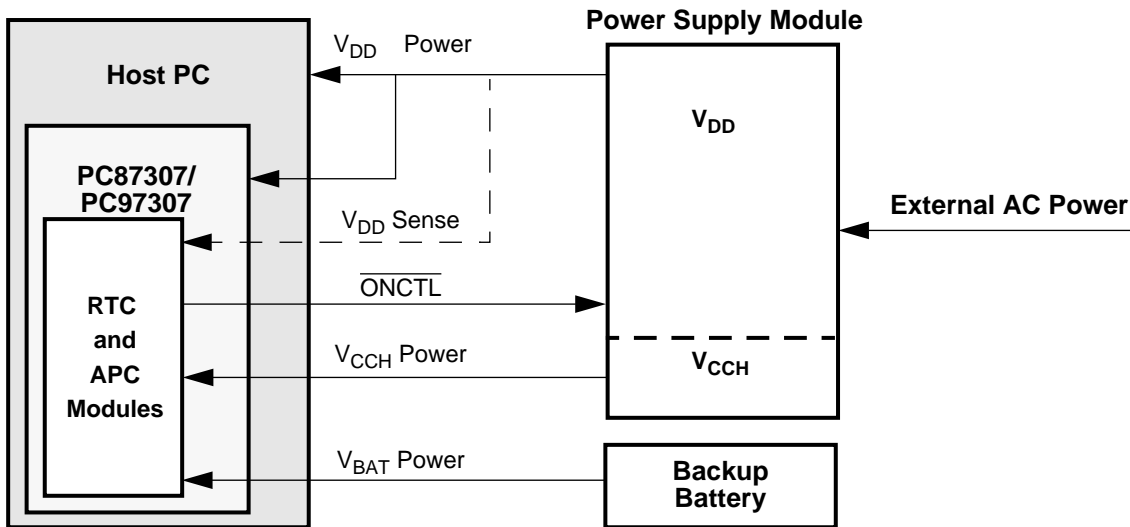


FIGURE 4-2. PC87307/PC97307 Power Supplies

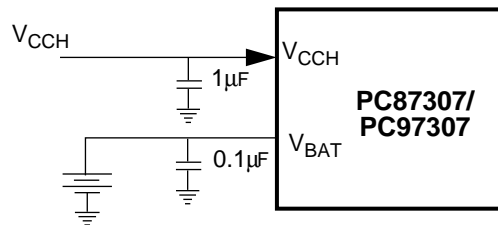


FIGURE 4-3. Typical Battery Configuration

System Bus Lockout

As the RTC switches to battery power all, input signals are locked out so that the internal registers can not be modified externally.

Power Up Detection

When system power is restored after a power failure, the power failure lock condition continues for a delay of 62 msec (minimum) to 125 msec (maximum) after the RTC switches from battery power to system power.

The power failure lock condition is switched off immediately in the following situations:

- If the Divider Chain Control bits (DV2-0, bits 6-4 in Control Register A) specify any mode other than 010, 100 or 011, all input signals are enabled immediately upon detection of system voltage above that of the battery voltage.
- When battery voltage is below 1 volt and MR is 1, all input signals are enabled immediately upon detection of system voltage above that of battery voltage. This also initializes registers at indexes 00h through 0Dh.
- If the VRT bit (bit 7 in Control Register D) is 0, all input signals are enabled immediately upon detection of system voltage above that of battery voltage.

Oscillator Activity

The RTC internal oscillator circuit is active whenever power is supplied to the RTC with the following exceptions:

- Software wrote 000 or 001 to the Divider Chain Control bits (DV2-0), i.e., bits 6-4, of Control Register A, and the RTC is supplied by V_{BAT} , or
- The RTC is supplied by V_{BAT} and the VRT bit of Control Register D is 0.

These conditions disables the oscillator.

When the oscillator becomes inactive, the APC is disabled.

4.1.4 Interrupt Handling

The RTC logic device has a single Interrupt Request line, \overline{IRQ} , which handles three interrupt conditions. The Periodic, Alarm, and Update-Ended interrupts are generated (\overline{IRQ} is driven low) if the respective enable bits in Control Register B are set when an interrupt event occurs.

Reading RTC Control Register C (CRC) clears all interrupt flags. Thus, it is recommended that when multiple interrupts are enabled, the interrupt service routine should first read and store the CRC register, then deal with all pending interrupts by referring to this stored status.

If an interrupt is not serviced before a second occurrence of the same interrupt condition, the second interrupt event is lost. Figure 4-5 illustrates interrupt and status timing in the part.

4.2 THE RTC REGISTERS

The RTC registers can be accessed at any time during non-battery backed operation. These registers cannot be written to before reading the VRT bit (bit 7 of the “RTC Control Register D (CRD), Index 0Dh” on page 55), thus preventing bank selection and other functions. The user must read the VRT bit as part of the startup activity.

These registers are listed in Table 4-1 and described in detail in the sections that follow.

4.2.1 RTC Control Register A (CRA), Index 0Ah

The CRA register controls periodic interrupt rate selection and bank selection.

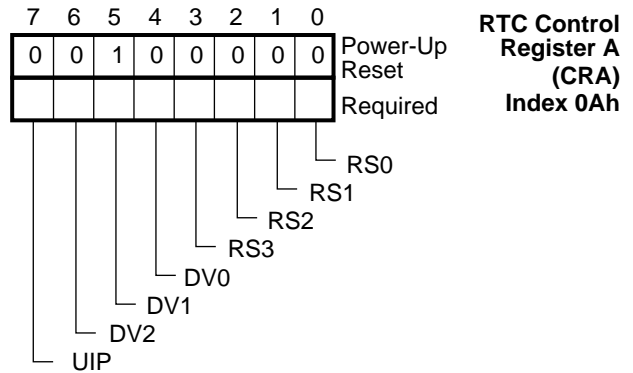


FIGURE 4-4. CRA Register Bitmap

Bits 3-0 - Periodic Interrupt Rate Select (RS3-0)

These read/write bits select one of fifteen output taps from the clock divider chain to control the rate of the periodic interrupt. See Table 4-2 and Figure 4-5.

Master reset does not affect these bits.

Bits 6-4 - Divider Chain Control (DV2-0)

These read/write bits control the configuration of the divider chain for timing generation and memory bank selection, as shown in Table 4-3.

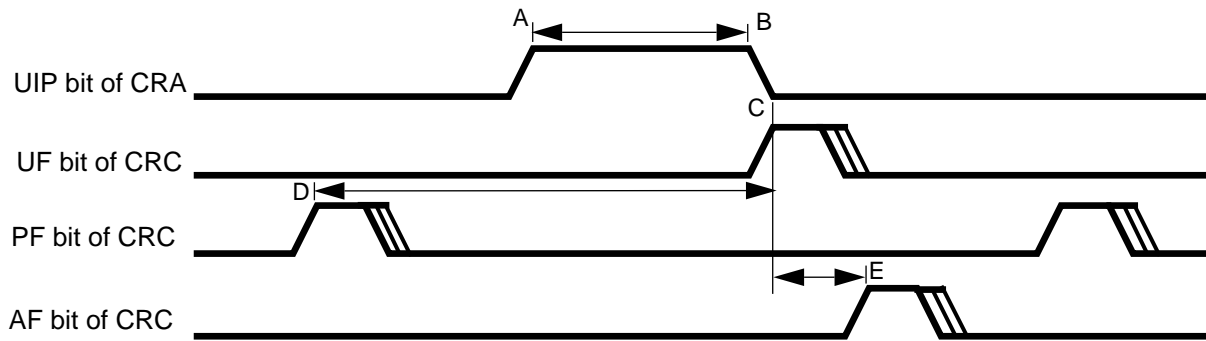
Master reset does not affect these bits.

Bit 7 - Update in Progress (UIP)

This read only bit is not affected by reset.

0 - An update will not occur within the next 244 μ sec. Bit 7 (the SET bit) of Control Register B (CRB) is 1.

1 - Timing registers are updated within 244 μ sec.



- A-B Update In Progress (UIP) bit high before update occurs = 244 μ sec
- D-C Periodic interrupt to update = Period (periodic int) / 2 + 244 μ sec
- C-E Update to Alarm Interrupt = 30.5 μ s
- UIP Update In Progress status bit
- UF Update-Ended Interrupt Flag (Update-Ended Interrupt if enabled)
- PF Periodic Flag (Periodic Interrupt if enabled)
- AF Alarm Flag (Alarm Interrupt if enabled)

Flags (and IRQ) are reset at the conclusion of Control Register C (CRC) read or by reset.

FIGURE 4-5. Interrupt/Status Timing

TABLE 4-2. Periodic Interrupt Rate Encoding

RS3-0 3 2 1 0	Periodic Interrupt Rate	
0 0 0 0	none	
0 0 0 1	3.90625	msec
0 0 1 0	7.8125	msec
0 0 1 1	122.070	μ sec
0 1 0 0	244.141	μ sec
0 1 0 1	488.281	μ sec
0 1 1 0	976.562	μ sec
0 1 1 1	1.953125	msec
1 0 0 0	3.90625	msec
1 0 0 1	7.8125	msec
1 0 1 0	15.625	msec
1 0 1 1	31.25	msec
1 1 0 0	62.5	msec
1 1 0 1	125	msec
1 1 1 0	250	msec
1 1 1 1	500	msec

TABLE 4-3. Divider Chain Control and Bank Selection

DV2-0 6 5 4	Selected Bank	Configuration
0 0 0	Bank 0	Oscillator Disabled ^a
0 0 1	Bank 0	Oscillator Disabled ^a
0 1 0	Bank 0	Normal Operation
0 1 1	Bank 1	Normal Operation
1 0 0	Bank 2	Normal Operation
1 0 1	Undefined	Test
1 1 0	Bank 0	Divider Chain Reset
1 1 1	Bank 0	Divider Chain Reset

a. The oscillator stops in this case only in the event of a power failure.

4.2.2 RTC Control Register B (CRB), Index 0Bh

This register enables the selection of various time and date options, as well as the use of interrupts.

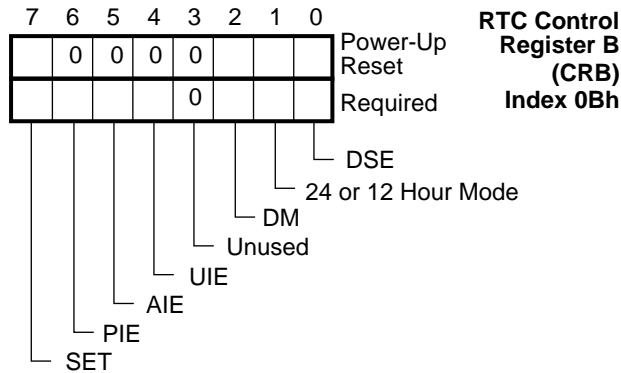


FIGURE 4-6. CRB Register Bitmap

Bit 0 - Daylight Savings Enable (DSE)

Master reset does not affect this read/write bit.

- 0 - Disables the daylight savings feature.
- 1 - Enables daylight savings feature, as follows:
 - In the spring, time advances from 1:59:59 to 3:00:00 on the first Sunday in April.
 - In the fall, time returns from 1:59:59 to 1:00:00 on the last Sunday in October.

Bit 1 - 24 or 12 Hour Mode

This is a read/write bit that is not affected by reset.

- 0 - Enables 12 hour format.
- 1 - Enables 24 hour format.

Bit 2 - Data Mode (DM)

This is a read/write bit that is not affected by reset.

- 0 - Enables BCD format.
- 1 - Enables binary format.

Bit 3 - Unused

This bit is defined as “Square Wave Enable” by the MC146818 and is not supported by the RTC. This bit is always read as 0.

Bit 4 - Update-Ended Interrupt Enable (UIE)

Master reset forces this read/write bit to 0.

- 0 - Disables generation of the Update-Ended interrupt.
- 1 - Enables generation of the Update-Ended interrupt. This interrupt is generated at the time an update occurs.

Bit 5 - Alarm Interrupt Enable (AIE)

Master reset forces this read/write bit to 0.

- 0 - Disables generation of the alarm interrupt.
- 1 - Enables generation of the Alarm interrupt. The alarm interrupt is generated immediately after a time update in which the Seconds, Minutes, and Hours time equal their respective alarm counterparts.

Bit 6 - Periodic Interrupt Enable (PIE)

Master reset forces this read/write bit to 0.

- 0 - Disables generation of the Periodic interrupt.
- 1 - Enables generation of the Periodic interrupt. Bits 3-0 of Control Register A (CRA) determine the rate of the Periodic interrupt.

Bit 7 - Set Mode (SET)

Master reset does not affect this read/write bit.

- 0 - The timing updates occur normally.
- 1 - The user copy of time is “frozen”, allowing the time registers to be accessed without regard for an occurrence of an update.

4.2.3 RTC Control Register C (CRC), Index 0Ch

This register indicates the status of interrupt request flags.

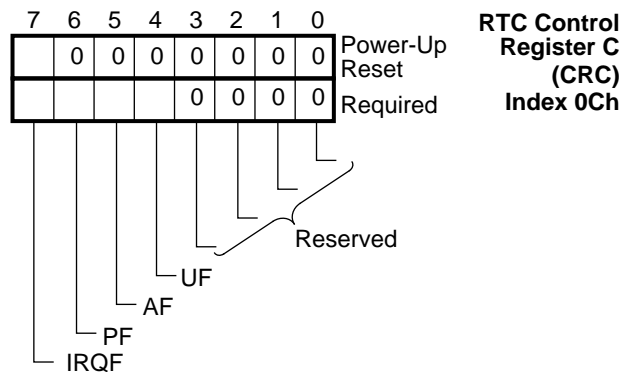


FIGURE 4-7. CRC Register Bitmap

Bits 3-0 - Reserved

These bits are reserved and always return 0000.

Bit 4 - Update-Ended Interrupt Flag (UF)

Master reset forces this read-only bit to 0. In addition, this bit is reset to 0 when this register is read.

- 0 - No update has occurred since the last read.
- 1 - Time registers have been updated.

Bit 5 - Alarm Interrupt Flag (AF)

Master reset forces this read-only bit to 0.

- 0 - No alarm was detected since the last read.
- 1 - An alarm condition was detected. This bit is reset to 0 when this register is read.

Bit 6 - Periodic Interrupt Flag (PF)

Master reset forces this read-only bit to 0. In addition, this bit is reset to 0 when this register is read.

- 0 - Indicates no transition occurred on the selected tap since the last read.
- 1 - A transition occurred on the selected tap of the divider chain.

Bit 7 - Interrupt Request Flag (IRQF)

This read-only bit is the inverse of the value on the $\overline{\text{IRQ}}$ output signal of the RTC/APC.

0 - $\overline{\text{IRQ}}$ is inactive (high).

1 - $\overline{\text{IRQ}}$ is active (low) and any of the following conditions exists: both PIE and PF are 1; both AIE and AF are 1; both UIE and UF are 1. (PIE, AIE and UIE are bits 6, 5 and 4, respectively of the CRB register.)

4.2.4 RTC Control Register D (CRD), Index 0Dh

This register indicates the validity of the RTC RAM data.

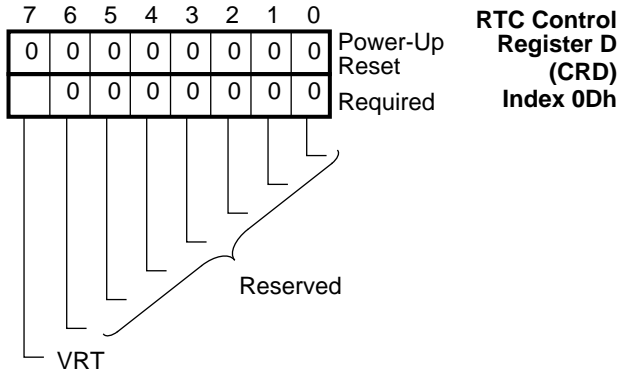


FIGURE 4-8. CRD Bitmap

Bits 6-0 - Reserved

These bits are reserved and are always 0.

Bit 7 - Valid RAM and Time (VRT)

The VRT bit senses the voltage that feeds this logical device (V_{CCH} or V_{BAT}) and indicates whether or not it was too low since the last time this bit was read. If it was too low, the RTC and RAM data are not valid.

This read-only bit is set to 1 when this register is read.

0 - The voltage that feeds the APC/RTC logical device was too low.

1 - The RTC and RAM data are valid.

WARNING:

If V_{CCH} ramps down at a rate exceeding 1 V/msec, it may reset this bit.

4.3 APC OVERVIEW

Advanced Power Supply Control (APC) is implemented within the RTC logical device. It enables the PC to power up automatically, as required by specific conditions, or to power down in an orderly, controlled manner, replacing the physical power supply On/Off switch.

The APC device is powered at all times that external AC power or battery backup power are connected to the RTC device. This is true even though the PC may be switched off or disconnected from the external AC power outlet, in which case the APC device is active but does not activate system power. The APC device powers up the entire PC system upon the occurrence of various events (including the power-on switch event).

WARNING:

The APC device does not function if the 32.768 KHz oscillator is not running.

The APC function produces the $\overline{\text{ONCTL}}$ signal to activate the system power supply, and the Power-Off Request (POR) interrupt request signal when there is a request for power off.

ONCTL: The $\overline{\text{ONCTL}}$ signal physically activates or deactivates the system power supply.

The $\overline{\text{ONCTL}}$ value depends on the following:

- External events
- Programmable parameter settings
- The system state when an external event occurs
- The state of the system power supply.

POR: The APC generates a Power-Off Request ($\overline{\text{POR}}$) interrupt request signal when the power switch is manually toggled to turn the power off. This enables a software controlled exit procedure (analogous to the `autoexec.bat` startup procedure in DOS operating systems) with automatic activation of preprogrammed features such as system status backup, system activity logging, file closing and backup, remote communications termination, print completion, etc.

Table 4-4 shows the registers used for Automatic Power Supply Control (APC) in the part.

TABLE 4-4. APC Control Register List

Index	Mnemonic	Description
40h	APCR1	APC Control Register 1
41h	APCR2	APC Control Register 2
42h	APSR	APC Status Register
47h	RLR	RAM Lock Register

4.3.1 User Selectable Parameters

The APC function enables users to tailor system response to power up, power down, power failure and battery operation situations.

User-selectable parameters include:

- Enabling various external events to wake up the system. See "Power Up" on page 58.
- Wake-up time for an automatic system wake-up. See "Predetermined Wake-Up" on page 60.

- Type of system recovery after a Power Failure state by setting the MOAP bit. See page “The MOAP Bit” on page 58.
- Immediate or delayed Switch Off shutdown. See “The SWITCH Input Signal” on page 59.
- 5 or 21 second time-out fail-safe shutdown. See “The SWITCH Input Signal” on page 59.

4.3.2 System Power States

The system power state may be No Power, Power On, Power Off or Power Failure. These states are illustrated in Figure 4-9 on page 57. Table 4-5 indicates the power-source combinations for each state. No other power-source combinations are valid.

In addition, the power sources and distribution for the entire PC system are described in “PC87307/PC97307 Power Supplies” on page 51.

TABLE 4-5. System Power States

V_{DD}	V_{CCH}	V_{BAT}	Power State
–	–	–	No Power
–	–	+	Power Failure
–	+	+ or -	Power Off
+	+	+ or -	Power On
+	–	+	Illegal State

WARNING:

It is illegal for V_{DD} to be present when V_{CCH} is absent.

No Power

This state exists when no external or battery power is connected to the device. This condition will not occur once a backup battery has been connected, except in the case of a malfunction. The APC undergoes initialization only when leaving this state.

Power On

This is the normal state when the PC is active. This state may be initiated by various events in addition to the normal physical switching on of the system. In this state, the PC power supply is powered by external AC power and produces V_{DD} and V_{CCH} . The PC system and the part are powered by V_{DD} , with the exception of the RTC logical device, which is powered by V_{CCH} .

Power Off (Suspended)

This is the normal state when the PC has been switched off and is not required to be active, but is still connected to a live external AC input power source. This state may be initiated directly or by software. The PC system is powered down. The RTC logical device remains active, powered by V_{CCH} .

Power Failure

This state occurs when the external power source to the PC stops supplying power, due to disconnection or power failure on the external AC input power source. The RTC continues to maintain timekeeping and RAM data under battery power (V_{BAT}), unless the oscillator stop bit was set in the RTC. In this case, the oscillator stops functioning if the system goes to battery power, and timekeeping data becomes invalid.

4.3.3 System Power Switching Logic

In the Power On state, the PC host is powered by the power-supply voltage V_{DD} . From this state the system enters the Power Off state, if the conditions for this state occur (See Section 4.4.3), or the Power Failure state if external power is removed.

In the Power Off state, the PC hosts do not receive power from the system power supply, except for RTC and APC which receive V_{CCH} . The system may enter the Power On state if the conditions for this state occur (see Section 4.4.3), or enter the Power Failure state if external power is removed.

If the system voltage falls to the level of $V_{BAT} + 500$ mV or less, the APC enters the Power Failure state and switches to battery power.

When power returns after a power failure, the APC enables power up after a delay of 1 second. The nature of the power up depends on the MOAP bit setting (See “The MOAP Bit” on page 58).

Knowing the system power state prior to a switch interrupt is required for correct Switch Event interpretation. The power state is defined by the following conditions:

V_{DD} present implies Power On

V_{CCH} present and V_{DD} absent implies Power Off.

If V_{BAT} falls below 2V with V_{CCH} absent, the oscillator, the timekeeping functions and the APC, all stop functioning.

If no external or battery-backup power is available, the system enters a No Power state. Upon leaving this state, the system is initialized.

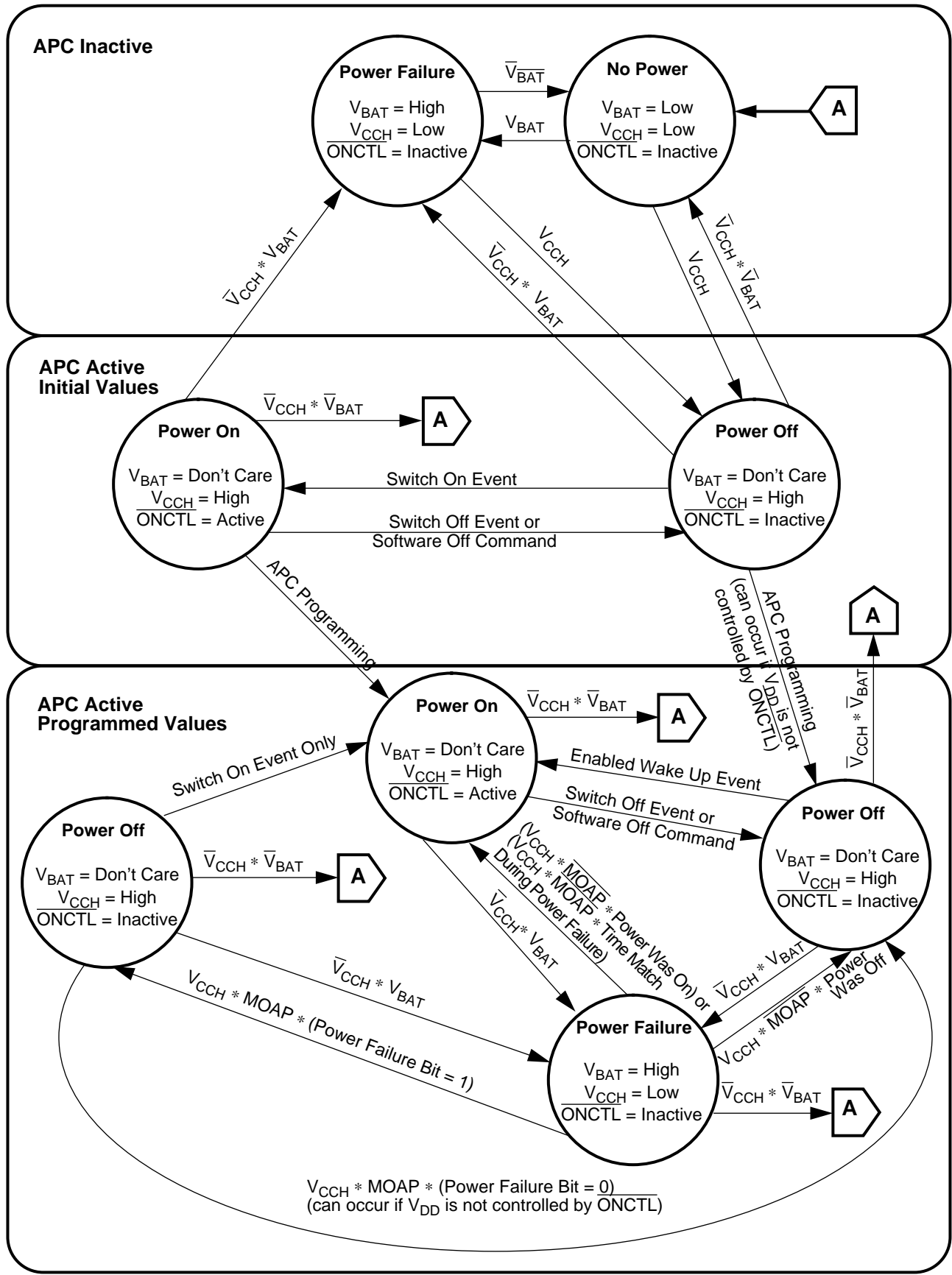


FIGURE 4-9. APC State Diagram

4.4 DETAILED FUNCTIONAL DESCRIPTION

4.4.1 The ONCTL Signal

The APC checks when activation or deactivation conditions are met, and sets or resets the ONCTL signal accordingly. This signal activates the system power supply. ONCTL is physically generated as the output of the ONCTL (set-reset) flip-flop. The state of ONCTL depends on the following:

- The status of the Mask ONCTL Activation (MOAP) bit
- Presence of activation conditions
- Power source condition
- The preceding state of ONCTL

The Preceding State of the ONCTL Signal

A power failure may occur when the system is active or inactive. The ONCTL flip-flop maintains the state of the ONCTL signal at the time of the power failure. When power is restored, the ONCTL signal returns the system to a state determined by the saved status of ONCTL and the saved value of the MOAP bit.

The MOAP Bit

The Mask ONCTL Activation in Power Failure (MOAP) bit (bit 4 of APCR1) is controlled by software. It makes it possible to choose the desired system response upon return from a power failure, and decide whether the system remains inactive until it is manually switched on, or resumes the state that prevailed at the time of the power failure, including enabling of “wake-up” events, as described in the next section.

Logical Conditions that Define the Status of the ONCTL Flip-Flop

The logical conditions described here set or reset the ONCTL flip-flop. They reflect the physical events described in “System Power-Up and Power-Off Activation Event Description” on page 59.

Conditions that set the ONCTL flip-flop:

- Timer Enable bit is 1 and there is a match between the real-time clock and the time specified in the pre-determined date registers.
- Switch On event occurred.

- Timer Match Enable bit is 1 and there is a match between the real-time clock and the time specified in the pre-determined date registers.

User software must ensure unused date/time fields are coherent, to ensure the comparison of valid bits gives the correct results.

- The RING enable bit (bit 3 of APCR2) is 1 and one of the following occurs:
 - Bit 2 of APCR2 is 0, and a high-to-low transition is detected on the RING input pin.
 - Bit 2 of APCR2 is 1 and a train of pulses is detected on the RING input pin.
- RI1,2 Enable bit(s) are 1 and a high to low transition is detected on the RI1,2 input pin(s).

Conditions that put the ONCTL flip-flop in a 1 state (inactive ONCTL signal):

- Switch Off Delay Enable bit is 0 and Switch Off event occurred.
- Switch Off Delay Enable bit is 1 and Fail-safe Timer reached terminal count.
- A 1 is written to Software Off Command bit.

4.4.2 Entering Power States

Power Up

When power is first applied to the RTC, the APC registers are initialized to default values defined in APCR1, APCR2 and APSR. See “Bank 2 Registers, APC Memory Bank” on page 65. This situation is defined by the appearance of V_{BAT} or V_{CCH} with no previous power.

The APC powers up when the RTC supply is applied from any source and is always in an active state. The RTC may be powered up, but inactive; this occurs if bit 0 of the register at index 30h (see Section 2.3 on page 26) of this logical device is not set. In this situation, the APC registers are not accessible, since they are only accessed via the RTC. This is also true of the general-purpose battery-backed RAM.

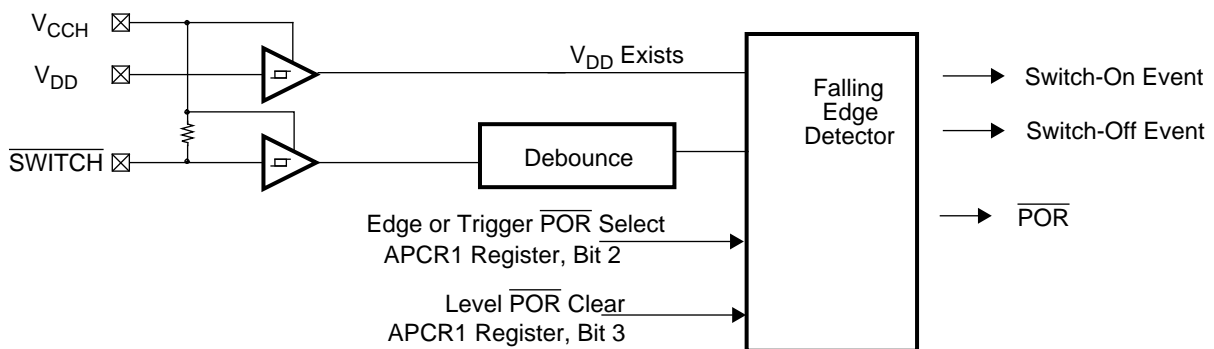


FIGURE 4-10. Switch Event Detector

Power Off Request ($\overline{\text{POR}}$)

The APC allows a maskable or non-maskable interrupt on the $\overline{\text{POR}}$ pin when the Switch Off event is detected on the $\overline{\text{SWITCH}}$ input pin.

This interrupt enables the user to perform an orderly exit procedure, automatically performing housekeeping functions such as file backups, printout completion and communications terminations, before powering down.

See Figure 4-10.

Power Failure

The APC is in a Power Failure state when it is powered by V_{BAT} , without V_{CCH} .

Upon entering a Power Failure state, the following events occur:

- The UART input signals ($\overline{\text{RI2}}, 1$), the $\overline{\text{SWITCH}}$ (ON/OFF switch) pin and $\overline{\text{RING}}$ pin (for detecting telephone line incoming signals for fax, modem or voice communications) are masked (high).

These signals remain masked until one second after exit from the Power Failure state, i.e., one second after switching from V_{BAT} to V_{CCH} , unless the MOAP bit is set to 1. See description of this bit on page 60.

- The $\overline{\text{ONCTL}}$ pin state is internally saved, and $\overline{\text{ONCTL}}$ is forced inactive.

One second after power returns, the $\overline{\text{ONCTL}}$ signal reverts to its saved state, if the MOAP bit (Mask $\overline{\text{ONCTL}}$ Activation, i.e., bit 4) of the APCR1 register is cleared to 0. If the MOAP bit is set to 1, $\overline{\text{ONCTL}}$ remains inactive. If MOAP = 0, when the one second delay expires, new events can activate $\overline{\text{ONCTL}}$, unless a time match occurs during Power Failure, in which case the APC "remembers" to activate $\overline{\text{ONCTL}}$ at the end of the one second delay.

If the MOAP bit (bit 4 of APCR1) and the Power Failure bit (bit 7 of APCR1) are both 1, then only the Switch On event can activate $\overline{\text{ONCTL}}$.

4.4.3 System Power-Up and Power-Off Activation Event Description

The APC may activate the host power supply when the following events occur:

- Physical On/Off switch is depressed and V_{DD} is absent.
- Preprogrammed wake-up time arrives.
- Communications input is detected on a modem.
- Ring signal is detected at a telephone input jack.

The PC may be powered down by the following events:

- Physical On/Off switch is depressed, and V_{DD} is present.
- Software controlled power down.
- Fail-safe power down in the event of power-down software hang-up. (See "Switch-Off Event".)

The $\overline{\text{SWITCH}}$ Input Signal

This signal provides two events: Switch-On and Switch-Off. In both, the physical switch line is debounced, i.e., the signal state is transferred only after 14 to 16 msec without transitions, which ensures the switch is no longer bouncing. See Figure 4-10.

Switch-On Event - Detection of a high to low transition on the debounced $\overline{\text{SWITCH}}$ input pin, when V_{DD} does not exist. The Switch-On event is masked (not detected) for one to two seconds after V_{DD} is removed.

Switch-Off Event - Detection of a high to low transition on the debounced $\overline{\text{SWITCH}}$ input pin, when V_{DD} exists. The Switch-Off event is masked for one to two seconds after V_{DD} was removed for the last time.

The Switch-Off event sets the Switch-Off Event Detect bit (bit 5 in APSR) to 1.

Switch-Off Delay - When the Switch Off Delay Enable bit (bit 6 in register APCR2) is 0, the Switch-Off event powers the system off immediately, i.e., the $\overline{\text{ONCTL}}$ output pin is deactivated immediately.

When the Switch-Off Delay Enable bit is 1 and a Switch-Off event occurs, a fail-safe timer starts a countdown of 5 or 21 seconds. (See bit 1 of the APCR1 register on page 60). If it is allowed to complete this sequence, the fail-safe timer sets the $\overline{\text{ONCTL}}$ signal high (inactive).

Switch-Off Event detection activates the Power-Off Request ($\overline{\text{POR}}$) that triggers a user-defined interrupt routine to conduct housekeeping activities prior to powering down. (The user may also detect the Switch-Off Event by polling the Switch-Off Detect bit, rather than the interrupt routine). The user must ensure that the power-off routine does not exceed the 5 or 21 second Switch-Off Delay, or else the routine must set bit 6 of APCR1 to stop and reset the fail-safe timer, thus preventing fail-safe timer causing power off before completion.

If the power-off routine gets "hung up", and the timer was not stopped and reset, then after the delay time has elapsed the timer will conclude its countdown and activate power off (deactivate $\overline{\text{ONCTL}}$).

The fails-safe timer is reset and stopped by writing 1 to the Fail-safe Timer Reset bit (bit 6 of APCR1). Switch-Off events detected while the timer is already counting are ignored. If during the count of the Fail-safe timer due to a switch off event with delay, V_{DD} goes down, the fail safe timer is stopped and reset and $\overline{\text{ONCTL}}$ is not deactivated.

$\overline{\text{POR}}$ is asserted on a Switch-Off Event. It can be configured as either edge or level triggered, according to the APCR1 register, bit 2. In edge mode, it is a negative pulse, and in level mode it remains asserted until cleared by a level $\overline{\text{POR}}$ Clear Command (bit 3 of the APCR1 register, see Figure 4-10). Selection of $\overline{\text{POR}}$ on the GPIO22/ $\overline{\text{POR}}$ pin is via the SuperI/O Configuration 2 register (at index 22h). Selection of the $\overline{\text{POR}}$ output buffer is via GPIO22 output buffer control bits (Port 2 Output Type and Port 2 Pull-up Control registers). See Table 8-1 on page 170.

Predetermined Wake-Up

The second, minute and hour values of the pre-determined wake-up times are contained in the Seconds Alarm, Minutes Alarm and Hours Alarm registers, respectively (indexes 01h, 03h and 05h of banks 0, 1 and 2). The Day of Week, Date of Month, Month, Year and Century of the pre-determined date is held in bank 2, registers indexes 43h-46h and 48h. These eight registers are compared with the corresponding Seconds, Minutes, Hours, Date of Week, Day of Month, Month and Year in all banks, register indexes 00, 02, 04, 06, 07, 08, 09 and Century register in bank 1, register index 48h.

Ring Signal Event

An incoming telephone call is an event that may activate a transfer from the Power-Off state to a Power-On state, in order to deal with the pending incoming voice, fax or modem communication.

The part can detect a $\overline{\text{RING}}$ pulse falling edge or a $\overline{\text{RING}}$ pulse train with a frequency of at least 16 Hz, that lasts at least 0.19 seconds.

During $\overline{\text{RING}}$ pulse train detection, the existence of falling edges on $\overline{\text{RING}}$ is monitored during time slots of 62.5 msec (16 Hz cycle time). A $\overline{\text{RING}}$ pulse train detect event occurs if falling edge(s) of $\overline{\text{RING}}$ were detected in three consecutive time slots, following a time slot in which no falling edge of $\overline{\text{RING}}$ was detected.

This method of detecting a $\overline{\text{RING}}$ pulse train filters out (does not detect) a $\overline{\text{RING}}$ pulse train of less than 11 Hz, might detect a $\overline{\text{RING}}$ pulse train of 11 Hz to 16 Hz, and guarantees detection of a $\overline{\text{RING}}$ pulse train of at least 16 Hz.

$\overline{\text{RI1,2}}$ Event

High to Low transitions on $\overline{\text{RI1}}$ or $\overline{\text{RI2}}$ indicate communications activity on the UART inputs, and these conditions may be used as events to “wake-up” the system.

NOTE: The APC can distinguish between two events of the same type if a minimum time of 2.5 periods of the 32KHz clock passed between their arrivals. Thus, if the APC detects an event, and another event of the same nature occurs once again in less than 70ms from the previous event, the APC might not detect the second event, i.e., the event will be lost.

4.5 APC REGISTERS

The APC registers reside in the APC bank 2 memory. The RAM Lock register also resides in this bank. See Table 4-4 on page 55.

The APC registers are not affected by system reset. They are initialized to 0 only when power is applied for the first time, i.e., application of one of the voltages V_{BAT} or V_{CCH} when no previous voltage was present.

4.5.1 APC Control Register 1 (APCR1), Index 40h

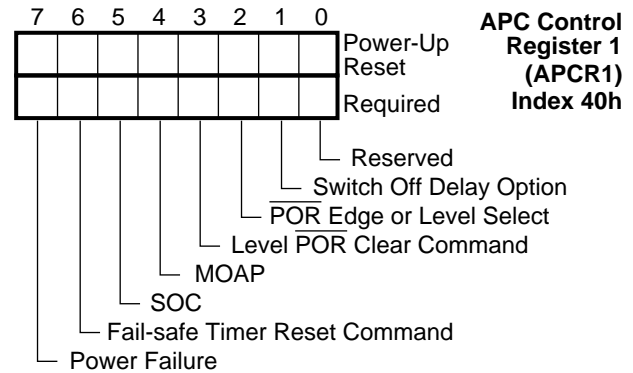


FIGURE 4-11. APCR1 Register Bitmap

Bit 0 - Reserved

Reserved.

Bit 1 - Switch Off Delay Option

0 - 4-5 seconds.

1 - 20-21 seconds.

Bit 2 - $\overline{\text{POR}}$ Edge or Level Select

0 - Edge $\overline{\text{POR}}$.

1 - Level $\overline{\text{POR}}$. Once $\overline{\text{POR}}$ is asserted, it remains asserted until cleared by Level $\overline{\text{POR}}$ Clear Command (bit 3).

Bit 3 - Level $\overline{\text{POR}}$ Clear Command

This is a write-only non-sticky bit. Read returns 0.

0 - Ignored.

1 - $\overline{\text{POR}}$ output signal is deactivated.

Bit 4 - Mask $\overline{\text{ONCTL}}$ Activation if Power Fail (MOAP)

0 - When power returns, sets the system to the power state that existed when power failed.

1 - While the Power Failure bit (bit 7 of APCR1) is set, mask $\overline{\text{ONCTL}}$ activation, except as a result of a Switch On Event.

Bit 5 - Software Off Command (SOC)

This bit is write-only and non-sticky. Read returns 0.

0 - Ignored.

1 - $\overline{\text{ONCTL}}$ output signal is deactivated.

Bit 6 - Fail-safe Timer Reset Command

This bit is write-only and non-sticky. Read returns 0.

0 - Ignored.

1 - Fail-safe timer is stopped and reset.

Bit 7 - Power Failure

Set to 1 when RTC/APC switches from V_{CCH} to V_{BAT} . Cleared to 0 by writing 1 to this bit. Writing 0 to this bit has no effect.

4.5.2 APC Control Register 2 (APCR2), Index 41h

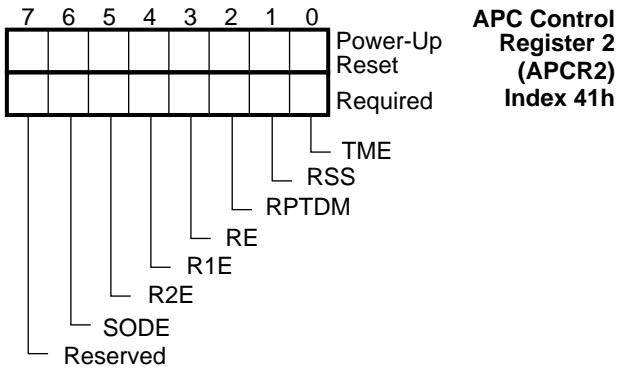


FIGURE 4-12. APCR2 Register Bitmap

Bit 0 - Timer Match Enable (TME)

- 0 - Pre-determined date or time event is ignored.
- 1 - Match between the RTC and the pre-determined date and time activates the $\overline{\text{ONCTL}}$ output signal. See MOAP (bit 4) of APCR1 for an overriding case.

Bit 1 - $\overline{\text{RING}}$ Source Select (RSS)

- 0 - $\overline{\text{RING}}$ source is $\overline{\text{RING}}/\overline{\text{XDCS}}$ signal, regardless of X-bus Data Buffer (XDB) select bit of SuperI/O Configuration 1 register.
- 1 - $\overline{\text{RING}}$ source is GPIO23/ $\overline{\text{RING}}$ signal.

Bit 2 - $\overline{\text{RING}}$ Pulse or Train Detection Mode (RPTDM)

- 0 - Detection of $\overline{\text{RING}}$ pulse falling edge.
- 1 - Detection of $\overline{\text{RING}}$ pulse train above 16 Hz for 0.19 sec.

Bit 3 - $\overline{\text{RING}}$ Enable (RE)

- 0 - $\overline{\text{RING}}$ input signal is ignored.
- 1 - $\overline{\text{RING}}$ detection activates the $\overline{\text{ONCTL}}$ output signal, unless it is overridden by the MOAP bit, bit 4 of the APCR1 register.

Bit 4 - $\overline{\text{RI1}}$ Enable (R1E)

- 0 - $\overline{\text{RI1}}$ input signal is ignored.
- 1 - A high to low transition on the $\overline{\text{RI1}}$ input pin activates the $\overline{\text{ONCTL}}$ output pin. See MOAP (bit 4) of APCR1 for an overriding case.

Bit 5 - $\overline{\text{RI2}}$ Enable (R2E)

- 0 - $\overline{\text{RI2}}$ input signal is ignored.
- 1 - A high to low transition on the $\overline{\text{RI2}}$ input pin activates the $\overline{\text{ONCTL}}$ output pin. See MOAP (bit 4) of APCR1 for an overriding case.

Bit 6 - Switch Off Delay Enable (SODE)

- 0 - $\overline{\text{ONCTL}}$ output pin is deactivated immediately after the Switch Off event.
- 1 - After the Switch Off Event, $\overline{\text{ONCTL}}$ output signal is deactivated after a 5 or 21 second Switch Off delay.

Bit 7 - Reserved

This bit is reserved.

4.5.3 APC Status Register (APSR), Index 42h

Bits 5-0 in this register are cleared to 0, when this register is read.

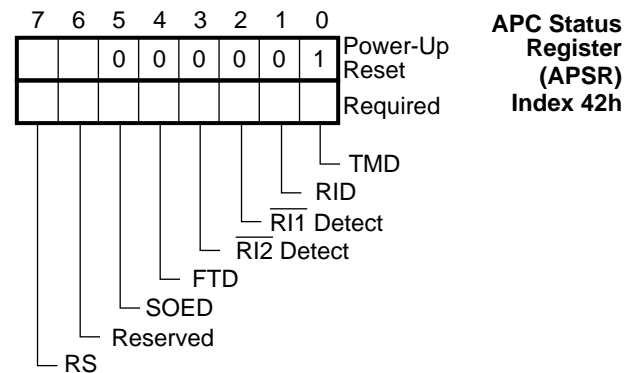


FIGURE 4-13. APSR Register Bitmap

Bit 0 - Timer Match Detect (TMD)

This bit is set to 1 when the RTC reaches the pre-determined date, regardless of the Timer Match Enable bit (bit 0 of APCR2). After first Power-Up, the RTC and the pre-determined date, are 0 and so this bit is set. It is recommended to clear this bit by reading this register after first Power-Up.

Bit 1 - $\overline{\text{RING}}$ Detect (RID)

This bit is set to 1 when a high to low transition is detected on the $\overline{\text{RING}}$ input pin and bit 2 of APCR2 is 0, or when a $\overline{\text{RING}}$ pulse train is detected on the $\overline{\text{RING}}$ input pin and bit 2 of APCR2 is 1, regardless of the status of the RING enable bit.

Bit 2 - $\overline{\text{RI1}}$ Detect

This bit is set to 1 when a high to low transition is detected on the $\overline{\text{RI1}}$ input signal, regardless of the $\overline{\text{RI1}}$ Enable bit.

Bit 3 - $\overline{\text{RI2}}$ Detect

This bit is set to 1 when a high to low transition is detected on the $\overline{\text{RI2}}$ input pin, regardless of the $\overline{\text{RI2}}$ Enable bit.

Bit 4 - Fail-Safe Timer Detect (FTD)

This bit is set to 1 when the Fail-safe timer reaches terminal count.

Bit 5 - Switch Off Event Detect (SOED)

This bit is set to 1 when a Switch Off event is detected, regardless of the Switch Off Delay Enable bit.

Bit 6 - Reserved

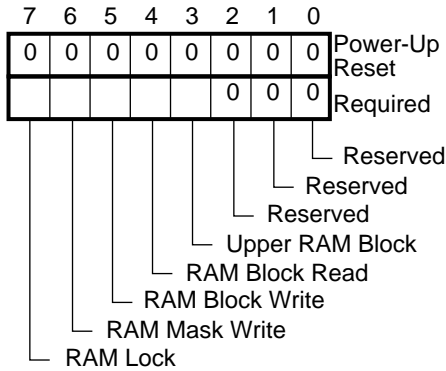
Reserved.

Bit 7 - $\overline{\text{RING}}$ Status Bit (RS)

Holds the instantaneous value of the selected $\overline{\text{RING}}$ pin.

4.5.4 RAM Lock Register (RLR), Index 47h

Once a non-reserved bit is set to 1 it can be cleared only by hardware (MR pin) reset.



**RAM Lock Register (RLR)
Index 47h**

FIGURE 4-14. RAM Lock Register

Bit 2-0 - Reserved

Reserved.

Bit 3 - Upper RAM Block

Controls access to the upper 128 RAM bytes, accessed via the Upper RAM Address and Data Ports of bank 1

0 - This bit has no effect on upper RAM access.

1 - Upper RAM Data Port of bank 1 is blocked: writes are ignored and reads return FFh.

Bit 4 - RAM Block Read

This bit controls reads from RAM bytes 80h-9Fh (00h-1Fh of upper RAM).

0 - This bit has no effect on upper RAM access.

1 - Reads from bytes 00h-1Fh of upper RAM return FFh.

Bit 5 - RAM Block Write

This bit controls writes to bytes 80h-9Fh (00h-1Fh of upper RAM).

0 - This bit has no effect on upper RAM access.

1 - Writes to bytes 00h-1Fh of upper RAM are ignored.

Bit 6 - RAM Mask Write

This bit controls writes to all RTC RAM.

0 - This bit has no effect on RAM access.

1 - Writes to bank 0 RAM and to upper RAM are ignored.

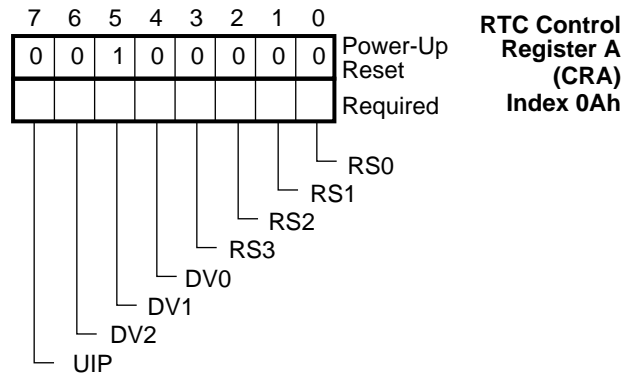
Bit 7 - RAM Lock

0 - This bit has no effect on RAM access.

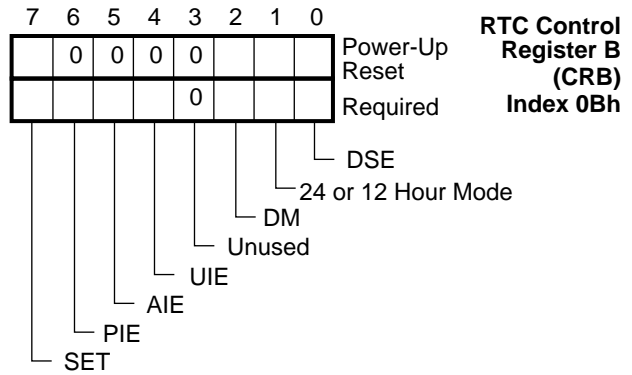
1 - Read and write to locations 38h-3Fh of all banks are blocked. Writes are ignored, and reads return FFh.

4.6 RTC AND APC REGISTER BITMAPS

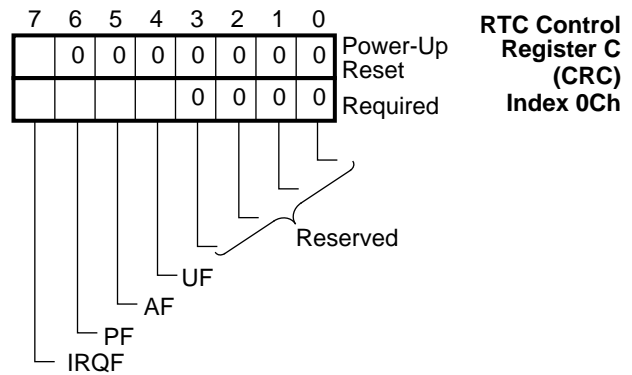
4.6.1 RTC Register Bitmaps



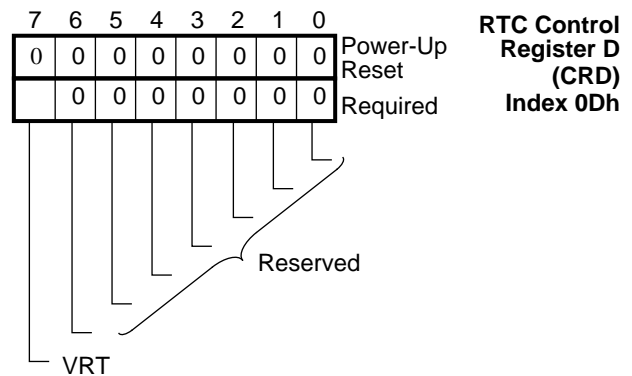
**RTC Control Register A (CRA)
Index 0Ah**



**RTC Control Register B (CRB)
Index 0Bh**

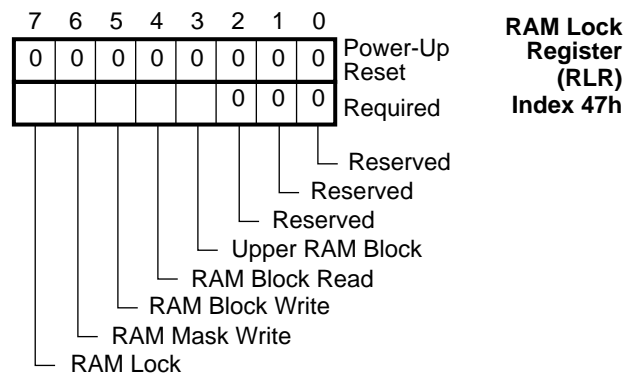
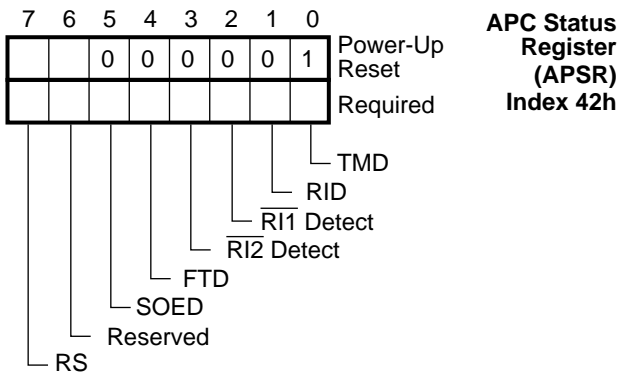
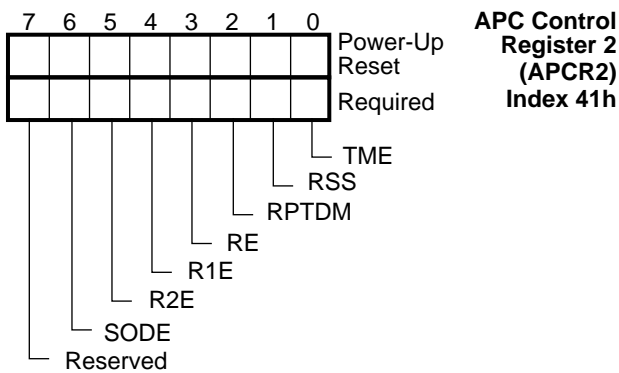
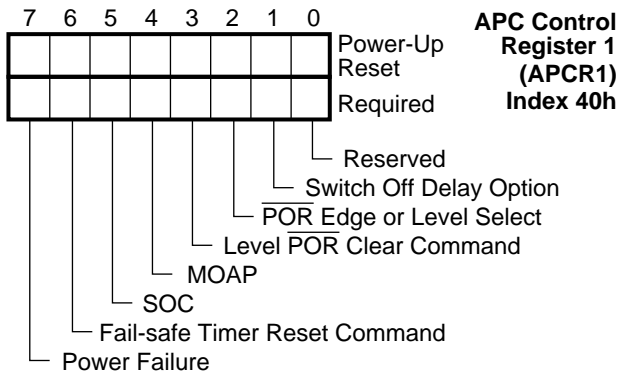


**RTC Control Register C (CRC)
Index 0Ch**



**RTC Control Register D (CRD)
Index 0Dh**

4.6.2 APC Register Bitmaps



4.7 REGISTER BANK TABLES

TABLE 4-6. Banks 1 and 2, Common 64-Byte Memory Map

Index	Function	BCD Format	Binary Format	Comments
00h	Seconds	00-59	00-3b	R/W
01h	Seconds Alarm	00-59	00-3b	R/W
02h	Minutes	00-59	00-3b	R/W
03h	Minutes Alarm	00-59	00-3b	R/W
04h	Hours	12 hr = 01-12 (AM)	01-0c (AM)	R/W
		12 hr = 81-92 (PM)	81-8c (PM)	R/W
		24 hr = 00-23	00-17	R/W
05h	Hours Alarm	12 hr = 01-12 (AM)	01-0c (AM)	R/W
		12 hr = 81-92 (PM)	81-8c (PM)	R/W
		24 hr = 00-23	00-17	R/W
06h	Day of Week	01-07	01-07 (Sunday = 1)	R/W
07h	Date of Month	01-31	01-1f	R/W
08h	Month	01-12	01-0c	R/W
09h	Year	00-99	00-63	R/W
0Ah	Control Register A			R/W (bit 7 is read only)
0Bh	Control Register B			R/W (bit 3 is read only)
0Ch	Control Register C			All bits read only
0Dh	Control Register D			All bits read only
0Eh-3Fh	General Purpose RAM			R/W

TABLE 4-7. Bank 0 Registers, General Purpose Memory Bank

Register	Index	Type	Power-on Value	Function
	00h-3Fh			The first 14 RTC registers and the first 50 RTC RAM bytes are shared among banks 0, 1 and 2.
	40h - 7Fh	R/W		General Purpose 64-Byte Battery-Backed RAM.

TABLE 4-8. Bank 1 Registers, RTC Memory Bank

Register	Index	Type	Power-on Value	Function
	00h-3Fh			Banks 0, 1 and 2 share the first 14 RTC registers and the first 50 RTC RAM bytes.
	40h-47h			Reserved. Writes have no effect and reads return 00h
Century	48h	R/W	00h	BCD Format: 00-99. Binary Format: 00-63
	49h-4Fh			Reserved
Upper RAM Address Port	50h	R/W		Bits 6-0: Address of the upper 128 RAM bytes. Bit 7: Reserved.
	51h-52h			Reserved
Upper RAM Data Port	53h	R/W		The byte pointed by the Upper RAM Address Port is accessed via this register.
	54h-7Fh			Reserved

TABLE 4-9. Bank 2 Registers, APC Memory Bank

Register	Index	Type	Power-On Value	Function
	00h - 3Fh			Banks 0, 1 and 2 share the first 14 RTC registers and the first 50 bytes of RTC RAM.
APC Control Register 1 (APCR1)	40h	R/W	00h	See "APC Control Register 1 (APCR1), Index 40h" on page 60
APC Control Register 2 (APCR2)	41h	R/W	00h	See "APC Control Register 2 (APCR2), Index 41h" on page 61
APC Status Register (APSR)	42h	R	1000001 (binary) (bit 7 is indeterminate)	See "APC Status Register (APSR), Index 42h" on page 61
Wake Up Day of Week	43h	R/W		BCD Format: 01-07 Binary Format: 01-07 (Sunday = 1)
Wake Up Date of Month	44h	R/W		BCD Format: 01-31 Binary Format: 01-1F
Wake Up Month	45h	R/W		BCD Format: 01-12 Binary Format: 01-0C
Wake Up Year	46h	R/W		BCD Format: 00-99 Binary Format: 00-63
RAM Lock	47h	R/W	00h; initialized also on MR pin reset.	See "RAM Lock Register (RLR), Index 47h" on page 62
Wake Up Century	48h	R/W		BCD Format: 00-99 Binary Format: 00-63
	49h-7Fh			Reserved

TABLE 4-10. Available General Purpose Bytes

Index	Bank	Number of Bytes	Notes
0Eh - 3Fh	All	50	
40h - 7Fh	Bank 0	64	
50h, 53h	Bank 1	128	Indirect access via 50h for address and 53h for data.
Total		242	

5.0 The Digital Floppy Disk Controller (FDC) (Logical Device 3)

The Floppy Disk Controller (FDC) is suitable for all PC-AT, EISA, PS/2, and general purpose applications. DP8473 and N82077 software compatibility is provided. Key features include a 16-byte FIFO, PS/2 diagnostic register support, perpendicular recording mode, CMOS disk input and output logic, and a high performance Digital Data Separator (DDS).

Figure 5-1 shows a functional block diagram of the FDC. The rest of this chapter describes the FDC functions, data transfer, the FDC registers, the phases of FDC commands, the result phase status registers and the FDC commands, in that order.

5.1 FDC FUNCTIONS

FDC functions are enabled when the FDC Function Enable bit (bit 3) of the Function Enable Register 1 (FER1) at offset 00h in logical device 8 is set to 1. See Section 9.2.3 on page 173.

The part is software compatible with the DP8473 and 82077 FDCs. Upon a power-on reset, the 16-byte FIFO is disabled. Also, the disk interface output signals are configured as active push-pull output signals, which are compatible with both CMOS input signals and open-collector, resistor-terminated, disk drive input signals.

The FIFO can be enabled with the CONFIGURE command. The FIFO can be very useful at high data rates, with systems that have a long DMA bus latency, or with multi-tasking systems such as the EISA or MCA bus structures.

The FDC supports all the DP8473 MODE command features as well as some additional features. These include control over the enabling of the FIFO for read and write operations, disabling burst mode for the FIFO, a bit that will configure the disk interface outputs as open-drain output signals, and programmability of the DENSEL output signal.

5.1.1 Microprocessor Interface

The Floppy Disk Controller (FDC) receives commands, transfers data, and returns status information via an FDC microprocessor interface. This interface consists of the A9-3, AEN, RD, and WR signals, which access the chip for read and write operations; the data signals D7-0; the address lines A2-0, which select the appropriate register (see Table 5-1); an IRQ signal, and the DMA interface signals DRQ, DACK, and TC.

5.1.2 System Operation Modes

The FDC operates in PC-AT or PS/2 drive mode, depending on the value of bit 2 of the SuperI/O Configuration 1 register at index 21h. See Section 2.4.3 on page 34.

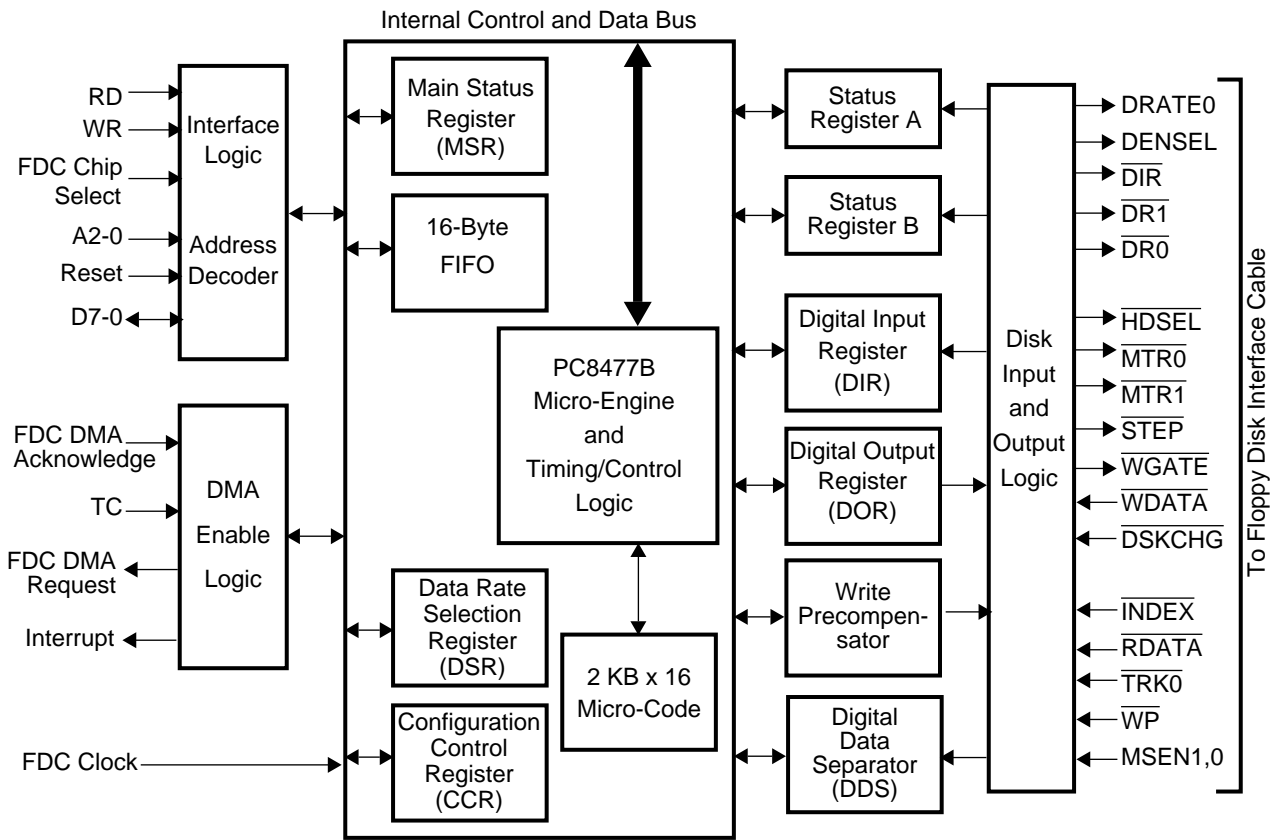


FIGURE 5-1. FDC Functional Block Diagram

PC-AT Drive Mode

The PC-AT register set is enabled. The DMA enable bit in the Digital Output Register (DOR) becomes valid (the appropriate IRQ and DRQ signals can be put in TRI-STATE). TC and DENSEL become active high signals (default to a 5.25" floppy disk drive).

PS/2 Drive Mode

This drive mode supports the PS/2 models 50/60/80 configuration and register set. The value of the DMA enable bit in the Digital Output Register (DOR) becomes unimportant (the IRQ and DRQ signals assigned to the FDC are always valid). TC and DENSEL become active low signals (default to 3.5" floppy drive).

5.2 DATA TRANSFER

5.2.1 Data Rates

The FDC supports the standard PC data rates of 250, 300 and 500 Kbps, as well as 1 Mbps. High performance tape and floppy disk drives that are currently emerging in the PC world, transfer data at 1 Mbps. The FDC also supports the perpendicular recording mode, a new format used for some high capacity disk drives at 1 Mbps.

The internal digital data separator needs no external components. It improves the window margin performance standards of the DP8473, and is compatible with the strict data separator requirements of floppy disk drives and tape drives.

The FDC contains write precompensation circuitry that defaults to 125 nsec for 250, 300, and 500 Kbps (41.67 nsec at 1 Mbps). These values can be overridden in software to disable write precompensation or to provide levels of precompensation up to 250 nsec.

The FDC has internal 24 mA data bus buffers which allow direct connection to the system bus. The internal 40 mA totem-pole disk interface buffers are compatible with both CMOS drive input signals and 150 resistor terminated disk drive input signals.

5.2.2 The Data Separator

The internal data separator is a fully digital PLL. The fully digital PLL synchronizes the raw data signal read from the disk drive. The synchronized signal is used to separate the encoded clock and data pulses. The data pulses are broken down into bytes, and then sent to the microprocessor by the controller.

The FDC supports data transfer rates of 250, 300, 500 Kbps and 1 Mbps in Modified Frequency Modulation (MFM) format.

The FDC has a dynamic window margin and lock range performance capable of handling a wide range of floppy disk drives. In addition, the data separator operates under a variety of conditions, including high fluctuations in the motor speed of tape drives that are compatible with floppy disk drives.

The dynamic window margin is the primary indicator of the quality and performance level of the data separator. It indicates the toleration of the data separator for Motor Speed Variation (MSV) of the drive spindle motor and bit jitter (or window margin).

Figure 5-2 shows the dynamic window margin in the performance of the FDC at different data rates, generated using a FlexStar FS-540 floppy disk simulator and a proprietary dynamic window margin test program written by National Semiconductor.

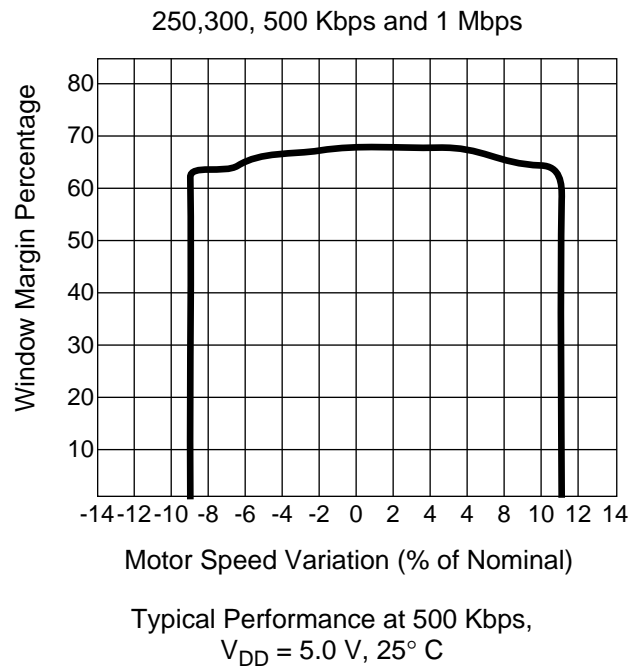


FIGURE 5-2. PC87307/PC97307 Dynamic Window Margin Performance

The x axis measures MSV. MSV is translated directly to the actual rate at which the data separator reads data from the disk. In other words, a faster than nominal motor results in a higher data rate.

The dynamic window margin performance curve also indicates how much bit jitter (or window margin) can be tolerated by the data separator. This parameter is shown on the y-axis of the graph. Bit jitter is caused by the magnetic interaction of adjacent data pulses on the disk, which effectively shifts the bits away from their nominal positions in the middle of the bit window. Window margin is commonly measured as a percentage. This percentage indicates how far a data bit can be shifted early or late with respect to its nominal bit position, and still be read correctly by the data separator. If the data separator cannot correctly decode a shifted bit, then the data is misread and a CRC error results.

The dynamic window margin performance curve supplies two pieces of information:

- The maximum range of MSV (also called "lock range") that the data separator can handle with no read errors.
- The maximum percentage of window margin (or bit jitter) that the data separator can handle with no read errors.

Thus, the area under the dynamic window margin curves in Figure 5-2 is the range of MSV and bit jitter that the FDC can handle with no read errors. The internal digital data separator of the FDC performs much better than comparable digital data separator designs, and does not require any external components.

The controller maximizes the internal digital data separator by implementing a read algorithm that enhances the lock characteristics of the fully digital Phase-Locked Loop (PLL). The algorithm minimizes the effect of bad data on the synchronization between the PLL and the data.

It does this by forcing the fully digital PLL to re-lock to the clock reference frequency any time the data separator attempts to lock to a non-preamble pattern. See the state diagram of this read algorithm in Figure 5-3.

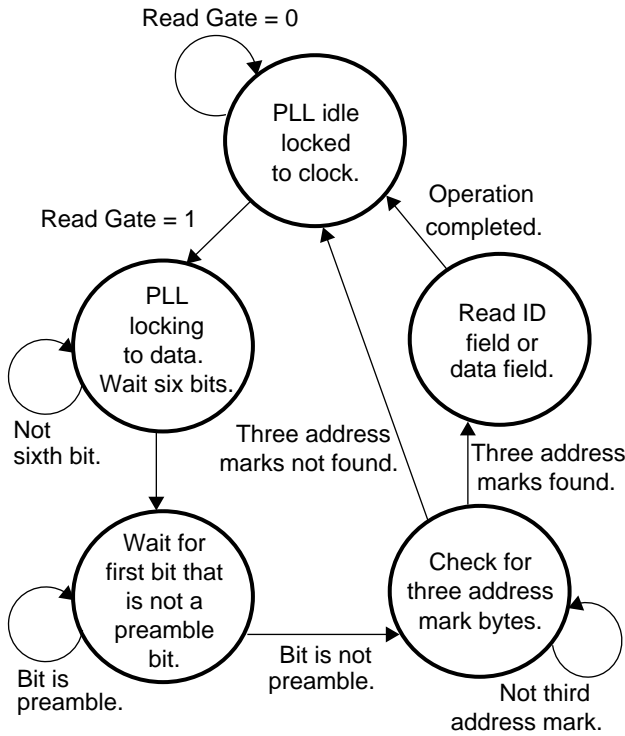


FIGURE 5-3. Read Algorithm State Diagram

5.2.3 Perpendicular Recording Mode Support

The FDC is fully compatible with perpendicular recording mode disk drives at all data transfer rates. These perpendicular drives are also called 4 Mbyte (unformatted) or 2.88 Mbyte (formatted) drives. This refers to their maximum storage capacity.

Perpendicular recording orients the magnetic flux changes (which represent bits) vertically on the disk surface, allowing for a higher recording density than conventional longitudinal recording methods. This increased recording density increases data rate by up to 1 Mbps, thereby doubling the storage capacity. In addition, the perpendicular 2.88 MB drive is read/write compatible with 1.44 MB and 720 KB diskettes (500 Kbps and 250 Kbps respectively).

The 2.88 MB drive has unique format and write data timing requirements due to its read/write head and pre-erase head design. This is illustrated in Figure 5-4.

Unlike conventional disk drives which have only a read/write head, the 2.88 MB drive has both a pre-erase head and read/write head. With conventional disk drives, the read/write head, itself, can rewrite the disk without problems. 2.88 MB drives need a pre-erase head to erase the magnetic flux on the disk surface before the read/write head can write to the disk surface. The pre-erase head is activated during disk write operations only, i.e. FORMAT and WRITE DATA commands.

In 2.88 MB drives, the pre-erase head leads the read/write head by 200 μm , which translates to 38 bytes at 1 Mbps (19 bytes at 500 Kbps).

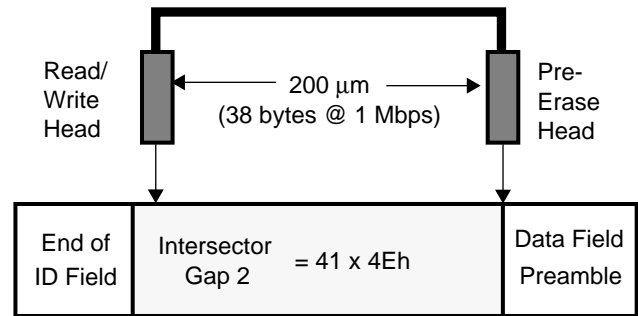


FIGURE 5-4. Perpendicular Recording Drive Read/Write Head and Pre-Erase Head

For both conventional and perpendicular drives, $\overline{\text{WGATE}}$ is asserted with respect to the position of the read/write head. With conventional drives, this means that $\overline{\text{WGATE}}$ is asserted when the read/write head is located at the beginning of the preamble to the data field.

With 2.88 MB drives, since the preamble must be erased before it is rewritten, $\overline{\text{WGATE}}$ should be asserted when the pre-erase head is located at the beginning of the preamble to the data field. This means that $\overline{\text{WGATE}}$ should be asserted when the read/write head is at least 38 bytes (at 1 Mbps) before the preamble. Tables 5-15 and 5-16 on page 95 show how the perpendicular format affects gap 2 and, consequently, $\overline{\text{WGATE}}$ timing, for different data rates.

Because of the 38-byte spacing between the read/write head and the pre-erase head at 1 Mbps, the gap 2 length of 22 bytes used in the standard IBM disk format is not long enough. The format standard for 2.88 MB drives at 1 Mbps called the Perpendicular Format, increases the length of gap 2 to 41 bytes. See Figure 5-20 on page 91.

The PERPENDICULAR MODE command puts the Floppy Disk Controller (FDC) into perpendicular recording mode, which allows it to read and write perpendicular media. Once this command is invoked, the read, write and format commands can be executed in the normal manner. The perpendicular mode of the FDC functions at all data rates, adjusting format and write data parameters accordingly. See "The PERPENDICULAR MODE Command" on page 94 for more details.

5.2.4 Data Rate Selection

The FDC sets the data rate in two ways. For PC compatible software, the Configuration Control Register (CCR) at offset 07h programs the data rate for the FDC. The lower bits D1 and D0 in the CCR set the data rate. The other bits should be set to zero. Table 5-6 on page 75 shows how to encode the desired data rate.

The lower two bits of the Data rate Select Register (DSR) at offset 04h can also set the data rate. These bits are encoded like the corresponding bits in the CCR. The remainder of the bits in the DSR have other functions. See the description of the DSR in Section 5.3.6 on page 75 for more details.

The data rate is determined by the last value written to either the CCR or the DSR. Either the CCR or the DSR can override the data rate selection of the other register. When the data rate is selected, the micro-engine and data separator clocks are scaled appropriately.

5.2.5 Write Precompensation

Write precompensation enables the \overline{WDATA} output signal to adjust for the effects of bit shift on the data as it is written to the disk surface.

Bit shift is caused by the magnetic interaction of data bits as they are written to the disk surface. It shifts these data bits away from their nominal position in the serial MFM data pattern. Bit shift makes it much harder for a data separator to read data and can cause soft read errors.

Write precompensation predicts where bit shift could occur within a data pattern. It then shifts the individual data bits early, late, or not at all so that when they are written to the disk, the shifted data bits are back in their nominal position.

The FDC supports software programmable write precompensation. Upon power up, the default write precompensation values shown in Table 5-8 on page 76, are used. In addition, the default starting track number for write precompensation is track zero

You can use the DSR to change the write precompensation using any of the values in Table 5-7 on page 76. Also, the CONFIGURE command can change the starting track number for write precompensation.

5.2.6 FDC Low-Power Mode Logic

The FDC of the part supports two low-power modes, manual and automatic.

In low-power mode, the micro-code is driven from the clock. Therefore, it is disabled while the clock is off. Upon entering the power-down state, bit 7, the RQM (Request For Master) bit, in the Main Status Register (MSR) of the FDC is cleared to 0.

For details about entering and exiting low-power mode by setting bit 6 of the Data rate Select Register (DSR) or by executing the LOW PWR option of the FDC MODE command, see "Recovery from Low-Power Mode" later in this section, the "Data Rate Select Register (DSR), Offset 04h, Write Operations" on page 75 and "The MODE Command" on page 92.

The DSR, Digital Output Register (DOR), and the Configuration Control Register (CCR) are unaffected and remain active in power-down mode. Therefore, you should make sure that the motor and drive select signals are turned off.

If the power to an external clock driving the part will be independently removed while the FDC is in power-down mode, it must not be done until 2 msec after the LOW PWR option of the FDC MODE command is issued.

Manual Low-Power Mode

Manual low power is enabled by writing a 1 to bit 6 of the DSR. The chip will power down immediately. This bit will be cleared to 0 after power up.

Manual low power can also be triggered by the MODE command. Manual low power mode functions as a logical OR function between the DSR low power bit and the LOW PWR option of the MODE command.

Automatic Low-Power Mode

Automatic low-power mode switches the controller to low power 500 msec (at the 500 Kbps MFM data rate) after it has entered the Idle state. Once automatic low-power mode is set, it does not have to be set again, and the controller automatically goes into low-power mode after entering the Idle state.

Automatic low-power mode can only be set with the LOW PWR option of the MODE command.

Recovery from Low-Power Mode

There are two ways the FDC section can recover from the power-down state.

Power up is triggered by a software reset via the DOR or DSR. Since a software reset requires initialization of the controller, this method might be undesirable.

Power up is also triggered by a read or write to either the Data Register (FIFO) or Main Status Register (MSR). This is the preferred way to power up since all internal register values are retained. It may take a few milliseconds for the clock to stabilize, and the microprocessor will be prevented from issuing commands during this time through the normal MSR protocol. That means that bit 7, the Request for Master (RQM) bit, in the MSR will be a 0 until the clock has stabilized. When the controller has completely stabilized after power up, the RQM bit in the MSR is set to 1 and the controller can continue where it left off.

5.2.7 Reset

The FDC can be reset by hardware or software.

A hardware reset consists of pulsing the Master Reset (MR) input signal. A hardware reset sets all of the user addressable registers and internal registers to their default values. The SPECIFY command values are unaffected by reset, so they must be initialized again.

The major default conditions affected by reset are:

- FIFO disabled
- DMA disabled
- Implied seeks disabled
- Drive polling enabled

A software reset can be triggered by bit 2 of the Digital Output Register (DOR) or bit 7 of the Data rate Select Register (DSR). Bit 7 of DSR clears itself, while bit 2 of DOR does not clear itself.

If the LOCK bit in the LOCK command was set to 1 before the software reset, the FIFO, THRESH, and PRETRK parameters in the CONFIGURE command will be retained. In addition, the FWR, FRD, and BST parameters in the MODE command will be retained if LOCK is set to 1. This function eliminates the need for total initialization of the controller after a software reset.

After a hardware (assuming the FDC is enabled in the FER) or software reset, the Main Status Register (MSR) is immediately available for read access by the microprocessor. It will return a 00h value until all the internal registers have been updated and the data separator is stabilized.

When the controller is ready to receive a command byte, the MSR returns a value of 80h (Request for Master (RQM, bit 7) bit is set). The MSR is guaranteed to return the 80h value within 250 μ sec after a hardware or software reset.

All other user addressable registers other than the Main Status Register (MSR) and Data Register (FIFO) can be accessed at any time, even during software reset.

5.3 THE REGISTERS OF THE FDC

The FDC registers are mapped to the offset address shown in Table 5-1, with the base address range provided by the on-chip address decoder. For PC-AT or PS/2 applications, the offset address range of the diskette controller is 00h through 07h from the index of logical device 3.

TABLE 5-1. The FDC Registers and Their Addresses

Symbol	Description	Offset			R/W
		A2	A1	A0	
SRA	Status Register A	0	0	0	R
SRB	Status Register B	0	0	1	R
DOR	Digital Output Register	0	1	0	R/W
TDR	Tape Drive Register	0	1	1	R/W
MSR	Main Status Register	1	0	0	R
DSR	Data Rate Select Register	1	0	0	W
FIFO	Data Register (FIFO)	1	0	1	R/W
-	(Bus in TRI-STATE)	1	1	0	X
DIR	Digital Input Register	1	1	1	R
CCR	CCR Configuration Control Register	1	1	1	W

The FDC supports two system operation modes: PC-AT drive mode and PS/2 drive mode (MicroChannel systems). Section 5.1.2 on page 66 describes each mode and "Bit 2 - PC-AT or PS/2 Drive Mode Select" on page 35 describes how each is enabled.

Unless specifically indicated otherwise, all fields in all registers are valid in both drive modes.

The FDC supports plug and play, as follows:

- The FDC interrupt can be routed on one of the following ISA interrupts: IRQ3-IRQ7, IRQ9-IRQ12 and IRQ15 (see PNP2 register).
- The FDC DMA signals can be routed to one of three 8-bit ISA DMA channels (see PNP2 register); and its base address is software configurable (see FBAL and FBAH registers).
- Upon reset, the DMA of the FDC is routed to the DRQ2 and DACK2 pins.

5.3.1 Status Register A (SRA), Offset 00h

Status Register A (SRA) monitors the state of assigned IRQ signal and some of the disk interface signals. SRA is a read-only register that is valid only in PS/2 drive mode.

SRA can be read at any time while PS/2 drive mode is active. In PC-AT drive mode, all bits are in TRI-STATE during a microprocessor read.

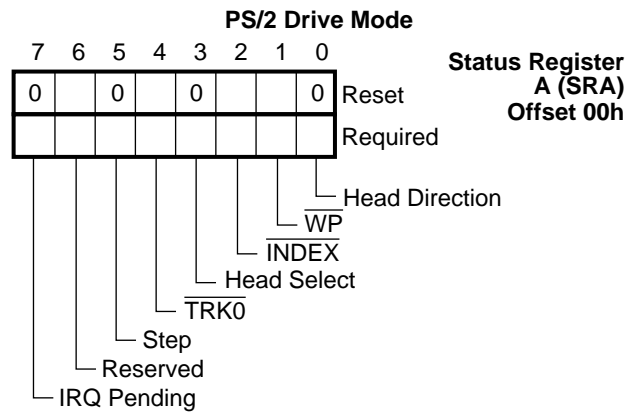


FIGURE 5-5. SRA Register Bitmap (PS/2 Drive Mode)

Bit 0 - Head Direction

This bit indicates the direction of the head of the Floppy Disk Drive (FDD). Its value is the inverse of the value of the DIR interface output signal.

- 0 - $\overline{\text{DIR}}$ is not active, i.e., the head of the FDD steps outward. (Default)
- 1 - $\overline{\text{DIR}}$ is active, i.e., the head of the FDD steps inward.

Bit 1 - Write Protect ($\overline{\text{WP}}$)

This bit indicates whether or not the selected Floppy Disk Drive (FDD) is write protected. Its value reflects the status of the $\overline{\text{WP}}$ disk interface input signal.

- 0 - $\overline{\text{WP}}$ is active, i.e., the FDD in the selected drive is write protected.
- 1 - $\overline{\text{WP}}$ is not active, i.e., the FDD in the selected drive is not write protected.

Bit 2 - Beginning of Track ($\overline{\text{INDEX}}$)

This bit indicates the beginning of a track. Its value reflects the status of the $\overline{\text{INDEX}}$ disk interface input signal.

- 0 - $\overline{\text{INDEX}}$ is active, i.e., it is the beginning of a track.
- 1 - $\overline{\text{INDEX}}$ is not active, i.e., it is not the beginning of a track.

Bit 3 - Head Select

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the HDSEL disk interface output signal.

- 0 - $\overline{\text{HDSEL}}$ is not active, i.e., the head of the FDD selects side 0. (Default)
- 1 - $\overline{\text{HDSEL}}$ is active, i.e., the head of the FDD selects side 1.

Bit 4 - At Track 0 ($\overline{\text{TRK0}}$)

This bit indicates whether or not the head of the Floppy Disk Drive (FDD) is at track 0. Its value reflects the status of the $\overline{\text{TRK0}}$ disk interface input signal.

- 0 - $\overline{\text{TRK0}}$ is active, i.e., the head of the FDD is at track 0.
- 1 - $\overline{\text{TRK0}}$ is not active, i.e., the head of the FDD is not at track 0.

Bit 5 - Step

This bit indicates whether or not the head of the Floppy Disk Drive (FDD) should move during a seek operation. Its value is the inverse of the STEP disk interface output signal.

- 0 - $\overline{\text{STEP}}$ is not active, i.e., the head of the FDD moves. (Default)
- 1 - $\overline{\text{STEP}}$ is active (low), i.e., the head of the FDD does not move.

Bit 6 - Reserved

This bit is reserved.

Bit 7 - IRQ Pending

This bit signals the completion of the execution phase of certain FDC commands. Its value reflects the status of the IRQ signal assigned to the FDC.

- 0 - The IRQ signal assigned to the FDC is not active.
- 1 - The IRQ signal assigned to the FDC is active, i.e., the FDD has completed execution of certain FDC commands.

5.3.2 Status Register B (SRB), Offset 01h

Status Register B (SRB) is a read-only diagnostic register that is valid only in PS/2 drive mode.

SRB can be read at any time while PS/2 drive mode is active. In PC-AT drive mode, all bits are in TRI-STATE during a microprocessor read.

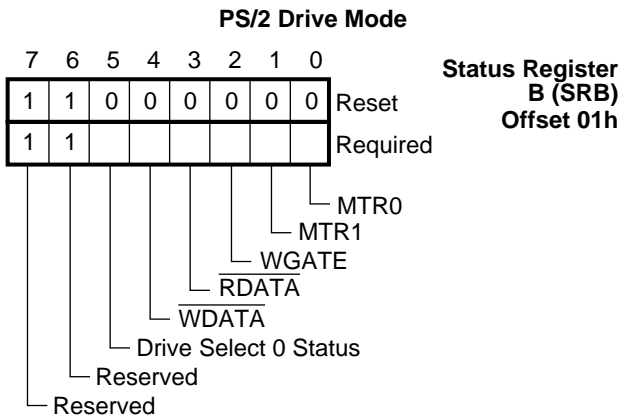


FIGURE 5-6. SRB Register Bitmap (PS/2 Drive Mode)

Bit 0 - Motor 0 Status (MTR0)

This bit indicates whether motor 0 is on or off. It reflects the status of the $\overline{\text{MTR0}}$ disk interface output signal.

This bit is cleared to 0 by a hardware reset and unaffected by a software reset.

- 0 - $\overline{\text{MTR0}}$ is not active. Motor 0 is off.
- 1 - $\overline{\text{MTR0}}$ is active. Motor 0 is on. (Default)

Bit 1 - Motor 1 Status (MTR1)

This bit indicates whether motor 1 is on or off. It reflects the status of the $\overline{\text{MTR1}}$ disk interface output signal.

This bit is cleared to 0 by a hardware reset and unaffected by a software reset.

- 0 - $\overline{\text{MTR1}}$ is not active. Motor 1 is off.
- 1 - $\overline{\text{MTR1}}$ is active. Motor 1 is on. (Default)

Bit 2 - Write Circuitry Status (WGATE)

This bit indicates whether the write circuitry of the selected Floppy Disk Drive (FDD) is enabled or not. It reflects the status of the $\overline{\text{WGATE}}$ disk interface output signal.

- 0 - $\overline{\text{WGATE}}$ is not active. The write circuitry of the selected FDD is enabled.
- 1 - $\overline{\text{WGATE}}$ is active. The write circuitry of the selected FDD is disabled. (Default)

Bit 3 - Read Data Status ($\overline{\text{RDATA}}$)

If read data was sent, this bit indicates whether an odd or even number of bits was sent.

Every inactive edge transition of the $\overline{\text{RDATA}}$ disk interface output signal causes this bit to change state.

- 0 - Either no read data was sent or an even number of bits of read data was sent. (Default)
- 1 - An odd number of bits of read data was sent.

Bit 4 - Write Data Status ($\overline{\text{WDATA}}$)

If write data was sent, this bit indicates whether an odd or even number of bits was sent.

Every inactive edge transition of the $\overline{\text{WDATA}}$ disk interface output signal causes this bit to change state.

- 0 - Either no write data was sent or an even number of bits of write data was sent. (Default)
- 1 - An odd number of bits of write data was sent.

Bit 5 - Drive Select 0 Status

This bit reflects the status of drive select bit 0 in the Digital Output Register (DOR). See Section 5.3.3.

It is cleared after a hardware reset and unaffected by a software reset.

- 0 - Either drive 0 or 2 is selected. (Default)
- 1 - Either drive 1 or 3 is selected.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

5.3.3 Digital Output Register (DOR), Offset 02h

DOR is a read/write register that can be written at any time. It controls the drive select and motor enable disk interface output signals, enables the DMA logic and contains a software reset bit.

The contents of the DOR is set to 00h after a hardware reset, and is unaffected by a software reset.

Table 5-2 shows how the bits of DOR select a drive and enable a motor when the FDC is enabled (bit 3 of the Function Enable Register 1 (FER1) at offset 00h of logical device 8 is 1) and bit 7 of the SuperI/O FDC Configuration register at index F0h is 1. Bit patterns not shown produce states that should not be decoded to enable any drive or motor.

When the FDC is enabled and bit 7 of the SuperI/O FDC Configuration register at index F0h is 1, $\overline{\text{MTR1}}$ presents a pulse that is the inverse of WR. This pulse is active whenever an I/O write to address 02h occurs. This pulse is delayed for between 25 and 80 nsec after the leading edge of WR. The leading edge of this pulse can be used to clock data into an external latch (e.g., 74LS175).

TABLE 5-2. Drive and Motor Pin Encoding for Four Drive Configurations and Drive Exchange Support

Digital Output Register Bits								Control Signals				Decoded Functions	
								MTR		DR			
7	6	5	4	3	2	1	0	1	0	1	0		
x	x	x	1	x	x	0	0	-	0	0	0	0	Activate Drive 0 and Motor 0
x	x	1	x	x	x	0	1	-	0	0	0	1	Activate Drive 1 and Motor 1
x	1	x	x	x	x	1	0	-	0	1	0	0	Activate Drive 2 and Motor 2
1	x	x	x	x	x	1	1	-	0	1	1	1	Activate Drive 3 and Motor 3
x	x	x	0	x	x	0	0	-	1	0	0	0	Activate Drive 0 and Deactivate Motor 0
x	x	0	x	x	x	0	1	-	1	0	0	1	Activate Drive 1 and deactivate Motor 1
x	0	x	x	x	x	1	0	-	1	1	0	0	Activate Drive 2 and Deactivate Motor 2
0	x	x	x	x	x	1	1	-	1	1	1	1	Activate Drive 3 and Deactivate Motor 3

Usually, the motor enable and drive select output signals for a particular drive are enabled together. Table 5-3 shows the DOR hexadecimal values that enable each of the four drives.

TABLE 5-3. Drive Enable Hexadecimal Values

Drive	DOR Value (Hex)
0	1C
1	2D
2	4E
3	8F

The motor enable and drive select signals for drives 2 and 3 are only available when four drives are supported, i.e., bit 7 of the SuperI/O FDC Configuration register at index F0h is 1, or when drives 2 and 0 are exchanged. These signals require external logic.

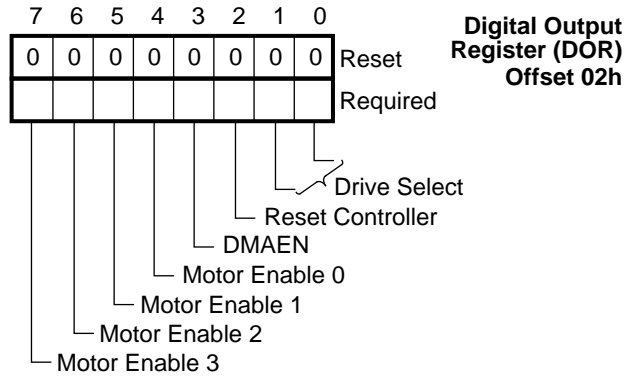


FIGURE 5-7. DOR Register Bitmap

Bits 1,0 - Drive Select

These bits select a drive, so that only one drive select output signal is active at a time.

See the four-drive encoding bit 7 of the SuperI/O FDC Configuration register at index F0h on page 37 and logical drive exchange bits 3,2 of TDR on page 74 for more information.

- 00 - Drive 0 is selected. (Default)
- 01 - Drive 1 is selected.
- 10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.
- 11 - If four drives are supported, drive 3 is selected.

Bit 2 - Reset Controller

This bit can cause a software reset. The controller remains in a reset state until this bit is set to 1.

A software reset affects the CONFIGURE and MODE commands. See Section 5.7.2 on page 88 and 5.7.7 on page 92, respectively. A software reset does not affect the Data rate Select Register (DSR), Configuration Control Register (CCR) and other bits of this register (DOR).

This bit must be low for at least 100 nsec. There is enough time during consecutive writes to the DOR to reset software by toggling this bit.

- 0 - Reset controller. (Default)
- 1 - No reset.

Bit 3 - DMA Enable (DMAEN)

In PC-AT drive mode, this bit enables DMA operations by controlling \overline{DACK} , TC and the appropriate DRQ and IRQ DMA signals. In PC-AT mode, this bit is set to 0 after reset.

In PS/2 drive mode, this bit is reserved, and \overline{DACK} , TC and the appropriate DRQ and IRQ signals are enabled. During reset, these signals remain enabled.

- 0 - In PC-AT drive mode, DMA operations are disabled. \overline{DACK} and TC are disabled, and the appropriate DRQ and IRQ signals are put in TRI-STATE. (Default)
- 1 - In PC-AT drive mode, DMA operations are enabled, i.e., \overline{DACK} , TC and the appropriate DRQ and IRQ signals are all enabled.

Bit 4 - Motor Enable 0

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 0, depending on the remaining bits of this register. See Table 5-2.

If two drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 0), this bit controls the motor output signal for drive 0.

- 0 - The motor signal for drive 0 is not active.
- 1 - The motor signal for drive 0 is active.

Bit 5 - Motor Enable 1

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 0, depending on the remaining bits of this register. See Table 5-2.

If two drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 0), this bit controls the motor output signal for drive 1.

- 0 - The motor signal for drive 1 is not active.
- 1 - The motor signal for drive 1 is active.

Bit 6 - Motor Enable 2

If drives 2 and 0 are exchanged (see logical drive exchange bits 3,2 of TDR on page 74), or if four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit controls the motor output signal for drive 2. See Table 5-2.

- 0 - The motor signal for drive 2 is not active.
- 1 - The motor signal for drive 2 is active.

Bit 7 - Motor Enable 3

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 3, depending on the remaining bits of this register. See Table 5-2.

- 0 - The motor signal for drive 3 is not active.
- 1 - The motor signal for drive 3 is active.

5.3.4 Tape Drive Register (TDR), Offset 03h

The TDR register is a read/write register that acts as the Floppy Disk Controller's (FDC) media and drive type register.

The TDR functions differently, depending on the mode set by bit 6 the SuperI/O FDC Configuration register at index F0h. See "Bit 6 - TDR Register Mode" on page 37.

AT Compatible TDR Mode

In this mode, the TDR assigns a drive number to the tape drive support mode of the data separator. All other logical drives can be assigned as floppy drive support. Bits 7-2 are in TRI-STATE during read operations.

Enhanced TDR Mode

In this mode, all the bits of the TDR define operations with PS/2 floppy disk drives.

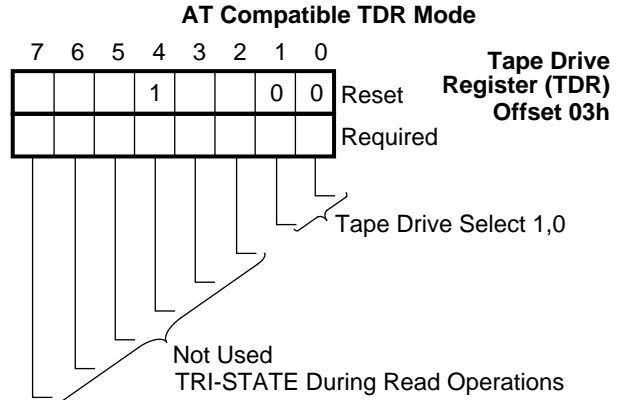


FIGURE 5-8. TDR Register Bitmap, AT Compatible TDR Mode

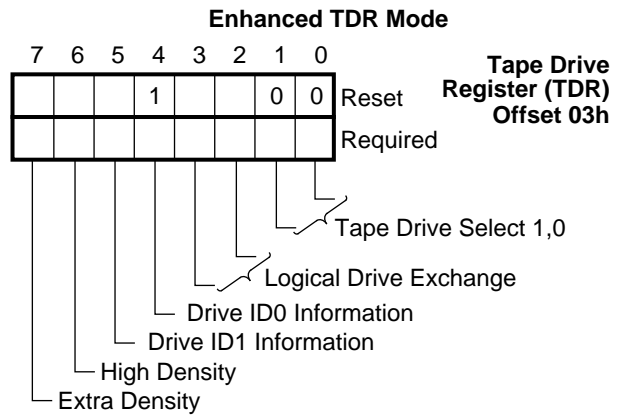


FIGURE 5-9. TDR Register Bitmap, Enhanced TDR Mode

TABLE 5-4. TDR Bit Utilization and Reset Values in Different Drive Modes

TDR Mode	Bit 6 of SuperI/O FDC Configuration Register	Bits of TDR							
		Extra Density	High Density	Drive ID1	Drive ID0	Logical Drive Exchange		Drive Select	
		7	6	5	4	3	2	1	0
AT Compatible	0	Not used. Floated in TRI-STATE during read operations.						0	0
Enhanced	1	Not Reset	Not Reset	1	1	0	0	0	0

Bits 1,0 - Tape Drive Select 1,0

These bits assign a logical drive number to a tape drive. Drive 0 is not available as a tape drive and is reserved as the floppy disk boot drive.

- 00 - No drive selected.
- 01 - Drive 1 selected.
- 10 - Drive 2 selected.
- 11 - Drive 3 selected.

Bits 3,2 - Logical Drive Control (Enhanced TDR Mode Only)

These read/write bits control logical drive exchange between drives 0 and 2, only. They enable software to exchange the physical floppy disk drive and motor control signals assigned to pins. Drive 3 is never exchanged for drive 2. When four drives are configured, i.e., bit 7 of SuperI/O FDC Configuration register at index F0h is 1, logical drives are not exchanged.

- 00 - No logical drive exchange.
- 01 - Disk drive and motor control signal assignment to pins exchanged between logical drives 0 and 1.
- 10 - Disk drive and motor control signal assignment to pins exchanged between logical drives 0 and 2.
- 11 - Reserved. Unpredictable results when configured.

Bits 5,4 - Drive ID1,0 Information

If the value of bits 1,0 of the Digital Output Register (DOR) are 00, these bits reflect the ID of drive 0, i.e., the value of bits 1,0, respectively, of the Drive ID register at index F1h. See "Bits 1,0 - Drive 0 ID" on page 37. If the value of bits 1,0 of the Digital Output Register (DOR) are 01, these bits reflect the ID of drive 1, i.e., the value of bits 3,2, respectively, of the Drive ID register at index F1h. See "Bits 3,2 - Drive 1 ID" on page 37.

Bit 6 - High Density (Enhanced TDR Mode Only)

Together with bit 7, this bit indicates the type of media currently in the active floppy disk drive. The value of this bit reflects the state of the MSEN0 signal. Table 5-5 shows how these bits encode media type.

TABLE 5-5. Media Type (Density) Encoding

Bit 7 (MSEN1)	Bit 6 (MSEN0)	Media Type
0	0	5.25"
0	1	2.88 M
1	0	1.44 M
1	1	720 K

Bit 7 - Extra Density (Enhanced TDR Mode Only)

Together with bit 6, this bit indicates the type of media currently in the active floppy disk drive. The value of this bit reflects the state of the MSEN1 signal. Table 5-5 shows how these bits encode media type.

5.3.5 Main Status Register (MSR), Offset 04h, Read Operations

This read-only register indicates the current status of the Floppy Disk Controller (FDC), indicates when the disk controller is ready to send or receive data through the Data Register (FIFO) and controls the flow of data to and from the Data Register (FIFO).

The MSR can be read at any time. It should be read before each byte is transferred to or from the Data Register (FIFO) except during a DMA transfer. No delay is required when reading this register after a data transfer.

The microprocessor can read the MSR immediately after a hardware or software reset, or recovery from a power down. The MSR contains a value of 00h, until the FDC clock has stabilized and the internal registers have been initialized.

When the FDC is ready to receive a new command, it reports a value of 80h for the MSR to the microprocessor. System software can poll the MSR until the MSR is ready. The MSR must report an 80h value (RQM set to 1) within 2.5 msec after reset or power up.

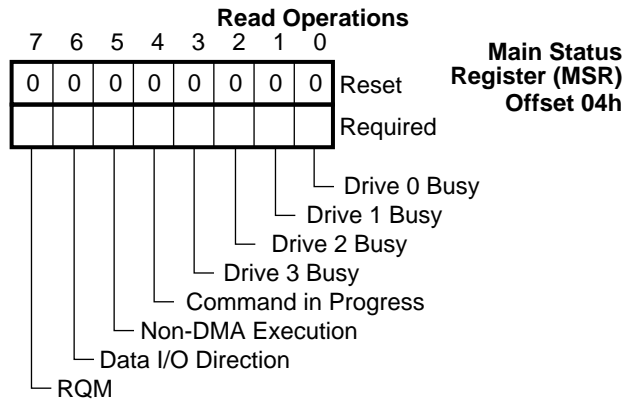


FIGURE 5-10. MSR Register Bitmap

Bit 0 - Drive 0 Busy

This bit indicates whether or not drive 0 is busy. It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 0. This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 0.

- 0 - Not busy.
- 1 - Busy.

Bit 1 - Drive 1 Busy

This bit indicates whether or not drive 1 is busy. It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 1. This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 1.

- 0 - Not busy.
- 1 - Busy.

Bit 2 - Drive 2 Busy

This bit indicates whether or not drive 2 is busy.
 It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 2.
 This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 2.
 0 - Not busy.
 1 - Busy.

Bit 3 - Drive 3 Busy

This bit indicates whether or not drive 3 is busy.
 It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 3.
 This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 3.
 0 - Not busy.
 1 - Busy.

Bit 4 - Command in Progress

This bit indicates whether or not a command is in progress. It is set after the first byte of the command phase is written. This bit is cleared after the last byte of the result phase is read.
 If there is no result phase in a command, the bit is cleared after the last byte of the command phase is written.
 0 - No command is in progress.
 1 - A command is in progress.

Bit 5 - Non-DMA Execution

This bit indicates whether or not the controller is in the execution phase of a byte transfer operation in non-DMA mode.
 This bit is used for multiple byte transfers by the microprocessor in the execution phase through interrupts or software polling.
 0 - The FDC is not in the execution phase.
 1 - The FDC is in the execution phase.

Bit 6 - Data I/O (Direction)

Indicates whether the controller is expecting a byte to be written or read, to or from the Data Register (FIFO).
 0 - Data will be written to the FIFO.
 1 - Data will be read from the FIFO.

Bit 7 - Request for Master (RQM)

This bit indicates whether or not the controller is ready to send or receive data from the microprocessor through the Data Register (FIFO). It is cleared to 0 immediately after a byte transfer and is set to 1 again as soon as the disk controller is ready for the next byte.
 During a Non-DMA execution phase, this bit indicates the status of the interrupt.
 0 - Not ready. (Default)
 1 - Ready to transfer data.

5.3.6 Data Rate Select Register (DSR), Offset 04h, Write Operations

This write-only register is used to program the data transfer rate, amount of write precompensation, power down mode, and software reset.
 The data transfer rate is programmed via the CCR, not the DSR, for PC-AT, PS/2 and MicroChannel applications. Other applications can set the data transfer rate in the DSR.
 The data rate of the floppy controller is determined by the most recent write to either the DSR or CCR.
 The DSR is unaffected by a software reset. A hardware reset sets the DSR to 02h, which corresponds to the default precompensation setting and a data transfer rate of 250 Kbps.

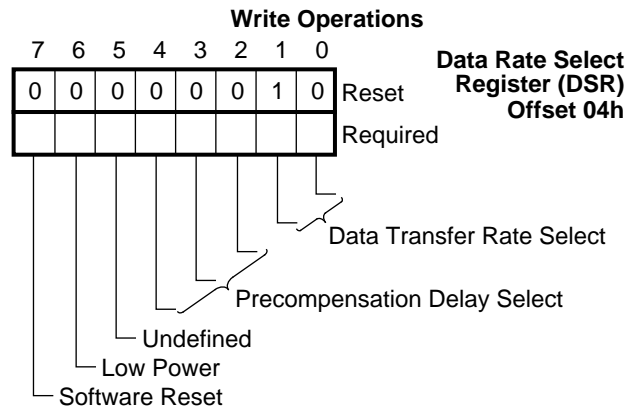


FIGURE 5-11. DSR Register Bitmap

Bits 1,0 - Data Transfer Rate Select

These bits determine the data transfer rate for the Floppy Disk Controller (FDC), depending on the supported speeds. Table 5-6 shows the data transfer rate selected by each value of this field.
 These bits are unaffected by a software reset, and are set to 10 (250 Kbps) after a hardware reset.

TABLE 5-6. Data Transfer Rate Encoding

DSR Bits		Data Transfer Rate
1	0	
0	0	500 Kbps
0	1	300 Kbps
1	0	250 Kbps
1	1	1 Mbps

Bits 4-2 - Precompensation Delay Select

This field sets the write precompensation delay that the Floppy Disk Controller (FDC) imposes on the WDATA disk interface output signal, depending on the supported speeds. Table 5-7 shows the delay for each value of this field.
 In most cases, the default delays shown in Table 5-8 are adequate. However, alternate values may be used for specific drive and media types.

Track 0 is the default starting track number for precompensation. The starting track number can be changed using the CONFIGURE command.

TABLE 5-7. Write Precompensation Delays

DSR Bits			Duration of Delay
4	3	2	
0	0	0	Default (Table 5-8)
0	0	1	41.7 nsec
0	1	0	83.3 nsec
0	1	1	125.0 nsec
1	0	0	166.7 nsec
1	0	1	208.3 nsec
1	1	0	250.0 nsec
1	1	1	0.0 nsec

TABLE 5-8. Default Precompensation Delays

Data Rate	Precompensation Delay
1 Mbps	41.7 nsec
500 Kbps	125.0 nsec
300 Kbps	125.0 nsec
250 Kbps	125.0 nsec

Bit 5 - Undefined

Should be set to 0.

Bit 6 - Low Power

This bit triggers a manual power down of the FDC in which the clock and data separator circuits are turned off. A manual power down can also be triggered by the MODE command.

After a manual power down, the FDC returns to normal power after a software reset, or an access to the Data Register (FIFO) or the Main Status Register (MSR).

- 0 - Normal power.
- 1 - Trigger power down.

Bit 7 - Software Reset

This bit controls the same kind of software reset of the FDC as bit 2 of the Digital Output Register (DOR). The difference is that this bit is automatically cleared to 0 (no reset) 100 nsec after it was set to 1.

See also "Bit 2 - Reset Controller" on page 72.

- 0 - No reset. (Default)
- 1 - Reset.

5.3.7 Data Register (FIFO), Offset 05h

The Data Register of the FDC is a read/write register that is used to transfer all commands, data and status information between the microprocessor and the FDC.

During the command phase, the microprocessor writes command bytes into the Data Register after polling the RQM (bit 7) and DIO (bit 6) bits in the MSR. During the result phase, the microprocessor reads result bytes from the Data Register after polling the RQM and DIO bits in the MSR.

Use of the FIFO buffer lengthens the interrupt latency period and, thereby, reduces the chance of a disk overrun or underrun error occurring. Typically, the FIFO buffer is used at a 1 Mbps data transfer rate or with multi-tasking operating systems.

Enabling and Disabling the FIFO Buffer

The 16-byte FIFO buffer can be used for DMA, interrupt, or software polling type transfers during the execution of a read, write, format or scan command.

The FIFO buffer is enabled and its threshold is set by the CONFIGURE command.

When the FIFO buffer is enabled, only execution phase byte transfers use it. If the FIFO buffer is enabled, it is not disabled after a software reset if the LOCK bit is set in the LOCK command.

The FIFO buffer is always disabled during the command and result phases of a controller operation. A hardware reset disables the FIFO buffer and sets its threshold to zero. The MODE command can also disable the FIFO for read or write operations separately.

After a hardware reset, the FIFO buffer is disabled to maintain compatibility with PC-AT systems.

Burst Mode Enabled and Disabled

The FIFO buffer can be used with burst mode enabled or disabled by the MODE command.

In burst mode, the DRQ or IRQ signal assigned to the FDC remains active until all of the bytes have been transferred to or from the FIFO buffer.

When burst mode is disabled, the appropriate DRQ or IRQ signal is deactivated for 350 nsec to allow higher priority transfer requests to be processed.

FIFO Buffer Response Time

During the execution phase of a command involving data transfer to or from the FIFO buffer, the maximum time the system has to respond to a data transfer service request is calculated by the following formula:

$$\text{Max_Time} = (\text{THRESH} + 1) \times 8 \times t_{\text{DRP}} - (16 \times t_{\text{ICP}})$$

This formula applies for all data transfer rates, whether the FIFO buffer is enabled or disabled. THRESH is a 4-bit value programmed by the CONFIGURE command, which sets the threshold of the FIFO buffer. If the FIFO buffer is disabled, THRESH is zero in the above formula. The last term in the formula, (16 x t_{ICP}) is an inherent delay due to the microcode overhead required by the FDC. This delay is also data rate dependent. Table 13-36 on page 192 specifies minimum and maximum values for t_{DRP} and t_{ICP}.

The programmable FIFO threshold (THRESH) is useful in adjusting the FDC to the speed of the system. A slow system with a sluggish DMA transfer capability requires a high value for THRESH. This gives the system more time to respond to a data transfer service request (DRQ for DMA mode or IRQ for interrupt mode). Conversely, a fast system with quick response to a data transfer service request can use a low value for THRESH.

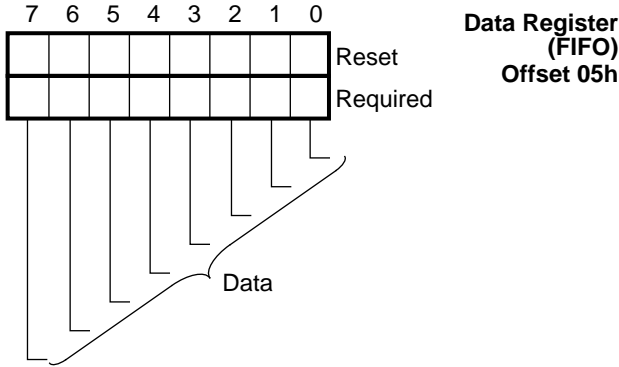


FIGURE 5-12. FDC Data Register Bitmap

5.3.8 Digital Input Register (DIR), Offset 07h, Read Operations

This read-only diagnostic register is used to detect the state of the DSKCHG disk interface input signal and some diagnostic signals. DIR is unaffected by a software reset.

The bits of the DIR register function differently depending on whether the FDC is operating in PC-AT drive mode or in PS/2 drive mode. See Section 5.1.2 on page 66.

In PC-AT drive mode, bits 6 through 0 are in TRI-STATE to prevent conflict with the status register of the hard disk at the same address as the DIR.

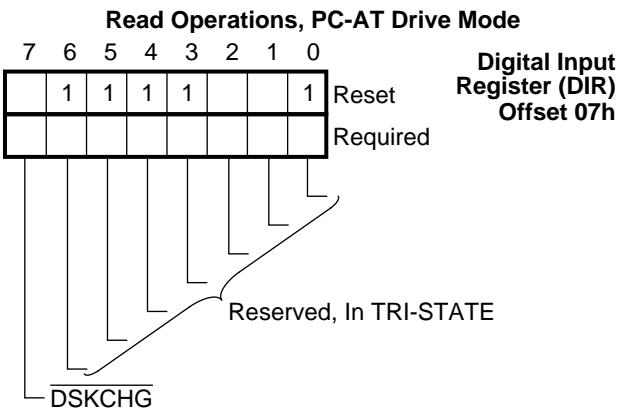


FIGURE 5-13. DIR Register Bitmap, Read Operations, PC-AT Drive Mode

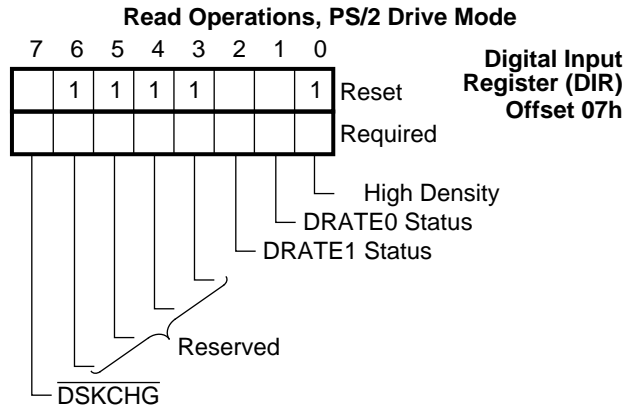


FIGURE 5-14. DIR Register Bitmap, Read Operations, PS/2 Drive Mode

Bit 0 - High Density (PS/2 Drive Mode Only)

In PC-AT drive mode, this bit is reserved, in TRI-STATE and used by the status register of the hard disk.

In PS/2 drive mode, this bit indicates whether the data transfer rate is high or low.

0 - The data transfer rate is high, i.e., 1 Mbps or 500 Kbps.

1 - The data transfer rate is low, i.e., 300 Kbps or 250 Kbps.

Bits 2,1 - Data Rate Select 1,0 (DRATE1,0) (PS/2 Drive Mode Only)

In PC-AT drive mode, these bits are reserved, in TRI-STATE and used by the status register of the hard disk.

In PS/2 drive mode, these bits indicate the status of the DRATE1,0 bits programmed in DSR or CCR, whichever is written last.

The significance of each value for these bits depends on the supported speeds. See Table 5-6.

00 - Data transfer rate is 500 Kbps.

01 - Data transfer rate is 300 Kbps.

10 - Data transfer rate is 250 Kbps.

11 - Data transfer rate is 1 Mbps.

Bits 6-3 - Reserved

These bits are reserved and are always 1. In PC-AT mode these bits are also in TRI-STATE. They are used by the status register of the fixed hard disk.

Bit 7 - Disk Changed (DSKCHG)

This bit reflects the status of the $\overline{\text{DSKCHG}}$ disk interface input signal.

During power down this bit is invalid, if it is read by the software.

0 - $\overline{\text{DSKCHG}}$ is not active.

1 - $\overline{\text{DSKCHG}}$ is active.

5.3.9 Configuration Control Register (CCR), Offset 07h, Write Operations

This write-only register can be used to set the data transfer rate (in place of the DSR) for PC-AT, PS/2 and MicroChannel applications. Other applications can set the data transfer rate in the DSR. See Section 5.3.6.

This register is not affected by a software reset.

The data rate of the floppy controller is determined by the last write to either the CCR register or to the DSR register.

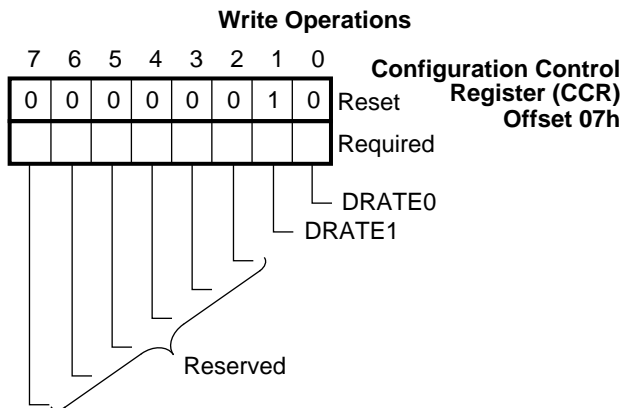


FIGURE 5-15. CCR Register Bitmap

Bits 1,0 - Data Transfer Rate Select 1,0 (DRATE 1,0)

These bits determine the data transfer rate for the Floppy Disk Controller (FDC), depending on the supported speeds.

Table 5-6 shows the data transfer rate selected by each value of this field.

These bits are unaffected by a software reset, and are set to 10 (250 Kbps) after a hardware reset.

Bits 7-2 - Reserved

These bits are reserved and should be set to 0.

5.4 THE PHASES OF FDC COMMANDS

FDC commands may be in the command phase, the execution phase or the result phase. The active phase determines how data is transferred between the Floppy Disk Controller (FDC) and the host microprocessor. When no command is in progress, the FDC may be either idle or polling a drive.

5.4.1 Command Phase

During the command phase, the microprocessor writes a series of bytes to the Data Register (FIFO). The first command byte contains the opcode for the command, which the controller can interpret to determine how many more command bytes to expect. The remaining command bytes contain the parameters required for the command.

The number of command bytes varies for each command. All command bytes must be written in the order specified in the Command Description Table in Section 5.7 on page 86. The execution phase starts immediately after the last byte in the command phase is written.

Prior to performing the command phase, the Digital Output Register (DOR) should be set and the data rate should be set with the Data rate Select Register (DSR) or the Configuration Control Register (CCR).

The Main Status Register (MSR) controls the flow of command bytes, and must be polled by the software before writing each command phase byte to the Data Register (FIFO). Prior to writing a command byte, bit 7 of MSR (RQM, Request for Master) must be set and bit 6 of MSR (DIO, Data I/O direction) must be cleared.

After the first command byte is written to the Data Register (FIFO), bit 4 of MSR (CMD PROG, Command in Progress) is also set and remains set until the last result phase byte is read. If there is no result phase, the CMD PROG bit is cleared after the last command byte is written.

A new command may be initiated after reading all the result bytes from the previous command. If the next command requires selection of a different drive or a change in the data rate, the DOR and DSR or CCR should be updated, accordingly. If the command is the last command, the software should deselect the drive.

Normally, command processing by the controller core and updating of the DOR, DSR, and CCR registers by the microprocessor are operations that can occur independently of one another. Software must ensure that these registers are not updated while the controller is processing a command.

5.4.2 Execution Phase

During the execution phase, the Floppy Disk Controller (FDC) performs the desired command.

Commands that involve data transfers (e.g., read, write and format operations) require the microprocessor to write or read data to or from the Data Register (FIFO) at this time. Some commands, such as SEEK or RECALIBRATE, control the read/write head movement on the disk drive during the execution phase via the disk interface signals. Execution of other commands does not involve any action by the microprocessor or disk drive, and consists of an internal operation by the controller.

Data can be transferred between the microprocessor and the controller during execution in DMA mode, interrupt transfer mode or software polling mode. The last two modes are non-DMA modes. All data transfer modes work with the FIFO enabled or disabled.

DMA mode is used if the system has a DMA controller. This allows the microprocessor to do other tasks while data transfer takes place during the execution phase.

If a non-DMA mode is used, an interrupt is issued for each byte transferred during the execution phase. Also, instead of using the interrupt during a non-DMA mode transfer, the Main Status Register (MSR) can be polled by software to indicate when a byte transfer is required.

DMA Mode - FIFO Disabled

DMA mode is selected by writing a 0 to the DMA bit in the SPECIFY command and by setting bit 3 of the DOR (DMA enabled) to 1.

In the execution phase when the FIFO is disabled, each time a byte is ready to be transferred, a DMA request (DRQ) is generated in the execution phase. The DMA controller should respond to the DRQ with a DMA acknowledge (DACK) and a read or write pulse. The DRQ is cleared by the leading edge of the active low DACK input signal. After the last byte is transferred, an interrupt is generated, indicating the beginning of the result phase.

During DMA operations, FDC address signals are ignored since AEN input signal is 1. The $\overline{\text{DACK}}$ signal acts as the chip select signal for the FIFO, in this case, and the state of the address lines A2-0 is ignored. The Terminal Count (TC) signal can be asserted by the DMA controller to terminate the data transfer at any time. Due to internal gating, TC is only recognized when $\overline{\text{DACK}}$ is low.

PC-AT Drive Mode

In PC-AT drive mode when the FIFO is disabled, the controller is in single byte transfer mode. That is, the system has the time it takes to transfer one byte, to service a DMA request (DRQ) from the controller. DRQ is deactivated between bytes.

PS/2 Drive Mode

In PS/2 drive mode, for DMA transfers with the FIFO disabled, instead of single byte transfer mode, the FIFO is enabled with THRESH = 0Fh. Thus, DRQ is asserted when one byte enters the FIFO during a read, and when one byte can be written to the FIFO during a write. DRQ is deactivated by the leading edge of the $\overline{\text{DACK}}$ input signal, and is asserted again when $\overline{\text{DACK}}$ becomes inactive high. This operation is very similar to burst mode transfer with the FIFO enabled except that DRQ is deactivated between bytes.

DMA Mode - FIFO Enabled

Read Data Transfers

Whenever the number of bytes in the FIFO is greater than or equal to (16 – THRESH), a DRQ is generated. This is the trigger condition for the FIFO read data transfers from the floppy controller to the microprocessor.

When the last byte in the FIFO has been read, DRQ becomes inactive. DRQ is asserted again when the FIFO trigger condition is satisfied. After the last byte of a sector is read from the disk, DRQ is again generated even if the FIFO has not yet reached its threshold trigger condition. This guarantees that all current sector bytes are read from the FIFO before the next sector byte transfer begins.

Burst Mode Enabled - DRQ remains active until enough bytes have been read from the controller to empty the FIFO.

Burst Mode Disabled - DRQ is deactivated after each read transfer. If the FIFO is not completely empty, DRQ is asserted again after a 350 nsec delay. This allows other higher priority DMA transfers to take place between floppy disk transfers.

In addition, this mode allows the controller to work correctly in systems where the DMA controller is put into a read verify mode, where only $\overline{\text{DACK}}$ signals are sent to the FDC, with no $\overline{\text{RD}}$ pulses. This read verify mode of the DMA controller is used in some PC software. When burst mode is disabled, a pulse from the $\overline{\text{DACK}}$ input signal may be issued by the DMA controller, to correctly clock data from the FIFO.

Write Data Transfers

Whenever the number of bytes in the FIFO is less than or equal to THRESH, a DRQ is generated. This is the trigger condition for the FIFO write data transfers from the microprocessor to the FDC.

Burst Mode Enabled - DRQ remains active until enough bytes have been written to the controller to completely fill the FIFO.

Burst Mode Disabled - DRQ is deactivated after each write transfer. If the FIFO is not full, DRQ is asserted again after a 350 nsec delay. Deactivation of DRQ allows other higher priority DMA transfers to take place between floppy disk transfers.

The FIFO has a byte counter which monitors the number of bytes being transferred to the FIFO during write operations whether burst mode is enabled or disabled. When the last byte of a sector is transferred to the FIFO, DRQ is deactivated even if the FIFO has not been completely filled. Thus, the FIFO is cleared after each sector is written. Only after the FDC has determined that another sector is to be written, is DRQ asserted again. Also, since DRQ is deactivated immediately after the last byte of a sector is written to the FIFO, the system will not be delayed by deactivation of DRQ and is free to do other operations.

Read and Write Data Transfers

The $\overline{\text{DACK}}$ input signal from the DMA controller may be held active during an entire burst, or a pulse may be issued for each byte transferred during a read or write operation. In burst mode, the FDC deactivates DRQ as soon as it recognizes that the last byte of a burst was transferred.

If a $\overline{\text{DACK}}$ pulse is issued for each byte, the leading edge of this pulse is used to deactivate DRQ. If a $\overline{\text{DACK}}$ pulse is issued, $\overline{\text{RD}}$ or $\overline{\text{WR}}$ is not required. This is the case during the read-verify mode of the DMA controller.

If $\overline{\text{DACK}}$ is held active during the entire burst, the trailing edge of the $\overline{\text{RD}}$ or $\overline{\text{WR}}$ pulse is used to deactivate DRQ. DRQ is deactivated within 50 nsec of the leading edge of $\overline{\text{DACK}}$, $\overline{\text{RD}}$, or $\overline{\text{WR}}$. This quick response should prevent the DMA controller from transferring extra bytes in most applications.

Overrun Errors

An overrun or underrun error terminates the execution of a command, if the system does not transfer data within the allotted data transfer time. (See Section 5.3.7 on page 76.) This puts the controller in the result phase.

During a read overrun, the microprocessor is required to read the remaining bytes of the sector before the controller asserts the appropriate IRQ signifying the end of execution.

During a write operation, an underrun error terminates the execution phase after the controller has written the remaining bytes of the sector with the last correctly written byte to the FIFO. Whether there is an error or not, an interrupt is generated at the end of the execution phase, and is cleared by reading the first result phase byte.

$\overline{\text{DACK}}$ asserted alone, without a $\overline{\text{RD}}$ or $\overline{\text{WR}}$ pulse, is also counted as a transfer. If pulses of $\overline{\text{RD}}$ or $\overline{\text{WR}}$ are not being issued for each byte, a $\overline{\text{DACK}}$ pulse must be issued for each byte so that the Floppy Disk Controller (FDC) can count the number of bytes correctly.

The VERIFY command, allows easy verification of data written to the disk without actually transferring the data on the data bus.

Interrupt Transfer Mode - FIFO Disabled

If interrupt transfer (non-DMA) mode is selected, the appropriate IRQ signal is asserted instead of DRQ, when each byte is ready to be transferred.

The Main Status Register (MSR) should be read to verify that the interrupt is for a data transfer. The RQM and NON DMA bits (bits 7 and 5, respectively) in the MSR are set to 1. The interrupt is cleared when the byte is transferred to or from the Data Register (FIFO). To transfer the data in or out of the Data register, you must use the address bits of the FDC together and RD or WR must be active, i.e., A2-0 must be valid. It is not enough to just assert the address bits of the FDC. RD or WR must also be active for a read or write transfer to be recognized.

The microprocessor should transfer the byte within the data transfer service time (see Section 5.3.7 on page 76). If the byte is not transferred within the time allotted, an overrun error is indicated in the result phase when the command terminates at the end of the current sector.

An interrupt is also generated after the last byte is transferred. This indicates the beginning of the result phase. The RQM and DIO bits (bits 7 and 6, respectively) in the MSR are set to 1, and the NON DMA bit (bit 5) is cleared to 0. This interrupt is cleared by reading the first result byte.

Interrupt Transfer Mode - FIFO Enabled

Interrupt transfer (non-DMA) mode with the FIFO enabled is very similar to interrupt transfer mode with the FIFO disabled. In this case, the appropriate IRQ signal is asserted instead of DRQ, under the same FIFO threshold trigger conditions.

The MSR should be read to verify that the interrupt is for a data transfer. The RQM and non-DMA bits (bits 7 and 5, respectively) in the MSR are set. To transfer the data in or out of the Data register, you must use the address bits of the FDC together and RD or WR must be active, i.e., A2-0 must be valid. It is not enough to just assert the address bits of the FDC. RD or WR must also be active for a read or write transfer to be recognized.

Burst mode may be used to hold the IRQ signal active during a burst, or burst mode may be disabled to toggle the IRQ signal for each byte of a burst. The Main Status Register (MSR) is always valid to the microprocessor. For example, during a read command, after the last byte of data has been read from the disk and placed in the FIFO, the MSR still indicates that the execution phase is active, and that data needs to be read from the Data Register (FIFO). Only after the last byte of data has been read by the microprocessor from the FIFO does the result phase begin.

The overrun and underrun error procedures for non-DMA mode are the same as for DMA mode. Also, whether there is an error or not, an interrupt is generated at the end of the execution phase, and is cleared by reading the first result phase byte.

Software Polling

If non-DMA mode is selected and interrupts are not suitable, the microprocessor can poll the MSR during the execution phase to determine when a byte is ready to be transferred. The RQM bit (bit 7) in the MSR reflects the state of the IRQ signal. Otherwise, the data transfer is similar to the interrupt mode described above, whether the FIFO is enabled or disabled.

5.4.3 Result Phase

During the result phase, the microprocessor reads a series of result bytes from the Data Register (FIFO). These bytes indicate the status of the command. They may indicate whether the command executed properly, or may contain some control information.

See the specific commands in "The FDC Command Set" on page 86 or "Data Register (FIFO), Offset 05h" on page 76 for details.

These result bytes are read in the order specified for that particular command. Some commands do not have a result phase. Also, the number of result bytes varies with each command. All result bytes must be read from the Data Register (FIFO) before the next command can be issued.

As it does for command bytes, the Main Status Register (MSR) controls the flow of result bytes, and must be polled by the software before reading each result byte from the Data Register (FIFO). The RQM bit (bit 7) and DIO bit (bit 6) of the MSR must both be set before each result byte can be read.

After the last result byte is read, the Command in Progress bit (bit 4) of the MSR is cleared, and the controller is ready for the next command.

For more information, see "The Result Phase Status Registers" on page 81.

5.4.4 Idle Phase

After a hardware or software reset, after the chip has recovered from power-down mode or when there are no commands in progress the controller is in the idle phase. The controller waits for a command byte to be written to the Data Register (FIFO). The RQM bit is set, and the DIO bit is cleared in the MSR.

After receiving the first command (opcode) byte, the controller enters the command phase. When the command is completed the controller again enters the idle phase. The Digital Data Separator (DDS) remains synchronized to the reference frequency while the controller is idle. While in the idle phase, the controller periodically enters the drive polling phase.

5.4.5 Drive Polling Phase

National Semiconductor's FDC supports the polling mode of old 8-inch drives, as a means of monitoring any change in status for each disk drive present in the system. This support provides backward compatibility with software that expects it.

In the idle phase, the controller enters a drive polling phase every 1 msec, based on a 500 Kbps data transfer rate. In the drive polling phase, the controller checks the status of each of the logical drives (bits 0 through 3 of the MSR). The internal ready line for each drive is toggled only after a hardware or software reset, and an interrupt is generated for drive 0.

At this point, the software must issue four SENSE INTERRUPT commands to clear the status bit for each drive, unless drive polling is disabled via the POLL bit in the CONFIGURE command. See "Bit 4 - Disable Drive Polling (POLL)" on page 88. The CONFIGURE command must be issued within 500 μ sec (worst case) of the hardware or software reset to disable drive polling.

Even if drive polling is disabled, drive stepping and delayed power-down occur in the drive polling phase. The controller checks the status of each drive and, if necessary, it issues a pulse on the STEP output signal with the DIR signal at the appropriate logic level.

The controller also uses the drive polling phase to automatically trigger power down. When the specified time that the motor may be off expires, the controller waits 512 msec, based on data transfer rates of 500 Kbps and 1 Mbps, before powering down, if this function is enabled via the MODE command.

If a new command is issued while the FDC is in the drive polling phase, the MSR does not indicate a ready status for the next parameter byte until the polling sequence completes the loop. This can cause a delay between the first and second bytes of up to 500 µsec at 250 Kbps.

5.5 THE RESULT PHASE STATUS REGISTERS

In the result phase of a command, result bytes that hold status information are read from the Data Register (FIFO) at offset 05h. These bytes are the result phase status registers.

The result phase status registers may only be read from the Data Register (FIFO) during the result phase of certain commands, unlike the Main Status Register (MSR), which is a read only register that is always valid.

5.5.1 Result Phase Status Register 0 (ST0)

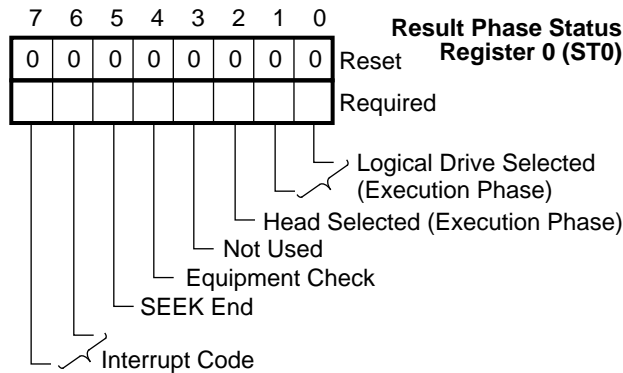


FIGURE 5-16. ST0 Result Phase Register Bitmap

Bits 1,0 - Logical Drive Selected

These two binary encoded bits indicate the logical drive selected at the end of the execution phase.

The value of these bits is reflected in bits 1,0 of the SR3 register, described on page 83.

- 00 - Drive 0 selected.
- 01 - Drive 1 selected.
- 10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.
- 11 - If four drives are supported, drive 3 is selected.

Bit 2 - Head Selected

This bit indicates which side of the Floppy Disk Drive (FDD) is selected. It reflects the status of the HDSEL signal at the end of the execution phase.

The value of this bit is reflected in bit 2 of the ST3 register, described on page 83.

- 0 - Side 0 is selected.
- 1 - Side 1 is selected.

Bit 3 - Not used.

This bit is not used and is always 0.

Bit 4 - Equipment Check

After a RECALIBRATE command, this bit indicates whether the head of the selected drive was at track 0, i.e., whether or not TRK0 was active. This information is used during the SENSE INTERRUPT command.

- 0 - Head was at track 0, i.e., a TRK0 pulse occurred after a RECALIBRATE command.
- 1 - Head was not at track 0, i.e., no TRK0 pulse occurred after a RECALIBRATE command.

Bit 5 - SEEK End

This bit indicates whether or not a SEEK, RELATIVE SEEK, or RECALIBRATE command was completed by the controller. Used during a SENSE INTERRUPT command.

- 0 - SEEK, RELATIVE SEEK, or RECALIBRATE command not completed by the controller.
- 1 - SEEK, RELATIVE SEEK, or RECALIBRATE command was completed by the controller.

Bits 7,6 - Interrupt Code (IC)

These bits indicate the reason for an interrupt.

- 00 - Normal termination of command.
- 01 - Abnormal termination of command. Execution of command was started, but was not successfully completed.
- 10 - Invalid command issued. Command issued was not recognized as a valid command.
- 11 - Internal drive ready status changed state during the drive polling mode. This only occurs after a hardware or software reset.

5.5.2 Result Phase Status Register 1 (ST1)

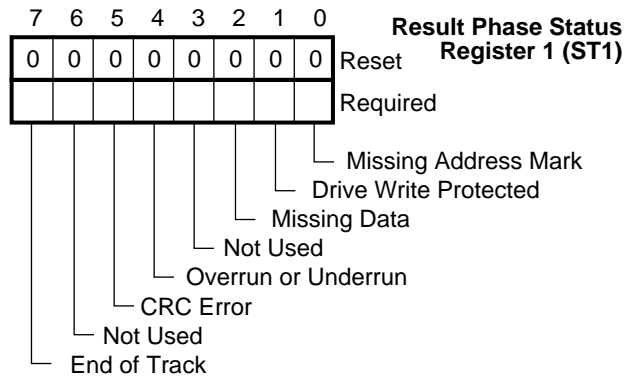


FIGURE 5-17. ST1 Result Phase Register Bitmap

Bit 0 - Missing Address Mark

This bit indicates whether or not the Floppy Disk Controller (FDC) failed to find an address mark in a data field during a read, scan, or verify command.

- 0 - No missing address mark.
- 1 - Address mark missing.

Bit 0 of the result phase Status register 2 (ST2) indicates the when and where the failure occurred. See Section 5.5.3 on page 82.

Bit 1 - Drive Write Protected

When a write or format command is issued, this bit indicates whether or not the selected drive is write protected, i.e., the WP signal is active.

- 0 - Selected drive is not write protected, i.e., \overline{WP} is not active.
- 1 - Selected drive is write protected, i.e., \overline{WP} is active.

Bit 2 - Missing Data

This bit indicates whether or not data is missing for one of the following reasons:

- Controller cannot find the sector specified in the command phase during the execution of a read, write, scan, or VERIFY command. An Address Mark (AM) was found however, so it is not a blank disk.
 - Controller cannot read any address fields without a CRC error during a READ ID command.
 - Controller cannot find starting sector during execution of READ A TRACK command.
- 0 - Data is not missing for one of these reasons.
 - 1 - Data is missing for one of these reasons.

Bit 3 - Not Used

This bit is not used and is always 0.

Bit 4 - Overrun or Underrun

This bit indicates whether or not the FDC was serviced by the microprocessor soon enough during a data transfer in the execution phase. For read operations, this bit indicates a data overrun. For write operations, it indicates a data underrun.

- 0 - FDC was serviced in time.
- 1 - FDC was not serviced fast enough. Overrun or underrun occurred.

Bit 5 - CRC Error

This bit indicates whether or not the FDC detected a Cyclic Redundancy Check (CRC) error.

- 0 - No CRC error detected.
 - 1 - CRC error detected.
- Bit 5 of the result phase Status register 2 (ST2) indicates when and where the error occurred. See Section 5.5.3.

Bit 6 - Not Used

This bit is not used and is always 0.

Bit 7 - End of Track

This bit is set to 1 when the FDC transfers the last byte of the last sector without the TC signal becoming active. The last sector is the End of Track sector number programmed in the command phase.

- 0 - The FDC did not transfer the last byte of the last sector without the TC signal becoming active.
- 1 - The FDC transferred the last byte of the last sector without the TC signal becoming active.

5.5.3 Result Phase Status Register 2 (ST2)

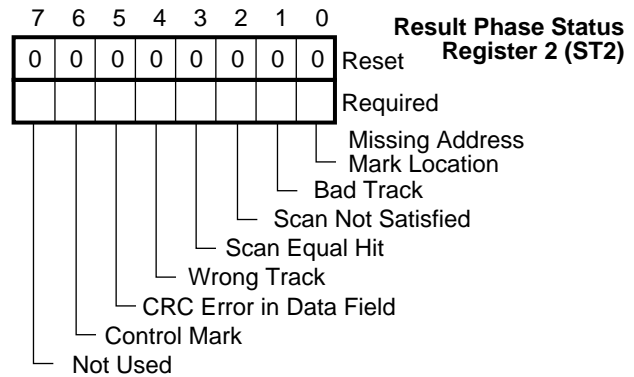


FIGURE 5-18. ST2 Result Phase Register Bitmap

Bit 0 - Missing Address Mark Location

If the FDC cannot find the address mark of a data field or of an address field during a read, scan, or verify command, i.e., bit 0 of ST1 is 1, this bit indicates when and where the failure occurred.

- 0 - The FDC failed to detect an address mark for the address field after two disk revolutions.
- 1 - The FDC failed to detect an address mark for the data field after it found the correct address field.

Bit 1 - Bad Track

This bit indicates whether or not the FDC detected a bad track

- 0 - No bad track detected.
- 1 - Bad track detected.

The desired sector is not found. If the track number recorded on any sector on the track is FFh and this number is different from the track address specified in the command phase, then there is a hard error in IBM format.

Bit 2 - Scan Not Satisfied

This bit indicates whether or not the value of the data byte from the microprocessor meets any of the conditions specified by the scan command used.

“The SCAN EQUAL, the SCAN LOW OR EQUAL and the SCAN HIGH OR EQUAL Commands” on page 101 and Table 5-21 describes the conditions.

- 0 - The data byte from the microprocessor meets at least one of the conditions specified.
- 1 - The data byte from the microprocessor does not meet any of the conditions specified.

Bit 3 - Scan Satisfied

This bit indicates whether or not the value of the data byte from the microprocessor was equal to a byte on the floppy disk during any scan command.

- 0 - No equal byte was found.
- 1 - A byte whose value is equal to the byte from the microprocessor was found on the floppy disk.

Bit 4 - Wrong Track

This bit indicates whether or not there was a problem finding the sector because of the track number.

0 - Sector found.

1 - Desired sector not found.

The desired sector is not found. The track number recorded on any sector on the track is different from the track address specified in the command phase.

Bit 5 - CRC Error in Data Field

When the FDC detected a CRC error in the correct sector (bit 5 of the result phase Status register 1 (ST1) is 1), this bit indicates whether it occurred in the address field or in the data field.

0 - The CRC error occurred in the address field.

1 - The CRC error occurred in the data field.

Bit 6 - Control Mark

When the controller tried to read a sector, this bit indicates whether or not it detected a deleted data address mark during execution of a READ DATA or scan commands, or a regular address mark during execution of a READ DELETED DATA command.

0 - No control mark detected.

1 - Control mark detected.

Bit 7 - Not Used

This bit is not used and is always 0.

5.5.4 Result Phase Status Register 3 (ST3)

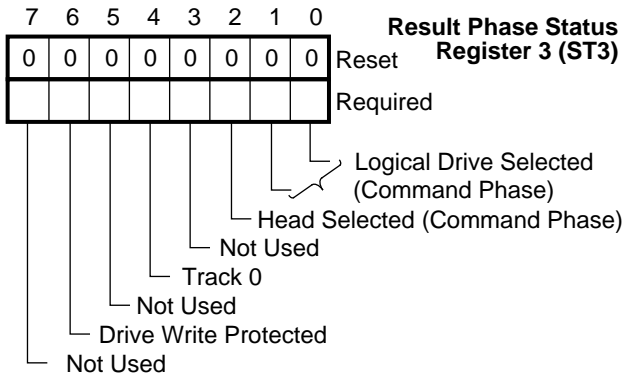


FIGURE 5-19. ST3 Result Phase Register

Bits 1,0 - Logical Drive Selected

These two binary encoded bits indicate the logical drive selected at the end of the command phase.

The value of these bits is the same as bits 1,0 of the SR0 register, described on page 81.

00 - Drive 0 selected.

01 - Drive 1 selected.

10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11 - If four drives are supported, drive 3 is selected.

Bit 2 - Head Selected

This bit indicates which side of the Floppy Disk Drive (FDD) is selected. It reflects the status of the HDSEL signal at the end of the command phase.

The value of this bit is the same as bit 2 of the SR0 register, described on page 81.

0 - Side 0 is selected.

1 - Side 1 is selected.

Bit 3 - Not Used

This bit is not used and is always 1.

Bit 4 - Track 0

This bit Indicates whether or not the head of the selected drive is at track 0.

0 - The head of the selected drive is not at track 0, i.e., $\overline{\text{TRK0}}$ is not active.

1 - The head of the selected drive is at track 0, i.e., $\overline{\text{TRK0}}$ is active.

Bit 5 - Not Used

This bit is not used and is always 1.

Bit 6 - Drive Write Protected

This bit indicates whether or not the selected drive is write protected, i.e., the $\overline{\text{WP}}$ signal is active (low).

0 - Selected drive is not write protected, i.e., $\overline{\text{WP}}$ is not active.

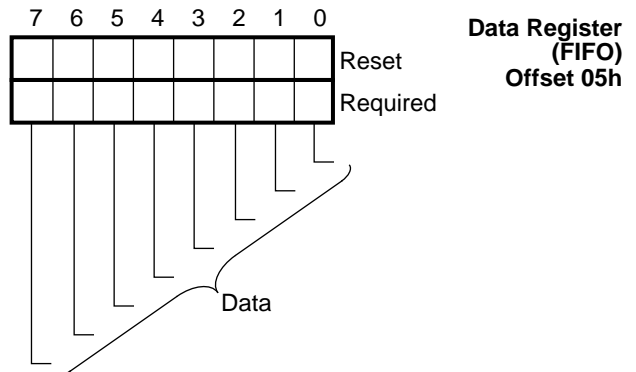
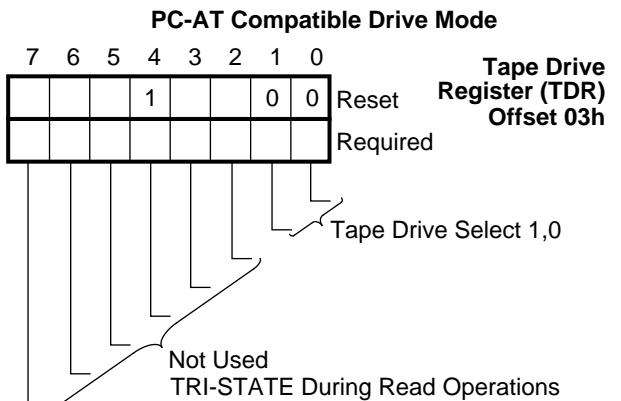
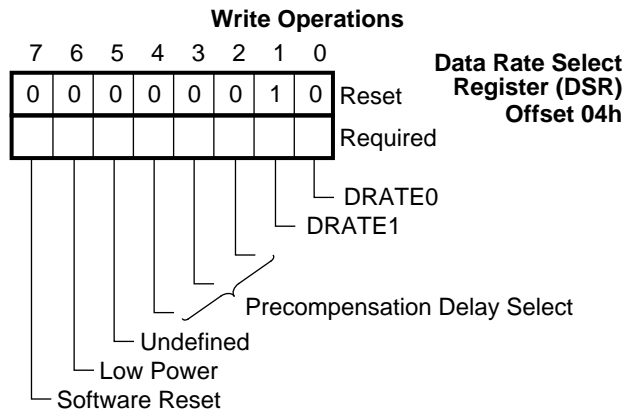
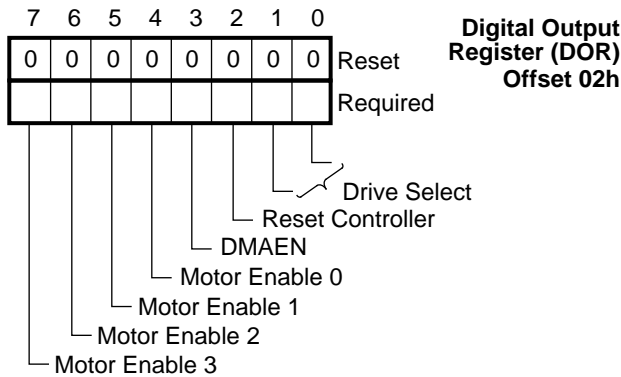
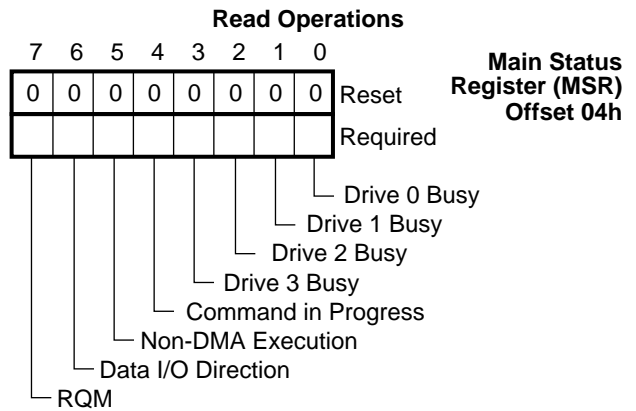
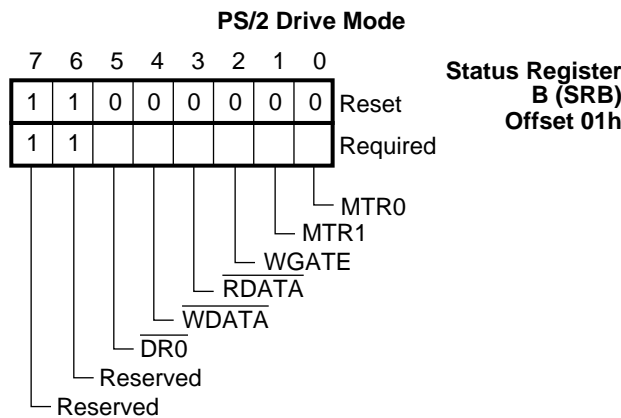
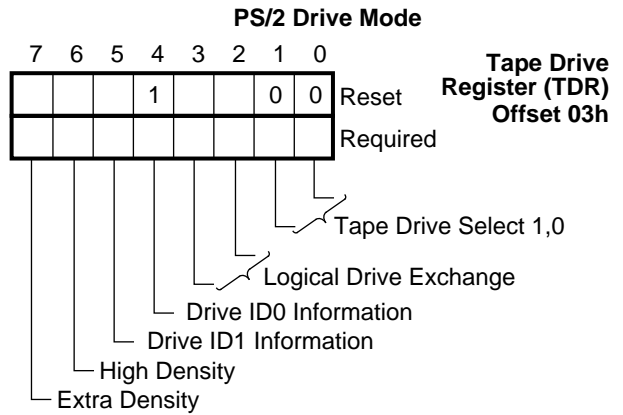
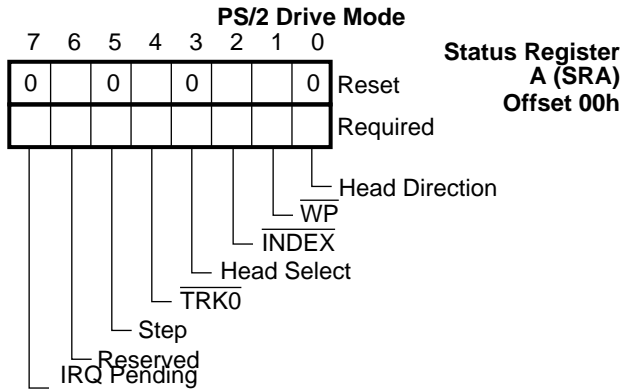
1 - Selected drive is write protected, i.e., $\overline{\text{WP}}$ is active.

Bit 7 - Not Used

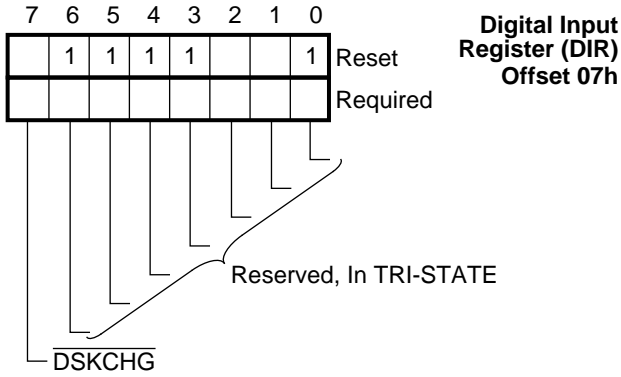
This bit is not used and is always 0.

5.6 FDC REGISTER BITMAPS

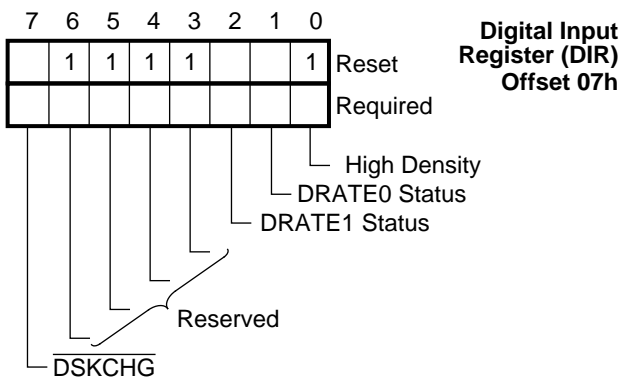
5.6.1 FDC Standard Register Bitmaps



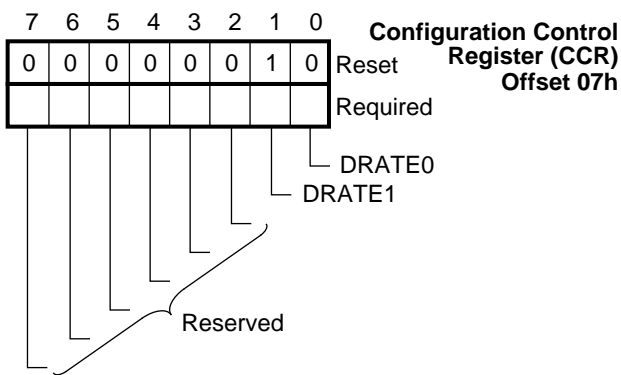
Read Operations, PC-AT Drive Mode



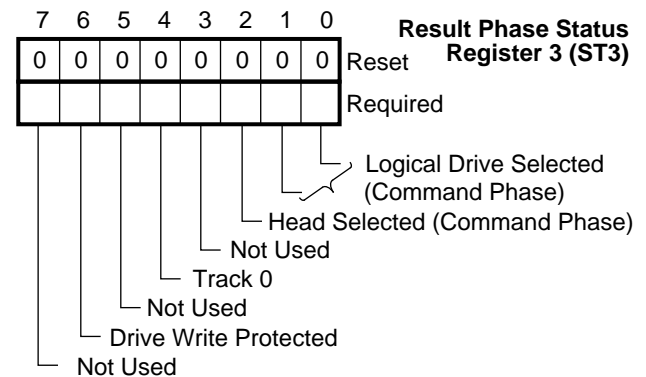
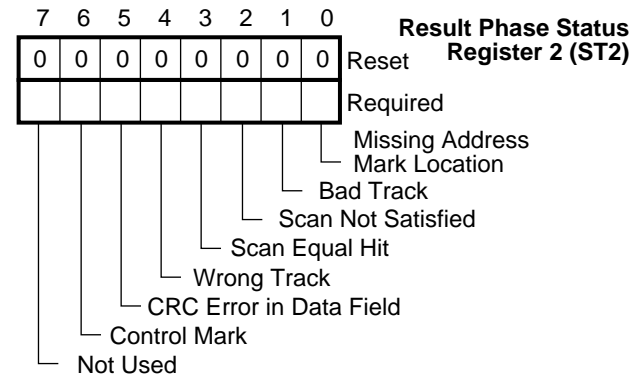
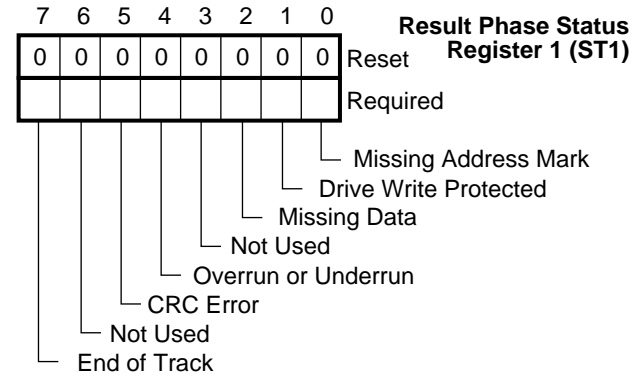
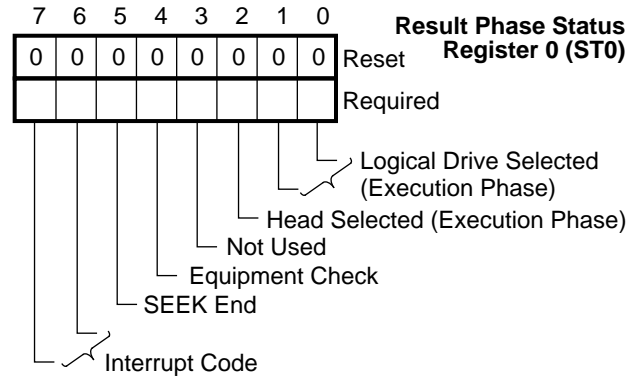
Read Operations, PS/2 Drive Mode



Write Operations



5.6.2 FDC Result Phase Status Register Bitmaps



5.7 THE FDC COMMAND SET

The first command byte for each command in the FDC command set is the opcode byte. The FDC uses this byte to determine how many command bytes to expect.

If an invalid command byte is issued to the controller, it immediately enters the result phase and the status is 80h, signifying an invalid command.

Table 5-9 shows the FDC commands in alphabetical order with the opcode, i.e., the first command byte, for each.

In this table:

- MT is a multi-track enable bit (See “Bit 7 - Multi-Track (MT)” on page 96.)
- MFM is a modified frequency modulation parameter (See “Bit 6 - Modified Frequency Modulation (MFM)” on page 90.)
- SK is a skip control bit. (See “Bit 5 - Skip Control (SK)” on page 96.)

Section 5.7.1 explains some symbols and abbreviations you will encounter in the descriptions of the commands.

All phases of each command are described in detail, starting with Section 5.7.2, with bitmaps of each byte in each phase.

Only named bits and fields are described in detail. When a bitmap shows a value (0 or 1) for a bit, that bit must have that value and is not described.

TABLE 5-9. FDC Command Set Summary

Command	Opcode							
	7	6	5	4	3	2	1	0
CONFIGURE	0	0	0	1	0	0	1	1
DUMPREG	0	0	0	0	1	1	1	0
FORMAT TRACK	0	MFM	0	0	1	1	0	1
INVALID	Invalid Opcode							
LOCK		0	0	1	0	1	0	0
MODE	0	0	0	0	0	0	0	1
NSC	0	0	0	1	1	0	0	0
PERPENDICULAR MODE	0	0	0	1	0	0	1	0
READ DATA	MT	MFM	SK	0	0	1	1	0
READ DELETED DATA	MT	MFM	SK	0	1	1	0	0
READ ID	0	MFM	0	0	1	0	1	0
READ TRACK	0	MFM	0	0	0	0	1	0
RECALIBRATE	0	0	0	0	0	1	1	1
RELATIVE SEEK	1	DIR	0	0	1	1	1	1
SCAN EQUAL	MT	MFM	SK	1	0	0	0	1
SCAN HIGH OR EQUAL	MT	MFM	SK	1	1	1	0	1
SCAN LOW OR EQUAL	MT	MFM	SK	1	1	0	0	1
SEEK	0	0	0	0	1	1	1	1
SENSE DRIVE STATUS	0	0	0	0	0	1	0	0
SENSE INTERRUPT	0	0	0	0	1	0	0	0
SET TRACK	0		1	0	0	0	0	1
SPECIFY	0	0	0	0	0	0	1	1
VERIFY	MT	MFM	SK	1	0	1	1	0
VERSION	0	0	0	1	0	0	0	0
WRITE DATA	MT	MFM	0	0	0	1	0	1
WRITE DELETED DATA	MT	MFM	0	0	1	0	0	1

5.7.1 Abbreviations Used in FDC Commands

BFR Buffer enable bit set in the MODE command. Enables open-collector output buffers.

BST Burst mode disable control bit set in MODE command. Disables burst mode for the FIFO, if the FIFO is enabled.

DC3-0 Drive Configuration for drives 3-0. Used to configure a logical drive to conventional or perpendicular mode in the PERPENDICULAR MODE command.

DENSEL
Density Select control bits set in the MODE command.

DIR Direction control bit used in RELATIVE SEEK command to indicate step in or out.

DMA DMA mode enable bit set in the SPECIFY command.

DS1-0 Drive Select for bits 1,0 used in most commands. Selects the logical drive.

EC Enable Count control bit set in the VERIFY command. When this bit is 1, SC (Sectors to read Count) command byte is required.

EIS Enable Implied Seeks. Set in the CONFIGURE command.

EOT End of Track parameter set in read, write, scan, and VERIFY commands.

ETR Extended Track Range set in the MODE command.

FIFO First-In First-Out buffer. Also a control bit set in the CONFIGURE command to enable or disable the FIFO.

FRD FIFO Read Disable control bit set in the MODE command

FWR FIFO Write disable control bit set in the MODE command.

Gap 2 The length of gap 2 in the FORMAT TRACK command and the portion of it that is rewritten in the WRITE DATA command depend on the drive mode, i.e., perpendicular or conventional. Figure 5-20 on page 91 illustrates gap 2 graphically. For more details, see "Bits 1,0 - Group Drive Mode Configuration (GDC)" on page 95.

Gap 3 Gap 3 is the space between sectors, excluding the synchronization field. It is defined in the FORMAT TRACK command. See Figure 5-20 on page 91.

GDC Group Drive Configuration for all drives. Configures all logical drives as conventional or perpendicular. Used in the PERPENDICULAR MODE command. Formerly, GAP2 and WG.

HD Head Select control bit used in most commands. Selects Head 0 or 1 of the disk.

IAF Index Address Field control bit set in the MODE command. Enables the ISO Format during the FORMAT command.

IPS Implied Seek enable bit set in the MODE, read, write, and scan commands.

LOCK Lock enable bit in the LOCK command. Used to prevent certain parameters from being affected by a software reset.

LOW PWR

Low Power control bits set in the MODE command.

MFM Modified Frequency Modulation parameter used in FORMAT TRACK, read, VERIFY and write commands.

MFT Motor Off Time. Now called Delay After Processing time. This delay is set by the SPECIFY command.

MNT Motor On Time. Now called Delay Before Processing time. This delay is set by the SPECIFY command.

MSB Most Significant Byte controls which whether the most or least significant byte is read or written in the SET TRACK command.

MT Multi-Track enable bit used in read, write, scan and VERIFY commands.

OW Overwrite control bit set in the PERPENDICULAR MODE command.

POLL Enable Drive Polling bit set in the CONFIGURE command.

PRETRK

Precompensation Track Number set in the CONFIGURE command

PTR Present Track number. Contains the internal 8-bit track number or the least significant byte of the 12-bit track number of one of the four logical disk drives. PTR is set in the SET TRACK command.

R255 Recalibration control bit set in MODE command. Sets maximum number of STEP pulses during RECALIBRATE command to 255.

RTN Relative Track Number used in the RELATIVE SEEK command.

SC Sector Count control bit used in the VERIFY command.

SK Skip control bit set in read and scan and VERIFY operations.

SRT Step Rate Time set in the SPECIFY command. Determines the time between STEP pulses for SEEK and RECALIBRATE operations.

ST0-3

Result phase Status registers 3-0 that contain status information about the execution of a command. See Sections 5.5.1 through 5.5.4.

THRESH

FIFO threshold parameter set in the CONFIGURE command

TMR Timer control bit set in the MODE command. Affects the timers set in the SPECIFY command.

WG Formerly, the Write Gate control bit. Now included in the Group Drive mode Configuration (GDC) bits in the PERPENDICULAR MODE command.

WLD Wildcard bit in the MODE command used to enable or disable the wildcard byte (FFh) during scan commands.

WNR Write Number controls whether to read an existing track number or to write a new one in the SET TRACK command.

5.7.2 The CONFIGURE Command

The CONFIGURE command controls some operation modes of the controller. It should be issued during the initialization of the FDC after power up.

The bits in the CONFIGURE registers are set to their default values after a hardware reset.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	1
0	0	0	0	0	0	0	0
0	EIS	FIFO	POLL	Threshold (THRESH)			
Precompensation Track Number (PRETRK)							

Third Command Phase Byte

Bits 3-0 - The FIFO Threshold (THRESH)

These bits specify the threshold of the FIFO during the execution phase of read and write data transfers.

This value is programmable from 00h to 0Fh. A software reset sets this value to 00 if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If the LOCK bit is 1, THRESH retains its value.

Use a high value of THRESH for systems that respond slowly and a low value for fast systems.

Bit 4 - Disable Drive Polling (POLL)

This bit enables and disabled drive polling. A software reset clears this bit to 0.

When drive polling is enabled, an interrupt is generated after a reset.

When drive polling is disabled, if the CONFIGURE command is issued within 500 msec of a hardware or software reset, then an interrupt is not generated. In addition, the four SENSE INTERRUPT commands to clear the Ready Changed State of the four logical drives is not required.

0 - Enable drive polling. (Default)

1 - Disable drive polling.

Bit 5 - Enable FIFO (FIFO)

This bit enables and disables the FIFO for execution phase data transfers.

If the LOCK bit (bit 7 of the opcode of the LOCK command) is 0, a software reset disables the FIFO, i.e., sets this bit to 1.

If the LOCK bit is 1, this bit retains its previous value after a software reset.

0 - FIFO enabled for read and write operations.

1 - FIFO disabled. (Default)

Bit 6 - Enable Implied Seeks (EIS)

This bit enables or disables implied seek operations. A software reset disables implied seeks, i.e., clears this bit to 0.

Bit 5 of the MODE command (Implied Seek (IPS)) can override the setting of this bit and enable implied seeks even if they are disabled by this bit.

When implied seeks are enabled, a seek or sense interrupt operation is performed before execution of the read, write, scan, or verify operation.

0 - Implied seeks disabled. The MODE command can still enable implied seek operations. (Default)

1 - Implied seeks enabled for read, write, scan and VERIFY operations, regardless of the value of the IPS bit in the MODE command.

Fourth Command Phase Byte, Bits 7-0, Precompensation Track Number (PRETRK)

This byte identifies the starting track number for write precompensation. The value of this byte is programmable from track 0 (00h) to track 255 (FFh).

If the LOCK bit (bit 7 of the opcode of the LOCK command) is 0, after a software reset this byte indicates track 0 (00h).

If the LOCK bit is 1, PRETRK retains its previous value after a software reset.

Execution Phase

Internal registers are written.

Result Phase

None.

5.7.3 The DUMPREG Command

The DUMPREG command supports system run-time diagnostics, and application software development and debugging.

DUMPREG has a one-byte command phase (the opcode) and a 10-byte result phase, which returns the values of parameters set in other commands. See the commands that set each parameter for a detailed description of the parameter.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0

Execution Phase

Internal registers read.

Result Phase

After a hardware or software reset, parameters in this phase are reset to their default values. Some of these parameters are unaffected by a software reset, depending on the state of the LOCK bit.

See the command that determines the setting for the bit or field for details.

7	6	5	4	3	2	1	0
Byte of Present Track Number (PTR) Drive 0							
Byte of Present Track Number (PTR) Drive 1							
Byte of Present Track Number (PTR) Drive 2							
Byte of Present Track Number (PTR) Drive 3							
Step Rate Time (SRT)				Delay After Processing			
Delay Before Processing						DMA	
Sectors per Track or End of Track (EOT) Sector #							
LOCK	0	DC3	DC2	DC1	DC0	GDC	
0	EIS	FIFO	POLL	THRESH			
Precompensation Track Number (PRETRK)							

First through Fourth Result Phase Bytes, Bits 7-0, Present Track Number (PTR) Drives 3-0

Each of these bytes contains either the internal 8-bit track number or the least significant byte of the 12-bit track number of the corresponding logical disk drive.

Fifth and Sixth Result Phase Bytes, Bits 7-0, Step Rate Time, Motor Off Time, Motor On Time and DMA

These fields are all set by the SPECIFY command. See Section 5.7.21 on page 105.

Seventh Result Phase Byte - Sectors Per Track or End of Track (EOT)

This byte varies depending on what commands have been previously executed.

If the last command issued was a FORMAT TRACK command, and no read or write commands have been issued since then, this byte contains the sectors per track value.

If a read or a write command was executed more recently than a FORMAT TRACK command, this byte specifies the number of the sector at the End of the Track (EOT).

Eighth Result Phase Byte

Bits 5-0 - DC3-0, GDC

Bits 5-0 of the second command phase byte of the PERPENDICULAR MODE command set bits 5-0 of this byte. See page 95.

Bit 7 - LOCK

This bit controls how the other bits in this command respond to a software reset. See page 92.

The value of this is determined by bit 7 of the opcode of the LOCK command.

0 - Bits in this command are set to their default values after a software reset. (Default)

1 - Bits in this command are unaffected by a software reset.

Ninth and Tenth Result Phase Bytes

These bytes reflect the values in the third and fourth command phase bytes of the CONFIGURE command. See page 88.

5.7.4 The FORMAT TRACK Command

This command formats one track on the disk in IBM, ISO, or Toshiba perpendicular format.

After a pulse from the INDEX signal is detected, data patterns are written on the disk including all gaps, Address Marks (AMs), address fields and data fields. See Figure 5-20.

The format of the track is determined by the following parameters:

- The MFM bit in the opcode (first command) byte, which indicates the type of the disk drive and the data transfer rate and determines the format of the address marks and the encoding scheme.
- The Index Address Format (IAF) bit (bit 6 in the second command phase byte) in the MODE command, which selects IBM or ISO format.
- The Group Drive Configuration (GDC) bits in the PERPENDICULAR MODE command, which select either conventional or Toshiba perpendicular format.
- A bytes-per-sector code, which determines the sector size. See Table 5-11 on page 90.
- A sectors per track parameter, which specifies how many sectors are formatted on the track.
- The data pattern byte, which is used to fill the data field of each sector.

Table 5-10 shows typical values for these parameters for specific PC compatible diskettes.

To allow flexible formatting, the microprocessor must supply the four address field bytes (track number, head number, sector number, bytes-per-sector code) for each sector formatted during the execution phase. This allows non-sequential sector interleaving.

This transfer of bytes from the microprocessor to the controller can be done in DMA or non-DMA mode (See Section 5.4.2 on page 78), with the FIFO enabled or disabled.

The FORMAT TRACK command terminates when a pulse from the INDEX signal is detected a second time, at which point an interrupt is generated.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	1	1	0	1
X	X	X	X	X	HD	DS1	DS0
Bytes-Per-Sector Code							
Sectors per Track							
Bytes in Gap 3							
Data Pattern							

TABLE 5-10. Typical Values for PC Compatible Diskette Media

Media Type	Bytes in Data Field (decimal)	Bytes-Per-Sector Code (hex)	End of Track (EOT) Sector # (hex)	Bytes in Gap 2 ^a (hex)	Bytes in Gap 3 ^b (hex)
360 KB	512	02	09	2A	50
1.2 MB	512	02	0F	1B	54
720 KB	512	02	09	1B	50
1.44 MB	512	02	12	1B	6C
2.88 MB ^c	512	02	24	1B	53

- a. Gap 2 is specified in the command phase of read, write, scan, and verify commands. Although this is the recommended value, the FDC ignores this byte in read, write, scan and verify commands.
- b. Gap 3 is the suggested value for the programmable GAP3 that is used in the FORMAT TRACK command and is illustrated in Figure 5-20.
- c. The 2.88 MB diskette media is a barium ferrite media intended for use in perpendicular recording drives at the data rate of up to 1 Mbps.

First Command Phase Byte, Opcode

Bit 6 - Modified Frequency Modulation (MFM)

This bit indicates the type of the disk drive and the data transfer rate, and determines the format of the address marks and the encoding scheme.

- 0 - FM mode, i.e., single density.
- 1 - MFM mode, i.e., double density.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

These bits indicate which logical drive is active. They reflect the values of bits 1,0 of the Digital Output Register (DOR) described on page 72 and of result phase status registers 0 and 3 (ST0 and ST3) described on pages 81 and 83, respectively.

- 00 - Drive 0 is selected. (Default)
- 01 - Drive 1 is selected.
- 10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.
- 11 - If four drives are supported, drive 3 is selected.

Bit 2 - Head Select (HD)

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the HDSEL disk interface output signal.

This bit reflects the value of bit 3 of Status Register A (SRA) described on page 70 and bit 2 of result phase status registers 0 and 3 (ST0 and ST3) described on pages 81 and 83, respectively.

- 0 - $\overline{\text{HDSEL}}$ is not active, i.e., the head of the FDD selects side 0. (Default)
- 1 - $\overline{\text{HDSEL}}$ is active, i.e., the head of the FDD selects side 1.

Third Command Phase Byte -Bytes-Per-Sector Code

This byte contains a code in hexadecimal format that indicates the number of bytes in a data field.

Table 5-11 shows the number of bytes in a data field for each code.

TABLE 5-11. Bytes per Sector Codes

Bytes-Per-Sector Code (hex)	Bytes in Data Field
00	128
01	256
02	512
03	1024
04	2048
05	4096
06	8192
07	16384

Fourth Command Phase Byte - Sectors Per Track

The value in this byte specifies how many sectors there are in the track.

Fifth Command Phase Byte - Bytes in Gap 3

The number of bytes in gap 3 is programmable. The number to program for Gap 3 depends on the data transfer rate and the type of the disk drive. Table 5-12 shows some typical values to use for Gap 3.

Figure 5-20 illustrates the track format for each of the formats recognized by the FORMAT TRACK command.

Sixth Command Phase Byte - Data Pattern

This byte contains the contents of the data field.

Execution Phase

The system transfers four ID bytes (track number, head number, sector number and bytes-per-sector code) per sector to the Floppy Disk Controller (FDC) in either a DMA or a non-DMA mode. Section 5.4.2 on page 78 describes these modes.

The entire track is formatted. The data block in the data field of each sector is filled with the data pattern byte.

Only the first three status bytes in this phase are significant.

TABLE 5-12. Typical Gap 3 Values

Drive Type and Data Transfer Rate	Bytes in Data Field (decimal)	Bytes-Per-Sector Code (hex)	End of Track (EOT) Sector # (hex)	Bytes in Gap 2 ^a (hex)	Bytes in Gap 3 ^b (hex)
250 Kbps MFM	256	01	12	0A	0C
	256	01	10	20	32
	512	02	08	2A	50
	512	02	09	2A	50
	1024	03	04	80	F0
	2048	04	02	C8	FF
	4096	05	01	C8	FF
500 Kbps MFM	256	01	1A	0E	36
	512	02	0F	1B	54
	512	02	12	1B	6C
	1024	03	08	35	74
	2048	04	04	99	FF
	4096	05	02	C8	FF
	8192	06	01	C8	FF

- a. Gap 2 is specified in the command phase of read, write, scan, and verify commands. Although this is the recommended value, the FDC ignores this byte in read, write, scan and verify commands.
- b. Gap 3 is the suggested value for use in the FORMAT TRACK command. This is the programmable Gap 3 illustrated in Figure 5-20.

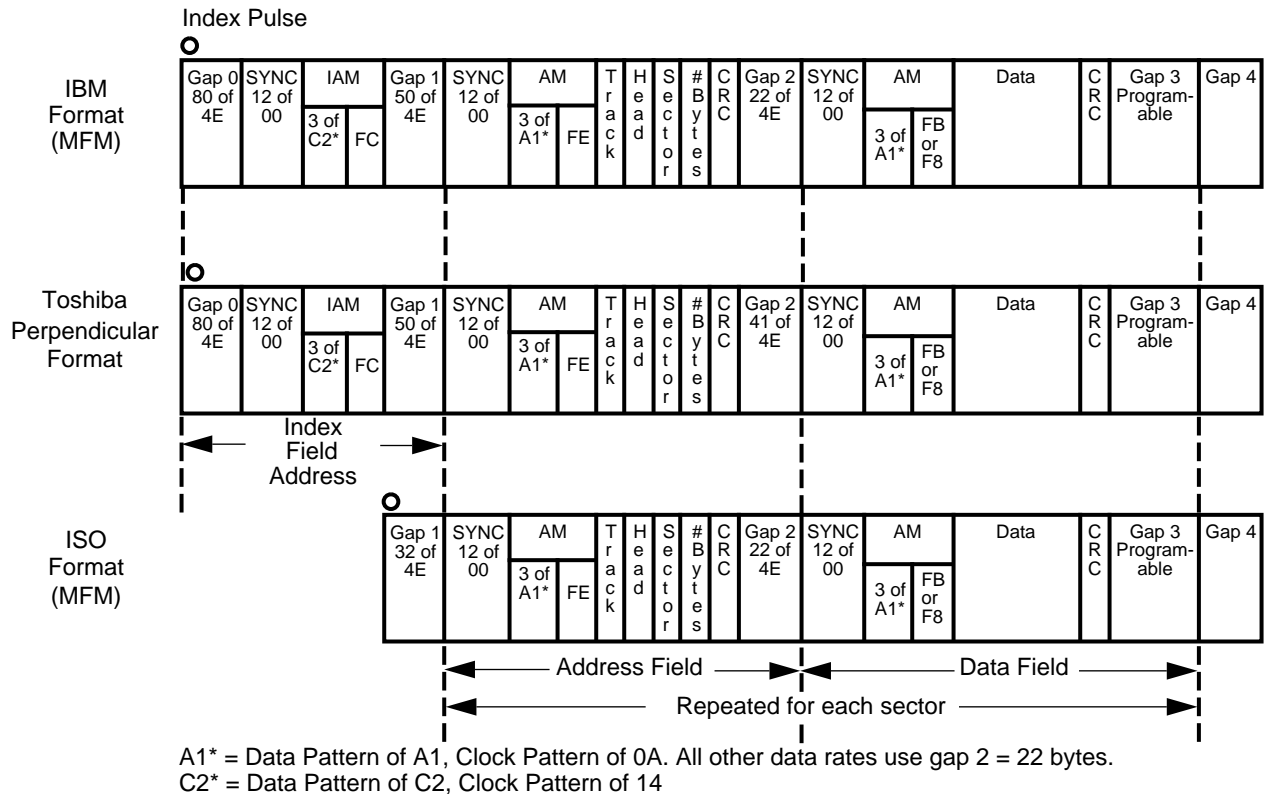


FIGURE 5-20. IBM, Perpendicular, and ISO Formats Supported by the FORMAT TRACK Command

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Undefined							
Undefined							
Undefined							
Undefined							

5.7.5 The INVALID Command

If an invalid command (illegal opcode byte in the command phase) is received by the Floppy Disk Controller (FDC), the controller responds with the result phase Status register 0 (ST0) in the result phase. See "Result Phase Status Register 0 (ST0)" on page 81

The controller does not generate an interrupt during this condition. Bits 7 and 6 in the MSR (see Section 5.3.6 page 75) are both set to 1, indicating to the microprocessor that the controller is in the result phase and the contents of ST0 must be read.

Command Phase

7	6	5	4	3	2	1	0
Invalid Opcodes							

Execution Phase

None.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0) (80h)							

The system reads the value 80h from ST0 indicating that an invalid command was received.

5.7.6 The LOCK Command

The LOCK command can be used to keep the FIFO enabled and to retain the values of some parameters after a software reset.

After the command byte of the LOCK command is written, its result byte must be read before the opcode of the next command can be read. The LOCK command is not executed until its result byte is read by the microprocessor.

If the part is reset after the command byte of the LOCK command is written but before its result byte is read, then the LOCK command is not executed. This prevents accidental execution of the LOCK command.

Command Phase

7	6	5	4	3	2	1	0
LOCK	0	0	1	0	1	0	0

Bit 7 - Control Reset Effect (LOCK)

This bit determines how the FIFO, THRESH, and PRETRK bits in the CONFIGURE command and, the FWR, FRD, and BST bits in the MODE command are affected by a software reset.

0 - Set default values after a software reset. (Default)

1 - Values are unaffected by a software reset.

Execution Phase

Internal register is written.

Result Phase

7	6	5	4	3	2	1	0
0	0	0	LOCK	0	0	0	0

Bit 4 - Control Reset Effect (LOCK)

Same as bit 7 of opcode in command phase.

5.7.7 The MODE Command

This command selects the special features of the controller. The bits in the command bytes of the MODE command are set to their default values after a hardware reset.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1
TMR	IAF	IPS	0	LOW PWR		0	ETR
FWR	FRD	BST	R255	0	0	0	0
DENSEL		BFR	WLD	Head Settle Factor			
0	0	0	0	0	0	0	0

Second Command Phase Byte

Bit 0 - Extended Track Range (ETR)

This bit determines how the track number is stored. It is cleared to 0 after a software reset.

0 - Track number is stored as a standard 8-bit value compatible with the IBM, ISO, and Toshiba Perpendicular formats.

This allows access of up to 256 tracks during a seek operation. (Default)

1 - Track number is stored as a 12-bit value.

The upper four bits of the track value are stored in the upper four bits of the head number in the sector address field.

This allows access of up to 4096 tracks during a seek operation. With this bit set, an extra byte is required in the SEEK command phase and SENSE INTERRUPT result phase.

Bits 3,2 - Low-Power Mode (LOW PWR)

These bits determine whether or not the FDC powers down and, if it does, they specify how long it will take.

These bits disable power down, i.e., are cleared to 0, after a software reset.

00 - Disables power down. (Default)

01 - Automatic power down.

At a 500 Kbps data transfer rate, the FDC goes into low-power mode 512 msec after it becomes idle.

At a 250 Kbps data transfer rate, the FDC goes into low-power mode 1 second after it becomes idle.

10 - Manual power down.

The FDC powers down mode immediately.

11 - Not used.

Bit 5 - Implied Seek (IPS)

This bit determines whether the Implied Seek (IPS) bit in a command phase byte of a read, write, scan, or verify command is ignored or READ.

A software reset clears this bit to its default value of 0.

0 - The IPS bit in the command byte of a read, write, scan, or verify is ignored. (Default)

Implied seeks can still be enabled by the Enable Implied Seeks (EIS) bit (bit 6 of the third command phase byte) in the CONFIGURE command.

1 - The IPS bit in the command byte of a read, write, scan, or verify is read.

If it is set to 1, the controller performs seek and sense interrupt operations before executing the command.

Bit 6 - Index Address Format (IAF)

This bit determines whether the controller formats tracks with or without an index address field.

A software reset clears this bit to its default value of 0.

0 - The controller formats tracks with an index address field. (IBM and Toshiba Perpendicular format).

1 - The controller formats tracks without an index address field. (ISO format).

Bit 7 - Motor Timer Values (TMR)

This bit determines which group of values to use to calculate the Delay Before Processing and Delay After Processing times. The value of each is programmed using the SPECIFY command, which is described on page 105 and in Tables 5-24 and 5-25.

A software reset clears this bit to its default value of 0.

0 - Use the TMR = 0 group of values. (Default)

1 - Use the TMR = 1 group of values.

Third Command Phase Byte

Bit 4 - RECALIBRATE Step Pulses (R255)

This bit determines the maximum number of RECALIBRATE step pulses the controller issues before terminating with an error, depending on the value of the Extended Track Range (ETR) bit, i.e., bit 0 of the second command phase byte in the MODE command.

A software reset clears this bit to its default value of 0.

0 - If ETR (bit 0) = 0, the controller issues a maximum of 85 recalibration step pulses.

If ETR (bit 0) = 1, the controller issues a maximum of 3925 recalibration step pulses. (Default)

1 - If ETR (bit 0) = 0, the controller issues a maximum of 255 recalibration step pulses.

If ETR (bit 0) = 1, the controller issues a maximum of 4095 recalibration step pulses.

Bit 5 - Burst Mode Disable (BST)

This bit enables or disables burst mode, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables burst mode, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, BST retains its value after a software reset.

0 - Burst mode enabled for FIFO execution phase data transfers. (Default)

1 - Burst mode disabled.

The FDC issues one DRQ or IRQ6 pulse for each byte to be transferred while the FIFO is enabled.

Bit 6 - FIFO Read Disable (FRD)

This bit enables or disables the FIFO for microprocessor read transfers from the controller, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables the FIFO for reads, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, FRD retains its value after a software reset.

0 - Enable FIFO. Execution phase of microprocessor read transfers use the internal FIFO. (Default)

1 - Disable FIFO. All read data transfers take place without the FIFO.

Bit 7 - FIFO Write Enable or Disable (FWR)

This bit enables or disables write transfers to the controller, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables the FIFO for writes, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, FWR retains its value after a software reset.

0 - Enable FIFO. Execution phase microprocessor write transfers use the internal FIFO. (Default)

1 - Disable FIFO. All write data transfers take place without the FIFO.

Fourth Command Phase Byte

Bits 3-0 - Head Settle Factor

This field is used to specify the maximum time allowed for the read/write head to settle after a seek during an implied seek operation.

The value specified by these bits (the head settle factor) is multiplied by the multiplier for selected data rate to specify a head settle time that is within the range for that data rate.

Use the following formula to determine the head settle factor that these bits should specify:

$$\text{Head Settle Factor} \times \text{Multiplier} = \text{Head Settle Time}$$

Table 5-13 shows the multipliers and head settle time ranges for each data transfer rate. The default head settle factor, i.e., value for these bits, is 8.

TABLE 5-13. Multipliers and Head Settle Time Ranges for Different Data Transfer Rates

Data Transfer Rate (Kbps)	Multiplier	Head Settle Time Range (msec)
250	8	0 - 120
300	6.666	0 - 100
500	4	0 - 60
1000	2	0 - 30

Bit 4 - Scan Wild Card (WLD)

This bit determines whether or not a value of FFh from either the microprocessor or the disk is recognized during a scan command as a wildcard character.

- 0 - A value of FFh from either the microprocessor or the disk during a scan command is interpreted as a wildcard character that always matches. (Default)
- 1 - The scan commands do not recognize a value of FFh as a wildcard character.

Bit 5 - CMOS Disk Interface Buffer Enable (BFR)

This bit configures drive output signals.

- 0 - Drive output signals are configured as standard 4 mA push-pull output signals (40 mA sink, 4 mA source). (Default)
- 1 - Drive output signals are configured as 40 mA open-drain output signals.

Bits 7,6 - Density Select Pin Configuration (DENSEL)

This field can configure the polarity of the Density Select output signal (DENSEL) as always low or always high, as shown in Table 4-3. This allows the user more flexibility with new drive types.

This field overrides the DENSEL polarity defined by the DENSEL polarity bit of the SuperI/O FDC configuration register at index F0h and described on page 36.

- 00 - The DENSEL signal is always low.
- 01 - The DENSEL signal is always high.
- 10 - The DENSEL signal is undefined.
- 11 - The polarity of the DENSEL signal is defined by the DENSEL Polarity bit (bit 5) of the SuperI/O FDC configuration register. See page 37. (Default)

TABLE 5-14. DENSEL Encoding

Bit 7	Bit 6	DENSEL Pin Definition
0	0	DENSEL low
0	1	DENSEL high
1	0	undefined
1	1	Set by bit 5 of the SuperI/O FDC configuration register at offset F0h.

Execution Phase

Internal registers are written.

Result Phase

None.

5.7.8 The NSC Command

The NSC command can be used to distinguish between the FDC versions and the 82077.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	0

Execution Phase

Result Phase

The result phase byte of the NSC command identifies the module as the floppy disk controller (FDC) of NSC by returning a value of 73h.

The 82077 and DP8473 return the value 80h, signifying an invalid command.

Bits 3-0 of this result byte are subject to change by NSC, and specify the version of the Floppy Disk Controller (FDC).

7	6	5	4	3	2	1	0
0	1	1	1	0	0	1	1

5.7.9 The PERPENDICULAR MODE Command

The PERPENDICULAR MODE command configures each of the four logical disk drives for perpendicular or conventional mode via the logical drive configuration bits 1,0 or 5-2, depending on the value of bit 7. The default mode is conventional. Therefore, if the drives in the system are conventional, it is not necessary to issue a PERPENDICULAR MODE command.

This command supports the unique FORMAT TRACK and WRITE DATA requirements of perpendicular (vertical) recording disk drives with a 4 MB unformatted capacity.

Perpendicular recording drives operate in extra high density mode at 1 or 2 Mbps, and are downward compatible with 1.44 MB and 720 KB drives at 500 kbps (high density) and 250 kbps (double density), respectively.

If the system includes perpendicular drives, this command should be issued during initialization of the FDC. Then, when a drive is accessed for a FORMAT TRACK or WRITE DATA command, the FDC adjusts the command parameters based on the data rate. See Table 5-15.

Precompensation is set to zero for perpendicular drives at any data rate.

Perpendicular recording type disk drives have a pre-erase head that leads the read or write head by 200 μm, which translates to 38 bytes at a 1 Mbps data transfer rate (19 bytes at 500 Kbps).

The increased space between the two heads requires a larger gap 2 between the address field and data field of a sector at 1 or 2 Mbps. See Perpendicular Format in Figure 5-20. A gap 2 length of 41 bytes (at 1 or 2 Mbps) ensures that the preamble in the data field is completely pre-erased by the pre-erase head.

Also, during WRITE DATA operations to a perpendicular drive, a portion of gap 2 must be rewritten by the controller to guarantee that the data field preamble has been pre-erased. See Table 5-15.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0
OW	0	DC3	DC2	DC1	DC0	GDC	

Second Command Phase Byte

A hardware reset clears all the bits to zero (conventional mode for all drives). PERPENDICULAR MODE command bits may be written at any time.

The settings of bits 1 and 0 in this byte override the logical drive configuration set by bits 5 through 2. If bits 1 and 0 are both 0, bits 5 through 2 configure the logical disk drives as conventional or perpendicular. Otherwise, bits 2 and 0 configure them. See Table 5-16.

Bits 1,0 - Group Drive Mode Configuration (GDC)

These bits configure all the logical disk drives as conventional or perpendicular. If the Overwrite bit (OW, bit 7) is 0, this setting may be overridden by bits 5-2.

It is not necessary to issue the FORMAT TRACK command if all drives are conventional.

These bits are cleared to 0 by a software reset.

- 00 - Conventional. (Default)
- 01 - Perpendicular. (500 Kbps)
- 10 - Conventional.
- 11 - Perpendicular. (1 or 2 Mbps)

Bits 5-2 -Drive 3-0 Mode Configuration (DC3-0)

If bits 1,0 are both 0, and bit 7 is 1, these bits configure logical drives 3-0 as conventional or perpendicular. Bits 5-2 (DC3-0) correspond to logical drives 3-0, respectively.

These bits are not affected by a software reset.

0 - Conventional drive. (Default)

It is not necessary to issue the FORMAT TRACK command for conventional drives.

1 - Perpendicular drive.

Bit 7 - Overwrite (OW)

This bit enables or disables changes in the mode of the logical drives by bits 5-2.

0 - Changes in mode of logical drives via bits 5-2 are ignored. (Default)

1 - Changes enabled.

Execution Phase

Internal registers are written.

Result Phase

None.

TABLE 5-15. Effect of Drive Mode and Data Rate on FORMAT TRACK and WRITE DATA Commands

Data Rates	Drive Mode	Length of Gap 2 in FORMAT TRACK Command	Portion of Gap 2 Rewritten in WRITE DATA Command
250, 300 or 500 Kbps	Conventional	22 bytes	0 bytes
	Perpendicular	22 bytes	19 bytes
1 or 2 Mbps	Conventional	22 bytes	0 bytes
	Perpendicular	41 bytes	38 bytes

TABLE 5-16. Effect of GDC Bits on FORMAT TRACK and WRITE DATA Commands

GDC Bits		Drive Mode	Length of Gap 2 in FORMAT TRACK Command	Portion of Gap 2 Rewritten in WRITE DATA Command
1	0			
0	0	Conventional	22 bytes	0 bytes
0	1	Perpendicular (≤500 Kbps)	22 bytes	19 bytes
1	0	Conventional	22 bytes	0 bytes
1	1	Perpendicular (1 or 2 Mbps)	41 bytes	38 bytes

5.7.10 The READ DATA Command

The READ DATA command reads logical sectors that contain a normal data address mark from the selected drive and makes the data available to the host microprocessor.

Command Phase

The READ DATA command phase bytes must specify the following ID information for the desired sector:

- Track number
- Head number
- Sector number
- Bytes-per-sector code (See Table 5-11.)
- End of Track (EOT) sector number. This allows the controller to read multiple sectors.
- The value of the data length byte is ignored and must be set to FFh.

After the last command phase byte is written, the controller waits the Delay Before Processing time (see Table 5-25 on page 106) for the selected drive. During this time, the drive motor must be turned on by enabling the appropriate drive and motor select disk interface output signals via the bits of the Digital Output Register (DOR). See "Digital Output Register (DOR), Offset 02h" on page 71.

	7	6	5	4	3	2	1	0
MT						1	1	0
IPS	X	X	X	X	HD	DS1	DS0	
Track Number								
Head Number								
Sector Number								
Bytes-Per-Sector Code								
End of Track (EOT) Sector Number								
Bytes Between Sectors - Gap 3								
Data Length (Obsolete)								

First Command Phase Byte

Bit 5 - Skip Control (SK)

This controls whether or not sectors containing a deleted address mark will be skipped during execution of the READ DATA command. See Table 5-17.

- 0 - Do not skip sector with deleted address mark.
- 1 - Skip sector with deleted address mark.

Bit 6 - Modified Frequency Modulation (MFM)

This bit indicates the type of the disk drive and the data transfer rate, and determines the format of the address marks and the encoding scheme.

- 0 - FM mode, i.e., single density.
- 1 - MFM mode, i.e., double density.

Bit 7 - Multi-Track (MT)

This bit controls whether or not the controller continues to side 1 of the disk after reaching the last sector of side 0.

- 0 - Single track. The controller stops at the last sector of side 0.
- 1 - Multiple tracks. the controller continues to side 1 after reaching the last sector of side 0.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

These bits indicate which logical drive is active. See "Bits 1,0 - Logical Drive Select (DS1,0)" on page 90.

- 00 - Drive 0 is selected. (Default)
- 01 - Drive 1 is selected.
- 10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.
- 11 - If four drives are supported, drive 3 is selected.

Bit 2 - Head (HD)

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the HDSEL disk interface output signal. See "Bit 2 - Head Select (HD)" on page 90.

- 0 - HDSEL is not active, i.e., the head of the FDD selects side 0. (Default)
- 1 - HDSEL is active, i.e., the FDD head selects side 1.

Bit 7 - Implied Seek (IPS)

This bit indicates whether or not an implied seek should be performed. See also, "Bit 5 - Implied Seek (IPS)" on page 93.

- A software reset clears this bit to its default value of 0.
- 0 - No implied seek operations. (Default)
- 1 - The controller performs seek and sense interrupt operations before executing the command.

Third Command Phase Byte - Track Number

The value in this byte specifies the number of the track to read.

Fourth Command Phase Byte - Head Number

The value in this byte specifies head to use.

Fifth Command Phase Byte - Sector Number

The value in this byte specifies the sector to read.

Sixth Command Phase Byte - Bytes-Per-Sector Code

This byte contains a code in hexadecimal format that indicates the number of bytes in a data field. Table 5-11 on page 90 indicates the number of bytes that corresponds to each code.

Seventh Command Phase Byte - End of Track (EOT) Sector Number

This byte specifies the number of the sector at the End Of the Track (EOT).

Eighth Command Phase Byte - Bytes Between Sectors - Gap 3

The value in this byte specifies how many bytes there are between sectors. See "Fifth Command Phase Byte - Bytes in Gap 3" on page 90.

Ninth Command Phase Byte - Data Length (Obsolete)

The value in this byte is ignored and must be set to FFh.

Execution Phase

In this phase, data read from the disk drive is transferred to the system via DMA or non-DMA modes. See 5.4.2 on page 78.

The controller looks for the track number specified in the third command phase byte. If implied seeks are enabled, the controller also performs all operations of a SENSE INTERRUPT command and of a SEEK command (without issuing these commands). Then, the controller waits the head settle time. See bits 3-0 of the fourth command phase byte of the MODE command on page 94.

The controller then starts the data separator and waits for the data separator to find the address field of the next sector. The controller compares the ID information (track number, head number, sector number, bytes-per-sector code) in that address field with the corresponding information in the command phase bytes of the READ DATA command.

If the contents of the bytes do not match, then the controller waits for the data separator to find the address field of the next sector. The process is repeated until a match or an error occurs.

Possible errors, the conditions that may have caused them and the actions that result are:

- The microprocessor aborted the command by writing to the FIFO.
If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.
- Two pulses of the $\overline{\text{INDEX}}$ signal were detected since the search began, and no valid ID was found.
If the track address differs, either the Wrong Track bit (bit 4) or the Bad Track bit (bit 1) (if the track address is FFh) is set in result phase Status register 2 (ST2). See Section 5.5.3 on page 82.
If the head number, sector number or bytes-per-sector code did not match, the Missing Data bit (bit 2) is set in result phase Status register 1 (ST1).
If the Address Mark (AM) was not found, the Missing Address Mark bit (bit 0) is set in ST1.
Section 5.5.2 on page 81 describes the bits of ST1.
- A CRC error was detected in the address field. In this case the CRC Error bit (bit 5) is set in ST1.

Once the address field of the desired sector is found, the controller waits for the data separator to find the data field for that sector.

If the data field (normal or deleted) is not found within the expected time, the controller terminates the operation, enters the result phase and sets bit 0 (Missing Address Mark) in ST1.

If a deleted data mark is found, and Skip (SK) control is set to 1 in the opcode command phase byte, the controller skips this sector and searches for the next sector address field as described above. The effect of Skip Control (SK) on the READ DATA command is summarized in Table 5-17.

TABLE 5-17. Skip Control Effect on READ DATA Command

Skip Control (SK)	Data Type	Sector Read?	Control Mark Bit 6 of ST2	Result
0	Normal	Y	0	Normal Termination
0	Deleted	Y	1	No More Sectors Read
1	Normal	Y	0	Normal Termination
1	Deleted	N	1	Sector Skipped

After finding the data field, the controller transfers data bytes from the disk drive to the host until the bytes-per-sector count has been reached, or until the host terminates the operation by issuing the Terminal Count (TC) signal, reaching the end of the track or reporting an overrun.

See also, Section "The Phases of FDC Commands" on page 78.

The controller then generates a Cyclic Redundancy Check (CRC) value for the sector and compares the result with the CRC value at the end of the data field.

After reading the sector, the controller reads the next logical sector unless one or more of the following termination conditions occurs:

- The DMA controller asserted the Terminal Count (TC) signal to indicate that the operation terminated. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to normal termination (00). See page 81.
- The last sector address (of side 1, if the Multi-Track enable bit (MT) was set to 1) was equal to the End of Track sector number. The End of Track bit (bit 7) in ST1 is set. The IC bits in ST0 are set to abnormal termination (01). This is the expected condition during non-DMA transfers.
- Overrun error. The Overrun bit (bit 4) in ST1 is set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01). If the microprocessor cannot service a transfer request in time, the last correctly read byte is transferred.
- CRC error. CRC Error bit (bit 5) in ST1 and CRC Error in Data Field bit (bit 5) in ST2, are set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01).

If the Multi-Track (MT) bit was set in the opcode command byte, and the last sector of side 0 has been transferred, the controller continues with side 1.

Result Phase

Upon terminating the execution phase of the READ DATA command, the controller asserts IRQ6, indicating the beginning of the result phase. The microprocessor must then read the result bytes from the FIFO.

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

The values that are read back in the result bytes are shown in Table 5-18. If an error occurs, the result bytes indicate the sector read when the error occurred.

5.7.11 The READ DELETED DATA Command

The READ DELETED DATA command reads logical sectors containing a Address Mark (AM) for deleted data from the selected drive and makes the data available to the host microprocessor.

This command is like the READ DATA command, except for the setting of the Control Mark bit (bit 6) in ST2 and the skipping of sectors. See description of execution phase.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	SK	0	1	1	0	0
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

See READ DATA command for a description of the command bytes.

Execution Phase

Data read from disk drive is transferred to the system in DMA or non-DMA modes. See Section 5.4.2 on page 78.

The effect of Skip Control (SK) on the READ DELETED DATA command is summarized in Table 5-19.

TABLE 5-18. Result Phase Termination Values with No Error

Multi-Track (MT)	Head # (HD)	End of Track (EOT) Sector Number	ID Information in Result Phase			
			Track Number	Head Number	Sector Number	Bytes-per-Sector Code
0	0	< EOT ^a Sector #	No Change	No Change	Sector ^b # + 1	No Change
0	0	= EOT ^a Sector #	Track ^c # + 1	No Change	1	No Change
0	1	< EOT ^a Sector #	No Change	No Change	Sector ^b # + 1	No Change
0	1	= EOT ^a Sector #	Track ^c # + 1	No Change	1	No Change
1	0	< EOT ^a Sector #	No Change	No Change	Sector ^b # + 1	No Change
1	0	= EOT ^a Sector #	No Change	1	1	No Change
1	1	< EOT ^a Sector #	No Change	No Change	Sector ^b # + 1	No Change
1	1	= EOT ^a Sector #	Track ^c # + 1	0	1	No Change

- a. End of Track sector number from the command phase.
- b. The number of the sector last operated on by controller.
- c. Track number programmed in the command phase

TABLE 5-19. SK Effect on READ DELETED DATA Command

Skip Control (SK)	Data Type	Sector Read?	Control Mark Bit 6 of ST2	Result
0	Normal	Y	1	No More Sectors Read
0	Deleted	Y	0	Normal Termination
1	Normal	N	1	Sector Skipped
1	Deleted	Y	0	Normal Termination

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

See Table 5-18 for the state of the result bytes when the command terminates normally.

5.7.12 The READ ID Command

The READ ID command finds the next available address field and returns the ID bytes (track number, head number, sector number, bytes-per-sector code) to the microprocessor in the result phase.

The controller reads the first ID Field header bytes it can find and reports these bytes to the system in the result bytes.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	1	0	1	0
X	X	X	X	X	HD	DS1	DS0

After the last command phase byte is written, the controller waits the Delay Before Processing time (see Table 5-25 on page 106) for the selected drive. During this time, the drive motor must be turned on by enabling the appropriate drive and motor select disk interface output signals via the bits of the Digital Output Register (DOR). See "Digital Output Register (DOR), Offset 02h" on page 71.

First Command Phase Byte, Opcode

See "Bit 6 - Modified Frequency Modulation (MFM)" on page 90.

Second Command Phase Byte

See "Second Command Phase Byte" on page 90 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Execution Phase

There is no data transfer during the execution phase of this command. An interrupt is generated when the execution phase is completed.

The READ ID command does not perform an implied seek.

After waiting the Delay Before Processing time, the controller starts the data separator and waits for the data separator to find the address field of the next sector. If an error condition occurs, the Interrupt Code (IC) bits in ST0 are set to abnormal termination (01), and the controller enters the result phase.

Possible errors are:

- The microprocessor aborted the command by writing to the FIFO.
If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.

- Two pulses of the $\overline{\text{INDEX}}$ signal were detected since the search began, and no Address Mark (AM) was found.

When the Address Mark (AM) is not found, the Missing Address Mark bit (bit 0) is set in ST1. Section 5.5.2 on page 81 describes the bits of ST1.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

5.7.13 The READ A TRACK Command

The READ A TRACK command reads sectors from the selected drive, in physical order, and makes the data available to the host.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	0	0	1	0
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

The command phase bytes of the READ A TRACK command are like those of the READ DATA command, except for the MT and SK bits. Multi-track and skip operations are not allowed in the READ A TRACK command. Therefore, bits 7 and 5 of the opcode command phase byte (MT and SK, respectively) must be 0.

First Command Phase Byte, Opcode

See "Bit 6 - Modified Frequency Modulation (MFM)" on page 90.

Second Command Phase Byte

See "Second Command Phase Byte" on page 90 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

See "Bit 5 - Implied Seek (IPS)" on page 93 for a description of the Implied Seek (IPS) bit.

Third through Ninth Command Phase Bytes

See "The READ DATA Command" on page 96.

Execution Phase

Data read from the disk drive is transferred to the system in DMA or non-DMA modes. See Section 5.4.2.

Execution of this command is like execution of the READ DATA command except for the following differences:

- The controller waits for a pulse from the $\overline{\text{INDEX}}$ signal before it searches for the address field of a sector.
If the microprocessor writes to the FIFO before the $\overline{\text{INDEX}}$ pulse is detected, the command enters the result phase with the Interrupt Code (IC) bits (bits 7,6) in ST0 set to abnormal termination (01).
- All the ID bytes of the sector address are compared, except the sector number. Instead, the sector number is set to 1, and then incremented for each successive sector read.
- If no match occurs when the ID bytes of the sector address are compared, the controller sets the Missing

Data bit (bit 2) in ST1, but continues to read the sector. If there is a CRC error in the address field being read, the controller sets CRC Error (bit 5) in ST1, but continues to read the sector.

- If there is a CRC error in the data field, the controller sets the CRC Error bit (bit 5) in ST1 and CRC Error in Data Field bit (bit 5) in ST2, but continues reading sectors.
- The controller reads a maximum of End of Track (EOT) physical sectors. There is no support for multi-track reads.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

5.7.14 The RECALIBRATE Command

The RECALIBRATE command issues pulses that make the head of the selected drive step out until it reaches track 0.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	1	1	1
X	X	X	X	X	HD	DS1	DS0

Second Command Phase Byte

See "Second Command Phase Byte" on page 90 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Execution Phase

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in "Main Status Register (MSR), Offset 04h, Read Operations" on page 74.

The controller waits the Delay Before Processing time (see Table 5-25 on page 106) for the selected drive., and then becomes idle. See "Idle Phase" on page 80.

Then, the controller issues pulses until the $\overline{\text{TRK0}}$ disk interface input signal becomes active or until the maximum number of RECALIBRATE step pulses have been issued.

Table 5-20 shows the maximum number of RECALIBRATE step pulses that may be issued, depending on the RECALIBRATE Step Pulses (R255) bit, bit 0 in the second command phase byte of the MODE command (page 92), and the Extended Track Range (ETR) bit, bit 4 of the third command byte of the MODE command (page 93).

If the number of tracks on the disk drive exceeds the maximum number of RECALIBRATE step pulses, it may be necessary to issue another RECALIBRATE command.

TABLE 5-20. Maximum RECALIBRATE Step Pulses for Values of R255 and ETR

R255	ETR	Maximum Number of RECALIBRATE Step Pulses
0	0	85 (default)
1	0	255
0	1	3925
1	1	4095

The pulses actually occur while the controller is in the drive polling phase. See "Drive Polling Phase" on page 80.

An interrupt is generated after the $\overline{\text{TRK0}}$ signal is asserted, or after the maximum number of RECALIBRATE step pulses is issued.

Software should ensure that the RECALIBRATE command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time.

No command, except a SENSE INTERRUPT command, should be issued while a RECALIBRATE command is in progress.

Result Phase

None.

5.7.15 The RELATIVE SEEK Command

The RELATIVE SEEK command issues $\overline{\text{STEP}}$ pulses that make the head of the selected drive step in or out a programmable number of tracks.

Command Phase

	7	6	5	4	3	2	1	0
	1	DIR	0	0	1	1	1	1
	X	X	X	X	X	HD	DS1	DS0
Relative Track Number (RTN)								

First Command Phase Byte, Opcode, Bit - 6 Step Direction DIR

This bit defines the step direction.
 0 - Step head out.
 1 - Step head in.

Second Command Phase Byte

See "Second Command Phase Byte" on page 90 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Third Command Phase Byte - Relative Track Number (RTN)

This value specifies how many tracks the head should step in or out from the current track.

Execution Phase

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in Section 5.3.5 on page 74.

The controller waits the Delay Before Processing time (see Table 5-25 on page 106) for the selected drive., and then becomes idle. See "Idle Phase" on page 80.

Then, the controller enters the idle phase and issues RTN $\overline{\text{STEP}}$ pulses until the $\overline{\text{TRK0}}$ disk interface input signal becomes active or until the specified number (RTN) of STEP pulses have been issued. After the RELATIVE SEEK operation is complete, the controller generates an interrupt.

Software should ensure that the RELATIVE SEEK command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time.

No command, except the SENSE INTERRUPT command, should be issued while a RELATIVE SEEK command is in progress.

Result Phase

None.

5.7.16 The SCAN EQUAL, the SCAN LOW OR EQUAL and the SCAN HIGH OR EQUAL Commands

The scan commands compare data read from the disk with data sent from the microprocessor. This comparison produces a match for each scan command, as follows, and as shown in Table 5-21:

- SCAN EQUAL - Disk data equals microprocessor data.
- SCAN LOW OR EQUAL - Disk data is less than or equal to microprocessor data.
- SCAN HIGH OR EQUAL - Disk data is greater than or equal to microprocessor data.

Command Phase

SCAN EQUAL

	7	6	5	4	3	2	1	0
MT		MFM	SK	1	0	0	0	1
IPS	X	X	X	X	X	HD	DS1	DS0
Track Number								
Head Number								
Sector Number								
Bytes-Per-Sector Code								
End of Track (EOT) Sector Number								
Bytes Between Sectors - Gap 3								
Sector Step Size								

SCAN LOW OR EQUAL

7	6	5	4	3	2	1	0
MT	MFM	SK	1	1	0	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sector Step Size							

SCAN HIGH OR EQUAL

7	6	5	4	3	2	1	0
MT	MFM	SK	1	1	1	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sector Step Size							

First through Eighth Command Phase Bytes - All Scan Commands

See READ DATA command for a description of the first eight command phase bytes.

Ninth Command Phase Byte, Sector Step Size

During execution, the value of this byte is added to the current sector number to determine the next sector to read.

Execution Phase

The most significant bytes of each sector are compared first. If wildcard mode is enabled in bit 4 of the fourth command phase byte in the MODE command (page 94), a value of FFh from either the disk or the microprocessor always causes a match.

After each sector is read, if there is no match, the next sector is read. The next sector is the current sector number plus the Sector Step Size specified in the ninth command phase byte.

The scan operation continues until the condition is met, the End of Track (EOT) is reached or the Terminal Count (TC) signal becomes active.

Read error conditions during scan commands are the same as read error conditions during the execution phase of the READ DATA command. See page 97.

If the Skip Control (SK) bit is set to 1, sectors with deleted data marks are ignored.

If all sectors read are skipped, the command terminates with bit 3 of ST2 set to 1, i.e., disk data equals microprocessor data.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

Table 5-21 shows how all the scan commands affect bits 3,2 of the Status 2 (ST2) result phase register. See "Result Phase Status Register 2 (ST2)" on page 82.

TABLE 5-21. The Effect of Scan Commands on the ST2 Register

Command	Result Phase Status Register 2 (ST2)		Condition
	Bit 3 - Scan Satisfied	Bit 2 - Scan Not Satisfied	
SCAN EQUAL	1 0	0 1	Disk = μ P Disk \neq μ P
SCAN LOW OR EQUAL	1 0 0	0 0 1	Disk = μ P Disk < μ P Disk > μ P
SCAN HIGH OR EQUAL	1 0 0	0 0 1	Disk = μ P Disk > μ P Disk < μ P

5.7.17 The SEEK Command

The SEEK command issues pulses of the $\overline{\text{STEP}}$ signal to the selected drive, to move it in or out until the desired track number is reached.

Software should ensure that the SEEK command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time. See "Digital Output Register (DOR), Offset 02h" on page 71.

No command, except a SENSE INTERRUPT command, should be issued while a SEEK command is in progress.

Command Phase

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See “Bit 0 - Extended Track Range (ETR)” on page 92.

In this case, a fourth command byte should be written in the command phase to hold the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek. Otherwise (ETR bit in MODE is 0), this command phase byte is not required. and, only three command bytes should be written.

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in Section 5.3.5 on page 74.

The controller waits the Delay Before Processing time (see Table 5-25 on page 106) for the selected drive, before issuing the first STEP pulse. After waiting the Delay Before Processing time, the controller becomes idle. See “Idle Phase” on page 80.

7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1
X	X	X	X	X	HD	DS1	DS0
Number of Track to Seek							
MSN of Track # to Seek							

Second Command Phase Byte

See READ DATA command for a description of these bits.

Third Command Phase Byte, Number of Track to Seek

The value in this byte is the number of the track to seek.

Fourth Command Phase Byte, Bits 7-4 - MSN of Track Number

If the track number is stored as a 12-bit value, these bits contain the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek.

Otherwise (the ETR bit in the MODE command is 0), this command phase byte is not required.

Execution Phase

During the execution phase of the SEEK command, the track number to seek to is compared with the present track number. The controller determines how many STEP pulses to issue and the DIR disk interface output signal indicates which direction the head should move.

The SEEK command issues step pulses while the controller is in the drive polling phase. The step pulse rate is determined by the value programmed in the second command phase byte of the SPECIFY command.

An interrupt is generated one step pulse period after the last step pulse is issued. A SENSE INTERRUPT command should be issued to determine the cause of the interrupt.

Result Phase

None.

5.7.18 The SENSE DRIVE STATUS Command

The SENSE DRIVE STATUS command indicates which drive and which head are selected, whether or not the head is at track 0 and whether or not the track is write protected in result phase Status register 3 (ST3). See “Result Phase Status Register 3 (ST3)” on page 83.

This command does not generate an interrupt.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0
X	X	X	X	X	HD	DS1	DS0

See READ DATA command for a description of these bits.

Execution Phase

Disk drive status information is detected and reported.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 3 (ST3)							

See “Result Phase Status Register 3 (ST3)” on page 83.

5.7.19 The SENSE INTERRUPT Command

The SENSE INTERRUPT command returns the cause of an interrupt that is caused by the change in status of any disk drive.

If a SENSE INTERRUPT command is issued when no interrupt is pending it is treated as an invalid command.

When to Issue SENSE INTERRUPT

The SENSE INTERRUPT command is issued to detect either of the following causes of an interrupt:

- The FDC became ready during the drive polling phase for an internally selected drive. See “Drive Polling Phase” on page 80. This can occur only after a hardware or software reset.
- A SEEK, RELATIVE SEEK or RECALIBRATE command terminated.

Interrupts caused by these conditions are cleared after the first result byte has been read. Use the Interrupt Code (IC) (bits 7,6) and SEEK End bits (bit 5) of result phase Status register 0 (ST0) to identify the cause of these interrupts. See “Bit 5 - SEEK End” on page 81 and Table 5-22.

TABLE 5-22. Interrupt Causes Reported by SENSE INTERRUPT

Bits of ST0			Interrupt Cause
7	6	5	
1	1	0	FDC became ready during drive polling mode. SEEK, RELATIVE SEEK or RECALIBRATE not completed.
0	0	1	SEEK, RELATIVE SEEK or RECALIBRATE terminated normally.
0	1	1	SEEK, RELATIVE SEEK or RECALIBRATE terminated abnormally.

When SENSE INTERRUPT is not Necessary

Interrupts that occur during most command operations do not need to be identified by the SENSE INTERRUPT. The microprocessor can identify them by checking the Request for Master (RQM) bit (bit 7) of the Main Status Register (MSR). See page "Bit 7 - Request for Master (RQM)" on page 75.

It is not necessary to issue a SENSE INTERRUPT command to detect the following causes of Interrupts:

- The result phase of any of the following commands started:
 - READ DATA, READ DELETED DATA, READ A TRACK, READ ID
 - WRITE DATA, WRITE DELETED
 - FORMAT TRACK
 - SCAN EQUAL, SCAN EQUAL OR LOW, SCAN EQUAL OR HIGH
 - VERIFY
- Data is being transferred in non-DMA mode, during the execution phase of some command.

Interrupts caused by these conditions are cleared automatically, or by reading or writing information from or to the Data Register (FIFO).

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0

Execution Phase

Status of interrupt is reported.

Result Phase

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See "Bit 0 - Extended Track Range (ETR)" on page 92.

In this case, a third result byte should be read to hold the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the current track.

Otherwise (ETR bit in MODE is 0), this command phase byte is not required. and, only two result phase bytes should be read.

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Byte of Present Track Number (PTR)							
MSN of PTR							

First Command Phase Byte, Result Phase Status Register 0

See "Result Phase Status Register 0 (ST0)" on page 81.

Second Command Phase Byte, Present Track Number (PTR)

The value in this byte is the number of the current track.

Fourth Command Phase Byte, Bits 7-4 - MSN of Track Number

If the track number is stored as a 12-bit value, these bits contain the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek.

Otherwise (the ETR bit in the MODE command is 0), this result phase byte is not required.

5.7.20 The SET TRACK Command

This command is used to verify (read) or change (write) the number of the present track.

This command could be useful for recovery from disk tracking errors, where the true track number could be read from the disk using the READ ID command, and used as input to the SET TRACK command to correct the Present Track number (PTR) stored internally.

Termination of this command does not generate an interrupt

Command Phase

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See "Bit 0 - Extended Track Range (ETR)" on page 92.

In this case, issue SET TRACK twice - once for the Most Significant Byte (MSB) of the number of the current track and once for the Least Significant Byte (LSB).

Otherwise (ETR bit in MODE is 0), issue SET TRACK only once, with bit 2 (MSB) of the second command phase byte set to 0.

7	6	5	4	3	2	1	0
0	WNR	1	0	0	0	0	1
0	0	1	1	0	MSB	DS1	DS0
Byte of Present Track Number (PTR)							

First Command Phase Byte, Bit 6 - Write Track Number (WNR)

- 0 - Read the existing track number.
The result phase byte already contains the track number, and the third byte in the command phase is a dummy byte.
- 1 - Change the track number by writing a new value to the result phase byte.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

- These bits indicate which logical drive is active. See "Bits 1,0 - Logical Drive Select (DS1,0)" on page 90.
- 00 - Drive 0 is selected.
 - 01 - Drive 1 is selected.
 - 10 - If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.
 - 11 - If four drives are supported, drive 3 is selected.

Bit 2 - Most Significant Byte (MSB)

- This bit, together with bits 1,0, determines the byte to read or write. See also Table 5-23.
- 0 - Least significant byte of the track number.
 - 1 - Most significant byte of the track number.

TABLE 5-23. Defining Bytes to Read or Write Using SET TRACK

MSB	DS1	DS0	Byte to Read or Write
2	1	0	
0	0	0	Drive 0 (LSB)
1	0	0	Drive 0 (MSB)
0	0	1	Drive 1 (LSB)
1	0	1	Drive 1 (MSB)
0	1	0	Drive 2 (LSB)
1	1	0	Drive 2 (MSB)
0	1	1	Drive 3 (LSB)
1	1	1	Drive 3 (MSB)

Execution Phase

Internal register is read or written.

Result Phase

7	6	5	4	3	2	1	0
Byte of Present Track Number(PTR)							

This byte is one byte of the track number that was read or written, depending on the value of WNR in the first command byte.

5.7.21 The SPECIFY Command

The SPECIFY command sets initial values for the following time periods:

- The delay before command processing starts, formerly called Motor On Time (MNT)
- The delay after command processing terminates, formerly called Motor Off Time (MFT)
- The interval step rate time.

The FDC uses the Digital Output Register (DOR) to enable the drive and motor select signals. See also, "Digital Output Register (DOR), Offset 02h" on page 71.

The delays may be used to support the μ PD765, i.e., to insert delays from selection of a drive motor until a read or write operation starts, and from termination of a command until the drive motor is no longer selected, respectively.

The parameters used by this command are undefined after power up, and are unaffected by any reset. Therefore, software should always issue a SPECIFY command as part of an initialization routine to initialize these parameters.

Termination of this command does not generate an interrupt.

Command Phase.

7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1
Step Rate Time (SRT)				Delay After Processing			
Delay Before Processing						DMA	

Second Command Phase Byte

Bits 3-0 - Delay After Processing Factor

These bits specify a factor that is multiplied by a constant to determine the delay after command processing ends, i.e., from termination of a command until the drive motor is no longer selected.

The value of the Motor Timer Values (TMR) bit (bit 7) of the second command phase byte in the MODE command determines which group of constants and delay ranges to use. See "Bit 7 - Motor Timer Values (TMR)" on page 93.

The specific constant that will be multiplied by this factor to determine the actual delay after processing for each data transfer rate is shown in Table 5-24.

Use the smallest possible value for this factor, except 0, i.e., 1. If this factor is 0, the value16 is used.

Bits 7-4 - STEP Time Interval Value (SRT)

These bits specify a value that is used to calculate the time interval between successive STEP signal pulses during a SEEK, IMPLIED SEEK, RECALIBRATE, or RELATIVE SEEK command.

Table 5-26 shows how this value is used to calculate the actual time interval.

TABLE 5-24. Constant Multipliers for Delay After Processing Factor and Delay Ranges

Data Transfer Rate (bps)	Bit 7 of MODE (TMR) = 0		Bit 7 of MODE (TMR) = 1	
	Constant Multiplier	Permitted Range (msec)	Constant Multiplier	Permitted Range (msec)
1 M	8	8 - 128	512	512 - 8192
500 K	16	16 - 256	512	512 - 8192
300 K	80 / 3	26.7 - 427	2560 / 3	853 - 13653
250 K	32	32 - 512	1024	1024 - 16384

TABLE 5-25. Constant Multipliers for Delay Before Processing Factor and Delay Ranges

Data Transfer Rate (bps)	Bit 7 of MODE (TMR) = 0		Bit 7 of MODE (TMR) = 1	
	Constant Multiplier	Permitted Range (msec)	Constant Multiplier	Permitted Range (msec)
1 M	1	1 - 128	32	32 - 4096
500 K	1	1 - 128	32	32 - 4096
300 K	10 / 3	3.3 - 427	160 / 3	53 - 6827
250 K	4	4 - 512	64	64 - 8192

TABLE 5-26. STEP Time Interval Calculation

Data Transfer Rate (bps)	Calculation of Time Interval	Permitted Range (msec)
1 M	$(16 - \text{SRT}) / 2$	0.5 - 8
500 K	$(16 - \text{SRT})$	1 - 16
300 K	$(16 - \text{SRT}) \times 1.67$	1.67 - 26.7
250 K	$(16 - \text{SRT}) \times 2$	2 - 32

The specific constant that will be multiplied by this factor to determine the actual delay before processing for each data transfer rate is shown in Table 5-25.

Use the smallest possible value for this factor, except 0, i.e., 1. If this factor is 0, the value 128 is used.

Execution Phase

Internal registers are written.

Result Phase

None.

Third Command Phase Byte

Bit 0 - DMA

This bit selects the data transfer mode in the execution phase of a read, write, or scan operation.

Data can be transferred between the microprocessor and the controller during execution in DMA mode or in non-DMA mode, i.e., interrupt transfer mode or software polling mode.

See "Execution Phase" on page 78 for a description of these modes.

0 - DMA mode is selected.

1 - Non-DMA mode is selected.

Bits 3-0 - Delay Before Processing Factor

These bits specify a factor that is multiplied by a constant to determine the delay before command processing starts, i.e., from selection of a drive motor until a read or write operation starts.

The value of the Motor Timer Values (TMR) bit (bit 7) of the second command phase byte in the MODE command determines which group of constants and delay ranges to use. See "Bit 7 - Motor Timer Values (TMR)" on page 93.

5.7.22 The VERIFY Command

The VERIFY command verifies the contents of data and/or address fields after they have been formatted or written.

VERIFY reads logical sectors containing a normal data Address Mark (AM) from the selected drive, without transferring the data to the host.

The TC signal cannot terminate this command since no data is transferred. Instead, VERIFY simulates a TC signal by setting the Enable Count (EC) bit to 1. In this case, VERIFY terminates when the number of sectors read equals the number of sectors to read, i.e., Sectors to read Count (SC). If SC = 0 then 256 sectors will be verified.

When EC is 0, VERIFY ends when the End of the Track (EOT) sector number equals the number of the sector checked. In this case, the ninth command phase byte is not needed and should be set to FFh.

Table 5-27 shows how different values for the VERIFY parameters affect termination.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	SK	1	0	1	1	0
EC	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sectors to read Count (SC)							

First Command Phase Byte

See READ DATA command for a description of these bits starting on page 96.

Second Command Phase Byte

Bits 2-0 - Drive Select (DS1,0) and Head (HD) Select

See the description of the Drive Select bits (DS1,0) and the Head (HD) select bit in the READ DATA command, starting on page 96.

Bit 7 - Enable Count Control (EC)

This bit controls whether the End of Track sector number or the Sectors to read Count (SC) triggers termination of the VERIFY command.

See also, Table 5-27.

0 - Terminate VERIFY when the number of the last sector read equals the End of Track (EOT) sector number.

The ninth command phase byte, i.e., Sectors to read Count (SC), is not needed and should be set to FFh.

1 - Terminate VERIFY when number of sectors read equals the number of sectors to read, i.e., Sectors to read Count (SC).

Third through Eighth Command Phase Bytes

See "The READ DATA Command" on page 96.

Always set the End of Track (EOT) sector number to the number of the last sector to be checked on each side of the disk. If EOT is greater than the number of sectors per side, the command terminates with an error and no useful Address Mark (AM) or CRC data is returned.

Ninth Command Phase Byte, Sectors to Read Count (SC)

This byte specifies the number of sectors to read. If the Enable Count (EC) control bit (bit 7) of the second command byte is 0, this byte is not needed and should be set to the value FFh.

Execution Phase

Data is read from the disk, as the controller checks for valid address marks in the address and data fields.

This command is identical to the READ DATA command, except that it does not transfer data during the execution phase. See "The READ DATA Command" on page 96.

If the Multi-Track (MT) parameter is 1 and SC is greater than the number of remaining formatted sectors on side 0, verification continues on side 1 of the disk.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

Table 5-27 shows how different conditions affect the termination status.

TABLE 5-27. VERIFY Command Termination Conditions

MT	EC	Sector Count (SC) or End of Track (EOT) Value	Termination Status
0	0	SC should be FFh EOT ≤ Sectors per Side ^a	No Errors
		SC should be FFh EOT > Sectors per Side	Abnormal Termination
0	1	SC ≤ Sectors per Side and SC ≤ EOT	No Errors
		SC > Sectors Remaining ^b or SC > EOT	Abnormal Termination
1	0	SC should be FFh EOT ≤ Sectors per Side	No Errors
		SC should be FFh EOT > Sectors per Side	Abnormal Termination
1	1	SC ≤ Sectors per Side and SC ≤ EOT	No Errors
		SC ≤ (EOT x 2) and EOT ≤ Sectors per Side	No Errors
		SC > (EOT x 2)	Abnormal Termination

a. The number of formatted sectors per side of the disk.

b. The number of formatted sectors left, which can be read, including side 1 of the disk if MT is 1.

5.7.23 The VERSION Command

The VERSION command returns the version number of the current Floppy Disk Controller (FDC).

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0

Execution Phase

None.

Result Phase

7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0

The result phase byte returns a value of 90h for an FDC that is compatible with the 82077.

Other controllers, i.e., the DP8473 and other NEC765 compatible controllers, return a value of 80h (invalid command).

5.7.24 The WRITE DATA Command

The WRITE DATA command receives data from the host and writes logical sectors containing a normal data Address Mark (AM) to the selected drive.

This command is like the READ DATA command, except that the data is transferred from the microprocessor to the controller instead of the other way around.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	0	0	0	1	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

See the READ DATA command starting on page 96 for a description of these bytes.

The controller waits the Delay Before Processing time before starting execution.

If implied seeks are enabled, i.e., IPS in the second command phase byte is 1, the operations performed by SEEK and SENSE INTERRUPT commands are performed (without these commands being issued).

Execution Phase

Data is transferred from the system to the controller via DMA or non-DMA modes and written to the disk. See "Execution Phase" starting on page 78 for a description of these data transfer modes.

The controller starts the data separator and waits for it to find the address field of the next sector. The controller compares the address ID (track number, head number, sector number, bytes-per-sector code) with the ID specified in the command phase.

If there is no match, the controller waits to find the next sector address field. This process continues until the desired sector is found. If an error condition occurs, the Interrupt Control (IC) bits (bits 7,6) in ST0 are set to abnormal termination, and the controller enters the result phase. See "Bits 7,6 - Interrupt Code (IC)" on page 81.

Possible errors are:

- The microprocessor aborted the command by writing to the FIFO.

If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.

- Two pulses of the $\overline{\text{INDEX}}$ signal were detected since the search began, and no valid ID was found.

If the track address differs, either the Wrong Track bit (bit 4) or the Bad Track bit (bit 1) (if the track address is FFh is set in result phase Status register 2 (ST2). See Section 5.5.3 on page 82.

If the head number, sector number or bytes-per-sector code did not match, the Missing Data bit (bit 2) is set in result phase Status register 1 (ST1).

If the Address Mark (AM) is not found, the Missing Address Mark bit (bit 0) is set in ST1.

Section 5.5.2 on page 81 describes the bits of ST1.

- A CRC error was detected in the address field. In this case the CRC Error bit (bit 5) is set in ST1.
- The controller detected an active the Write Protect ($\overline{\text{WP}}$) disk interface input signal, and set bit 1 of ST1 to 1.

If the correct address field is found, the controller waits for all (conventional drive mode) or part (perpendicular drive mode) of gap 2 to pass. See Figure 5-20 on page 91. The controller then writes the preamble field, Address Marks (AM) and data bytes to the data field. The microprocessor transfers the data bytes to the controller.

After writing the sector, the controller reads the next logical sector, unless one or more of the following termination conditions occurs:

- The DMA controller asserted the Terminal Count (TC) signal to indicate that the operation terminated. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to normal termination (00). See page 81.
- The last sector address (of side 1, if the Multi-Track enable bit (MT) was set to 1) was equal to the End of Track sector number. The End of Track bit (bit 7) in ST1 is set. The IC bits in ST0 are set to abnormal termination (01). This is the expected condition during non-DMA transfers.

- Overrun error. The Overrun bit (bit 4) in ST1 is set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01). If the microprocessor cannot service a transfer request in time, the last correctly written byte is written to the disk.

If the Multi-Track (MT) bit was set in the opcode command byte, and the last sector of side 0 has been transferred, the controller continues with side 1.

Result Phase

Upon terminating the execution phase of the WRITE DATA command, the controller asserts IRQ6, indicating the beginning of the result phase. The microprocessor must then read the result bytes from the FIFO.

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

The values that are read back in the result bytes are shown in Table 5-18 on page 98. If an error occurs, the result bytes indicate the sector read when the error occurred.

5.7.25 The WRITE DELETED DATA Command

The WRITE DELETED DATA command receives data from the host and writes logical sectors containing a deleted data Address Mark (AM) to the selected drive.

This command is identical to the WRITE DATA command, except that a deleted data AM, instead of a normal data AM, is written to the data field.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	0	0	1	0	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

See the READ DATA command starting on page 96 and WRITE DATA on page 108 for a description of these bytes.

Execution Phase

Data is transferred from the system to the controller in DMA or non-DMA modes, and written to the disk. See "Execution Phase" starting on page 78 for a description of these data transfer modes.

Result Phase

Upon terminating the execution phase of the WRITE DATA command, the controller asserts IRQ6, indicating the beginning of the result phase. The microprocessor must then read the result bytes from the FIFO.

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

The values that are read back in the result bytes are shown in Table 5-18 on page 98. If an error occurs, the result bytes indicate the sector read when the error occurred.

5.8 EXAMPLE OF A FOUR-DRIVE CIRCUIT USING THE PC87307/PC97307

Figure 5-21 shows one implementation of a four-drive circuit. Refer to Table 5-2 on page 72 to see how to encode the drive and motor bits for this configuration.

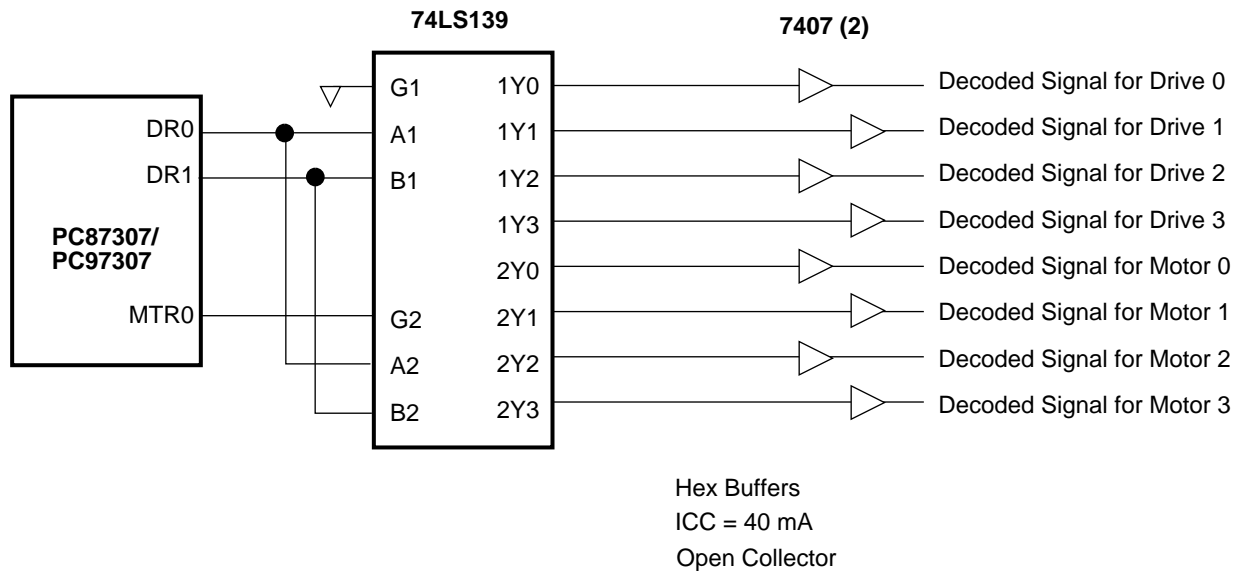


FIGURE 5-21. PC87307/PC97307 Four Floppy Disk Drive Circuit

6.0 Parallel Port (Logical Device 4)

The Parallel Port is a communications device that transfers parallel data between the system and an external device. Originally designed to output data to an external printer, the use of this port has grown to include bidirectional communications, increased data rates and additional applications (such as network adaptors).

6.1 PARALLEL PORT CONFIGURATION

The part offers a wide range of Parallel Port configurations. It utilizes the most advanced protocols in current use, while maintaining full backward compatibility to support existing hardware and software. It supports two Standard Parallel Port (SPP) modes of operation for parallel printer ports (as found in the IBM PC-AT, PS/2 and Centronics systems), two Enhanced Parallel Port (EPP) modes of operation, and one Extended Capabilities Port (ECP) mode. This versatility is achieved by user software control of the mode in which the device functions.

The IEEE 1284 standard establishes a widely accepted handshake and transfer protocol that ensures transfer data integrity. This parallel interface fully supports the IEEE 1284 standard of parallel communications, in both Legacy and Plug and Play configurations, in all modes except the EPP revision 1.7 mode described in the next section.

6.1.1 Parallel Port Operation Modes

The part supports Standard Parallel Port (SPP), Enhanced Parallel Port (EPP) and Extended Capabilities Port (ECP) configurations.

- In the Standard Parallel Port (SPP) configuration, data rates of several hundred bytes per second are achieved. This configuration supports the following operation modes:
 - In SPP Compatible mode the port is write-only (for data). Data transfers are software-controlled and are accompanied by status and control handshake signals.
 - PP FIFO mode enhances SPP Compatible mode by the addition of an output data FIFO, and operates as a state-machine instead of software-controlled operation.
 - In SPP Extended mode, the parallel port becomes a read/write port, that can transfer a full data byte in either direction.
- The Enhanced Parallel Port (EPP) configuration supports two modes that offer higher bi-directional throughput and more efficient hardware-based handling.
 - The EPP revision 1.7 mode lacks a comprehensive handshaking scheme to ensure data transfer integrity between communicating devices with dissimilar data rates. This is the only mode that does not meet the requirements of the IEEE 1284 standard handshake and transfer protocol.
 - EPP revision 1.9 mode offers data transfer enhancement, while meeting the IEEE 1284 standard.
- The Extended Capabilities Port (ECP) configuration extends the port capabilities beyond EPP modes by adding a bi-directional 16-level FIFO with threshold interrupts, for PIO and DMA data transfer, including demand DMA operation. In this mode, the device becomes

a hardware state-machine with highly efficient data transfer control by hardware in real-time.

The part enters the ECP mode by default after reset.

The ECP configuration supports several modes that are determined by bits 7-5 of the ECP Extended Control Register (ECR) at offset 402h. Section 6.6 on page 128 describes these modes in detail. The ECR register is described in Section 6.5.12 on page 124.

6.1.2 Configuring Operation Modes

The operation mode of the parallel port is determined by configuration bits that are controlled by software. If ECP mode is set upon initial system configuration, the operation mode may also be changed during run-time.

- **Configuration at System Initialization (Static)** - The parallel port operation mode is determined at initial system configuration by bits 7-4 of the SuperI/O Parallel Port Configuration register at index F0h of logical device 4. See Section 2.7.1 on page 37.
- **Configuration at System Initialization with Run-Time Reconfiguration (Dynamic)** - The parallel port operation mode is initially ECP, but may be changed by additional mode selection bits if bit 4 of the SuperI/O Parallel Port Configuration register at index F0h of logical device 4 is 1, and bits 7-5 of the same register are 110 or 111.

In this case, the operation mode is determined by bits 7-5 of the parallel port Extended Control register (ECR) at parallel port base address + 402h and by bits 7 and 4 of the Control2 register at second level offset 2. These registers are accessed via the internal ECP Mode Index and Data registers at parallel port base address + 403 and parallel port base address + 404h, respectively.

Table 6-1 shows how to configure the parallel port for the different operation modes.

Table 2-4 on page 26 shows how to allocate a range for the base address of the parallel port for each mode. Parallel port address decoding is described in Chapter 2.2.2 on page 25.

The parallel port supports Plug and Play operation. Its interrupt can be routed on one of the following ISA interrupts: IRQ1 to IRQ15 except for IRQ 2 and 13. Its DMA signals can be routed to one of three 8-bit ISA DMA channels. See Section 6.5.19 on page 127.

The parallel port device is activated by setting bit 4 of the system Function Enable Register 1 (FER1) to 1. See Section 9.2.3 on page 173.

6.1.3 Output Pin Protection

The parallel port output pins are protected against potential damage from connecting an unpowered port to a powered-up printer.

6.2 STANDARD PARALLEL PORT (SPP) MODES

Compatible SPP mode is a data write-only mode that outputs data to a parallel printer, using handshake bits, under software control.

In SPP Extended mode, parallel data transfer is bi-directional. Table 6-12 on page 134 lists the output signals for the standard 25-pin, D-type connector. Table 6-2 lists the reset states for handshake output pins in this mode.

TABLE 6-1. Parallel Port Mode Selection

Configuration Time	Operation Mode	SuperI/O Parallel Port Configuration Register (Index F0h) ^a	Extended Control Register (ECR) of the Parallel Port (Offset 402h) ^b	Control2 Register of the Parallel Port (Offset 02h) ^c	Notes
		7 6 5	7 6 5	4	
Configuration at System Initialization (Static)	SPP Compatible	0 0 0	-	-	-
	SPP Extended	0 0 1	-	-	-
	EPP Revision 1.7	0 1 0	-	-	-
	EPP Revision 1.9	0 1 1	-	-	-
Configuration at System Initialization with Run-Time Reconfiguration (Dynamic)	SPP Compatible	1 0 0	0 0 0	-	d
	PP FIFO	or 1 1 1	0 1 0	-	d
	SPP Extended		0 0 1	-	d
	EPP Revision 1.7	1 1 1	1 0 0	0	d
	EPP Revision 1.9			1	d
	ECP(Default)	1 0 0 or 1 1 1	0 1 1	-	-

- a. Section 2.7.1 on page 37 describes the bits of the SuperI/O Parallel Port configuration register.
- b. See Section 6.5.12 on page 124
- c. Before modifying this bit, set bit 4 of the SuperI/O Parallel Port configuration register at index F0h to 1.
- d. Use bit 7 of the Control2 register at second level offset 2 of the parallel port to further specify compatibility. See Section 6.5.17 on page 126.

TABLE 6-2. Parallel Port Reset States

Signal	Reset Control	State After Reset
SLIN	MR	TRI-STATE
INIT	MR	Zero
$\overline{\text{AFD}}$	MR	TRI-STATE
STB	MR	TRI-STATE
IRQ5,7	MR	TRI-STATE

TABLE 6-3. Standard Parallel Port (SPP) Registers

Offset	Name	Description	R/W
00h	DTR	Data	R/W
01h	STR	Status	R
02h	CTR	Control	R/W
03h		-	TRI-STATE

6.2.1 Standard Parallel Port (SPP) Modes Register Set

In all Standard Parallel Port (SPP) modes, port operation is controlled by the registers listed in Table 6-3.

All register bit assignments are compatible with the assignments in existing SPP devices.

A single Data Register DTR is used for data input and output (see Section 6.2.2). The direction of data flow is determined by the system setting in bit 5 of the Control Register CTR.

6.2.2 SPP Data Register (DTR), Offset 00h

This bidirectional data port transfers 8-bit data in the direction determined by bit 5 of SPP register CTR at offset 02h and mode.

The read or write operation is activated by the system $\overline{\text{RD}}$ and $\overline{\text{WR}}$ strobes.

Table 6-4 tabulates DTR register operation.

TABLE 6-4. SPP DTR Register Read and Write Modes

Mode	Bit 5 of CTR	$\overline{\text{RD}}$	$\overline{\text{WR}}$	Result
SPP Compatible	x	1	0	Data written to PD7-0.
	x	0	1	Data read from the output latch

Bit 5 - PE Status

This bit reflects the current state of the printer paper end signal (PE). The printer sets this bit high when it detects the end of the paper.

- 0 - Printer has paper.
- 1 - End of paper in printer.

Bit 6 - ACK Status

This bit reflects the current state of the printer acknowledge signal, ACK. The printer pulses this signal low after it has received a character and is ready to receive another one. This bit follows the state of the ACK pin.

- 0 - Character reception complete.
- 1 - No character received .

Bit 7 - Printer Status

This bit reflects the current state of the printer BUSY signal. The printer sets this bit low when it is busy and cannot accept another character.

- This bit is the inverse of the (BUSY/ $\overline{\text{WAIT}}$) pin.
- 0 - Printer busy.
 - 1 - Printer not busy.

6.2.4 SPP Control Register (CTR), Offset 02h

The control register provides all the output signals that control the printer. Except for bit 5, it is a read and write register.

Normally when the Control Register (CTR) is read, the bit values are provided by the internal output data latch. These bit values can be superseded by the logic level of the STB, AFD, INIT, and SLIN signals, if these signals are forced high or low by external voltage. To force these signals high or low the corresponding bits should be set to their inactive states (e.g., AFD, STB and SLIN should all be 0; INIT should be 1).

Section 6.3.10 describes the transfer operations that are possible in EPP modes.

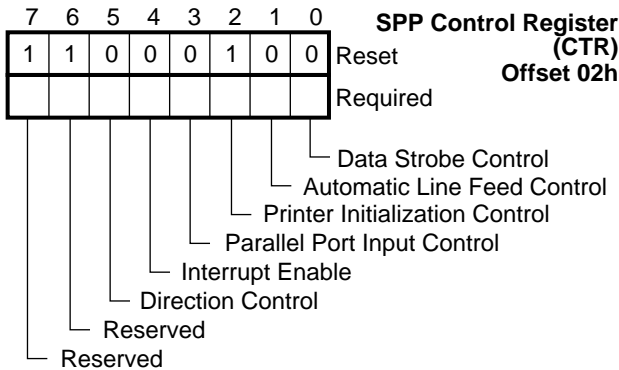


FIGURE 6-3. CTR Register Bitmap (SPP Mode)

Bit 0 - Data Strobe Control

Bit 0 directly controls the data strobe signal to the printer via the $\overline{\text{STB}}$ signal.

This bit is the inverse of the $\overline{\text{STB}}$ signal.

Bit 1 - Automatic Line Feed Control

This bit directly controls the automatic line feed signal to the printer via the $\overline{\text{AFD}}$ pin. Setting this bit high causes the printer to automatically feed after each line is printed.

- This bit is the inverse of the $\overline{\text{AFD}}$ signal.
- 0 - No automatic line feed. (Default)
 - 1 - Automatic line feed

Bit 2 - Printer Initialization Control

This bit directly controls the signal to initialize the printer via the $\overline{\text{INIT}}$ pin. Setting this bit to low initializes the printer.

- The value of the $\overline{\text{INIT}}$ signal reflects the value of this bit. The default setting of 1 on this bit prevents printer initialization in SPP mode, and enables ECP mode after reset.
- 0 - Initialize Printer.
 - 1 - No action (Default).

Bit 3 - Select Input Signal Control

This bit directly controls the select in signal to the printer via the SLIN signal. Setting this bit high selects the printer.

- It is the inverse of the $\overline{\text{SLIN}}$ signal.
- This bit must be cleared to 0 before enabling the EPP or ECP mode.
- 0 - Printer not selected. (Default)
 - 1 - Printer selected and online.

Bit 4 - Interrupt Enable

Bit 4 controls the interrupt generated by the $\overline{\text{ACK}}$ signal. Its function changes slightly depending on the parallel port mode selected.

In ECP mode, this bit should be set to 0.

In the following description, IRQx indicates an interrupt allocated for the parallel port.

- 0 - In SPP Compatible, SPP Extended and EPP modes, IRQx is floated. (Default)
- 1 - In SPP Compatible mode, IRQx follows $\overline{\text{ACK}}$ transitions. In SPP Extended mode, IRQx is set active on the trailing edge of ACK. In EPP modes, IRQx follows $\overline{\text{ACK}}$ transitions, or is set when an EPP time-out occurs.

Bit 5 - Direction Control

This bit determines the direction of the parallel port in SPP Extended mode only. In the (default) SPP Compatible mode, this bit has no effect, since the port functions for output only.

This is a read/write bit in EPP modes. In SPP modes it is a write only bit. A read from it returns 1.

In SPP Compatible mode and in EPP modes it does not control the direction. See Table 6-4.

- 0 - Data output to PD7-0 in SPP Extended mode during write cycles. (Default)
- 1 - Data input from PD7-0 in SPP Extended mode during read cycles.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

6.3 ENHANCED PARALLEL PORT (EPP) MODES

EPP modes allow greater throughput than SPP modes by supporting faster transfer times (8, 16 or 32-bit data transfers in a single read or write operation) and a mechanism that allows the system to address peripheral device registers directly. Faster transfers are achieved by automatically generating the address and data strobes.

The connector pin assignments for these modes are listed in Table 6-12 on page 134.

EPP modes support revision 1.7 and revision 1.9 of the IEEE 1284 standard, as shown in Table 6-1.

In Legacy mode, EPP modes are supported for a parallel port whose base address is 278h or 378h, but not for a parallel port whose base address is 3BCh. (There are no EPP registers at 3BFh.) In both Legacy and Plug and Play modes, bits 2, 1 and 0 of the parallel port base address must be 000 in EPP modes.

SPP-type data transactions may be conducted in EPP modes. The appropriate registers are available for this type of transaction. (See Table 6-5.) As in the SPP modes, software must generate the control signals required to send or receive data.

6.3.1 Enhanced Parallel Port (EPP) Register Set

Table 6-5 lists the EPP registers. All are single-byte registers.

Bits 0, 1 and 3 of the CTR register must be 0 and bit 2 must be 1 before the EPP registers can be accessed, since the signals controlled by these bits are controlled by hardware during EPP accesses. Once these bits are set to 0 by the software driver, multiple EPP access cycles may be invoked.

When EPP modes are enabled, the software can perform SPP Extended mode cycles. In other words, if there is no access to one of the EPP registers, EPP Address (ADDR) or EPP Data Registers 0-3 (DATA0-3), EPP modes behave like SPP Extended mode, except for the interrupt, which is pulse triggered instead of level triggered.

Bit 7 of STR ($\overline{\text{BUSY}}$ status) must be set to 1 before writing to DTR in EPP modes to ensure data output to PD7-0.

The enhanced parallel port monitors the IOCHRDY signal during EPP cycles. If IOCHRDY is driven low for more than 10 μsec , an EPP time-out event occurs, which aborts the cycle by asserting IOCHRDY, thus releasing the system from a stuck EPP peripheral device. (This time-out event is only functional when the clock is applied to this logical device).

When the cycle is aborted, $\overline{\text{ASTRB}}$ or $\overline{\text{DSTRB}}$ becomes inactive, and the time-out event is signaled by asserting bit 0 of STR. If bit 4 of CTR is 1, the time-out event also pulses the IRQ5 or IRQ7 signals when enabled. (IRQ5 and IRQ7 can be routed to any other IRQ lines via the Plug and Play block).

EPP cycles to the external device are activated by invoking read or write cycles to the EPP.

TABLE 6-5. Enhanced Parallel Port (EPP) Registers

Offset	Name	Description	Mode	R/W
00h	DTR	SPP Data	SPP or EPP	R/W
01h	STR	SPP Status	SPP or EPP	R
02h	CTR	SPP Control	SPP or EPP	R/W
03h	ADDR	EPP Address	EPP	R/W
04h	DATA0	EPP Data Port 0	EPP	R/W
05h	DATA1	EPP Data Port 1	EPP	R/W
06h	DATA2	EPP Data Port 2	EPP	R/W
07h	DATA3	EPP Data Port 3	EPP	R/W

6.3.2 SPP or EPP Data Register (DTR), Offset 00h

The DTR register is the SPP Compatible or SPP Extended data register. A write to DTR sets the state of the eight data pins on the 25-pin D-shell connector.

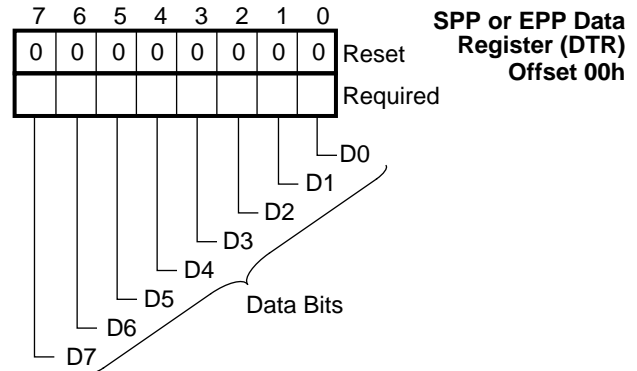


FIGURE 6-4. SPP or EPP DTR Register Bitmap

6.3.3 SPP or EPP Status Register (STR), Offset 01h

This status port is read only. A read presents the current status of the five pins on the 25-pin D-shell connector, and the IRQ as shown in Figure 6-5.

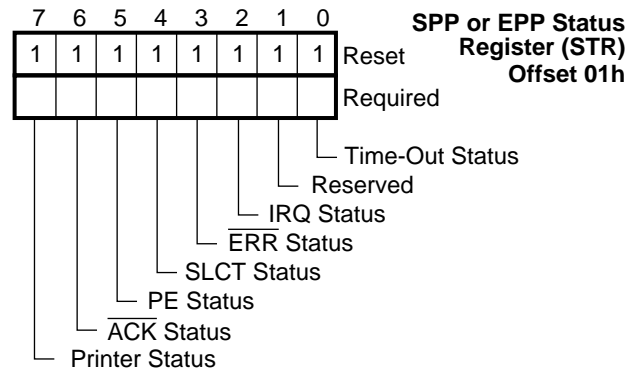


FIGURE 6-5. SPP or EPP STR Register Bitmap

The bits of this register have the identical function in EPP mode as in SPP mode. See Section 6.2.3 for a detailed description of each bit.

6.3.4 SPP or EPP Control Register (CTR), Offset 02h

This control port is read or write. A write operation to it sets the state of four pins on the 25-pin D-shell connector, and controls both the parallel port interrupt enable and direction.

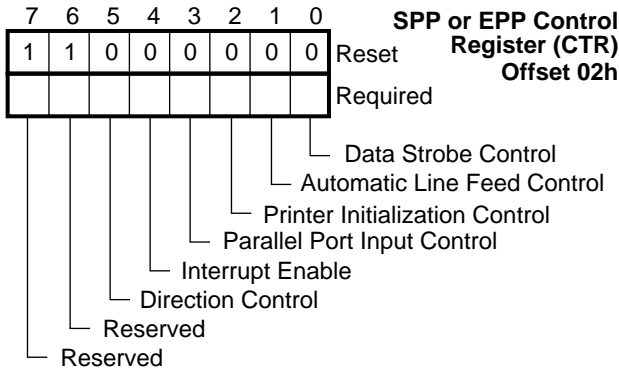


FIGURE 6-6. SPP or EPP CTR Register Bitmap

The bits of this register have the identical function in EPP modes as in SPP modes. See Section 6.2.4 for a detailed description of each bit.

6.3.5 EPP Address Register (ADDR), Offset 03h

This port is added in EPP modes to enhance system throughput by enabling registers in the remote device to be directly addressed by hardware.

This port can be read or written. Writing to it initiates an EPP device or register selection operation.

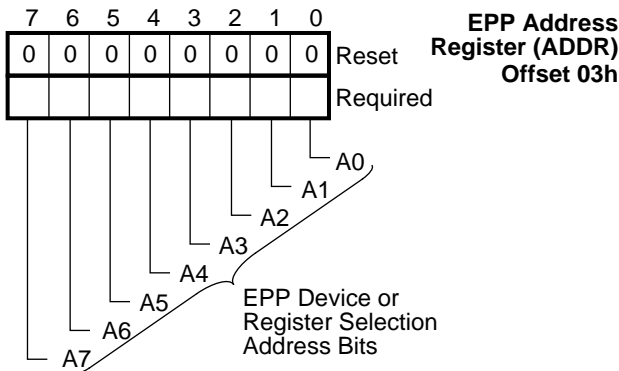


FIGURE 6-7. EPP ADDR Register Bitmap

6.3.6 EPP Data Register 0 (DATA0), Offset 04h

DATA0 is a read/write register. Accessing it initiates device read or write operations of bits 7 through 0.

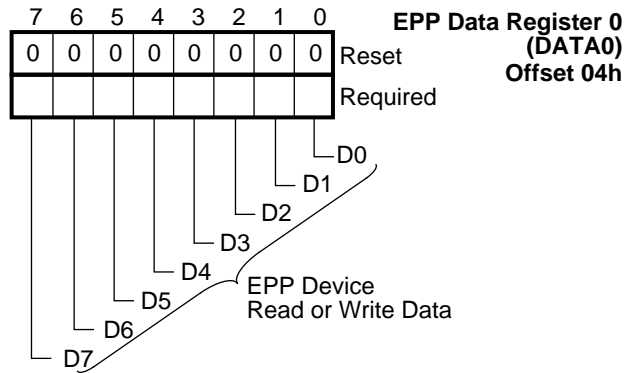


FIGURE 6-8. EPP DATA0 Register Bitmap

6.3.7 EPP Data Register 1 (DATA1), Offset 05h

DATA1 is only accessed to transfer bits 15 through 8 of a 16/32-bit read or write to EPP Data Register 0 (DATA0).

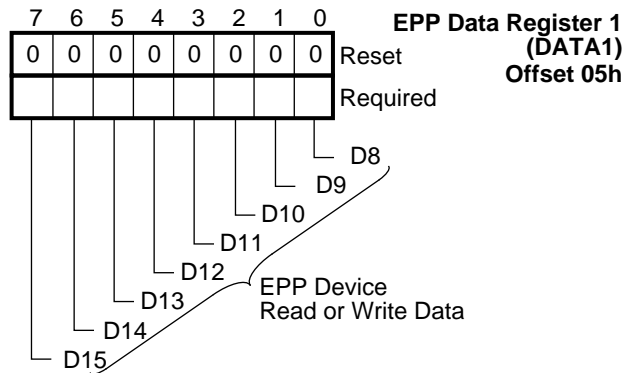


FIGURE 6-9. EPP DATA1 Register Bitmap

6.3.8 EPP Data Register 2 (DATA2), Offset 06h

This is the third EPP data register. It is only accessed to transfer bits 23 through 16 of a 32-bit read or write to EPP Data Register 0 (DATA0).

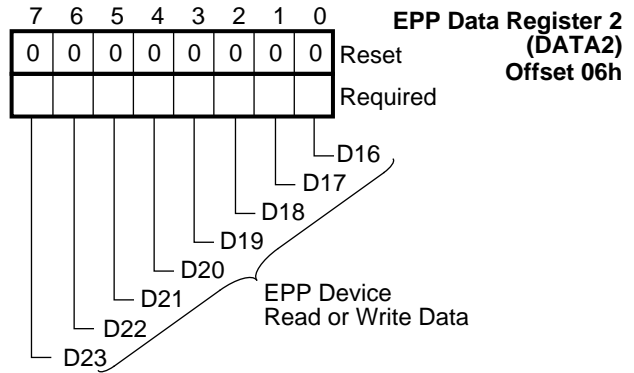


FIGURE 6-10. EPP DATA2 Register Bitmap

6.3.9 EPP Data Register 3 (DATA3), Offset 07h

This is the fourth EPP data register. It is only accessed to transfer bits 31 through 24 of a 32-bit read or write to EPP Data Register 0 (DATA0).

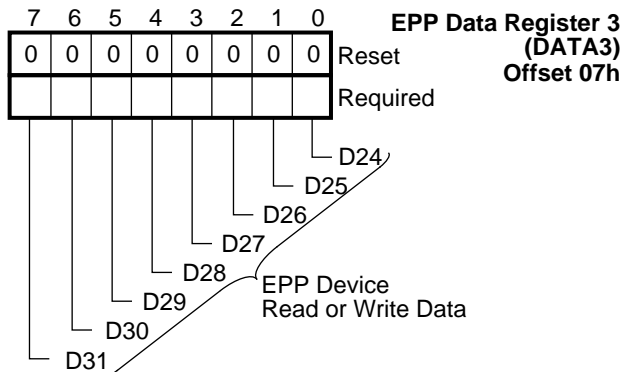


FIGURE 6-11. EPP DATA3 Register Bitmap

6.3.10 EPP Mode Transfer Operations

The EPP transfer operations are address read or write, and data read or write. An EPP transfer is composed of a system read or write cycle from or to an EPP register, and an EPP read or write cycle from a peripheral device to an EPP register or from an EPP register to a peripheral device.

EPP 1.7 Address Write

The following procedure selects a peripheral device or register as illustrated in Figure 6-12.

1. The system writes a byte to the EPP Address register. \overline{WR} becomes low to latch D7-0 into the EPP Address register. The latch drives the EPP Address register onto PD7-0 and the EPP pulls \overline{WRITE} low.
2. The EPP pulls \overline{ASTRB} low to indicate that data was sent.
3. If \overline{WAIT} was low during the system write cycle, $\overline{IOCHRDY}$ becomes low. When \overline{WAIT} becomes high, the EPP pulls $\overline{IOCHRDY}$ high.
4. When $\overline{IOCHRDY}$ becomes high, it causes \overline{WR} to become high. If \overline{WAIT} is high during the system write cycle, then the EPP does not pull $\overline{IOCHRDY}$ to low.
5. When \overline{WR} becomes high, it causes the EPP to pull first \overline{ASTRB} and then \overline{WRITE} to high. The EPP can change PD7-0 only when \overline{WRITE} and \overline{ASTRB} are both high.

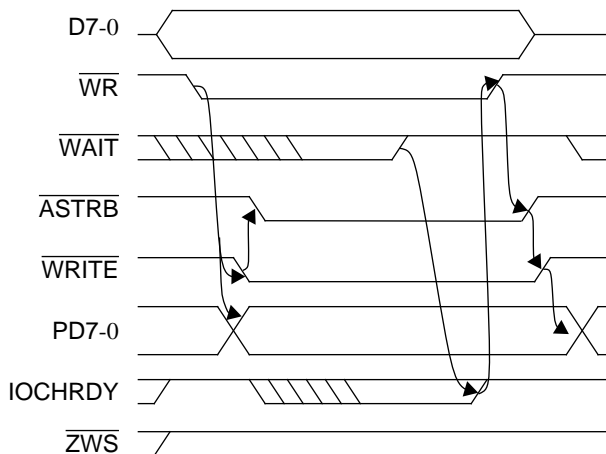


FIGURE 6-12. EPP 1.7 Address Write

EPP 1.7 Address Read

The following procedure reads from the EPP Address register as shown in Figure 6-13.

1. The system reads a byte from the EPP Address register. \overline{RD} goes low to gate PD7-0 into D7-0.
2. The EPP pulls \overline{ASTRB} low to signal the peripheral to start sending data.
3. If \overline{WAIT} is low during the system read cycle. Then the EPP pulls $\overline{IOCHRDY}$ low. When \overline{WAIT} becomes high, the EPP stops pulling $\overline{IOCHRDY}$ to low.
4. When $\overline{IOCHRDY}$ becomes high, it causes \overline{RD} to become high. If \overline{WAIT} is high during the system read cycle then the EPP does not pull $\overline{IOCHRDY}$ to low.
5. When \overline{RD} becomes high, it causes the EPP to pull \overline{ASTRB} high. The EPP can change PD7-0 only when \overline{ASTRB} is high. After \overline{ASTRB} becomes high, the EPP puts D7-0 in TRI-STATE.

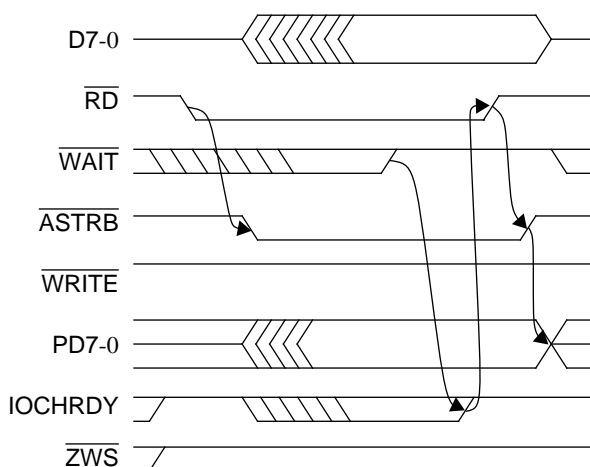


FIGURE 6-13. EPP 1.7 Address Read

EPP 1.7 Data Write and Read

This procedure writes to the selected peripheral device or register.

EPP 1.7 data read or write operations are similar to EPP 1.7 Address register read or write operations, except that the data strobe ($\overline{\text{DSTRB}}$ signal), and the EPP Data register, replace the address strobe ($\overline{\text{ASTRB}}$ signal) and the EPP Address register, respectively.

EPP Revision 1.7 and 1.9 Zero Wait State (ZWS) Address Write and Read Operations

The following procedure performs a short write to the selected peripheral device or register. See also Figure 6-14.

1. The system writes a byte to the EPP Address register. $\overline{\text{WR}}$ becomes low to latch D7-0 into the EPP Data register. The latch drives the EPP Data register to PD7-0.
2. The EPP first pulls $\overline{\text{WRITE}}$ low, and then pulls $\overline{\text{ASTRB}}$ low to indicate that data has been sent.
3. If $\overline{\text{WAIT}}$ was high during the system write cycle, $\overline{\text{ZWS}}$ goes low and IOCHR DY stays high.
4. When the system pulls $\overline{\text{WR}}$ high, the EPP pulls $\overline{\text{ASTRB}}$, $\overline{\text{ZWS}}$ and then $\overline{\text{WRITE}}$ to high. The EPP can change PD7-0 only when $\overline{\text{WRITE}}$ and $\overline{\text{ASTRB}}$ are high.
5. If the peripheral is fast enough to pull $\overline{\text{WAIT}}$ low before the system terminates the write cycle, the EPP pulls IOCHR DY to low, but does not pull $\overline{\text{ZWS}}$ to low, thus carrying out a normal (non-ZWS EPP 1.7) write operation.

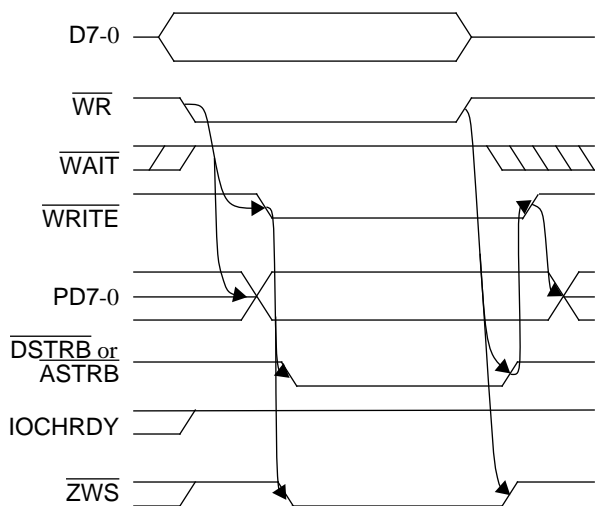


FIGURE 6-14. EPP Write with Zero Wait States

A read operation is similar, except for the data direction, activation of $\overline{\text{RD}}$ instead of $\overline{\text{WR}}$, and $\overline{\text{WRITE}}$ stays high.

6.3.11 EPP 1.7 and 1.9 Zero Wait State Data Write and Read Operations

EPP 1.7 zero wait state data write and read operations are similar to EPP zero wait state address write and read operations, with the exception that the data strobe ($\overline{\text{DSTRB}}$ signal), and a data register, replace the address strobe ($\overline{\text{ASTRB}}$ signal) and the address register, respectively.

EPP 1.9 Address Write

The following procedure selects a peripheral or register as shown in Figure 6-15.

1. The system writes a byte to the EPP Address register.
2. The EPP pulls IOCHR DY low, and waits for $\overline{\text{WAIT}}$ to become low.
3. When $\overline{\text{WAIT}}$ becomes low, the EPP pulls $\overline{\text{WRITE}}$ to low and drives the latched byte onto PD7-0. If $\overline{\text{WAIT}}$ was already low, steps 2 and 3 occur concurrently.
4. The EPP pulls $\overline{\text{ASTRB}}$ low and waits for $\overline{\text{WAIT}}$ to become high.
5. When $\overline{\text{WAIT}}$ becomes high, the EPP stops pulling IOCHR DY low, and waits for $\overline{\text{WR}}$ to become high.
6. When $\overline{\text{WR}}$ becomes high, the EPP pulls $\overline{\text{ASTRB}}$ high, and waits for $\overline{\text{WAIT}}$ to become low.
7. If no EPP write is pending when $\overline{\text{WAIT}}$ becomes low, the EPP pulls $\overline{\text{WRITE}}$ to high. Otherwise, $\overline{\text{WRITE}}$ remains low, and the EPP may change PD7-0.

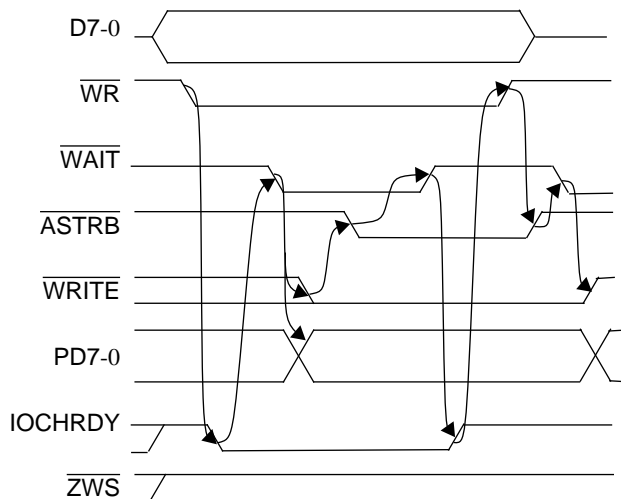


FIGURE 6-15. EPP 1.9 Address Write

EPP 1.9 Address Read

The following procedure reads from the address register.

1. The system reads a byte from the EPP address register. When $\overline{\text{RD}}$ becomes low, the EPP pulls IOCHR DY low, and waits for $\overline{\text{WAIT}}$ to become low.
2. When $\overline{\text{WAIT}}$ becomes low, the EPP pulls $\overline{\text{ASTRB}}$ low and waits for $\overline{\text{WAIT}}$ to become high. If $\overline{\text{WAIT}}$ was already low, steps 2 and 3 occur concurrently.
3. When $\overline{\text{WAIT}}$ becomes high, the EPP stops pulling IOCHR DY low, and waits for $\overline{\text{RD}}$ to become high.
4. When $\overline{\text{RD}}$ becomes high, the EPP latches PD7-0 (to provide sufficient hold time), pulls $\overline{\text{ASTRB}}$ high, and puts D7-0 in TRI-STATE.

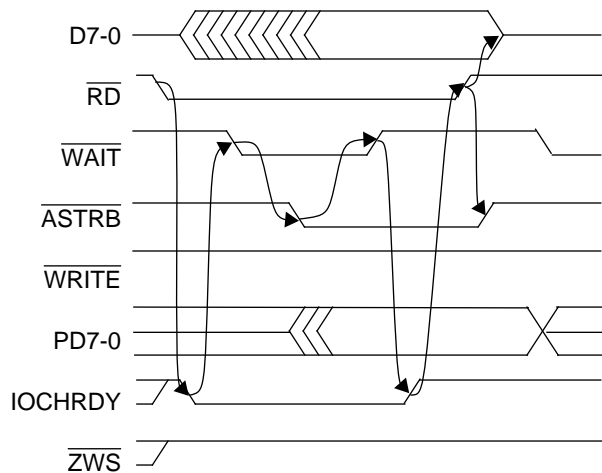


FIGURE 6-16. EPP 1.9 Address Read

EPP 1.9 Data Write and (Backward) Data Read

This procedure writes to the selected peripheral drive or register.

EPP 1.9 data read and write operations are similar to EPP 1.9 address read and write operations, except that the data strobe (DSTRB signal) and EPP Data register replace the address strobe (ASTRB signal) and the EPP Address register, respectively.

6.4 EXTENDED CAPABILITIES PARALLEL PORT (ECP)

In the Extended Capabilities Port (ECP) modes, the device is a state machine that supports a 16-byte FIFO that can be configured for either direction, command and data FIFO tags (one per byte), a FIFO threshold interrupt for both directions, FIFO empty and full status bits, automatic generation of strobes (by hardware) to fill or empty the FIFO, transfer of commands and data, and Run Length Encoding (RLE) expanding (decompression) as explained below. The FIFO can be accessed by PIO or system DMA cycles.

6.4.1 ECP Modes

ECP modes are enabled as described in Table 6-1 on page 112. The ECP mode is selected at reset by setting bits 7-5 of the SuperI/O Parallel Port Configuration register at index F0h (see Section 2.7.1 on page 37) to 100 or 111. Thereafter, the mode is controlled via the bits 7-5 of the ECP Extended Control Register (ECR) at offset 402h of the parallel port. See Section 6.5.12 on page 124.

Table 6-9 lists the ECP modes. See Table 6-11 on page 129 and Section 6.6 on page 128 for more detailed descriptions of these modes.

6.4.2 Software Operation

Software should operate as described in “*Extended Capabilities Port Protocol and ISA Interface Standard*”.

Some of these operations are:

- Software should enable ECP after bits 3-0 of the parallel port Control Register (CTR) are set to 0100.

- When ECP is enabled, software should switch modes only through modes 000 or 001.
 - When ECP is enabled, the software should change direction only in mode 001.
 - Software should not switch from mode 010 or 011, to mode 000 or 001, unless the FIFO is empty.
 - Software should switch to mode 011 when bits 0 and 1 of DCR are 0.
 - Software should switch to mode 010 when bit 0 of DCR is 0.
 - Software should disable ECP only in mode 000 or 001.
5. Software should switch to mode 100 when bits 0, 1 and 3 of the DCR are 0.
 6. Software should switch from mode 100 to mode 000 or 001 only when bit 7 of the DSR (BUSY) is 1. Otherwise, an on-going EPP cycle can be aborted.
 7. When the ECP is in mode 100, software should write 0 to bit 5 of the DCR before performing EPP cycles.

Software may switch from mode 011 backward to modes 000 or 001, when there is an on-going ECP read cycle. In this case, the read cycle is aborted by deasserting AFD. The FIFO is reset (empty) and a potential byte expansion (RLE) is automatically terminated since the new mode is 000 or 001.

6.4.3 Hardware Operation

The \overline{ZWS} signal is asserted by the ECP when ECP modes are enabled, and an ECP register is accessed by system PIO instructions, thus using a system zero wait states cycle (except during read cycles from ECR).

The ECP uses an internal clock, which can be frozen to reduce power consumption during power down. In this power-down state the DMA is disabled, all interrupts (except ACK) are masked, and the FIFO registers are not accessible (access is ignored). The other ECP registers are unaffected by power-down and are always accessible when the ECP is enabled. During power-down the FIFO status and contents become inaccessible, and the system reads bit 2 of ECR as 0, bit 1 of ECR as 1 and bit 0 of ECR as 1, regardless of the actual values of these bits. The FIFO status and contents are not lost, however, and when the clock activity resumes, the values of these bits resume their designated functions.

When the clock is frozen, an on-going ECP cycle may be corrupted, but the next ECP cycle will not start even if the FIFO is not empty in the forward direction, or not full in the backward direction. If the ECP clock starts or stops toggling during a system cycle that accesses the FIFO, the cycle may yield wrong data.

ECP output signals are inactive when the ECP is disabled.

Only the FIFO, DMA and RLE do not function when the clock is frozen. All other registers are accessible and functional. The FIFO, DMA and RLE are affected by ECR modifications, i.e., they are reset when exits from modes 010 or 011 are carried out even while the clock is frozen.

6.5 ECP MODE REGISTERS

The ECP registers are each a byte wide, and are listed in Table 6-6 in order of their offsets from the base address of the parallel port. In addition, the ECP has control registers at second level offsets, that are accessed via the EIR and EDR registers. See Section 6.5.2 on page 120.

TABLE 6-6. Extended Capabilities Parallel Port (ECP) Registers

Offset	Symbol	Description	Modes (ECR Bits)	R/W
			7 6 5	
000h	DATAR	Parallel Port Data Register	0 0 0 0 0 1	R/W
000h	AFIFO	ECP Address FIFO	0 1 1	W
001h	DSR	Status Register	All Modes	R
002h	DCR	Control Register	All Modes	R/W
400h	CFIFO	Parallel Port Data FIFO	0 1 0	W
400h	DFIFO	ECP Data FIFO	0 1 1	R/W
400h	TFIFO	Test FIFO	1 1 0	R/W
400h	CNFGA	Configuration Register A	1 1 1	R
401h	CNFGB	Configuration Register B	1 1 1	R
402h	ECR	Extended Control Register	All Modes	R/W
403h	EIR	Extended Index Register	All Modes	R/W
404h	EDR	Extended Data Register	All Modes	R/W
405h	EAR	Extended Auxiliary Status Register	All Modes	R/W
Control Registers at Second Level Offsets				
00h		Control0	All Modes	R/W
02h		Control2	All Modes	R/W
04h		Control4	All Modes	R/W
05h		PP Config0	All Modes	R/W

6.5.1 Accessing the ECP Registers

The AFIFO, CFIFO, DFIFO and TFIFO registers access the same ECP FIFO. The FIFO is accessed at Base + 000h, or Base + 400h, depending on the mode field of ECR and the register.

The FIFO can be accessed by system DMA cycles, as well as system PIO cycles.

When the DMA is configured and enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically (by hardware) issues DMA requests to fill the FIFO (in the forward direction when bit 5 of DCR is 0) or to empty the FIFO (in the backward direction when bit 5 of DCR is 1). All DMA transfers are to or from these registers. The ECP does not assert DMA requests for more than 32 consecutive DMA cycles. The ECP stops requesting the DMA when TC is detected during an ECP DMA cycle.

A "Demand DMA" feature reduces system overhead caused by DMA data transfers. When this feature is enabled by bit 6 of the PP Config0 register at second level offset 05h, it prevents servicing of DMA requests until after four have accumulated and are held pending. See "Bit 6 - Demand DMA Enable" on page 128.

Writing into a full FIFO, and reading from an empty FIFO, are ignored. The written data is lost, and the read data is undefined. The FIFO empty and full status bits are not affected by such accesses.

Some registers are not accessible in all modes of operation, or may be accessed in one direction only. Accessing a non accessible register has no effect. Data read is undefined; data written is ignored; and the FIFO does not update. The SPP registers (DTR, STR and CTR) are not accessible when the ECP is enabled.

To improve noise immunity in ECP cycles, the state machine does not examine the control handshake response lines until the data has had time to switch.

In ECP modes:

- DATAR replaces DTR of SPP/EPP
- DSR replaces STR of SPP/EPP
- DCR replaces CTR of SPP/EPP

6.5.2 Second Level Offsets

The EIR, EDR, and EAR registers support enhanced control and status features. When bit 4 of the Parallel Port Configuration register is 1 (as described in Section 2.7.1 on page 37), EIR and EDR serve as index and data registers, respectively.

EIR and EDR at offsets 403 and 404, respectively, access the control registers (Control0, Control2, Control4 and PP Config0) at second level offsets 00h, 02h, 04h and 05h, respectively. These control registers are functional only. Accessing these registers is possible when bit 4 of the SuperI/O Parallel Port Configuration register at index F0h of logical device 4 is 1 and when bit 2 or 10 of the base address is 1.

**6.5.3 ECP Data Register (DATAR),
Bits 7-5 of ECR = 000 or 001, Offset 000h**

The ECP Data Register (DATAR) register is the same as the DTR register (see Section 6.2.2), except that a read always returns the values of the PD7-0 signals instead of the register latched data.

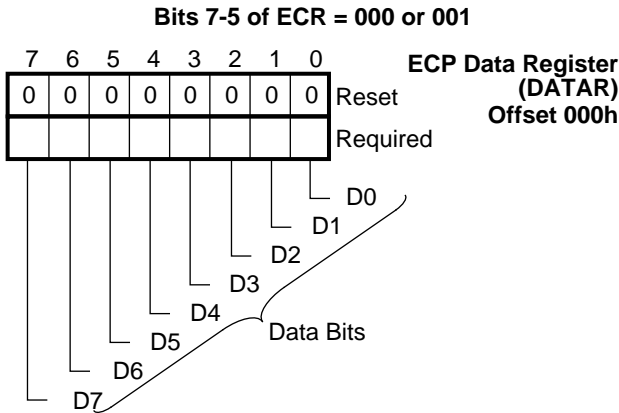


FIGURE 6-17. DATAR Register Bitmap

**6.5.4 ECP Address FIFO (AFIFO) Register,
Bits 7-5 of ECR = 011, Offset 000h**

The ECP Address FIFO Register (AFIFO) is write only. In the forward direction (when bit 5 of DCR is 0) a byte written into this register is pushed into the FIFO and tagged as a command.

Reading this register returns undefined contents. Writing to this register in a backward direction (when bit 5 of DCR is 1) has no effect and the data is ignored.

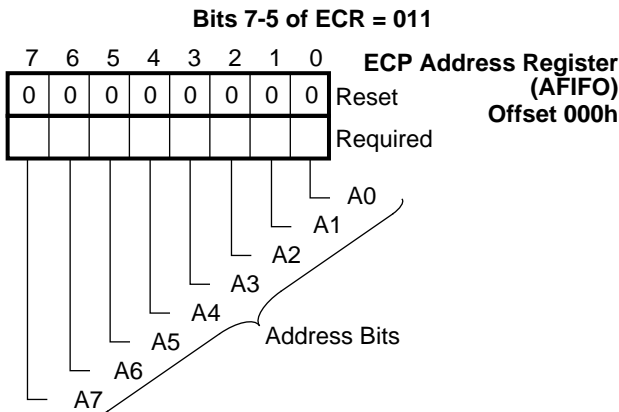


FIGURE 6-18. AFIFO Register Bitmap

6.5.5 ECP Status Register (DSR), Offset 001h

This read-only register displays device status. Writes to this DSR have no effect and the data is ignored.

This register should not be confused with the DSR register of the Floppy Disk Controller (FDC).

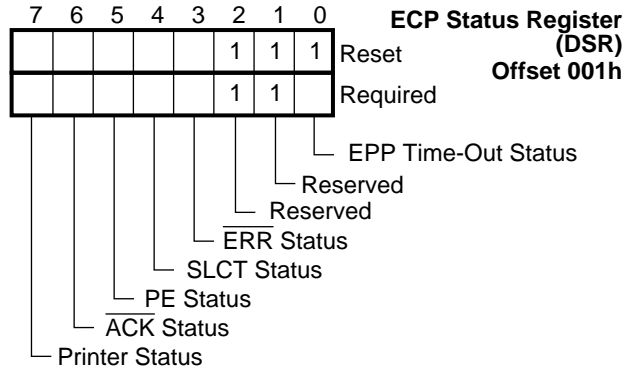


FIGURE 6-19. ECP DSR Register Bitmap

Bits 0 - EPP Time-Out Status

In EPP modes only, this is the time-out status bit. In all other modes this bit has no function and has the constant value 1.

This bit is cleared when an EPP mode is enabled. Thereafter, this bit is set to 1 when a time-out occurs in an EPP cycle and is cleared when DSR is read.

In EPP modes:

- 0 - An EPP mode is set. No time-out occurred since DSR was last read.
- 1 - Time-out occurred on EPP cycle (minimum of 10 μ sec). (Default)

Bits 2,1 - Reserved

These bits are reserved and are always 1.

Bit 3 - $\overline{\text{ERR}}$ Status

This bit reflects the status of the $\overline{\text{ERR}}$ signal.

- 0 - Printer error.
- 1 - No printer error.

Bit 4 - SLCT Status

This bit reflects the status of the Select signal. The printer sets this signal high when it is online and selected

- 0 - Printer not selected. (Default)
- 1 - Printer selected and on-line.

Bit 5 - PE Status

This bit reflects the status of the Paper End (PE) signal.

- 0 - Paper not ended.
- 1 - No paper in printer.

Bit 6 - $\overline{\text{ACK}}$ Status

This bit reflects the status of the $\overline{\text{ACK}}$ signal. This signal is pulsed low after a character is received.

- 0 - Character received.
- 1 - No character received. (Default)

Bit 7 -Printer Status

This bit reflects the inverse of the state of the BUSY signal.
 0 - Printer is busy (cannot accept another character now).
 1 - Printer not busy (ready for another character).

6.5.6 ECP Control Register (DCR), Offset 002h

Reading this register returns the register content (not the signal values, as in SPP mode).

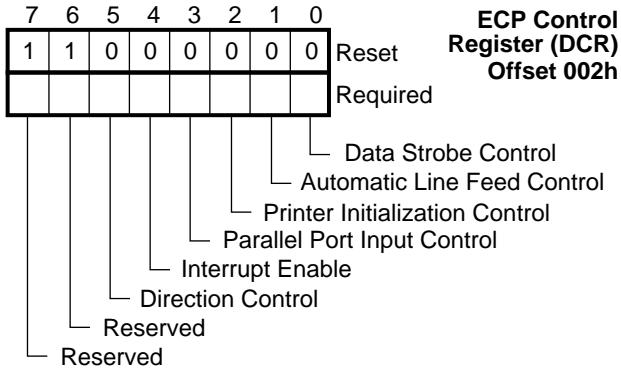


FIGURE 6-20. DCR Register Bitmap

Bit 0 - Data Strobe Control

Bit 0 directly controls the data strobe signal to the printer via the \overline{STB} signal. It is the inverse of the \overline{STB} signal.
 0 - The \overline{STB} signal is inactive in all modes except 010 and 011. In these modes, it may be active or inactive as set by the software.
 1 - In all modes, \overline{STB} is active.

Bit 1 - Automatic Line Feed Control

This bit directly controls the automatic feed XT signal to the printer via the \overline{AFD} signal. Setting this bit high causes the printer to automatically feed after each line is printed. This bit is the inverse of the \overline{AFD} signal.
 In mode 011, \overline{AFD} is activated by both ECP hardware and by software using this bit.
 0 - No automatic line feed. (Default)
 1 - Automatic line feed.

Bit 2 - Printer Initialization Control

Bit 2 directly controls the signal to initialize the printer via the INIT signal. Setting this bit to low initializes the printer. The INIT signal follows this bit.
 0 - Initialize printer. (Default)
 1 - Printer initialized.

Bit 3 - Parallel Port Input Control

This bit directly controls the select input device signal to the printer via the SLIN signal. It is the inverse of the SLIN signal.
 This bit must be set to 1 before enabling the EPP or ECP modes.
 0 - The printer is not selected.
 1 - The printer is selected.

Bit 4 - Interrupt Enable

Bit 4 enables the interrupt generated by the \overline{ACK} signal. In ECP mode, this bit should be set to 0. This bit does not float the IRQ pin.
 0 - Masked. (Default)
 1 - Enabled.

Bit 5 - Direction Control

This bit determines the direction of the parallel port.
 This is a read/write bit in EPP mode. In SPP mode it is a write only bit. A read from it returns 1. In SPP Compatible mode and in EPP mode it does not control the direction. See Table 6-4.
 The ECP drives the PD7-0 pins in the forward direction, but does not drive them in the backward direction.
 This bit is readable and writable. In modes 000 and 010 the direction bit is forced to 0, internally, regardless of the data written into this bit.
 0 - ECP drives forward in output mode. (Default)
 1 - ECP direction is backward.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

6.5.7 Parallel Port Data FIFO (CFIFO) Register, Bits 7-5 of ECR = 010, Offset 400h

The Parallel Port FIFO (CFIFO) register is write only. A byte written to this register by PIO or DMA is pushed into the FIFO and tagged as data.
 Reading this register has no effect and the data read is undefined.

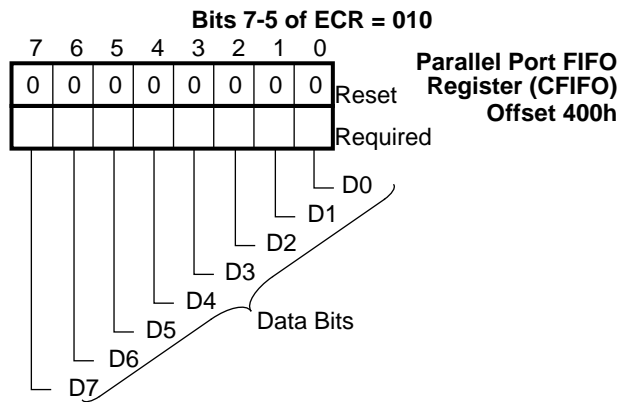


FIGURE 6-21. CFIFO Register Bitmap

6.5.8 ECP Data FIFO (DFIFO) Register, Bits 7-5 of ECR = 011, Offset 400h

This bi-directional FIFO functions as either a write-only device when bit 5 of DCR is 0, or a read-only device when it is 1.
 In the forward direction (bit 5 of DCR is 0), a byte written to the ECP Data FIFO (DFIFO) register by PIO or DMA is pushed into the FIFO and tagged as data. Reading this register when set for write-only has no effect and the data read is undefined.
 In the backward direction (bit 5 of DCR is 1), the ECP automatically issues ECP read cycles to fill the FIFO.

Reading from this register pops a byte from the FIFO. Writing to this register when it is set for read-only has no effect, and the data written is ignored.

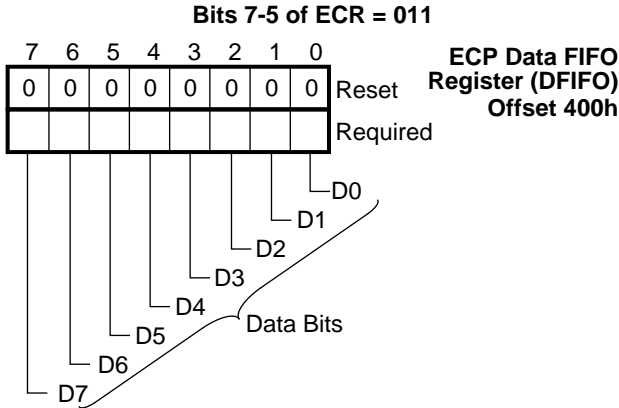


FIGURE 6-22. DFIFO Register Bitmap

6.5.9 Test FIFO (TFIFO) Register, Bits 7-5 of ECR = 110, Offset 400h

A byte written into the Test FIFO (TFIFO) register is pushed into the FIFO. A byte read from this register is popped from the FIFO. The ECP does not issue an ECP cycle to transfer the data to or from the peripheral device.

The TFIFO is readable and writable in both directions. In the forward direction (bit 5 of DCR is 0) PD7-0 are driven, but the data is undefined.

The FIFO does not stall when overwritten or underrun (access is ignored). Bytes are always read from the top of the FIFO, regardless of the direction bit setting (bit 5 of DCR). For example if 44h, 33h, 22h, 11h is written into the FIFO, reading the FIFO returns 44h, 33h, 22h, 11h (in the same order it was written).

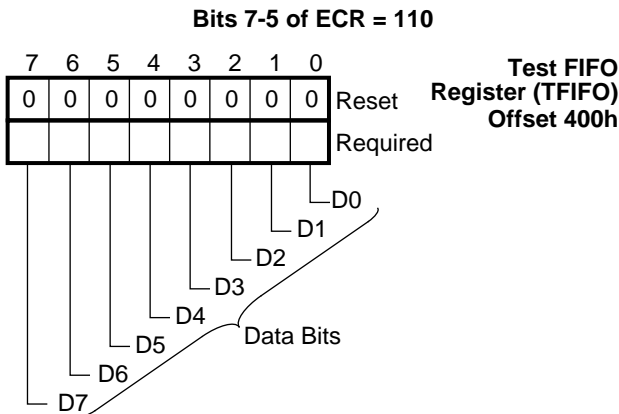


FIGURE 6-23. TFIFO Register Bitmap

6.5.10 Configuration Register A (CNFGA), Bits 7-5 of ECR = 111, Offset 400h

This register is read only. Reading CNFGA always returns 100 on bits 2 through 0 and 0001 on bits 7 through 4.

Writing this register has no effect and the data is ignored.

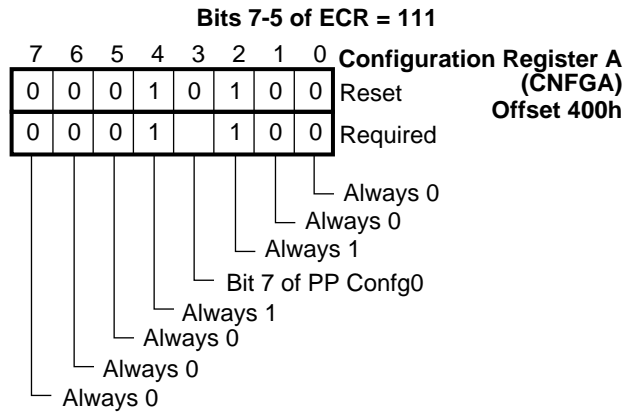


FIGURE 6-24. CNFGA Register Bitmap

Bits 2-0 - Reserved

These bits are reserved and are always 100.

Bit 3 - Bit 7 of PP Config0

This bit reflects the value of bit 7 of the ECP PP Config0 register (second level offset 05h), which has no specific function. Whatever value is put in bit 7 of PP Config0 will appear in this bit.

This bit reflects a specific system configuration parameter, as opposed to other devices, e.g., 8-bit data word length.

Bit 7-4 - Reserved

These bits are reserved and are always 0001.

6.5.11 Configuration Register B (CNFGB), Bits 7-5 of ECR = 111, Offset 401h

Configuration register B (CNFGB) is read only. Reading this register returns the configured parallel port interrupt line and DMA channel, and the state of the interrupt line.

Writing to this register has no effect and the data is ignored.

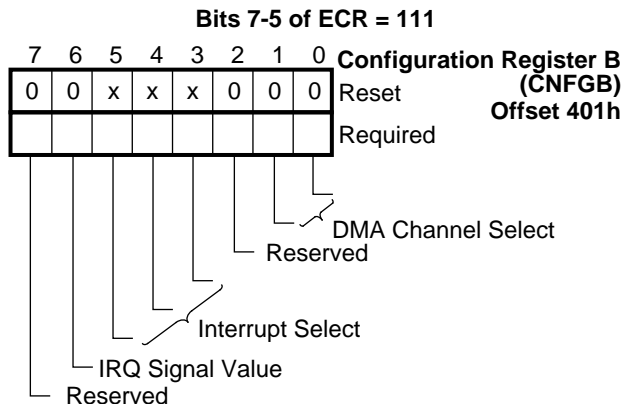


FIGURE 6-25. CNFGB Register Bitmap

Bits 1,0 - DMA Channel Select

These bits reflect the value of bits 1,0 of the PP Config0 register (second level offset 05h). Microsoft's ECP Protocol and ISA Interface Standard defines these bits as shown in Table 6-7.

Bits 1,0 of PP Config0 are read/write bits, but CNFGB bits are read only.

Upon reset, these bits are initialized to 00.

TABLE 6-7. ECP Mode DMA Selection

Bit 1	Bit 0	DMA Configuration
0	0	8-bit DMA selected by jumpers. (Default)
0	1	DMA channel 1 selected.
1	0	DMA channel 2 selected.
1	1	DMA channel 3 selected.

Bit 2 - Reserved

This bit is reserved and is always 0.

Bits 5-3 - Interrupt Select Bits

These bits reflect the value of bits 5-3 of the PP Config0 register at second level index 05h. Microsoft's ECP Protocol and ISA Interface Standard defines these bits as shown in Table 6-8.

Bits 5-3 of PP Config0 are read/write bits, but CNFGB bits are read only.

Upon reset, these bits have undefined values.

TABLE 6-8. ECP Mode Interrupt Selection

Bit 5	Bit 4	Bit 3	Interrupt Selection
0	0	0	Selected by jumpers.
0	0	1	IRQ7 selected.
0	1	0	IRQ9 selected.
0	1	1	IRQ10 selected.
1	0	0	IRQ11 selected.
1	0	1	IRQ14 selected.
1	1	0	IRQ15 selected.
1	1	1	IRQ5 selected.

Bit 6 - IRQ Signal Value

This bit holds the value of the IRQ signal configured by the Interrupt Select register (index 70h of this logical device).

Bit 7 - Reserved

This bit is reserved and is always 0.

6.5.12 Extended Control Register (ECR), Offset 402h

This register controls the ECP and parallel port functions. On reset this register is initialized to 00010101. IOCHRDY is driven low on an ECR read when the ECR status bits do not hold updated data.

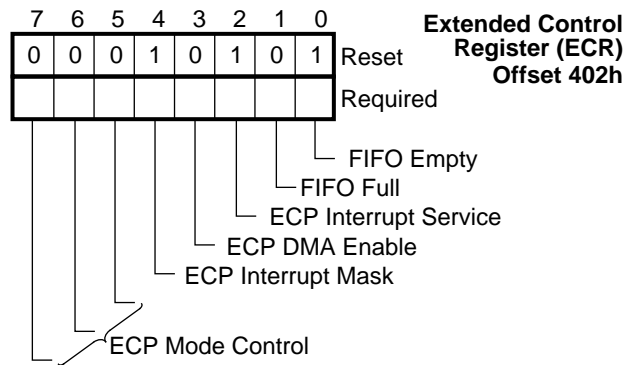


FIGURE 6-26. ECR Register Bitmap

Bit 0 - FIFO Empty

This bit continuously reflects the FIFO state, and therefore can only be read. Data written to this bit is ignored.

When the ECP clock is frozen this bit is read as 1, regardless of the actual FIFO state.

- 0 - The FIFO has at least one byte of data.
- 1 - The FIFO is empty or ECP clock is frozen.

Bit 1 - FIFO Full

This bit continuously reflects the FIFO state, and therefore can only be read. Data written to this bit is ignored.

When the ECP clock is frozen this bit is read as 1, regardless of the actual FIFO state.

- 0 - The FIFO has at least one free byte.
- 1 - The FIFO is full or ECP clock frozen.

Bit 2 - ECP Interrupt Service

This bit enables servicing of interrupt requests. It is set to 1 upon reset, and by the occurrence of interrupt events. It is set to 0 by software.

While this bit is 1, neither the DMA nor the interrupt events listed below will generate an interrupt.

While this bit is 0, the interrupt setup is "armed" and an interrupt is generated on occurrence of an interrupt event.

While the ECP clock is frozen, this bit always returns a 0 value, although it retains its proper value and may be modified.

When one of the following interrupt events occurs while this bit is 0, an interrupt is generated and this bit is set to 1 by hardware.

- DMA is enabled (bit 3 of ECR is 1) and terminal count is reached.
 - FIFO write threshold reached (no DMA - bit 3 of ECR is 0; forward direction (bit 5 of DCR is 0), and there are eight or more bytes free in the FIFO).
 - FIFO read threshold reached (no DMA - bit 3 of ECR is 0; read direction set - bit 5 of DCR is 1, and there are eight or more bytes to read from the FIFO).
- 0 - The DMA and the above interrupts are not disabled.
 - 1 - The DMA and the above three interrupts are disabled.

Bit 3 - ECP DMA Enable

- 0 - The DMA request signal (DRQ3-0) is set to TRI-STATE and the appropriate acknowledge signal (DACK3-0) is assumed inactive.
- 1 - The DMA is enabled and the DMA starts when bit 2 of ECR is 0.

Bit 4 - ECP Interrupt Mask

- 0 - An interrupt is generated on $\overline{\text{ERR}}$ assertion (the high-to-low edge of ERR). An interrupt is also generated while ERR is asserted when this bit is changed from 1 to 0; this prevents the loss of an interrupt between ECR read and ECR write.
- 1 - No interrupt is generated.

Bits 7-5 - ECP Mode Control

These bits set the mode for the ECP device. See Section 6.6 for a more detailed description of operation in each of these ECP modes. The ECP modes are listed in Table 6-9 and described in detail in Table 6-11.

TABLE 6-9. ECP Modes Encoding

ECR Bit Encoding			Mode Name
Bit 7	Bit 6	Bit 5	
0	0	0	Standard
0	0	1	PS/2
0	1	0	Parallel Port FIFO
0	1	1	ECP FIFO
1	0	0	EPP Mode
1	1	0	FIFO Test
1	1	1	Configuration

6.5.13 ECP Extended Index Register (EIR), Offset 403h

The parallel port is partially configured by bits within the logical device address space. These configuration bits are accessed via this read/write register and the Extended Data Register (EDR) (see Section 6.5.14), when bit 4 of the Super/O Parallel Port Configuration register at index F0h of logical device 4 is set to 1. See Section 2.7.1 on page 37.

The configuration bits within the parallel port address space are initialized to their default values on reset, and not when the parallel port is activated.

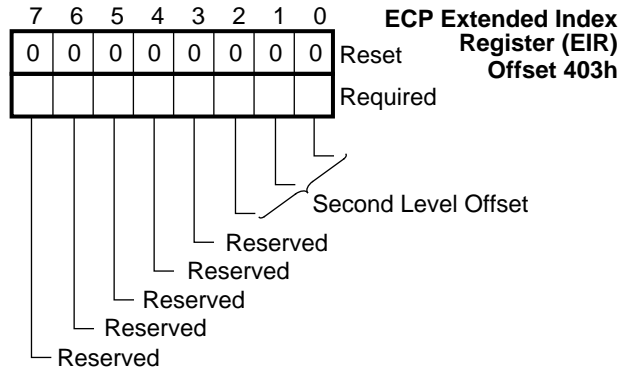


FIGURE 6-27. EIR Register Bitmap

Bits 2-0 - Second Level Offset

Data written to these bits is used as a second level offset for accesses to a specific control register. Second level offsets of 00h, 02h, 04h and 05h are supported. Attempts to access registers at any other offset have no effect.

TABLE 6-10. Second Level Offsets

Second Level Offset	Control Register Name	Described in Section
00h	Control0	6.5.16 on page 126
02h	Control2	6.5.17 on page 126
04h	Control4	6.5.18 on page 127
05h	PP Cnfg0	6.5.19 on page 127

- 000 - Access the Control0 register.
- 010 - Access the Control2 register.
- 100 - Access the Control4 register.
- 101 - Access the PP Cnfg0 register.

Bits 7-3 - Reserved

These bits are treated as 0 for offset calculations. Writing any other value to them has no effect. These bits are read only. They return 00000 on reads and must be written as 00000.

6.5.14 ECP Extended Data Register (EDR), Offset 404h

This read/write register is the data port of the control register indicated by the index stored in the EIR. Reading or writing this register reads or writes the data in the control register whose second level offset is specified by the EIR.

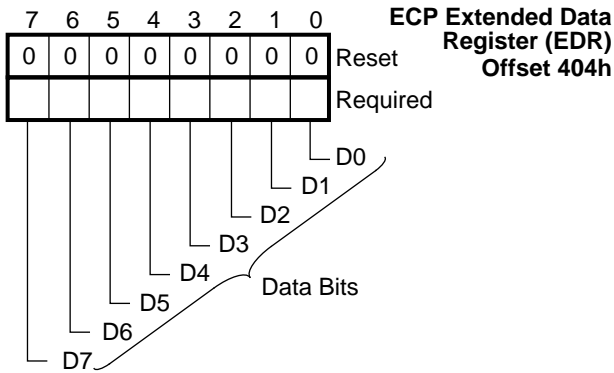


FIGURE 6-28. EDR Register Bitmap

Bits 7-0 - Data Bits

These read/write data bits transfer data to and from the Control Register pointed at by the EIR register.

6.5.15 ECP Extended Auxiliary Status Register (EAR), Offset 405h

Upon reset, this register is initialized to 00h.

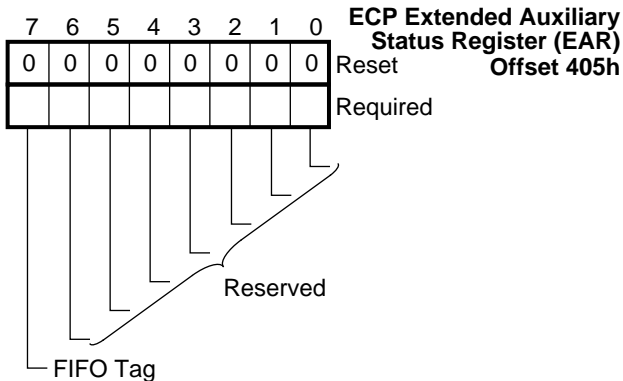


FIGURE 6-29. EAR Register Bitmap

Bits 6-0 - Reserved

These bits are reserved.

Bit 7 - FIFO Tag

Read only. In mode 011, when bit 5 of the DCR is 1 (backward direction), this bit reflects the value of the tag bit (BUSY status) of the word currently in the bottom of the FIFO.

In other modes this bit is indeterminate.

6.5.16 Control0, Second Level Offset 00h

Upon reset, this register is initialized to 00h.

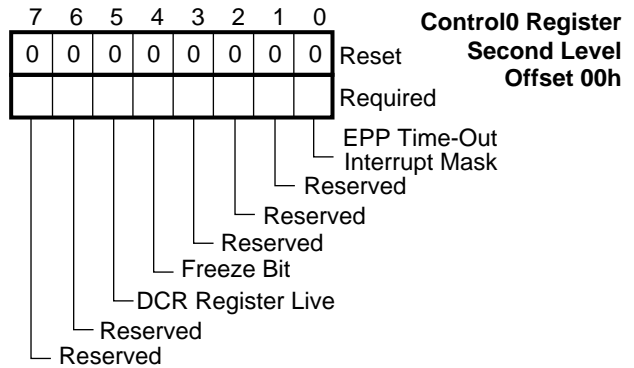


FIGURE 6-30. Control0 Register Bitmap

Bit 0 - EPP Time-Out Interrupt Mask

- 0 - The EPP time-out is masked.
- 1 - The EPP time-out is generated.

Bit 3-1 - Reserved

This bit is reserved.

Bit 4 - Freeze Bit

In mode 011, setting this bit to 1 freezes part of the interface with the peripheral device, and clearing this bit to 0 releases and initializes it. In all other modes the value of this bit is ignored.

Bit 5 - DCR Register Live

When this bit is 1, reading the DCR (see 6.5.6 on page 122) reads the interface control lines pin values regardless of the mode selected. Otherwise, reading the DCR reads the content of the register.

Bits 7, 6 - Reserved

This bit is reserved.

6.5.17 Control2, Second Level Offset 02h

Upon reset, this register is initialized to 00h.

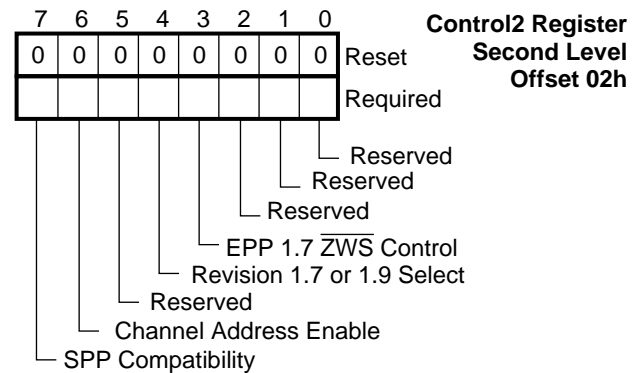


FIGURE 6-31. Control2 Register Bitmap

Bits 2-0 - Reserved

These bits are reserved.

Bit 3 - EPP 1.7 ZWS Control

Upon reset this bit is initialized to 0. This bit controls assertion of ZWS on EPP 1.7 access.

There is no ZWS assertion on SPP and on EPP 1.9 access. ZWS is always asserted on ECP access.

Control of ZWS assertion on parallel port access, except in EPP mode, is done via the SuperI/O Configuration 1 register. See 2.4.3 on page 34.

0 - ZWS not asserted on EPP 1.7 access.

1 - ZWS asserted on EPP 1.7 access.

Bit 4 - EPP 1.7/1.9 Select

Selects EPP version 1.7 or 1.9.

0 - EPP version 1.7.

1 - EPP version 1.9.

Bit 5 - Reserved

This bit is reserved.

Bit 6 - Channel Address Enable

When this bit is 1, mode is 011, direction is backward, there is an input command (BUSY is 0), and bit 7 of the data is 1, the command is written into the FIFO.

Bit 7 - SPP Compatibility

See the Mode Select field (bits 7 through 5 of the ECR register) on page 125 for a description of each mode.

0 - Modes 000, 001 and 100 are identical to ECP.

1 - Modes 000 and 001 of the ECP are identical with Compatible and Extended modes of the SPP (see Section 6.1 on page 111), and mode 100 of the ECP is compatible with EPP mode.

Modes 000, 001 and 100 differ as follows:

000, 001 and 100 – Reading DCR returns pin values of bits 3-0.

000 and 001 – Reading DCR returns 1 for bit 5.

000, or 001 or 100 when bit 5 of DCR is 0 (forward direction) – Reading DATAR returns register latched value instead of pin values.

000, 001, and 100, when bit 4 of DCR is 0 – IRQx is floated.

001 – $\overline{\text{IRQx}}$ is a level interrupt generated on the trailing edge of ACK. Bit 2 of the DSR is the IRQ status bit (same behavior as bit 2 of the STR).

6.5.18 Control4, Second Level Offset 04h

Upon reset this register is initialized to 00000111.

This register enables control of the fairness mechanism of the DMA by programming the maximum number of bus cycles that the parallel port DMA request signals can remain active, and the minimum number of clock cycles that they will remain inactive after they were deactivated.

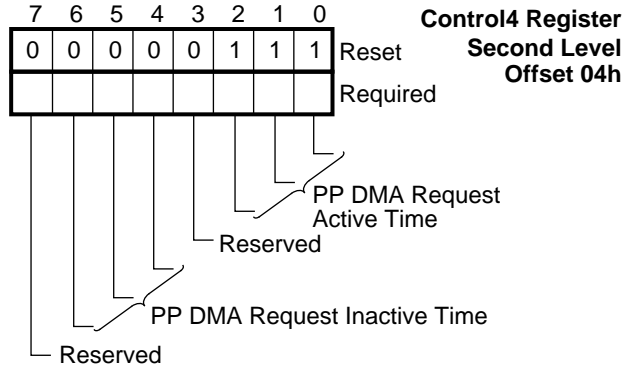


FIGURE 6-32. Control4 Register Bitmap

Bits 2-0 - Parallel Port DMA Request Active Time

This field specifies the maximum number of consecutive bus cycles that the parallel port DMA signals can remain active.

The default value is 111, which specifies 32 cycles.

When these bits are 0, the number is 1 cycle.

Otherwise, the number is $4(n+1)$ where n is the value of these bits.

Bit 3 - Reserved

This bit is reserved.

Bits 6-4 - Parallel Port DMA Request Inactive Time

This field specifies the minimum number of clock cycles that the parallel port DMA signals remain inactive after being deactivated by the fairness mechanism.

The default value is 000, which specifies 8 clock cycles.

Otherwise, the number of clock cycles is $8 + 32n$, where n is the value of these bits.

Bit 7 - Reserved

This bit is reserved.

6.5.19 PP Config0, Second Level Offset 05h

Upon reset this register is initialized to 00h.

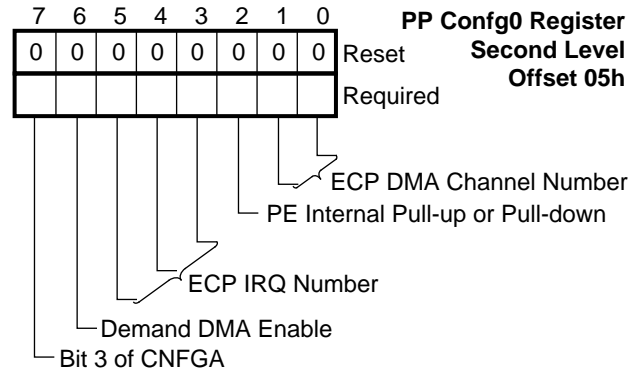


FIGURE 6-33. PP Config0 Register Bitmap

Bits 1, 0 - ECP DMA Channel Number

These bits identify the ECP DMA channel number, as reflected on bits 1 and 0 of the ECP CNFGB register. See Section 6.5.11 on page 123. Actual ECP DMA routing is controlled by the DMA channel select register (index 74h) of this logical device.

Microsoft's ECP protocol and ISA interface standard define bits 1 and 0 of CNFGB as shown in Table 6-7 on page 124.

Bit 2 - Paper End (PE) Internal Pull-up or Pull-down Resistor Select

- 0 - PE has a nominal 25 K Ω internal pull-down resistor.
- 1 - PE has a nominal 25 K Ω internal pull-up resistor.

Bits 5- 3 - ECP IRQ Number

These bits identify the ECP IRQ number, as reflected on bits 5 through 3 of the ECP CNFGB register. See Section 6.5.11 on page 123. Actual ECP IRQ routing is controlled by interrupt select register (index 70h) of this logical device.

Microsoft's ECP protocol and ISA interface standard defines bits 5 through 3 of CNFGB, as shown in 6-8 on page 124.

Bit 6 - Demand DMA Enable

If enabled, DRQ is asserted when a FIFO threshold of 4 is reached or when flush-time-out expires, except when DMA fairness prevents DRQ assertion. The threshold of 4 is for four empty entries forward and for four valid entries backward.

Once DRQ is asserted, it is held asserted for four DMA transfers, as long as the FIFO is able to process these four transfers, i.e., FIFO not empty backward.

When these four transfers are done, the DRQ behaves as follows:

- If DMA fairness prevents DRQ assertion (as in the case of 32 consecutive DMA transfers) then DRQ becomes low.
- If the FIFO is not able to process another four transfers (below threshold), then DRQ is becomes low.
- If the FIFO is able to process another four transfers (still above the threshold and no fairness to prevent DRQ assertion), then DRQ is held asserted as detailed above.

The flush time-out is an 8-bit counter that counts 256 clocks of 24 MHz and triggers DRQ assertion when the terminal-count is reached, i.e., when flush time-out expires). The counter is enabled for counting backward when the peripheral state machine writes a byte and DRQ is not asserted. Once enabled, it counts the 24 MHz clocks. The counter is reset and disabled when DRQ is asserted. The counter is also reset and disabled for counting forward and when demand the DMA is disabled.

This mechanism is reset whenever ECP mode is changed, the same way the FIFO is flushed in this case.

- 0 - Disabled.
- 1 - Enabled.

Bit 7 - Bit 3 of CNFGA

This bit may be utilized by the user. The value of this bit is reflected on bit 3 of the ECP CNFGA register.

6.6 DETAILED ECP MODE DESCRIPTIONS

Table 6-11 summarizes the functionality of the ECP in each mode. The following Sections describe how the ECP functions in each mode, in detail.

6.6.1 Software Controlled Data Transfer (Modes 000 and 001)

Software controlled data transfer is supported in modes 000 and 001. The software generates peripheral-device cycles by modifying the DATAR and DCR registers and reading the DSR, DCR and DATAR registers. The negotiation phase and nibble mode transfer, as defined in the IEEE 1284 standard, are performed in these modes.

In these modes the FIFO is reset (empty) and is not functional, the DMA and RLE are idle.

Mode 000 is for the forward direction only; the direction bit (bit 5 of DCR) is forced to 0 and PD7-0 are driven. Mode 001 is for both the forward and backward directions. The direction bit controls whether or not pins PD7-0 are driven.

6.6.2 Automatic Data Transfer (Modes 010 and 011)

Automatic data transfer (ECP cycles generated by hardware) is supported only in modes 010 and 011 (Parallel Port and ECP FIFO modes). Automatic DMA access to fill or empty the FIFO is supported in modes 010, 011 and 110. Mode 010 is for the forward direction only; the direction bit is forced to 0 and PD7-0 are driven. Mode 011 is for both the forward and backward directions. The direction bit controls whether PD7-0 are driven.

Automatic Run Length Expanding (RLE) is supported in the backward direction.

Forward Direction (Bit 5 of DCR = 0)

When the ECP is in forward direction and the FIFO is not full (bit 1 of ECR is 0) the FIFO can be filled by software writes to the FIFO registers (AFIFO and DFIFO in mode 011, and CFIFO in mode 010).

When DMA is enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically issues DMA requests to fill the FIFO with data bytes (not including command bytes).

When the ECP is in forward direction and the FIFO is not empty (bit 0 of ECR is 0) the ECP pops a byte from the FIFO and issues a write signal to the peripheral device. The ECP drives AFD according to the operation mode (bits 7-5 of ECR) and according to the tag of the popped byte as follows:

- In Parallel Port FIFO mode (mode 010) $\overline{\text{AFD}}$ is controlled by bit 1 of DCR.
- In ECP mode (mode 011) $\overline{\text{AFD}}$ is controlled by the popped tag. $\overline{\text{AFD}}$ is driven high for normal data bytes and driven low for command bytes.

ECP (Forward) Write Cycle

An ECP write cycle starts when the ECP drives the popped tag onto AFD and the popped byte onto PD7-0. When BUSY is low the ECP asserts STB. In 010 mode the ECP deactivates $\overline{\text{STB}}$ to terminate the write cycle. In 011 mode the ECP waits for BUSY to be high.

When BUSY is high, the ECP deactivates $\overline{\text{STB}}$, and changes AFD and PD7-0 only after BUSY is low.

TABLE 6-11. ECP Modes

ECP Mode (ECR Bits)			ECP Mode Name	Operation Description
7	6	5		
0	0	0	Standard	Write cycles are under software control. STB, AFD, INIT and SLIN are open-drain output signals. Bit 5 of DCR is forced to 0 (forward direction) and PD7-0 are driven. The FIFO is reset (empty). Reading DATAR returns the last value written to DATAR.
0	0	1	PS/2	Read and write cycles are under software control. The FIFO is reset (empty). STB, AFD, INIT and SLIN are push-pull output signals.
0	1	0	Parallel Port FIFO	Write cycles are automatic, i.e., under hardware control (STB is controlled by hardware). Bit 5 of DCR is forced to 0 internally (forward direction) and PD7-0 are driven. STB, AFD, INIT and SLIN are push-pull output signals.
0	1	1	ECP FIFO	The FIFO direction is automatic, i.e., controlled by bit 5 of DCR. Read and write cycles to the device are controlled by hardware (STB and AFD are controlled by hardware). STB, AFD, INIT and SLIN are push-pull output signals.
1	0	0	EPP	EPP mode is enabled by bits 7 through 5 of the SuperI/O Parallel Port Configuration register, as described in Section 2.7.1 on page 37. In this mode, registers DATAR, DSR, and DCR are used as registers at offsets 00h, 01h and 02h of the EPP instead of registers DTR, STR, and CTR. STB, AFD, INIT, and SLIN are push-pull output buffers. When there is no access to one of the EPP registers (ADDR, DATA0, DATA1, DATA2 or DATA3), mode 100 behaves like mode 001, i.e., software can perform read and write cycles. The software should check that bit 7 of the DSR is 1 before reading or writing the DATAR register, to avoid corrupting an ongoing EPP cycle.
1	0	1	Reserved	
1	1	0	FIFO Test	The FIFO is accessible via the TFIFO register. The ECP does not issue ECP cycles to fill or empty the FIFO.
1	1	1	Configuration	CNFGA and CNFGB registers are accessible.

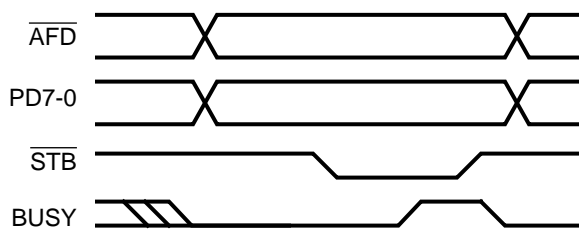


FIGURE 6-34. ECP Forward Write Cycle

Backward Direction (Bit 5 of DCR is 1)

When the ECP is in the backward direction, and the FIFO is not full (bit 1 of ECR is 0), the ECP issues a read cycle to the peripheral device and monitors the BUSY signal. If BUSY is high the byte is a data byte and it is pushed into the FIFO. If BUSY is low the byte is a command byte.

The ECP checks bit 7 of the command byte. If it is high the byte is ignored, if it is low the byte is tagged as an RLC byte (not pushed into the FIFO but used as a Run Length Count to expand the next byte read). Following an RLC read the ECP issues a read cycle from the peripheral device to read the data byte to be expanded. This byte is considered a data byte, regardless of its BUSY state (even if it is low). This byte is pushed into the FIFO (RLC+1) times (e.g. for RLC=0, push the byte once. For RLC=127 push the byte 128 times).

When the ECP is in the backward direction, and the FIFO is not empty (bit 0 of ECR is 0), the FIFO can be emptied by software reads from the FIFO register (true only for the DFIFO in mode 011).

When DMA is enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically issues DMA requests to empty the FIFO (only in mode 011).

ECP (Backward) Read Cycle

An ECP read cycle starts when the ECP drives \overline{AFD} low.

The peripheral device drives BUSY high for a normal data read cycle, or drives BUSY low for a command read cycle, and drives the byte to be read onto PD7-0.

When \overline{ACK} is asserted the ECP drives \overline{AFD} high. When \overline{AFD} is high the peripheral device deasserts \overline{ACK} . The ECP reads the PD7-0 byte, then drives \overline{AFD} low. When \overline{AFD} is low the peripheral device may change BUSY and PD7-0 states in preparation for the next cycle.

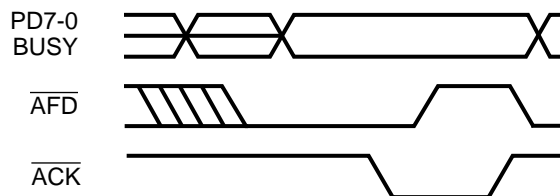


FIGURE 6-35. ECP (Backward) Read Cycle

Notes:

1. FIFO-full condition is checked before every expanded byte push.
2. Switching from modes 010 or 011 to other modes removes pending DMA requests and aborts pending RLE expansion.
3. FIFO pushes and pops are neither synchronized nor linked at the hardware level. The FIFO will not delay these operations, even if performed concurrently. Care must be taken by the programmer to utilize the empty and full FIFO status bits to avoid corrupting PD7-0 or D7-0 while a previous FIFO port access not complete.
4. In the forward direction, the empty bit is updated when the ECP cycle is completed, not when the last byte is popped from the FIFO (valid cleared on cycle end).
5. \overline{ZWS} is not asserted for DMA cycles.
6. The one-bit command/data tag is used only in the forward direction.

6.6.3 Automatic Address and Data Transfers (Mode 100)

Automatic address and data transfer (EPP cycles generated by hardware) is supported in mode 100. Fast transfers are achieved by automatically generating the address and data strobes.

In this mode, the FIFO is reset (empty) and is not functional, the DMA and RLE are idle.

The direction of the automatic data transfers is determined by the RD and WR signals. The direction of software data transfer can be forward or backward, depending on bit 5 of the DCR. Bit 5 of the DCR determines the default direction of the data transfers only when there is no on-going EPP cycles.

In EPP mode 100, registers DATAR, DSR and DCR are used instead of DTR, STR and CTR respectively.

Some differences are caused by the registers. Reading DATAR returns pins values instead of register value returned when reading DTR. Reading DSR returns register value instead of pins values returned when reading STR. Writing to the DATAR during an on-going EPP 1.9 forward cycle (i.e. - when bit 7 of DSR is 1) causes the new data to appear immediately on PD7-0, instead of waiting for BUSY to become low to switch PD7-0 to the new data when writing to the DTR.

In addition, the bit 4 of the DCR functions differently relative to bit 4 of the CTR (IRQ float).

6.6.4 FIFO Test Access (Mode 110)

Mode 110 is for testing the FIFO in PIO and DMA cycles. Both read and write operations (pop and push) are supported, regardless of the direction bit.

In the forward direction PD7-0 are driven, but the data is undefined. This mode can be used to measure the system-ECP cycle throughput, usually with DMA cycles. This mode can also be used to check the FIFO depth and its interrupt threshold, usually with PIO cycles.

6.6.5 Configuration Registers Access (Mode 111)

The two configuration registers, CNFGA and CNFGB, are accessible only in this mode.

6.6.6 Interrupt Generation

An interrupt is generated when any of the events described in this section occurs. Interrupt events 2, 3 and 4 are level events. They are shaped as interrupt pulses, and are masked (inactive) when the ECP clock is frozen.

Event 1

Bit 2 of ECR is 0, bit 3 of ECR is 1 and TC is asserted during ECP DMA cycle. Interrupt event 1 is a pulse event.

Event 2

Bit 2 of ECR is 0, bit 3 of ECR is 0, bit 5 of DCR is 0 and there are eight or more bytes free in the FIFO.

This event includes the case when bit 2 of ECR is cleared to 0 and there are already eight or more bytes free in the FIFO (modes 010, 011 and 110 only).

Event 3

Bit 2 of ECR is 0, bit 3 of ECR is 0, bit 5 of DCR is 1 and there are eight or more bytes to be read from the FIFO.

This event includes the case when bit 2 of ECR is cleared to 0 and there are already eight or more bytes to be read from the FIFO (modes 011 and 110 only).

Event 4

Bit 4 of ECR is 0 and \overline{ERR} is asserted (high to low edge) or \overline{ERR} is asserted when bit 4 of ECR is modified from 1 to 0.

This event may be lost when the ECP clock is frozen.

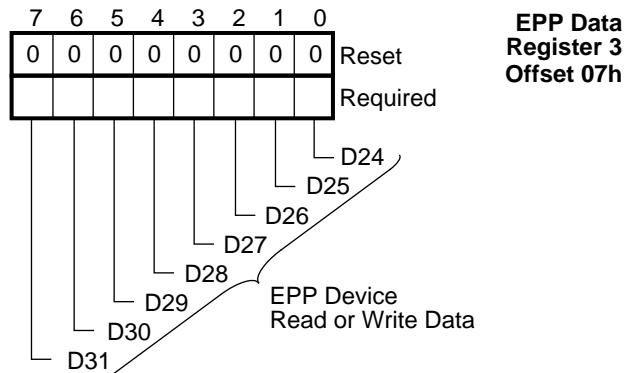
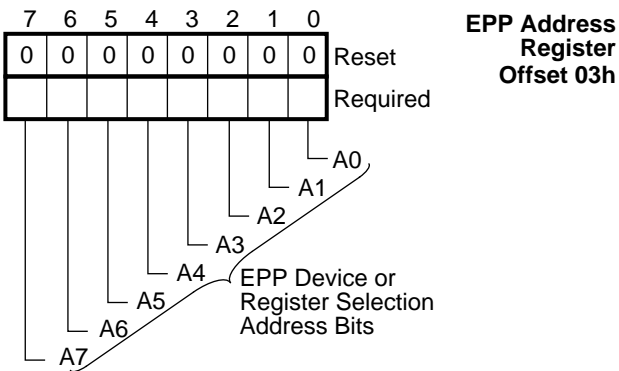
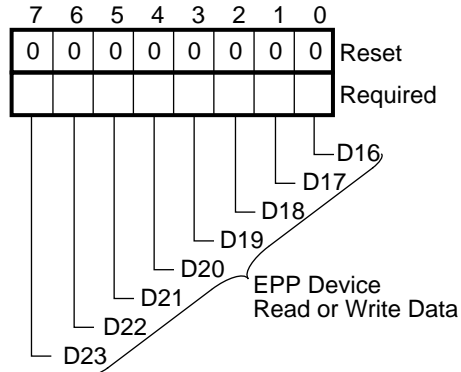
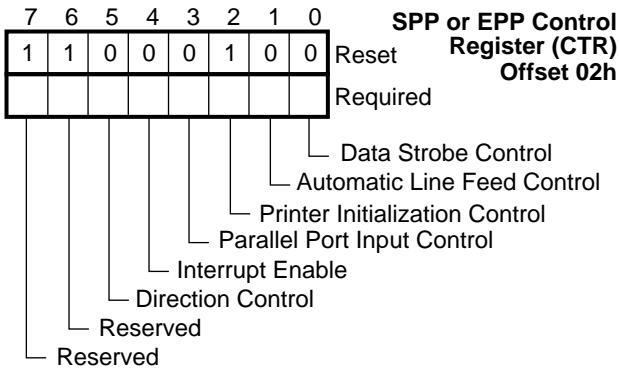
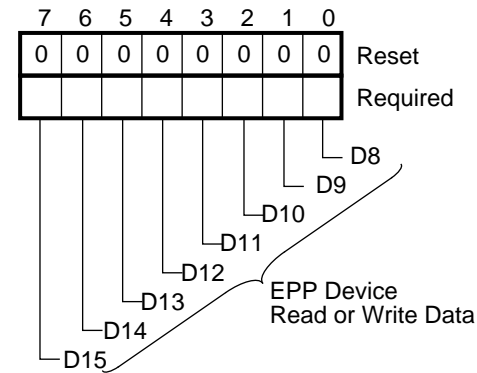
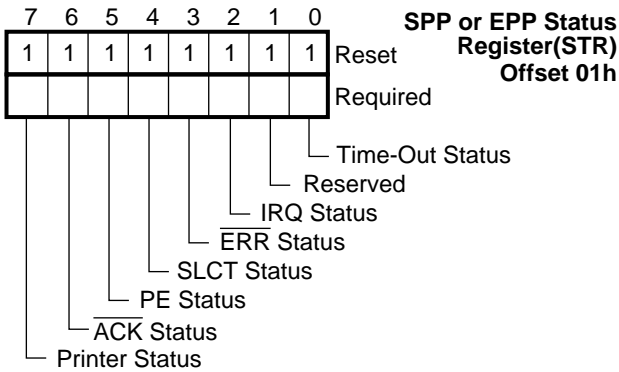
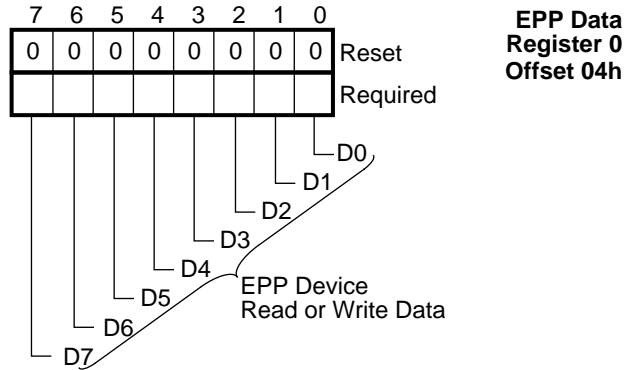
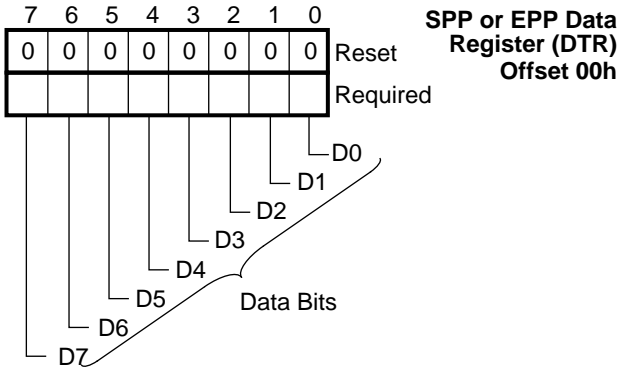
Event 5

When bit 4 of DCR is 1 and \overline{ACK} is deasserted (low-to-high edge).

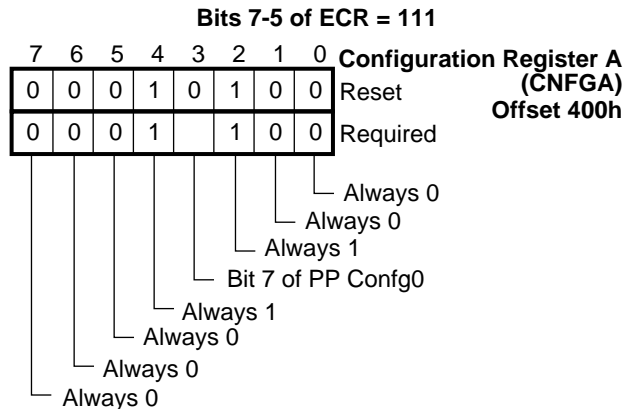
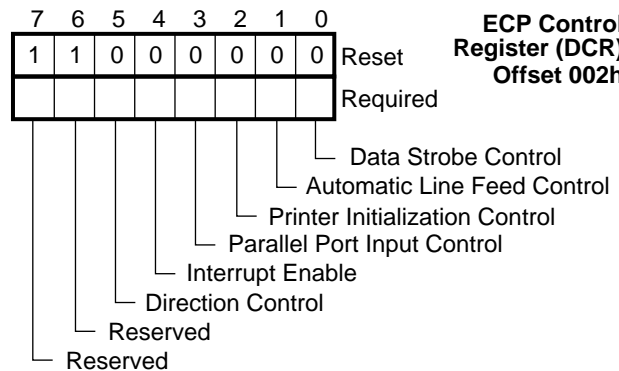
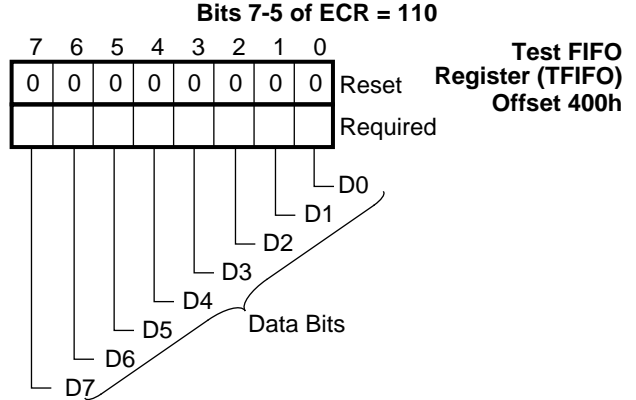
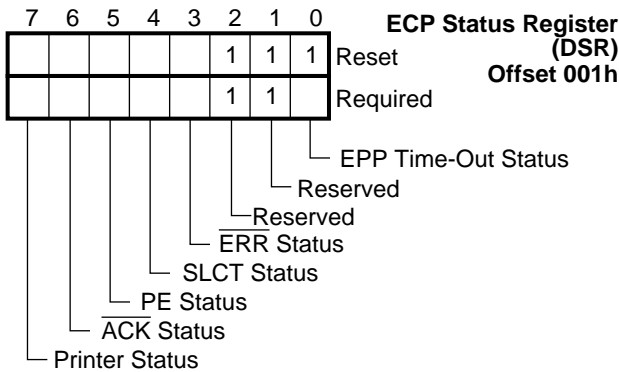
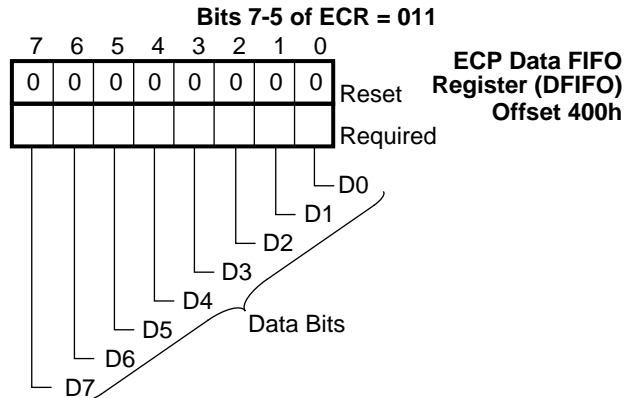
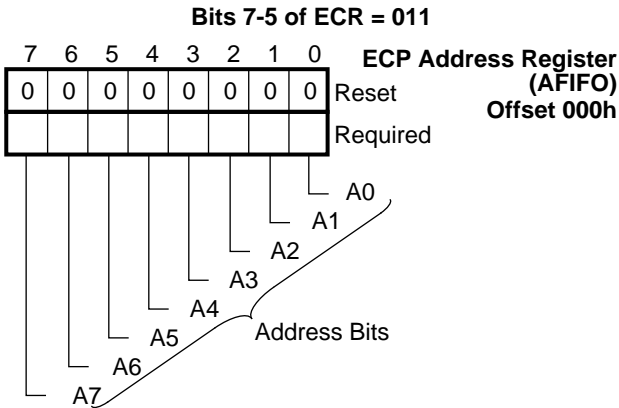
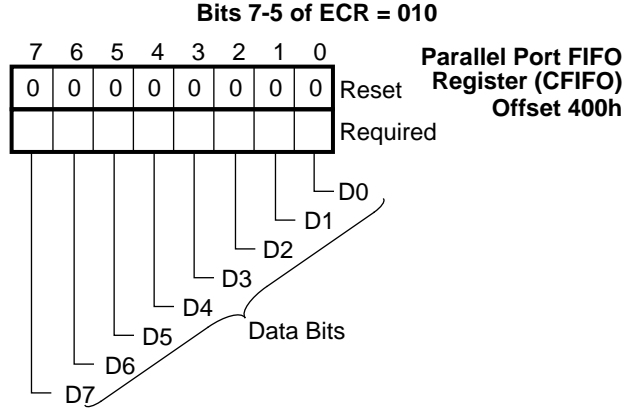
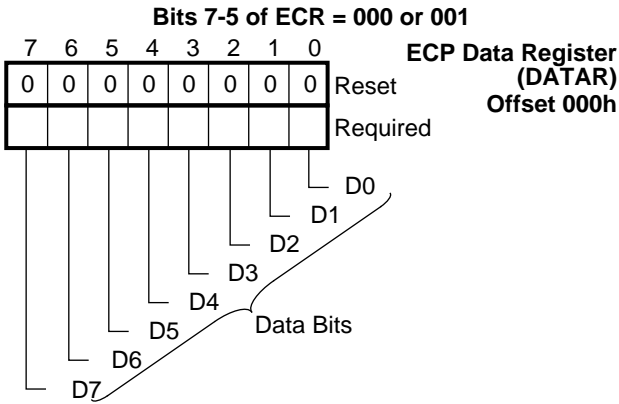
This event behaves as in the normal SPP mode, i.e., the IRQ signal follows the \overline{ACK} signal transition.

6.7 PARALLEL PORT REGISTER BITMAPS

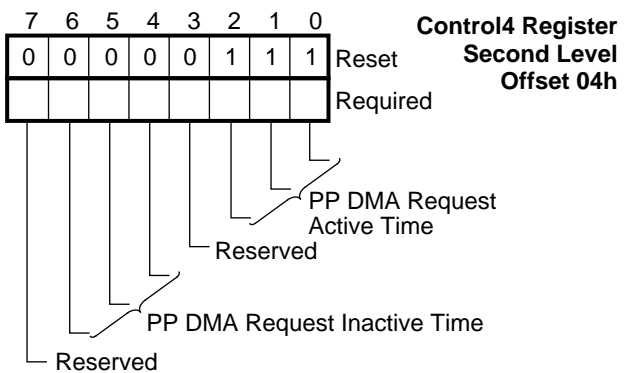
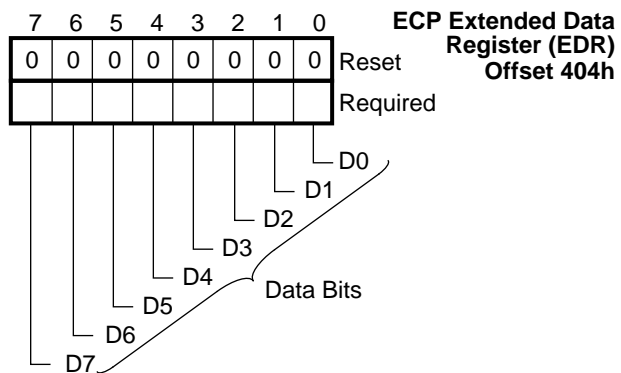
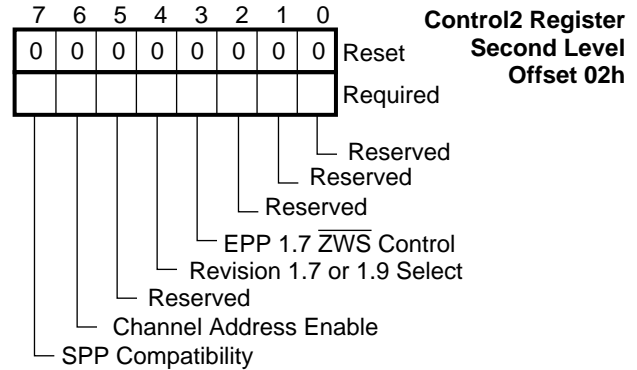
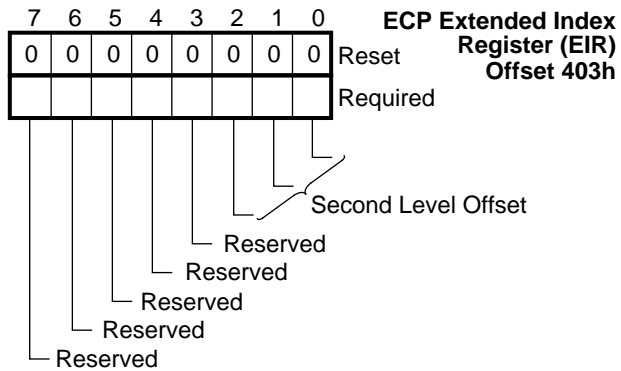
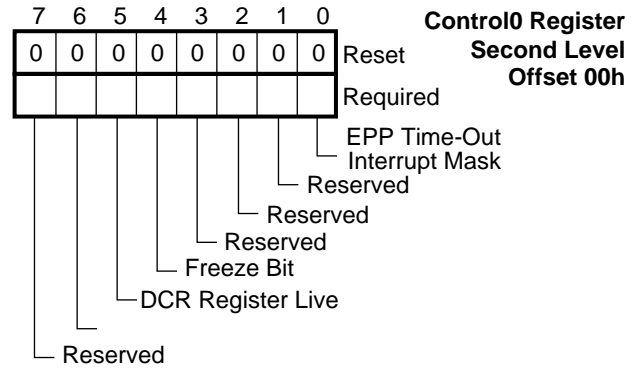
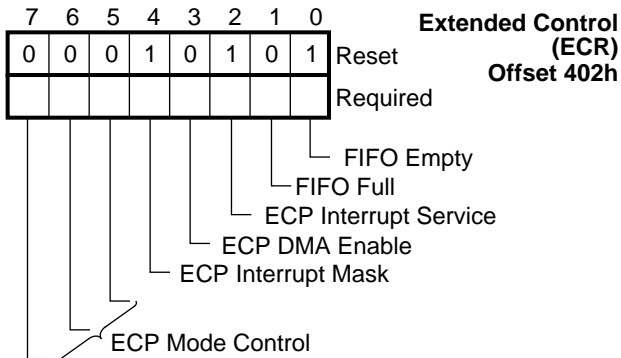
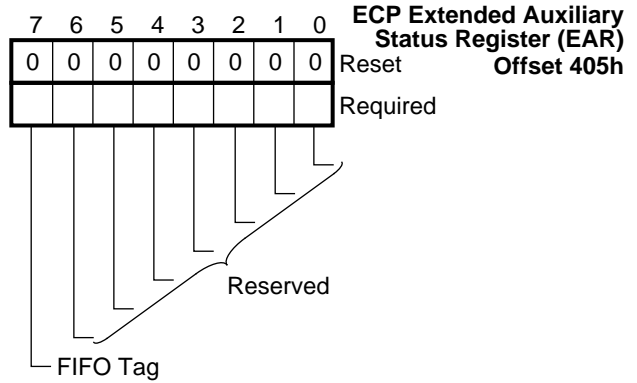
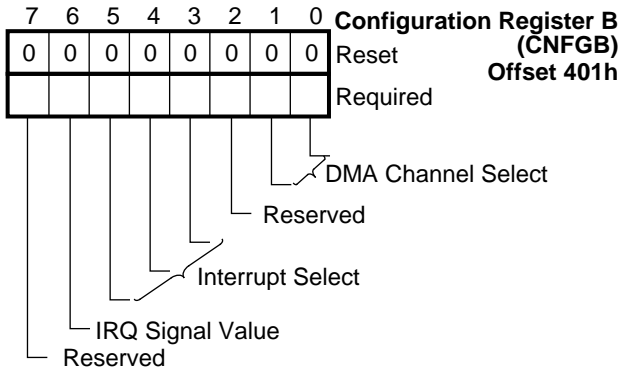
6.7.1 EPP Modes Parallel Port Register Bitmaps

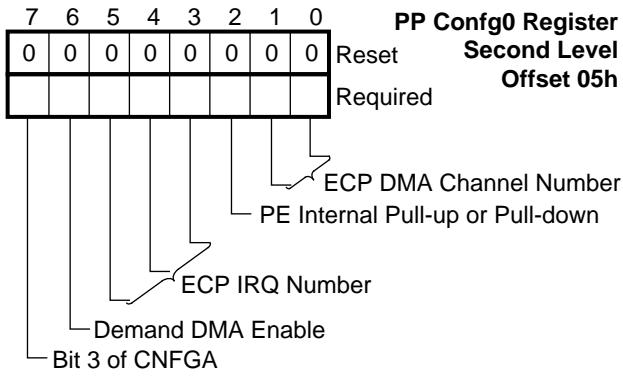


6.7.2 ECP Modes Parallel Port Register Bitmaps



Bits 7-5 of ECR = 111





6.8 PARALLEL PORT PIN/SIGNAL LIST

Table 6-12 shows the standard 25-pin, D-type connector definition for various parallel port operations.

TABLE 6-12. Parallel Port Pinout

Connector Pin	Pin No.	SPP, ECP Mode	I/O	EPP Mode	I/O
1	112	STB	I/O	WRITE	I/O
2	122	PD0	I/O	PD0	I/O
3	123	PD1	I/O	PD1	I/O
4	124	PD2	I/O	PD2	I/O
5	125	PD3	I/O	PD3	I/O
6	126	PD4	I/O	PD4	I/O
7	127	PD5	I/O	PD5	I/O
8	128	PD6	I/O	PD6	I/O
9	129	PD7	I/O	PD7	I/O
10	113	ACK	I	ACK	I
11	111	BUSY	I	WAIT	I
12	115	PE	I	PE	I
13	114	SLCT	I	SLCT	I
14	119	AFD	I/O	DSTRB	I/O
15	116	ERR	I	ERR	I
16	117	INIT	I/O	INIT	I/O
17	118	SLIN	I/O	ASTRB	I/O
18 - 23		GND		GND	
25		GND		GND	

7.0 UART1 and UART2 (with IR) (Logical Devices 5 and 6)

This section describes the functionality of the Legacy UART (16450/16550), Enhanced UART and the IR modes.

UART1 supports standard 16450/16550 mode.

UART2 supports standard 16450/16550, Enhanced UART and IR modes.

UART1 implements a subset of UART2 functionality. It supports UART mode hard-wired communications, but does not support IR communication. Therefore, all explanations of IR communication in this section do not apply to UART1.

The UART module provides advanced, versatile serial communications features with infrared capabilities. It supports four modes of operation: UART, Sharp-IR, IrDA 1.0 SIR (hereafter called SIR) and Consumer-IR (also called TV-Remote or Consumer remote-control). In UART mode, the module can function as a standard 16450 or 16550, or as an Extended UART.

Existing 16550-based legacy software is completely and transparently supported. Module organization and specific fallback mechanisms switch the module to 16550 compatibility mode upon reset or when initialized by 16550 software.

The module includes two DMA channels that can support all operational modes. The device can use either 1 or 2 DMA channels. One channel is required for infrared based applications since infrared communications work in half duplex fashion. Two channels would normally be needed to handle high-speed full duplex UART based applications.

7.1 FEATURES

- Fully compatible with 16550 and 16450 devices
- Automatic fallback to 16550 compatibility mode
- Extended UART mode
- UART baud rates up to 1.5 Mbps
- Sharp-IR with selectable internal or external modulation/demodulation
- IrDA 1.0 SIR with data rates up to 115.2 Kbps
- Consumer-IR (TV-Remote) mode
- Full duplex infrared capability for diagnostics
- Transmission deferral (in Consumer-IR mode)
- Selectable 16 or 32-level transmission and reception FIFOs (RX_FIFO & TX_FIFO respectively)
- Multiple optical transceiver support
- Automatic or manual transceiver configuration
- Support for Plug-n-Play infrared adapters

7.2 FUNCTIONAL MODES OVERVIEW

This multi-mode module can be configured to act as any one of several different functions. Although each mode is unique, certain system resources and features are common to some or to all modes.

7.2.1 UART Modes: 16450 or 16550, and Extended

UART modes support serial data communications with a remote peripheral device or modem using a wired interface. The device transmits and receives data concurrently in full-duplex operation, performing parallel-to-serial and serial-to-parallel conversion and other functions required to exchange parallel data with the system. It also interfaces with external devices using a programmable serial communications format.

The following UART modes are supported:

- 16450 or 16550 mode (Non-Extended modes)
- Extended mode

The 16450 or 16550 mode is functionally and software-compatible with the standard 16450 or 16550 UARTs. This is the default mode of operation after power up, after reset or when initialized by software written for the 16450 or 16550 UART (Special mechanisms switch the module automatically to 16550 UART mode when standard 16550 software is run).

The 16550 UART mode has all the features of the 16450 mode, with the addition of 16-byte data FIFOs for more efficient data I/O.

In Extended mode, additional features become available that enhance the UART performance, such as additional interrupts and DMA ability (see "Extended UART Mode" on page 137).

The UART supports baud rates of up to 115.2 Kbps in 16450 or 16550 mode, and up to 1.5 Mbps in Extended mode.

7.2.2 Sharp-IR, IrDA SIR Infrared Modes

The Sharp-IR mode provides bidirectional communication by transmitting and receiving infrared radiation. In this mode, infrared I/O circuits was added to the UART, which operates at 38.4 Kbps in half-duplex, using normal UART serial data formats with Digital Amplitude Shift Keying (DASK) modulation. The modulation/demodulation can be operated internally or externally.

In SIR mode, the system functions similarly to the Sharp-IR mode, but at 115.2 Kbps.

7.2.3 Consumer IR Mode

Consumer-IR mode supports all the protocols presently used in remote-controlled home entertainment equipment: RC-5, RC-6, RECS 80, NEC and RCA. The serial format is not compatible with UART operation, and specific circuitry performs all the hardware tasks required for signal conditioning and formatting. The software is responsible for the generation of the infrared code to be transmitted, and for the interpretation of the received code.

7.3 REGISTER BANK OVERVIEW

Eight register banks, each containing eight registers, control UART operation. All registers use the same 8-byte address space to indicate offsets 00h through 07h, and the active bank must be selected by the software.

The register bank organization enables access to the banks as required for activation of all module modes, while maintaining transparent compatibility with 16450 or 16550 software, which activates only the registers and specific bits used in those devices. For details, See Section 7.4.

The Bank Selection Register (BSR) selects the active bank and is common to all banks. See Figure 7-1. Therefore, each bank defines seven new registers.

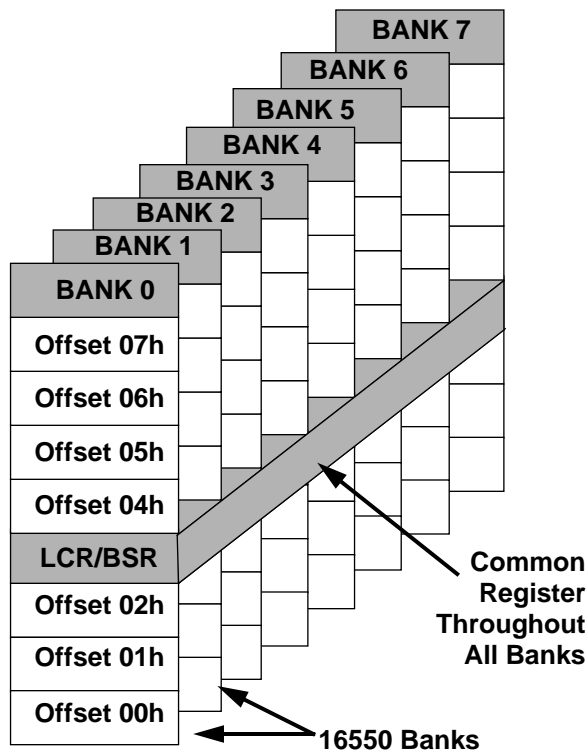


FIGURE 7-1. Register Bank Architecture

The default bank selection after system reset is 0, which places the module in the UART 16550 mode. Additionally, setting the baud rate in bank 1 (as required to initialize the 16550 UART) switches the module to a Non-Extended UART mode. This ensures that running existing 16550 software will switch the system to the 16550 configuration without software modification.

Table 7-1 shows the main functions of the registers in each bank. Banks 0-3 control both UART and infrared modes of operation; banks 4-7 control and configure the infrared modes only.

TABLE 7-1. Register Bank Summary

Bank	UART	IR Mode	Main Functions
0	✓	✓	Global Control and Status
1	✓	✓	Legacy Bank
2	✓	✓	Baud Generator Divisor, Extended Control and Status
3	✓	✓	Module Revision ID and Shadow Registers
4		✓	IR mode setup
5		✓	Infrared Control
6		✓	Infrared Physical Layer Configuration
7		✓	Consumer-IR and Optical Transceiver Configuration

Banks 0 and 1 are the 16550 register banks. The registers in these banks are equivalent to the registers contained in the 16550 UARTs and are accessed by 16550 software drivers as if the module was a 16550. Bank 1 contains the baud divisor ports. Bank 0 registers control all other aspects of the UART function, including data transfers, format setup parameters, interrupt setup and status monitoring.

Bank 2 contains the non-legacy Baud Generator Divisor ports, and controls the extended features special to this UART, that are not included in the 16550 repertoire. These include DMA usage. See "Extended UART Mode" on page 137.

Bank 3 contains the Module Revision ID and shadow registers. The Module Revision ID (MRID) register contains a code that identifies the revision of the module when read by software. The shadow registers contain the identical content as reset-when-read registers within bank 0. Reading their contents from the shadow registers lets the system read the register content without re-setting them.

Bank 4 contains setup parameters for the Infra-red modes.

Bank 5 registers control infrared parameters related to the logical system I/O parameters.

Bank 6 registers control physical characteristics involved in infrared communications (e.g. pulse width selection).

Bank 7 registers are dedicated to Consumer-IR configuration and control.

7.4 UART MODES – DETAILED DESCRIPTION

The UART modes support serial data communications with a remote peripheral device or modem using a wired interface.

The module provides receive and transmit channels that can operate concurrently in full-duplex mode. This module performs all functions required to conduct parallel data interchange with the system and composite serial data exchange with the external data channel, including:

- Format conversion between the internal parallel data format and the external programmable composite serial format. See Figure 7-2.
- Serial data timing generation and recognition
- Parallel data interchange with the system using a choice of bi-directional data transfer mechanisms
- Status monitoring for all phases of the communications activity

The module supplies modem control registers, and a prioritized interrupt system for efficient interrupt handling.

7.4.1 16450 or 16550 UART Mode

The module defaults to 16450 mode after power up or reset. UART 16550 mode is equivalent to 16450 mode, with the addition of a 16-byte data FIFO for more efficient data I/O. Transparent compatibility is maintained with this UART mode in this module.

Despite the many additions to the basic UART hardware and organization, the UART responds correctly to existing software drivers with no software modification required. When 16450 software initializes and addresses this module, it will in always perform as a 16450 device.

Data transfer takes place by use of data buffers that interface internally in parallel and with the external data channel in a serial format. 16 or 32-byte data FIFOs may reduce host overhead by enabling multiple-byte data transfers within a single interrupt. With FIFOs disabled, this module is equivalent to the standard 16450 UART. With FIFOs enabled, the hardware functions as a standard 16550 UART.

The composite serial data stream interfaces with the data channel through signal conditioning circuitry such as TTL/RS232 converters, modem tone generators, etc.

Data transfer is accompanied by software-generated control signals, which may be utilized to activate the communications channel and “handshake” with the remote device. These may be supplied directly by the UART, or generated by control interface circuits such as telephone dialing and answering circuits, etc.

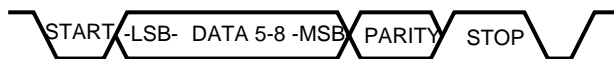


FIGURE 7-2. Composite Serial Data

The composite serial data stream produced by the UART is illustrated in Figure 7-2. A data word containing five to eight bits is preceded by start bits and followed by an optional parity bit and a stop bit. The data is clocked out, LSB first, at a predetermined rate (the baud rate).

The data word length, parity bit option, number of start bits and baud rate are programmable parameters.

The UART includes a programmable baud generator that produces the baud rate clocks and associated timing signals for serial communication.

The system can monitor this module status at any time. Status information includes the type and condition of the transfer operation in process, as well as any error conditions (e.g., parity, overrun, framing, or break interrupt).

The module resources include modem control capability and a prioritized interrupt system. Interrupts can be programmed to match system requirements, minimizing the CPU overhead required to handle the communications link.

Programmable Baud Generator

This module contains a programmable baud generator that generates the clock rates for serial data communication (both transmit and receive channels). It divides its input clock by any divisor value from 1 to $2^{16} - 1$. The output clock frequency of the baud generator must be programmed to be sixteen times the baud rate value. A 24 MHz input frequency is divided by a prescale value (PRESL field of EXCR2 - see page 155. Its default value is 13) and by a 16-bit programmable divisor value contained in the Baud Generator Divisor High and Low registers (BGD(H) and BGD(L) - see page 152). Each divisor value yields a clock signal (BOUT) and a further division by 16 produces the baud rate clock for the serial data stream. It may also be output as a test signal when enabled (see bit 7 of EXCR1 on page 154.)

These user-selectable parameters enable the user to generate a large choice of serial data rates, including all standard baud rates. A list of baud rates and their settings appears in Table 7-14 on page 153.

Module Operation

Before module operation can begin, both the communications format and baud rate must be programmed by the software. The communications format is programmed by loading a control byte into the LCR register, while the baud rate is selected by loading an appropriate value into the baud generator divisor registers and the divisor preselect values (PRESL) into EXCR2 (see page 155).

The software can read the status of the module at any time during operation. The status information includes full or empty state for both transmission and reception channels, and any other condition detected on the received data stream, like parity error, framing error, data overrun, or break event.

7.4.2 Extended UART Mode

In Extended UART mode of operation, the module configuration changes and additional features become available which enhance UART capabilities.

- The interrupt sources are no longer prioritized; they are presented bit-by-bit in the EIR (see page 143).
- An auxiliary status and control register replaces the scratchpad register. It contains additional status and control flag bits (“Auxiliary Status and Control Register (ASCR), Bank 0, Offset 07h” on page 150).
- The TX_FIFO can generate interrupts when the number of outgoing bytes in the TX_FIFO drops below a programmable threshold. In the Non-Extended UART modes, only reception FIFOs have the thresholding feature.
- DMA capability is available.
- Interrupts occur when the transmitter becomes empty or a DMA event occurs.

7.5 SHARP-IR MODE – DETAILED DESCRIPTION

This mode supports bidirectional data communication with a remote device using infrared radiation as the transmission medium. Sharp-IR uses Digital Amplitude Shift Keying (DASK) and allows serial communication at baud rates up to 38.4 Kbaud. The format of the serial data is similar to the UART data format. Each data word is sent serially beginning with a zero value start bit, followed by up to eight data bits (LSB first), an optional parity bit, and ending with at least one stop bit with a binary value of one. A logical zero is signalled by sending a 500 KHz continuous pulse train of infrared radiation. A logical 1 is signalled by the absence of any infrared signal. This module can perform the modulation and demodulation operations internally, or can rely on the external optical module to perform them.

Sharp-IR device operation is similar to the operation in UART mode, the main difference being that data transfer operations are normally performed in half duplex fashion, and the modem control and status signals are not used. Selection of the Sharp-IR mode is controlled by the Mode Select (MDSL) bits in the MCR register when the module is in Extended mode, or by the IR_SL bits in the IRCR1 register when the module is not in extended mode. This prevents legacy software, running in non-extended mode, from spuriously switching the module to UART mode, when the software writes to the MCR register.

7.6 SIR MODE – DETAILED DESCRIPTION

This operational mode supports bidirectional data communication with a remote device using infrared radiation as the transmission medium.

SIR allows serial communication at baud rates up to 115.2 Kbaud. The serial data format is similar to the UART data format. Each data word is sent serially beginning with a 0 value start bit, followed by eight data bits (LSB first), an optional parity bit, and ending with at least one stop bit with a binary value of 1.

A zero value is signalled by sending a single infrared pulse. A one value is signalled by not sending any pulse. The width of each pulse can be either 1.6 μ sec or 3/16 of the time required to transmit a single bit. (1.6 μ sec equals 3/16 of the time required to transmit a single bit at 115.2 Kbps). This way, each word begins with a pulse for the start bit.

The module operation in SIR is similar to the operation in UART mode, the main difference being that data transfer operations are normally performed in half duplex fashion. Selection of the IrDA 1.0 SIR mode is controlled by the MDSL bits in the MCR register when the UART is in Extended mode, or by the IR_SL bits in the IRCR1 register when the UART is not in Extended mode. This prevents legacy software, running in Non-Extended mode, from spuriously switching the module to UART mode, when the software writes to the MCR register.

7.7 CONSUMER-IR MODE – DETAILED DESCRIPTION

The Consumer-IR circuitry in this module is designed to optimally support all the major protocols presently used in remote-controlled home entertainment equipment: RC-5, RC-6, RECS 80, NEC and RCA.

This module, in conjunction with an external optical device, provides the physical layer functions necessary to support these protocols. These functions include: modulation, demodulation, serialization, deserialization, data buffering, status reporting, interrupt generation, etc.

The software is responsible for the generation of the infrared code to be transmitted, and for the interpretation of the received code.

7.7.1 Consumer-IR Transmission

The code to be transmitted consists of a sequence of bytes that represent either a bit string or a set of run-length codes. The number of bits or run-length codes usually needed to represent each infrared code bit depends on the infrared protocol to be used. The RC-5 protocol, for example, needs two bits or between one and two run-length codes to represent each infrared code bit.

Transmission is initiated when the CPU or DMA module writes code bytes into the empty TX_FIFO. Transmission is normally completed when the CPU sets the S_EOT bit in the ASCR register (See Section 7.11.10 on page 150), before writing the last byte, or when the DMA controller activates the TC (terminal count) signal. Transmission will also terminate if the CPU simply stops transferring data and the transmitter becomes empty. In this case, however, a transmitter-underrun condition will be generated, which must be cleared in order to begin the next transmission.

The transmission bytes are either de-serialized or run-length encoded, and the resulting bit string modulates a carrier signal and is sent to the transmitter LED. The transfer rate of this bit string, like in the UART mode, is determined by the value programmed in the baud generator divisor registers. Unlike a UART transmission, start, stop and parity bits are not included in the transmitted data stream. A logic 1 in the bit string keeps the LED off, so no infrared signal is transmitted. A logic 0, generates a sequence of modulating pulses which will turn on the transmitter LED. Frequency and pulse width of the modulating pulses are programmed by the MCFR and MCPW fields in the IRTXMC register as well as the TXHSC bit in the RCCFG register. Sections 7.17.2 and 7.17.3 describe these registers in detail.

The RC_MMD field selects the transmitter modulation mode. If C_PLS mode is selected, modulating pulses are generated continuously for the entire logic 0 bit time. If 6_PLS or 8_PLS mode is selected, six or eight pulses are generated each time a logic 0 bit is transmitted following a logic 1 bit. The total transmission time for the logic 0 bits must be equal-to or greater-than 6 or 8 times the period of the modulation subcarrier, otherwise, fewer pulses will be transmitted.

C_PLS modulation mode is used for RC-5, RC-6, NEC and RCA protocols. 8_PLS or 6_PLS modulation mode is used for the RECS 80 protocol. The 8_PLS or 6_PLS mode allows minimization of the number of bits needed to represent the RECS 80 infrared code sequence. The current transmitter implementation supports only the modulated modes of the RECS 80 protocol. It does not support Flash mode.

7.7.2 Consumer-IR Reception

The Consumer-IR receiver is significantly different from a UART receiver in two ways. Firstly, the incoming infrared signals are DASK modulated. Therefore, demodulation may be necessary. Secondly, there are no start bits in the incoming data stream.

Whenever an infrared signal is detected, receiver operations depend on whether or not receiver demodulation is enabled. If demodulation is disabled, the receiver immediately becomes active. If demodulation is enabled, the receiver checks the carrier frequency of the incoming signal, and be-

comes active only if the frequency is within the programmed range. Otherwise, the signal is ignored and no other action is taken.

When the receiver enters the active state, the RXACT bit in the ASCR register is set to 1. Once in the active state, the receiver keeps sampling the infrared input signal and generates a bit string where a logic 1 indicates an idle condition and a logic 0 indicates the presence of infrared energy. The infrared input is sampled regardless of the presence of infrared pulses at a rate determined by the value loaded into the baud generator divisor registers. The received bit string is either de-serialized and assembled into 8-bit characters, or it is converted to run-length encoded values. The resulting data bytes are then transferred into the RX_FIFO.

The receiver also sets the RXWDG bit in the ASCR register each time an infrared pulse signal is detected. This bit is automatically cleared when the ASCR register is read, and it is intended to assist the software in determining when the infrared link has been idle for a certain time. The software can then stop the data reception by writing a 1 into the RXACT bit to clear it and return the receiver to the inactive state.

The frequency bandwidth for the incoming modulated infrared signal is selected by the DFR and DBW fields in the IR_RXDC register.

There are two Consumer-IR reception data modes: "Over-sampled" and "Programmed T Period" mode. For either mode the sampling rate is determined by the setting of the baud generator divisor registers.

The "Over-sampled" mode can be used with the receiver demodulator either enabled or disabled. It should be used with the demodulator disabled when a detailed snapshot of the incoming signal is needed, for example to determine the period of the carrier signal. If the demodulator is enabled, the stream of samples can be used to reconstruct the incoming bit string. To obtain good resolution, a fairly high sampling rate should be selected.

The "Programmed-T-Period" mode should be used with the receiver demodulator enabled. The T Period represents one half bit time for protocols using biphase encoding, or the basic unit of pulse distance for protocols using pulse distance encoding. The baud rate is usually programmed to match the T Period. For long periods of logic low or high, the receiver samples the demodulated signal at the programmed sampling rate.

Whenever a new infrared energy pulse is detected, the receiver synchronizes the sampling process to the incoming signal timing. This reduces timing related errors and eliminates the possibility of missing short infrared pulse sequences, especially with the RECS 80 protocol.

In addition, the "Programmed-T-Period" sampling minimizes the amount of data used to represent the incoming infrared signal, therefore reducing the processing overhead in the host CPU.

7.8 FIFO TIME-OUTS

Time-out mechanisms prevent received data from remaining in the RX_FIFO indefinitely, if the programmed interrupt or DMA thresholds are not reached.

An RX_FIFO time-out generates a Receiver Data Ready interrupt and/or a receiver DMA request if bit 0 of IER and/or bit 2 of MCR (in Extended mode) are set to 1 respectively. An RX_FIFO time-out also sets bit 0 of ASCR to 1 if the RX_FIFO is below the threshold. When a Receiver Data Ready interrupt occurs, this bit is tested by the software to

determine whether a number of bytes indicated by the RX_FIFO threshold can be read without checking bit 0 of the LSR register.

The conditions that must exist for a time-out to occur in the various modes of operation are described below.

When a time-out has occurred, it can only be reset when the FIFO is read by the CPU or DMA controller.

7.8.1 UART, SIR or Sharp-IR Mode Time-Out Conditions

Two timers (timer1 and timer 2) are used to generate two different time-out events (A and B, respectively). Timer 1 times out after 64 μ sec. Timer 2 times out after four character times.

Time-out event A generates an interrupt and sets the RXF_TOUT bit (bit 0 of ASCR) when all of the following are true:

- At least one byte is in the RX_FIFO, and
- More than 64 μ sec or four character times, whichever is greater, have elapsed since the last byte was loaded into the RX_FIFO from the receiver logic, and
- More than 64 μ sec or four character times, whichever is greater, have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

Time-out event B activates the receiver DMA request and is invisible to the software. It occurs when all of the following are true:

- At least one byte is in the RX_FIFO, and
- More than 64 μ sec or four character times, whichever is smaller, have elapsed since the last byte was loaded into the RX_FIFO from the receiver logic, and
- More than 64 μ sec or four character times, whichever is smaller, have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

7.8.2 Consumer-IR Mode Time-Out Conditions

The RX_FIFO time-out, in Consumer-IR mode, is disabled while the receiver is active. It occurs when all of the following are true:

- At least one byte has been in the RX_FIFO for 64 μ sec or more, and
- The receiver has been inactive (RXACT = 0) for 64 μ sec or more, and
- More than 64 μ sec have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

7.8.3 Transmission Deferral

This feature allows software to send high-speed data in Programmed Input/Output (PIO) mode without the risk of generating a transmitter underrun.

Transmission deferral is available only in Extended mode and when the TX_FIFO is enabled. When transmission deferral is enabled (TX_DFR bit in the MCR register set to 1) and the transmitter becomes empty, an internal flag is set that locks the transmitter. If the CPU now writes data into the TX_FIFO, the transmitter does not start sending the data until the TX_FIFO level reaches either 14 for a 16-level TX_FIFO, or 30 for a 32-level TX_FIFO, at which time the

internal flag is cleared. The internal flag is also cleared and the transmitter starts transmitting when a time-out condition is reached. This prevents some bytes from being in the TX_FIFO indefinitely if the threshold is not reached.

The time-out mechanism is implemented by a timer that is enabled when the internal flag is set and there is at least one byte in the TX_FIFO. Whenever a byte is loaded into the TX_FIFO the timer gets reloaded with the initial value. If no bytes are loaded for a 64-μsec time, the timer times out and the internal flag is cleared, thus enabling the transmitter.

7.9 AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE

The automatic fallback feature supports existing legacy software packages that use the 16550 UART by automatically turning off any Extended mode features and switches the UART to Non-Extended mode when either of the LBGD(L) or LBGD(H) ports in bank 1 is read from or written to by the CPU.

This eliminates the need for user intervention prior to running a legacy program.

In order to avoid spurious fallbacks, alternate baud rate registers are provided in bank 2. Any program designed to take advantage of the UART's extended features, should not use LBGD(L) and LBGD(H) to change the baud rate. It should use the BGD(L) and BGD(H) registers instead. Access to these ports will not cause fallback.

Fallback can occur in any mode. In Extended UART mode, fallback is always enabled. In this case, when a fallback occurs, the following happens:

- Transmission and Reception FIFOs switch to 16 levels.
- A value of 13 is selected for the baud generator prescaler
- The BTEST and ETDLBK bits in the EXCR1 register are cleared.
- UART mode is selected.
- A switch to a Non-Extended UART mode occurs.

When a fallback occurs in a Non-Extended UART mode, the last two of the above actions do not take place.

No switch to UART mode occurs if either SIR or Sharp-IR mode was selected. This prevents spurious switching to UART mode when a legacy program running in infrared mode accesses the baud generator divisor registers from bank 1.

Fallback from a Non-Extended mode can be disabled by setting the LOCK bit in register EXCR2. When LOCK is set to 1 and the UART is in a Non-Extended mode, two scratch registers overlaid with LBGD(L) and LBGD(H) are enabled. Any attempted CPU access of LBGD(L) and LBGD(H) accesses the scratch registers, and the baud rate setting is not affected. This feature allows existing legacy programs to run faster than 115.2 Kbps.

7.10 OPTICAL TRANSCIEVER INTERFACE

This module implements a flexible interface for the external infrared transceiver. Several signals are provided for this purpose. A transceiver module with one or two reception signals, or two transceiver modules can interface directly with this module without any additional logic.

Since various operational modes are supported by this module, the transmitter power as well as the receiver filter in the transceiver module must be configured according to the selected mode.

This module provides four interface pins to control the infrared transceiver. ID/IRSL(2-0) are three I/O pins and ID3 is an Input pin. All of these pins are powered up as inputs.

When in input mode, they can be used to read the identification data of Plug-n-Play infrared adapters.

When in output mode, the logic levels of IRSL(2-0) can be either controlled directly by the software by setting bits 2-0 of the IRCFG1 register, or they can be automatically selected by this module whenever the operation mode changes.

The automatic transceiver configuration is enabled by setting the AMCFG bit (bit 7) in the IRCFG4 register to 1. It allows the low-level functional details of the transceiver module being used to be hidden from the software drivers.

The operation mode settings for the automatic configuration are determined by various bit fields in the Infrared Interface Configuration registers (IRCFG[4-1]) that must be programmed when the UART is initialized.

The ID0/IRSL0/IRRX2 pin can also be used as an input to support an additional infrared reception signal. In this case, however, only two configuration pins are available.

The IRSL0_DS and IRSL21_DS bits in the IRCFG4 register determines the direction of IRSL(2-0).

7.11 BANK 0 – GLOBAL CONTROL AND STATUS REGISTERS

In the Non-Extended modes of operation, bank 0 is compatible with both the 16450 and the 16550. Upon reset, this module defaults to the 16450 mode. In the Extended mode, all the Registers (except RXD/ TXD) offer additional features.

TABLE 7-2. Bank 0 Serial Controller Base Registers

Offset	Register Name	Description
00h	RXD/ TXD	Receiver Data Port/ Transmitter Data Port
01h	IER	Interrupt Enable Register
02h	EIR/ FCR	Event Identification Register/ FIFO Control Register
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h	MCR	Modem Control Register
05h	LSR	Link Status Register
06h	MSR	Modem Status Register
07h	SCR/ ASCR	Scratch Register/ Auxiliary Status and Control Register

7.11.1 Receiver Data Port (RXD) or the Transmitter Data Port (TXD), Bank 0, Offset 00h

These ports share the same address.

RXD is accessed during CPU read cycles. It is used to read data from the Receiver Holding Register when the FIFOs are disabled, or from the bottom of the RX_FIFO when the FIFOs are enabled. See Figure 7-3.

TXD is accessed during CPU write cycles. It is used to write data to the Transmitter Holding Register when the FIFOs are disabled, or to the TX_FIFO when the FIFOs are enabled. See Figure 7-4.

DMA cycles always access the TXD and RXD ports, regardless of the selected bank.

Receiver Data Port (RXD), Bank 0, Offset 00h

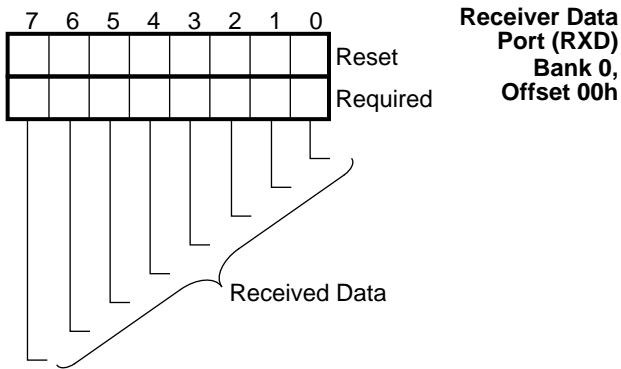


FIGURE 7-3. RXD Register Bitmap

Bits 7-0 - Received Data

Used to access the Receiver Holding Register when the FIFOs are disabled, or the bottom of the RX_FIFO when the FIFOs are enabled.

Transmitter Data Port (TXD), Bank 0, Offset 00h

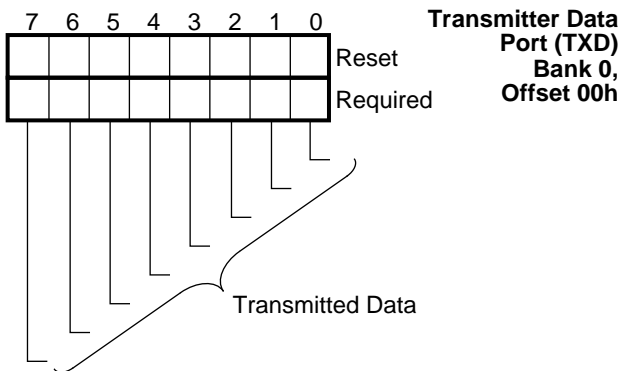


FIGURE 7-4. TXD Register Bitmap

Bits 7-0 - Transmitted Data

Used to access the Transmitter Holding Register when the FIFOs are disabled or the top of TX_FIFO when the FIFOs are enabled.

7.11.2 Interrupt Enable Register (IER), Bank 0, Offset 01h

This register controls the enabling of various interrupts. Some interrupts are common to all operating modes of the module, while others are mode specific. Bits 4 to 7 can be set in Extended mode only. They are cleared in Non-Extended mode. The bits of the Interrupt Enable Register (IER) are defined differently, depending on the operating mode of the module.

The different modes can be divided into the following four groups:

- Non-Extended (which includes UART, Sharp-IR and SIR).
- UART and Sharp-IR in Extended mode.
- SIR in Extended mode.
- Consumer-IR.

The following sections describe the bits in this register for each of these modes.

The reset mode for the IER is the Non-Extended UART mode.

When edge-sensitive interrupt triggers are employed, user is advised to clear all IER bits immediately upon entering the interrupt service routine and to re-enable them prior to exiting (or alternatively, to disable CPU interrupts and re-enable prior to exiting). This will guarantee proper interrupt triggering in the interrupt controller in case one or more interrupt events occur during execution of the interrupt routine.

If the LSR, MSR or EIR registers are to be polled, interrupt sources which are identified by self-clearing bits should have their corresponding IER bits set to 0, to prevent spurious pulses on the interrupt output pin.

If an interrupt source must be disabled, the CPU can do so by clearing the corresponding bit in the IER register. However, if an interrupt event occurs just before the corresponding enable bit in the IER register is cleared, a spurious interrupt may be generated. To avoid this problem, the clearing of any IER bit should be done during execution of the interrupt service routine. If the interrupt controller is programmed for level-sensitive interrupts, the clearing of IER bits can also be performed outside the interrupt service routine, but with the CPU interrupt disabled.

Interrupt Enable Register (IER), in the Non-Extended Modes (UART, SIR and Sharp-IR)

Upon reset, the IER supports UART, SIR and Sharp-IR in the Non-Extended modes. Figure 7-5 shows the bitmap of the Interrupt Enable Register in these modes.

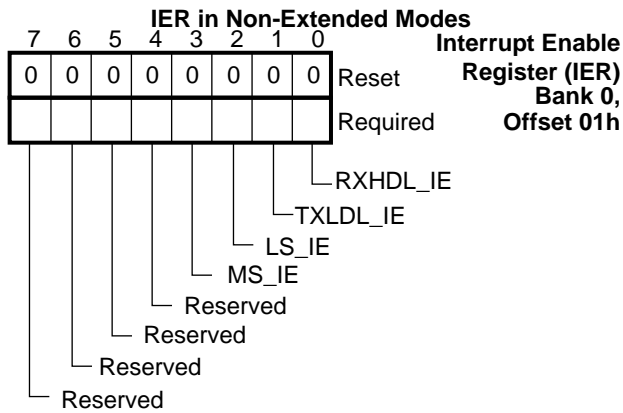


FIGURE 7-5. IER Register Bitmap, Non-Extended Mode

Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

Setting this bit enables interrupts on Receiver High-Data-Level, or RX_FIFO Time-Out events (EIR Bits 3-0 are 0100 or 1100. See “Non-Extended Mode Interrupt Priorities” on page 144).

- 0 - Disable Receiver High-Data-Level and RX_FIFO Time-Out interrupts (Default).
- 1 - Enable Receiver High-Data-Level and RX_FIFO Time-Out interrupts.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts on Transmitter Low-Data-Level-events (EIR Bits 3-0 are 0010. See “Non-Extended Mode Interrupt Priorities” on page 144).

- 0 - Disable Transmitter Low-Data-Level Interrupts (Default).
- 1 - Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Link Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Link Status events. (EIR Bits 3-0 are 0110. See “Non-Extended Mode Interrupt Priorities” on page 144).

- 0 - Disable Link Status Interrupts (LS_EV) (Default).
- 1 - Enable Link Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events. (EIR Bits 3-0 are 0000. See See Table 7-3 on page 144).

- 0 - Disable Modem Status Interrupts (MS_EV) (Default).
- 1 - Enable Modem Status Interrupts (MS_EV).

Bits 7-4 - Reserved

These bits are reserved.

Interrupt Enable Register (IER), in the Extended Modes of UART, Sharp-IR and SIR

Figure 7-6 shows the bitmap of the Interrupt Enable Register in these modes.

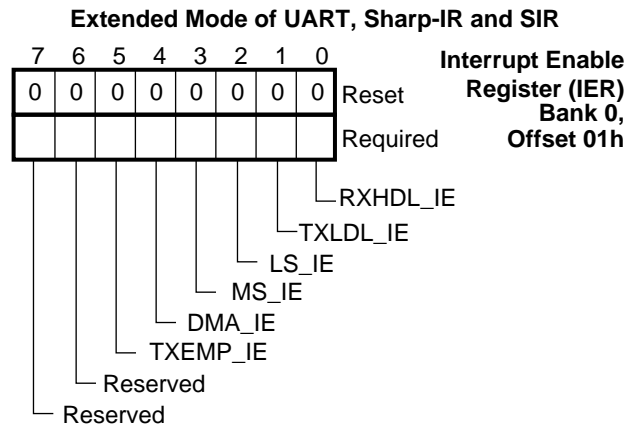


FIGURE 7-6. IER Register Bitmap, Extended Modes of UART and Sharp-IR

Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

Setting this bit enables interrupts when the RX_FIFO is equal to or above the RX_FIFO threshold level, or an RX_FIFO time out occurs.

- 0 - Disable Receiver Data Ready interrupt. (Default)
- 1 - Enable Receiver Data Ready interrupt.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts when the TX_FIFO is below the threshold level or the Transmitter Holding Register is empty.

- 0 - Disable Transmitter Low-Data-Level Interrupts (Default).
- 1 - Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Link Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Link Status events.

- 0 - Disable Link Status Interrupts (LS_EV) (Default)
- 1 - Enable Link Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events.

- 0 - Disable Modem Status Interrupts (MS_EV) (Default)
- 1 - Enable Modem Status Interrupts (MS_EV).

Bit 4 - DMA Interrupt Enable (DMA_IE)

Setting this bit enables the interrupt on terminal count when the DMA is enabled.

- 0 - Disable DMA terminal count interrupt (Default)
- 1 - Enable DMA terminal count interrupt.

Bit 5 - Transmitter Empty Interrupt Enable (TXEMP_IE)

Setting this bit enables interrupt generation if the transmitter and TX_FIFO become empty.

- 0 - Disable Transmitter Empty interrupts (Default)
- 1 - Enable Transmitter Empty interrupts.

Bits 7,6 - Reserved

Reserved.

Interrupt Enable Register (IER), Consumer-IR Mode, Bank 0, Offset 01h

Figure 7-7 shows the bitmap of the Interrupt Enable Register (IER) in this mode.

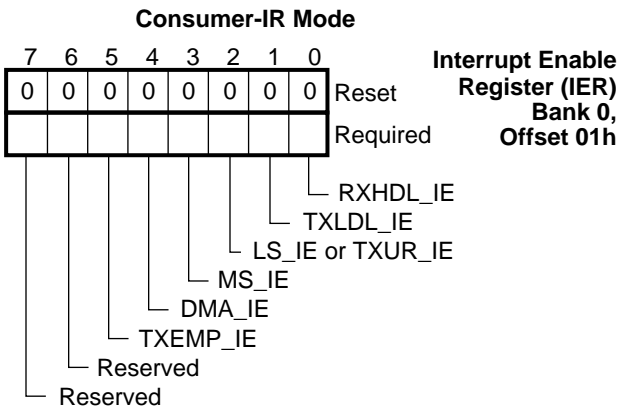


FIGURE 7-7. IER Register Bitmap, Consumer-IR Mode

Bit 1-0 -

Same as in the Extended Modes of UART and Sharp-IR (See previous sections).

Bit 2 - Link Status Interrupt Enable (LS_IE) or TX_FIFO Underrun Interrupt Enable (TXUR_IE)

On reception, Setting this bit enables Link Status Interrupts.

On transmission, Setting this bit enables TX_FIFO underrun interrupts.

- 0 - Disable Link Status and TX_FIFO underrun interrupts (Default)
- 1 - Enable Link Status and TX_FIFO underrun interrupts.

Bit 7-3 -

Same as in the Extended Modes of UART and Sharp-IR (See the section "Interrupt Enable Register (IER), in the Extended Modes of UART, Sharp-IR and SIR" on page 142).

7.11.3 Event Identification Register (EIR), Bank 0, Offset 02h

The **Event Identification Register (EIR)** and the **FIFO Control Register (FCR)** (see next register description) share the same address. The **EIR** is accessed during CPU read cycles while the **FCR** is accessed during CPU write cycles. The Event Identification Register (EIR) indicates the interrupt source. The function of this register changes according to the selected mode of operation.

Event Identification Register (EIR), Non-Extended Mode

When Extended mode is not selected (EXT_SL bit in EXCR1 register is set to 0), this register is the same as in the 16550.

In a Non-Extended UART mode, this module prioritizes interrupts into four levels. The EIR indicates the highest level of interrupt that is pending. The encoding of these interrupts is shown in Table 7-3.

When the EIR is being read, the display of the highest priority pending interrupt is frozen; new interrupt requests are recorded, but the indication is not updated until the access is complete.

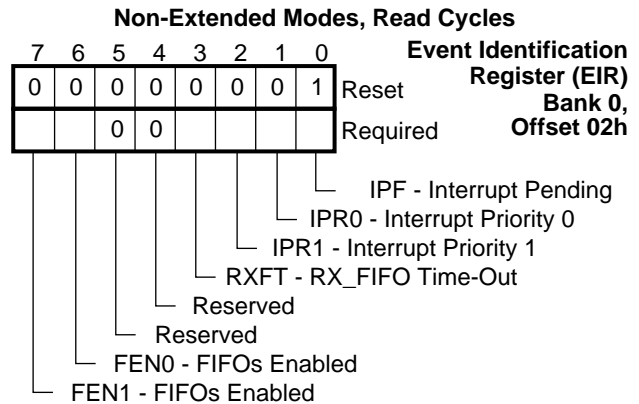


FIGURE 7-8. EIR Register Bitmap, Non-Extended Modes

Bit 0 - Interrupt Pending Flag (IPF)

- 0 - There is an interrupt pending.
- 1 - No interrupt pending. (Default)

Bits 2,1 - Interrupt Priority 1,0 (IPR1,0)

When bit 0 (IPF) is 0, these bits indicate the pending interrupt with the highest priority. See Table 7-3. Default value is 00.

Bit 3 - RX_FIFO Time-Out (RXFT)

In the 16450 mode, this bit is always 0. In the 16550 mode (FIFOs enabled), this bit is set to 1 when an RX_FIFO read time-out occurred and the associated interrupt is currently the highest priority pending interrupt.

Bits 5,4 - Reserved

Read/Write 0.

Bit 7,6 - FIFOs Enabled (FEN1,0)

- 0 - No FIFO enabled. (Default)
- 1 - FIFOs are enabled (bit 0 of FCR is set to 1).

TABLE 7-3. Non-Extended Mode Interrupt Priorities

EIR Bits 3 2 1 0	Interrupt Set and Reset Functions			
	Priority Level	Interrupt Type	Interrupt Source	Interrupt Reset Control
0 0 0 1	-	None	None	-
0 1 1 0	Highest	Link Status	Parity error, framing error, data overrun or break event	Read Link Status Register (LSR).
0 1 0 0	Second	Receiver High Data Level Event	Receiver Holding Register (RXD) full, or RX_FIFO level equal to or above threshold.	Reading the RXD or, RX_FIFO level drops below threshold.
1 1 0 0	Second	RX_FIFO Time-Out	At least one character is in the RX_FIFO, and no character has been input to or read from the RX_FIFO for 4 character times.	Reading the RXD port.
0 0 1 0	Third	Transmitter Low Data Level Event	Transmitter Holding Register or TX_FIFO empty.	Reading the EIR Register if this interrupt is currently the highest priority pending interrupt, or writing into the TXD port.
0 0 0 0	Fourth	Modem Status	Any transition on \overline{CTS} , \overline{DSR} or \overline{DCD} or a low to high transition on RI.	Reading the Modem Status Register (MSR).

Event Identification Register (EIR), Extended Mode

In Extended mode, each of the previously prioritized and encoded interrupt sources is broken down into individual bits. Each bit in this register acts as an interrupt pending flag, and is set to 1 when the corresponding event occurred or is pending, regardless of the IER register bit setting.

When this register is read the DMA event bit (bit 4) is cleared if an 8237 type DMA is used. All other bits are cleared when the corresponding interrupts are acknowledged by reading the relevant register (e.g. reading MSR clears MS_EV bit).

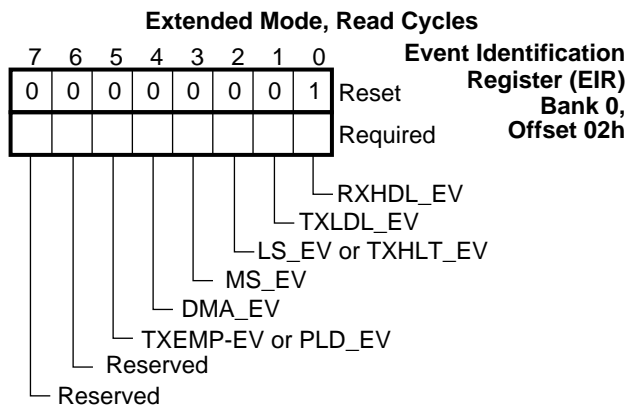


FIGURE 7-9. EIR Register Bitmap, Extended Mode

Bit 0 - Receiver High-Data-Level Event (RXHDL_EV)

When FIFOs are disabled, this bit is set to 1 when a character is in the Receiver Holding Register.

When FIFOs are enabled, this bit is set to 1 when the RX_FIFO is above threshold or an RX_FIFO time-out has occurred.

Bit 1 - Transmitter Low-Data-Level Event (TXLDL_EV)

When FIFOs are disabled, this bit is set to 1 when the Transmitter Holding Register is empty.

When FIFOs are enabled, this bit is set to 1 when the TX_FIFO is below the threshold level.

Bit 2 - Link Status Event (LS_EV) or Transmitter Halted Event (TXHLT_EV)

In the **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 when a receiver error or break condition is reported.

When FIFOs are enabled, the Parity Error(PE), Frame Error(FE) and Break(BRK) conditions are only reported when the associated character reaches the bottom of the RX_FIFO. An Overrun Error (OE) is reported as soon as it occurs.

In the **Consumer-IR** mode, this bit indicates that a Link Status Event (LS_EV) or a Transmitter Halted Event (TXHLT_EV) occurred. It is set to 1 when any of the following conditions occurs:

- A receiver overrun.
- A transmitter underrun.

Bit 3 - Modem Status Event (MS_EV)

In UART mode this bit is set to 1 when any of the 0 to 3 bits in the MSR register is set to 1.

In any **IR** mode, the function of this bit depends on the setting of the IRMSSL bit in the IRCR2 register (see Table 7-4 and also "Bit 1 - MSR Register Function Select in Infrared Mode (IRMSSL)" on page 158).

TABLE 7-4. Modem Status Event Detection Enable

IRMSSL Value	Bit Function
0	Modem Status Event (MS_EV)
1	Forced to 0.

Bit 4 - DMA Event Occurred (DMA_EV)

When an 8237 type DMA controller is used, this bit is set to 1 when a DMA terminal count (TC) is signalled. It is cleared upon read.

Bit 5 - Transmitter Empty (TXEMP_EV)

In **UART, Sharp-IR** and **Consumer-IR** modes, this bit is the same as bit 6 of the LSR register. It is set to 1 when the transmitter is empty.

Bits 7,6 - Reserved

Read/Write 0.

7.11.4 FIFO Control Register (FCR), Bank 0, Offset 02h

The FIFO Control Register (FCR) is write only. It is used to enable the FIFOs, clear the FIFOs and set the interrupt thresholds levels for the reception and transmission FIFOs.

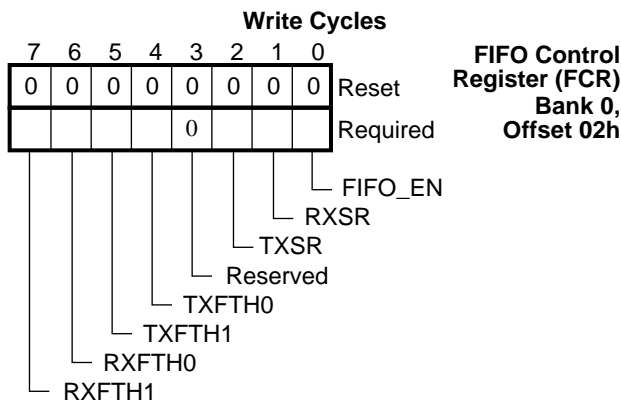


FIGURE 7-10. FCR Register Bitmap

Bit 0 - FIFO Enable (FIFO_EN)

When set to 1 enables both the Transmission and Reception FIFOs. Resetting this bit clears both FIFOs.

In **Consumer-IR** modes the FIFOs are always enabled and the setting of this bit is ignored.

Bit 1 - Receiver Soft Reset (RXSR)

Writing a 1 to this bit generates a receiver soft reset, which clears the RX_FIFO and the receiver logic. This bit is automatically cleared by the hardware.

Bit 2 - Transmitter Soft Reset (TXSR)

Writing a 1 to this bit generates a transmitter soft reset, which clears the TX_FIFO and the transmitter logic. This bit is automatically cleared by the hardware.

Bit 3 - Reserved

Read/Write 0.

Writing to this bit has no effect on the UART operation.

Bits 5,4 - TX_FIFO Threshold Level (TXFTH1,0)

In **Non-Extended** modes, these bits have no effect.

In **Extended** modes, these bits select the TX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the TX_FIFO drops below the encoded threshold.

TABLE 7-5. TX_FIFO Level Selection

TXFTH (Bits 5,4)	TX_FIFO Tresh. (16 Levels)	TX_FIFO Tresh. (32 Levels)
00(Default)	1	1
01	3	7
10	9	17
11	13	25

Bits 7,6 - RX_FIFO Threshold Level (RXFTH1,0)

These bits select the RX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the RX_FIFO is equal to or above the encoded threshold.

TABLE 7-6. RX_FIFO Level Selection

RXFTH (Bits 5,4)	RX_FIFO Tresh. (16 Levels)	RX_FIFO Tresh. (32 Levels)
00(Default)	1	1
01	4	8
10	8	16
11	14	26

7.11.5 Link Control Register (LCR), Bank 0, Offset 03h, and Bank Selection Register (BSR), All Banks, Offset 03h

The **Link Control Register (LCR)** and the **Bank Select Register (BSR)** (see the next register) share the same address.

The **Link Control Register (LCR)** selects the communications format for data transfers in UART, SIR and Sharp-IR modes.

Upon reset, all bits are set to 0.

Reading the register at this address location returns the content of the BSR. The content of LCR may be read from the Shadow of Link Control Register (SH_LCR) register in bank 3 (See Section 7.13.2 on page 157). During a write operation to this register at this address location, the setting of bit 7 (Bank Select Enable, BKSE) determines whether LCR or BSR is to be accessed, as follows:

- If bit 7 is 0, the write affects both LCR and BSR.
- If bit 7 is 1, and it is not one of the codes that selects bank 1 (see Table 7-9, "Bank Selection Encoding" on page 147), the write affects only BSR, and LCR remains unchanged. This prevents the communications format from being spuriously affected when a bank other than 0 or 1 is accessed.

Upon reset, all bits are set to 0.

Link Control Register (LCR), All Banks, Offset 03h

Bits 6-0 are only effective in **UART**, **Sharp-IR** and **SIR** modes. They are ignored in **Consumer-IR** mode.

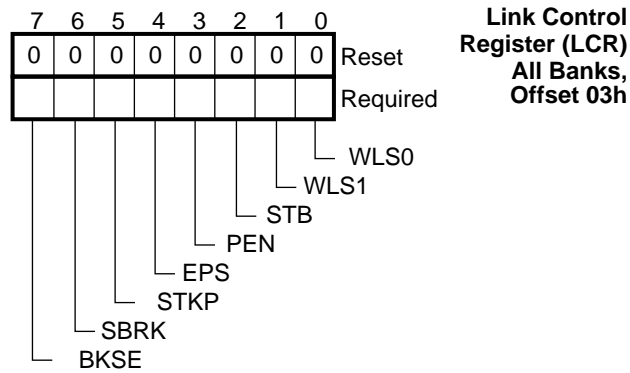


FIGURE 7-11. LCR Register Bitmap

Bits 1,0 - Character Length Select (WLS1,0)

These bits specify the number of data bits in each transmitted or received serial character. Table 7-7 shows how to encode these bits.

TABLE 7-7. Word Length Select Encoding

WLS1	WLS0	Character Length
0	0	5 (Default)
0	1	6
1	0	7
1	1	8

Bits 2 - Number of Stop Bits (STB)

This bit specifies the number of stop bits transmitted with each serial character.

- 0 - One stop bit is generated. (Default)
- 1 - If the data length is set to 5-bits via bits 1,0 (WLS1,0), 1.5 stop bits are generated. For 6, 7 or 8 bit word lengths, two stop bits are transmitted. The receiver checks for one stop bit only, regardless of the number of stop bits selected.

Bit 3 - Parity Enable (PEN)

This bit enable the parity bit See Table 7-8 on page 146. The parity enable bit is used to produce an even or odd number of 1s when the data bits and parity bit are summed, as an error detection device.

- 0 - No parity bit is used. (Default)
- 1 - A parity bit is generated by the transmitter and checked by the receiver.

Bit 4 - Even Parity Select (EPS)

When Parity is enabled (PEN is 1), this bit, together with bit 5 (STKP), controls the parity bit as shown in Table 7-8.

- 0 - If parity is enabled, an odd number of logic 1s are transmitted or checked in the data word bits and parity bit. (Default)

- 1 - If parity is enabled, an even number of logic 1s are transmitted or checked.

Bit 5 - Stick Parity (STKP)

When Parity is enabled (PEN is 1), this bit, together with bit 4 (EPS), controls the parity bit as show in Table 7-8.

TABLE 7-8. Bit Settings for Parity Control

PEN	EPS	STKP	Selected Parity Bit
0	x	x	None
1	0	0	Odd
1	1	0	Even
1	0	1	Logic 1
1	1	1	Logic 0

Bit 6 - Set Break (SBRK)

This bit enables or disables a break. During the break, the transmitter can be used as a character timer to accurately establish the break duration.

This bit acts only on the transmitter front-end and has no effect on the rest of the transmitter logic.

When set to 1 the following occurs:

- If a **UART** mode is selected, the SOUT pin is forced to a logic 0 state.
- If **SIR** mode is selected, pulses are issued continuously on the IRTX pin.
- If **Sharp-IR** mode is selected and internal modulation is enabled, pulses are issued continuously on the IRTX pin.
- If **Sharp-IR** mode is selected and internal modulation is disabled, the IRTX pin is forced to a logic 1 state.

To avoid transmission of erroneous characters as a result of the break, use the following procedure to set SBRK:

1. Wait for the transmitter to be empty. (TXEMP = 1).
2. Set SBRK to 1.
3. Wait for the transmitter to be empty, and clear SBRK when normal transmission must be restored.

Bit 7 - Bank Select Enable (BKSE)

- 0 - This register functions as the Link Control Register (LCR).
- 1 - This register functions as the Bank Select Register (BSR).

7.11.6 Bank Selection Register (BSR), All Banks, Offset 03h

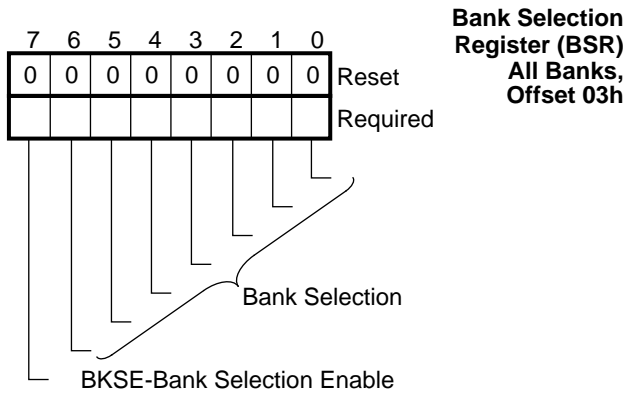


FIGURE 7-12. BSR Register Bitmap

The **Bank Selection Register (BSR)** selects which register bank is to be accessed next.

About accessing this register see the description of bit 7 of the LCR Register.

Bits 6-0 - Bank Selection

When bit 7 is set to 1, bits 6-0 of BSR select the bank, as shown in Table 7-9.

Bit 7 - Bank Selection Enable (BKSE)

- 0 - Bank 0 is selected.
- 1 - Bits 6-0 specify the selected bank.

TABLE 7-9. Bank Selection Encoding

BSR Bits								Bank Selected	LCR
7	6	5	4	3	2	1	0		
0	x	x	x	x	x	x	x	0	LCR is written
1	0	x	x	x	x	x	x	1	
1	1	x	x	x	x	1	x	1	
1	1	x	x	x	x	x	1	1	
1	1	1	0	0	0	0	0	2	LCR is not written
1	1	1	0	0	1	0	0	3	
1	1	1	0	1	0	0	0	4	
1	1	1	0	1	1	0	0	5	
1	1	1	1	0	0	0	0	6	
1	1	1	1	0	1	0	0	7	
1	1	1	1	1	x	0	0	Reserved	
1	1	0	x	x	x	0	0	Reserved	

7.11.7 Modem/Mode Control Register (MCR), Bank 0, Offset 04h

This register controls the interface with the modem or data communications set, and the device operational mode when the device is in the **Extended** mode. The register function differs for Extended and Non-Extended modes.

Modem/Mode Control Register (MCR), Non-Extended Mode, Bank 0, Offset 04h

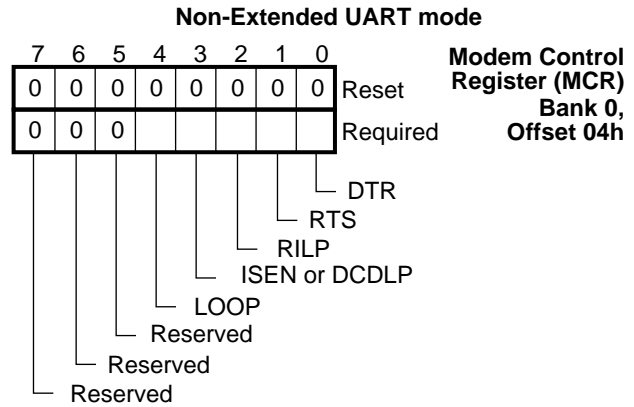


FIGURE 7-13. MCR Register Bitmap, Non-Extended Mode

Bit 0 - Data Terminal Ready (DTR)

This bit controls the \overline{DTR} signal output. When set to 1, \overline{DTR} is driven low. When loopback is enabled (LOOP is set to 1), this bit internally drives \overline{DSR} .

Bit 1 - Request To Send (RTS)

This bit controls the \overline{RTS} signal output. When set to 1, drives \overline{RTS} low. When loopback is enabled (LOOP is set), this bit drives \overline{CTS} , internally.

Bit 2 - Loopback Interrupt Request (RILP)

When loopback is enabled, this bit internally drives \overline{RI} . Otherwise it is unused.

Bit 3 - Interrupt Signal Enable (ISEN) or Loopback DCD (DCDLP)

In normal operation (standard 16450 or 16550) mode, this bit controls the interrupt signal and must be set to 1 in order to enable the interrupt request signal.

When loopback is enabled, the interrupt output signal is always enabled, and this bit internally drives \overline{DCD} .

New programs should always keep this bit set to 1 during normal operation. The interrupt signal should be controlled through the Plug-n-Play logic.

Bit 4 - Loopback Enable (LOOP)

When this bit is set to 1, it enables loopback. This bit accesses the same internal register as bit 4 of the EXCR1 register. (see "Bit 4 - Loopback Enable (LOOP)" on page 154 for more information on the Loopback mode).

- 0 - Loopback disabled. (Default)
- 1 - Loopback enabled.

Bits 7-5 - Reserved

Read/Write 0.

Modem/Mode Control Register (MCR), Extended Mode, Bank 0, Offset 04h

In Extended mode, this register is used to select the operation mode (IrDA, Sharp, etc.) of the device and to enable the DMA interface. In these modes, the interrupt output signal is always enabled, and loopback can be enabled by setting bit 4 of the EXCR1 register.

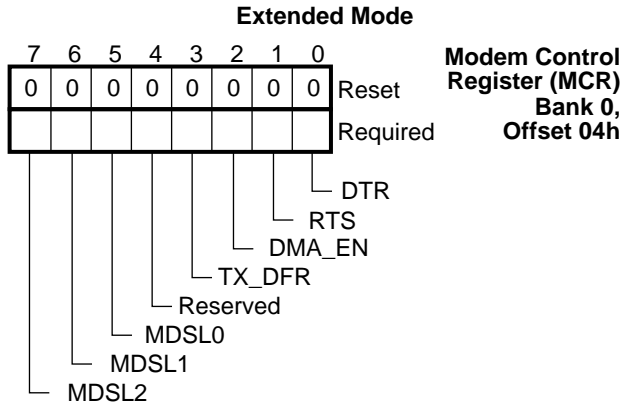


FIGURE 7-14. MCR Register Bitmap, Extended Modes

Bit 0 - Data Terminal Ready (DTR)

This bit controls the DTR signal output. When set to 1, DTR is driven low. When loopback is enabled (LOOP is set), this bit internally drives both \overline{DSR} and \overline{RI} .

Bit 1 - Request To Send (RTS)

This bit controls the RTS signal output. When set to 1, RTS is driven low. When loopback is enabled (LOOP is set), this bit internally drives both \overline{CTS} and \overline{DCD} .

Bit 2 - DMA Enable (DMA_EN)

When set to 1, DMA mode of operation is enabled. When DMA is selected, transmit and/or receive interrupts should be disabled to avoid spurious interrupts.

DMA cycles always address the Data Holding Registers or FIFOs, regardless of the selected bank.

Bit 3 - Transmission Deferral (TX_DFR)

For a detailed description of the Transmission Deferral see "Transmission Deferral" on page 139.

0 - No transmission deferral enabled. (Default)

1 - Transmission deferral enabled.

This bit is effective only if the Transmission FIFOs is enabled.

Bit 4 - Reserved

Read/Write 0.

Bits 7-5 - Mode Select (MDSL2-0)

These bits select the operational mode of the module when in **Extended** mode, as shown in Table 7-10.

When the mode is changed, the transmission and reception FIFOs are flushed, Link Status and Modem Status Interrupts are cleared, and all of the bits in the auxiliary status and control register are cleared.

TABLE 7-10. The Module Operation Modes

MDSL2 (Bit 7)	MDSL1 (Bit 6)	MDSL0 (Bit 5)	Operational Mode
0	0	0	UART mode (Default)
0	0	1	Reserved
0	1	0	Sharp-IR
0	1	1	SIR
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Consumer-IR
1	1	1	Reserved

7.11.8 Link Status Register (LSR), Bank 0, Offset 05h

This register provides status information concerning the data transfer. Bits 1 through 4 indicate link status events. These bits are sticky (they accumulate the occurrence of error conditions since the last time they were read). They are cleared when one of the following events occurs:

- Hardware reset.
- The receiver is soft-reset.
- The LSR register is read.

Upon reset this register assumes the value of 0x60h.

The bit definitions change depending upon the operation mode of the module.

Bits 4 through 1 of the LSR are the error conditions that generate a Receiver Link Status interrupt whenever any of the corresponding conditions are detected and that interrupt is enabled.

The LSR is intended for read operations only. Writing to the LSR is not permitted

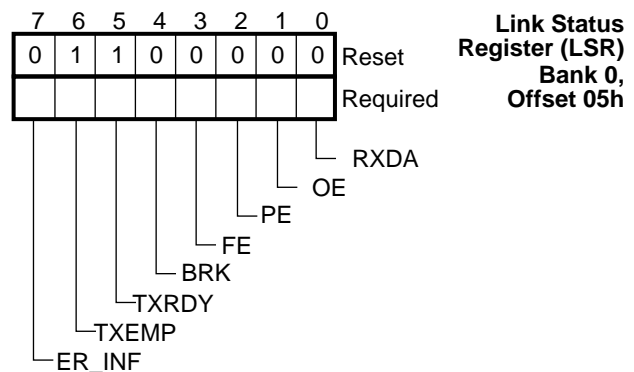


FIGURE 7-15. LSR Register Bitmap

Bit 0 - Receiver Data Available (RXDA)

Set to 1 when the Receiver Holding Register is full.

If the FIFOs are enabled, this bit is set when at least one character is in the RX_FIFO.

Cleared when the CPU reads all the data in the Holding Register or in the RX_FIFO.

Bit 1 - Overrun Error (OE)

This bit is set to 1 as soon as an overrun condition is detected by the receiver.

Cleared upon read.

With FIFOs Disabled:

An overrun occurs when a new character is completely received into the receiver front-end section and the CPU has not yet read the previous character in the receiver holding register. The new character is discarded, and the receiver holding register is not affected.

With FIFOs Enabled:

An overrun occurs when a new character is completely received into the receiver front-end section and the RX_FIFO is full. The new character is discarded, and the RX_FIFO is not affected.

Bit 2 - Parity Error (PE)

In **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 if the received data character does not have the correct parity, even or odd as selected by the parity control bits of the LCR register.

If the FIFOs are enabled, this error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.

This bit is cleared upon read.

Bit 3 - Framing Error (FE)

In **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 when the received data character does not have a valid stop bit (i.e., the stop bit following the last data bit or parity bit is a 0).

If the FIFOs are enabled, this Framing Error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.

After a framing error is detected, the receiver will try to resynchronize.

If the bit following the erroneous stop bit is 0, the receiver assumes it to be a valid start bit and shifts in the new character. If that bit is a 1, the receiver enters the idle state and awaits the next start bit.

This bit is cleared upon read.

Bit 4 - Break Event Detected (BRK)

In **UART, Sharp-IR** and **SIR** modes this bit is set to 1 when a break event is detected (i.e. when a sequence of logic 0 bits, equal or longer than a full character transmission, is received). If the FIFOs are enabled, the break condition is associated with the particular character in the RX_FIFO to which it applies. In this case, the BRK bit is set when the character reaches the bottom of the RX_FIFO.

When a break event occurs, only one zero character is transferred to the Receiver Holding Register or to the RX_FIFO.

The next character transfer takes place after at least one logic 1 bit is received followed by a valid start bit.

This bit is cleared upon read.

Bit 5 - Transmitter Ready (TXRDY)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty.

It is cleared when a data character is written to the TXD register.

Bit 6 - Transmitter Empty (TXEMP)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty, and the transmitter front-end is idle.

Bit 7 - Error in RX_FIFO (ER_INF)

In **UART, Sharp-IR** and **SIR** modes, this bit is set to a 1 if there is at least 1 framing error, parity error or break indication in the RX_FIFO.

This bit is always 0 in the 16450 mode.

This bit is cleared upon read.

7.11.9 Modem Status Register (MSR), Bank 0, Offset 06h

The function of this register depends on the selected operational mode. When a **UART** mode is selected, this register provides the current-state as well as state-change information of the status lines from the modem or data transmission module.

When any of the infrared modes is selected, the register function is controlled by the setting of the **IRMSSL** bit in the **IRCR2** (see page 158). If **IRMSSL** is 0, the **MSR** register works as in **UART** mode. If **IRMSSL** is 1, the **MSR** register returns the value 30 hex, regardless of the state of the modem input lines.

When loopback is enabled, the **MSR** register works similarly except that its status input signals are internally driven by appropriate bits in the **MCR** register since the modem input lines are internally disconnected. Refer to the **DTR** & **RTS** bits at the **MCR** (see page 147) and to the **LOOP** & **ETDLBK** bits at the **EXCR1** (see page 154) for more information.

A description of the various bits of the **MSR** register, with Loopback disabled and **UART** Mode selected, is provided below.

When bits 0, 1, 2 or 3 is set to 1, a Modem Status Event (**MS_EV**) is generated if the **MS_IE** bit is enabled in the **IER**

Bits 0 to 3 are set to 0 as a result of any of the following events:

- A hardware reset occurs.
- The operational mode is changed and the **IRMSSL** bit is 0.
- The **MSR** register is read.

In the reset state, bits 4 through 7 are indeterminate as they reflect their corresponding input signals.

Note: The modem status lines can be used as general purpose inputs. They have no effect on the transmitter or receiver operation.

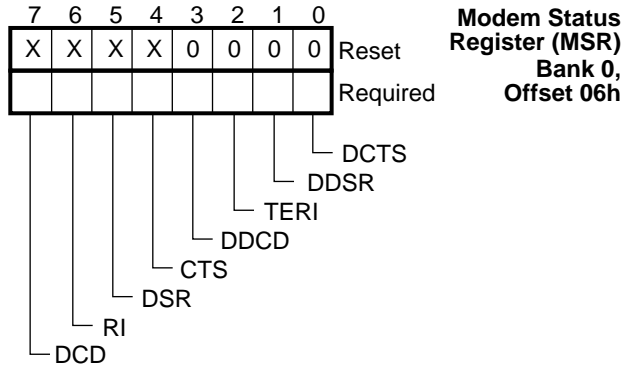


FIGURE 7-16. MSR Register Bitmap

Bit 0 - Delta Clear to Send (DCTS)

Set to 1, when the \overline{CTS} input signal changes state. This bit is cleared upon read.

Bit 1 - Delta Data Set Ready (DDSR)

Set to 1, when the \overline{DSR} input signal changes state. This bit is cleared upon read

Bit 2 - Trailing Edge Ring Indicate (TERI)

Set to 1, when the \overline{RI} input signal changes state from low to high. This bit is cleared upon read

Bit 3 - Delta Data Carrier Detect (DDCD)

Set to 1, when the \overline{DCD} input signal changes state. 1 - DCD signal state changed.

Bit 4 - Clear To Send (CTS)

This bit returns the inverse of the \overline{CTS} input signal.

Bit 5 - Data Set Ready (DSR)

This bit returns the inverse of the \overline{DSR} input signal.

Bit 6 - Ring Indicate (RI)

This bit returns the inverse of the \overline{RI} input signal.

Bit 7 - Data Carrier Detect (DCD)

This bit returns the inverse of the \overline{DCD} input signal.

7.11.10 Scratchpad Register (SPR), Bank 0, Offset 07h

This register shares a common address with the ASCR Register. In **Non-Extended** mode, this is a scratch register (as in the 16550) for temporary data storage.

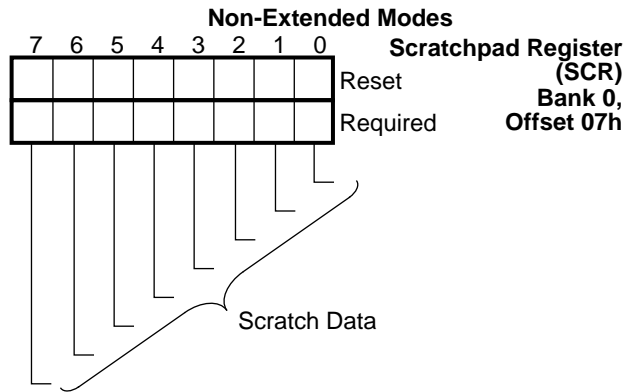


FIGURE 7-17. SPR Register Bitmap

7.11.11 Auxiliary Status and Control Register (ASCR), Bank 0, Offset 07h

This register shares a common address with the previous one (SCR).

This register is accessed when the **Extended** mode of operation is selected. The definition of the bits in this case is dependent upon the mode selected in the MCR register, bits 7 through 5. This register is cleared upon hardware reset or when the operational mode changes. Bits 2 and 6 are cleared when the transmitter is "soft reset". Bits 0,1,4 and 5 are cleared when the receiver is "soft reset".

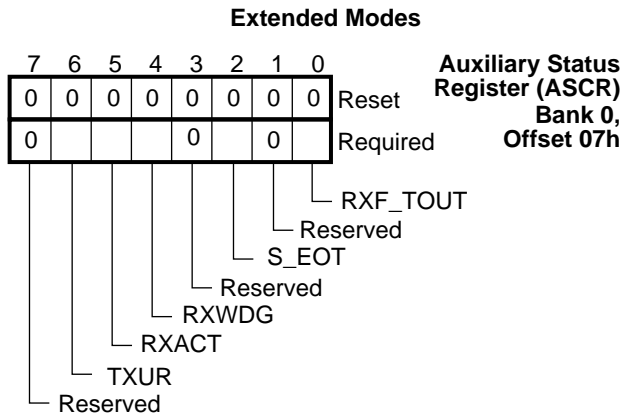


FIGURE 7-18. ASCR Register Bitmap

Bit 0 - RX_FIFO Time-Out (RXF_TOUT)

This bit is read only and set to 1 when an RX_FIFO time-out occurs. It is cleared when a character is read from the RX_FIFO.

Bit 1 -Reserved

Read/Write 0.

Bit 2 - Set End of Transmission (S_EOT)

In **Consumer-IR** mode this is the Set End of Transmission bit. When a 1 is written into this bit position before writing the last character into the TX_FIFO, data transmission is gracefully completed.

In this mode, if the CPU simply stops writing data into the TX_FIFO at the end of the data stream, a transmitter underrun is generated and the transmitter stops. In this case this is not an error, but the software must clear the underrun before the next transmission can occur. This bit is automatically cleared by hardware when a character is written to the TX_FIFO.

Bit 3 - Reserved

Read/Write 0.

Bit 4 - Reception Watchdog (RXWDG)

In **Consumer-IR** mode, this is the Reception Watchdog (RXWDG) bit. It is set to 1 each time a pulse or pulse-train (modulated pulse) is detected by the receiver. It can be used by the software to detect a receiver idle condition. It is cleared upon read.

Bit 5 - Receiver Active (RXACT)

In **Consumer-IR** Mode this is the Receiver Active (RXACT) bit. It is set to 1 when an infrared pulse or pulse-train is received. If a 1 is written into this bit position, the bit is cleared and the receiver is deactivated. When this bit is set, the receiver samples the infrared input continuously at the programmed baud rate and transfers the data to the RX_FIFO. See "Consumer-IR Reception" on page 138.

Bit 6 - Infrared Transmitter Underrun (TXUR)

In the **Consumer-IR** mode, this is the Transmitter Underrun flag. This bit is set to 1 when a transmitter underrun occurs. It is always cleared when a mode other than Consumer-IR is selected. This bit must be cleared, by writing 1 into it, to re-enable transmission.

Bit 7 - Reserved

Read/Write 0.

Bank 1 – The LEGACY Baud Generator DIVISOR PORTS

This register bank contains two baud generator divisor ports, and a bank select register.

The Legacy Baud-rate Generator Divisor (LBGD) port provides an alternate path to the Baud Divisor Generator register. This bank is implemented to maintain compatibility with 16550 standard and to support existing legacy software packages. In case of using legacy software, the addresses 0 and 1 are shared with the data ports RXD/TXD (see page 141). The selection between them is controlled by the value of the BKSE bit (LCR bit 7 page 145).

TABLE 7-11. Bank 1 Register Set

Offset	Register Name	Description
00h	LBGD(L)	Legacy Baud Generator Divisor Port (Low Byte)
01h	LBGD(H)	Legacy Baud Generator Divisor Port (High Byte)
02h		Reserved
03h	LCR/BSR	Link Control / Bank Select Register
04h - 07h		Reserved

In addition, a fallback mechanism maintains this compatibility by forcing the UART to revert to 16550 mode if 16550 software addresses the module after a different mode was set. Since setting the baud divisor values is a necessary initialization of the 16550, setting the divisor values in bank 1 forces the UART to enter 16550 mode. (This is called fallback.)

To enable other modes to program their desired baud rates without activating this fallback mechanism, the baud divisor register in bank 2 should be used.

7.11.12 Legacy Baud Generator Divisor Ports (LBGD(L) and LBGD(H)), Bank 1, Offsets 00h and 01h

The programmable baud rates in the Non-Extended mode are achieved by dividing a 24 MHz clock by a prescale value of 13, 1.625 or 1. This prescale value is selected by the PRESL field of EXCR2 (see page 155). This clock is subdivided by the two baud generator divisor buffers, which output a clock at 16 times the desired baud rate (this clock is the BAUDOUT clock). This clock is used by I/O circuitry, and after a last division by 16 produces the output baud rate.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden). The baud generator divisor must be loaded during initialization to ensure proper operation of the baud generator. Upon loading either part of it, the baud generator counter is immediately loaded. Table 7-14 on page 153 shows typical baud divisors. After reset the divisor register contents are indeterminate.

Any access to the **LBGD(L)** or **LBGD(H)** ports causes a reset to the default Non-Extended mode, i.e., 16550 mode (See "Automatic Fallback to A Non-Extended UART Mode" on page 140). To access a Baud Generator Divisor when in the **Extended** mode, use the port pair in bank 2 (BGD on page 152).

Table 7-12 shows the bits which are cleared when Fallback occurs during **Extended** or **Non-Extended** modes.

If the UART is in **Non-Extended** mode and the LOCK bit is 1, the content of the divisor (BGD) ports will not be affected and no other action is taken.

When programming the baud rate, the new divisor is loaded upon writing into LBGD(L) and LBGD(H). After reset, the contents of these registers are indeterminate.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden.) Table 7-14 shows typical baud divisors.

TABLE 7-12. Bits Cleared On Fallback

Register	UART Mode & LOCK bit before Fallback		
	Extended Mode	Non-Extended Mode	Non-Extended Mode
	LOCK = x	LOCK = 0	LOCK = 1
MCR	2 to 7	none	none
EXCR1	0, 5 and 7	5 and 7	none
EXCR2	0 to 5	0 to 5	none
IRCR1	2 and 3	none	none

TABLE 7-13. Bank 2 Register Set

Offset	Register Name	Description
00h	BGD(L)	Baud Generator Divisor Port (Low byte)
01h	BGD(H)	Baud Generator Divisor Port (High byte)
02h	EXCR1	Extended Control Register 1
03h	LCR/BSR	Link Control/ Bank Select Register
04h	EXCR2	Extended Control Register 2
05h	Reserved	
06h	TXFLV	TX_FIFO Level
07h	RXFLV	RX_FIFO Level

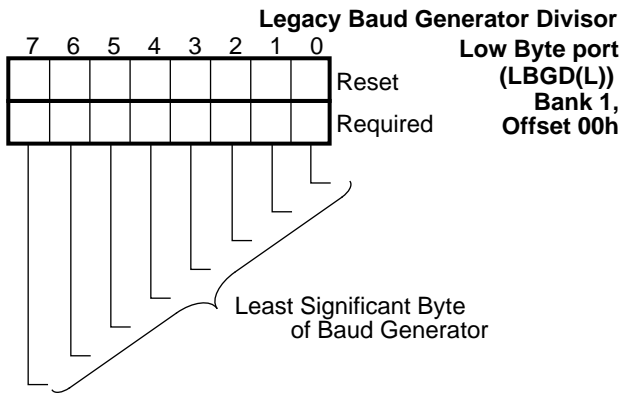


FIGURE 7-19. LBGD(L) Register Bitmap

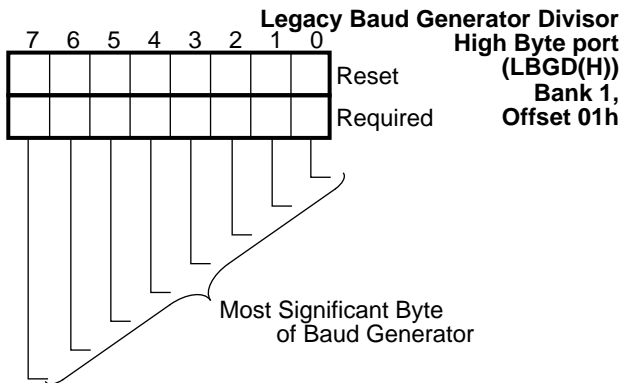


FIGURE 7-20. LBGD(H) Register Bitmap

7.11.13 Link Control Register (LCR) and Bank Select Register (BSR), Bank 1, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.12 BANK 2 – EXTENDED CONTROL AND STATUS REGISTERS

Bank 2 contains two alternate Baud Generator Divisor ports and the Extended Control Registers (EXCR1 and EXCR2).

7.12.1 Baud Generator Divisor Ports, LSB (BGD(L)) and MSB (BGD(H)), Bank 2, Offsets 00h and 01h

These ports perform the same function as the Legacy Baud Divisor Ports in Bank 1 and are accessed identically to them, but do not change the operation mode of the module when accessed. Refer to Section 7.11.12 on page 151 for more detail.

Use these ports to set the baud rate when operating in Extended mode to avoid fallback to a Non-Extended operation mode, i.e., 16550 compatible. When programming the baud rate, writing to BGDH causes the baud rate to change immediately.

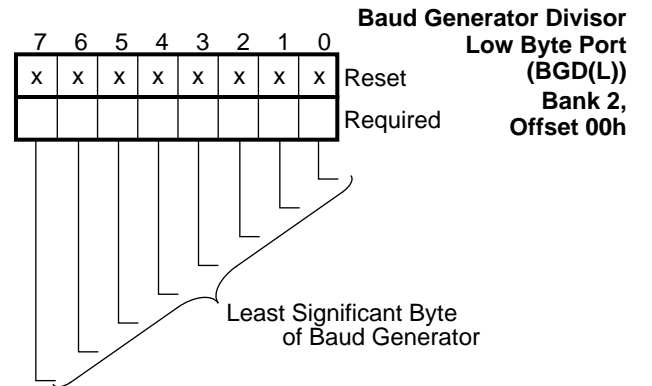


FIGURE 7-21. BGD(L) Register Bitmap

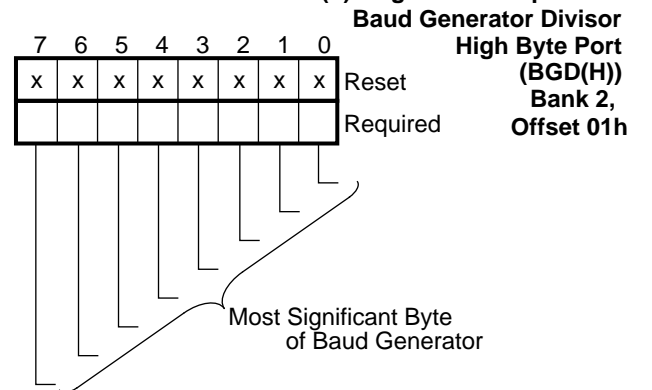


FIGURE 7-22. BGD(H) Register Bitmap

TABLE 7-14. Baud Generator Divisor Settings

Prescaler Value	13		1.625		1	
	Divisor	% Error	Divisor	% Error	Divisor	% Error
50	2304	0.16%	18461	0.00%	30000	0.00%
75	1536	0.16%	12307	0.01%	20000	0.00%
110	1047	0.19%	8391	0.01%	13636	0.00%
134.5	857	0.10%	6863	0.00%	11150	0.02%
150	768	0.16%	6153	0.01%	10000	0.00%
300	384	0.16%	3076	0.03%	5000	0.00%
600	192	0.16%	1538	0.03%	2500	0.00%
1200	96	0.16%	769	0.03%	1250	0.00%
1800	64	0.16%	512	0.16%	833	0.04%
2000	58	0.53%	461	0.12%	750	0.00%
2400	48	0.16%	384	0.16%	625	0.00%
3600	32	0.16%	256	0.16%	416	0.16%
4800	24	0.16%	192	0.16%	312	0.16%
7200	16	0.16%	128	0.16%	208	0.16%
9600	12	0.16%	96	0.16%	156	0.16%
14400	8	0.16%	64	0.16%	104	0.16%
19200	6	0.16%	48	0.16%	78	0.16%
28800	4	0.16%	32	0.16%	52	0.16%
38400	3	0.16%	24	0.16%	39	0.16%
57600	2	0.16%	16	0.16%	26	0.16%
115200	1	0.16%	8	0.16%	13	0.16%
230400	---	---	4	0.16%	---	---
460800	---	---	2	0.16%	---	---
750000	---	---	---	---	2	0.00%
921600	---	---	1	0.16%	---	---
1500000	---	---	---	---	1	0.00%

7.12.2 Extended Control Register 1 (EXCR1), Bank 2, Offset 02h

Use this register to control module operation in the Extended mode. Upon reset all bits are set to 0.

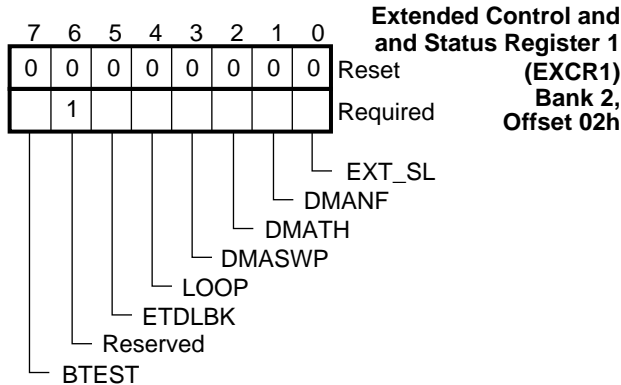


FIGURE 7-23. EXCR1 Register Bitmap

Bit 0 - Extended Mode Select (EXT_SL)

When set to 1, the Extended mode is selected.

Bit 1 - DMA Fairness Control (DMANF)

This bit controls the maximum duration of DMA burst transfers.

- 0 - DMA requests are forced inactive after approximately 10.5 μ sec of continuous transmitter and/or receiver DMA operation. (Default)
- 1 - A transmission DMA request is deactivated when the TX_FIFO is full. A reception DMA request is deactivated when the RX_FIFO is empty.

Bit 2 - DMA FIFO Threshold (DMATH)

This bit selects the TX_FIFO and RX_FIFO threshold levels used by the DMA request logic to support demand transfer mode.

A transmission DMA request is generated when the TX_FIFO level is below the threshold.

A reception DMA request is generated when the RX_FIFO level reaches the threshold or when a DMA timeout occurs.

Table 7-15 lists the threshold levels for each FIFO.

TABLE 7-15. DMA Threshold Levels

Bit Value	DMA Threshold for FIFO Type		
	RX_FIFO	Tx_FIFO (16 Levels)	Tx_FIFO (32 Levels)
0	4	13	29
1	10	7	23

Bit 3 - DMA Swap (DMASWP)

This bit selects the routing of the DMA control signals between the internal DMA logic and the configuration module of the chip. When this bit is 0, the transmitter

and receiver DMA control signals are not swapped. When it is 1, they are swapped. A block diagram illustrating the control signals routing is given in Fig. 7-24.

The swap feature is particularly useful when only one 8237 DMA channel is used to serve both transmitter and receiver. In this case only one external DRQ/DACK signal pair will be interconnected to the swap logic by the configuration module. Routing the external DMA channel to either the transmitter or the receiver DMA logic is then simply controlled by the DMASWP bit. This way, the infrared device drivers do not need to know the details of the configuration module.

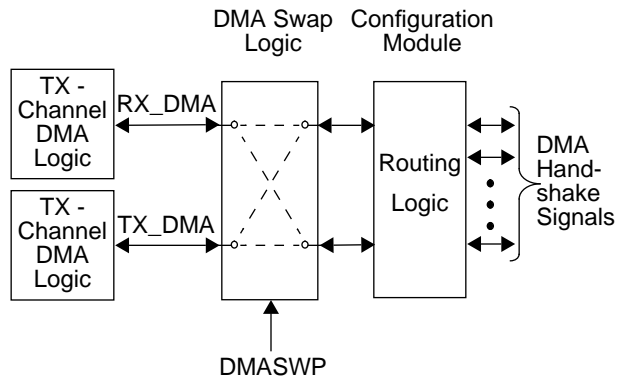


FIGURE 7-24. DMA Control Signals Routing

Bit 4 - Loopback Enable (LOOP)

During loopback, the transmitter output is connected internally to the receiver input, to enable system self-test of serial communications. In addition to the data signal, all additional signals within the UART are interconnected to enable real transmission and reception using the UART mechanisms.

When this bit is set to 1, loopback is selected. This bit accesses the same internal register as bit 4 in the MCR register, when the UART is in a Non-Extended mode.

Loopback behaves similarly in both Non-Extended and Extended modes.

When Extended mode is selected, the \overline{DTR} bit in the MCR register internally drives both \overline{DSR} and \overline{RI} , and the RTS bit drives CTS and DCD.

During loopback, the following actions occur:

1. The transmitter and receiver interrupts are fully operational. The Modem Status Interrupts are also fully operational, but the interrupt sources are now the lower bits of the MCR register. Modem interrupts in infrared modes are disabled unless the IRMSSL bit in the IRCR2 register is 0. Individual interrupts are still controlled by the IER register bits.
2. The DMA control signals are fully operational.
3. UART and infrared receiver serial input signals are disconnected. The internal receiver input signals are connected to the corresponding internal transmitter output signals.
4. The UART transmitter serial output is forced high and the infrared transmitter serial output is forced low, unless the ETDLBK bit is set to 1. In which case they function normally.

- The modem status input pins (\overline{DSR} , \overline{CTS} , \overline{RI} and \overline{DCD}) are disconnected. The internal modem status signals, are driven by the lower bits of the MCR register.

Bit 5 - Enable Transmitter During Loopback (ETDLBK)

When this bit is set to 1, the transmitter serial output is enabled and functions normally when loopback is enabled.

Bit 6 - Reserved

Write 1.

Bit 7 - Baud Generator Test (BTEST)

When set, this bit routes the baud generator to the \overline{DTR} pin for testing purposes.

7.12.3 Link Control Register (LCR) and Bank Select Register (BSR), Bank 2, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.12.4 Extended Control and Status Register 2 (EXCR2), Bank 2, Offset 04h

This register configures the transmitter and receiver FIFOs, and the baud generator prescaler.

Upon reset all bits are set to 0.

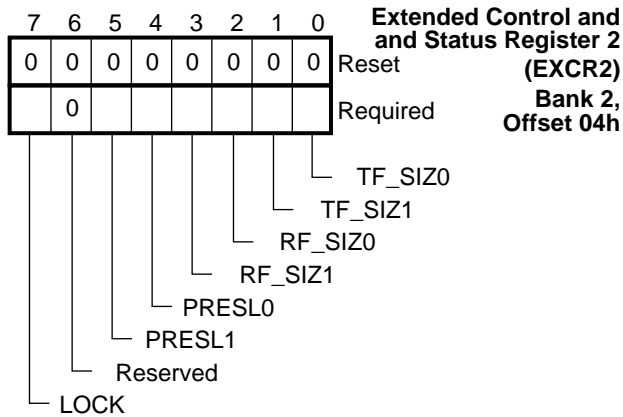


FIGURE 7-25. EXCR2 Register Bitmap

Bits 1,0 - TX_FIFO Size (TF_SIZ1,0)

These bits select the number of levels for the TX_FIFO. They are effective only when the FIFOs are enabled. (See Table 7-16).

TABLE 7-16. TX_FIFO Size Encoding

TF_SIZ1	TF_SIZ0	FIFO Depth
0	0	16
0	1	32
1	x	Reserved

Bits 3,2 - RX_FIFO Size (RF_SIZ1,0)

These bits select the number of levels for the RX_FIFO. They are effective only when the FIFOs are enabled. (See Table 7-17).

TABLE 7-17. RX_FIFO Size Encoding

RF_SIZ1	RF_SIZ0	FIFO Depth
0	0	16
0	1	32
1	x	reserved

Bits 5,4 - Prescaler Select

The prescaler divides the 24 MHz input clock frequency to provide the clock for the baud generator. (See Table 7-18).

TABLE 7-18. Prescaler Select

Bit 5	Bit 4	Prescaler Value
0	0	13
0	1	1.625
1	0	Reserved
1	1	1.0

Bit 6 - Reserved

Read/write 0.

Bit 7 - Baud Divisor Register Lock (LOCK)

When set to 1, accesses to the baud generator divisor register through LBGD(L) and LBGD(H) as well as fall-back are disabled from non-extended mode.

In this case two scratchpad registers overlaid with LBGD(L) and LBGD(H) are enabled, and any attempted CPU access of the baud generator divisor register through LBGD(L) and LBGD(H) will access the scratchpad registers instead. This bit must be set to 0 when extended mode is selected.

7.12.5 Reserved Register, Bank 2, Offset 05h

This register is reserved.

Bits 7-0 - Reserved

Read/write 0's.

7.12.6 TX_FIFO Current Level Register (TXFLV), Bank 2, Offset 06h

This read-only register returns the number of bytes in the TX_FIFO. It can be used to facilitate programmed I/O modes during recovery from transmitter underrun in one of the fast infrared modes.

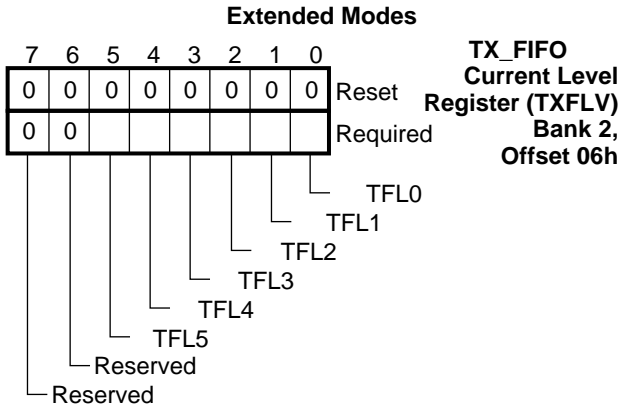


FIGURE 7-26. TXFLV Register Bitmap

Bits 5-0 - Number of Bytes in TX_FIFO (TFL(5-0))
These bits specify the number of bytes in the TX_FIFO.

Bits 7,6 - Reserved
Read/Write 0's.

7.12.7 RX_FIFO Current Level Register (RXFLV), IrDA or Consumer-IR Modes, Bank 2, Offset 07h

This read-only register returns the number of bytes in the RX_FIFO. It can be used for software debugging.

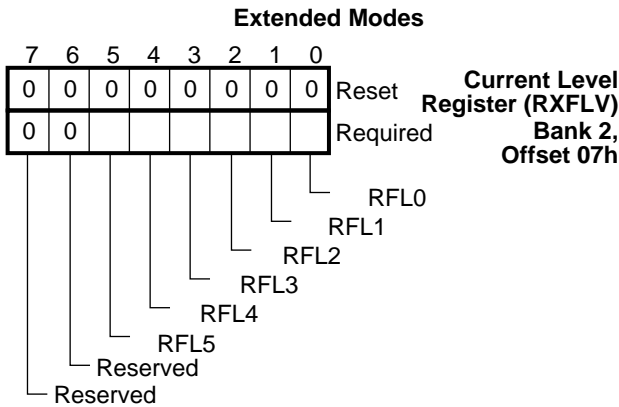


FIGURE 7-27. RXFLV Register Bitmap

Bits 5-0 - Number of Bytes in RX_FIFO (RFL(5-0))
These bits specify the number of bytes in the RX_FIFO.

Bits 7,6 - Reserved
Read/Write 0's.

Note: The contents of TXFLV and RXFLV are not frozen during CPU reads. Therefore, invalid data could be returned if the CPU reads these registers during normal transmitter and receiver operation. To obtain correct data, the software should perform three consecutive reads and then take the data from the second read, if first and second read yield the same result, or from the third read, if first and second read yield different results.

7.13 BANK 3 – MODULE REVISION ID AND SHADOW REGISTERS

Bank 3 contains the Module Revision ID register which identifies the revision of the module, shadow registers for monitoring various registers whose contents are modified by being read, and status and control registers for handling the flow control.

TABLE 7-19. Bank 3 Register Set

Offset	Register Name	Description
00h	MRID	Module Revision ID Register
01h	SH_LCR	Shadow of LCR Register (Read Only)
02h	SH_FCR	Shadow of FIFO Control Register (Read Only)
03h	LCR/BSR	Link Control Register/ Bank Select Register
04h-07h		Reserved

7.13.1 Module Revision ID Register (MRID), Bank 3, Offset 00h

This read-only register identifies the revision of the module. When read, it returns the module ID and revision level. This module returns the code 2xh, where x indicates the revision number.

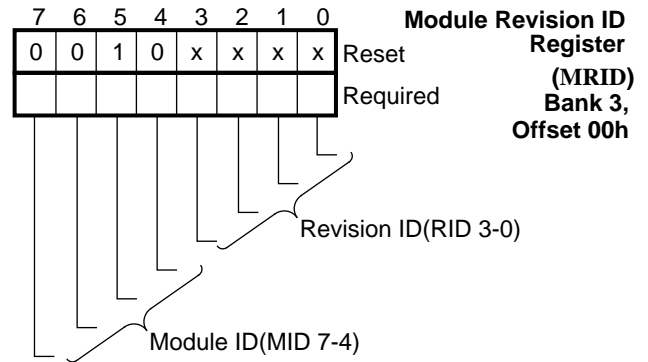


FIGURE 7-28. MRID Register Bitmap

Bits 3-0 - Revision ID (MID3-0)

The value in these bits identifies the revision level.

Bits 7-4 - Module ID (MID7-4)

The value in these bits identifies the module type.

7.13.2 Shadow of Link Control Register (SH_LCR), Bank 3, Offset 01h

This register returns the value of the LCR register. The LCR register is written into when a byte value according to Table 7-9 on page 147, is written to the LCR/BSR registers location (at offset 03h) from any bank.

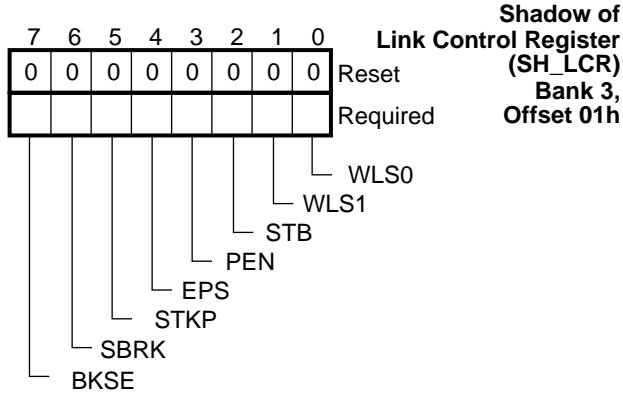


FIGURE 7-29. SH_LCR Register Bitmap

See “Link Control Register (LCR), All Banks, Offset 03h” on page 146 for bit descriptions.

7.13.3 Shadow of FIFO Control Register (SH_FCR), Bank 3, Offset 02h

This read-only register returns the contents of the FCR register in bank 0.

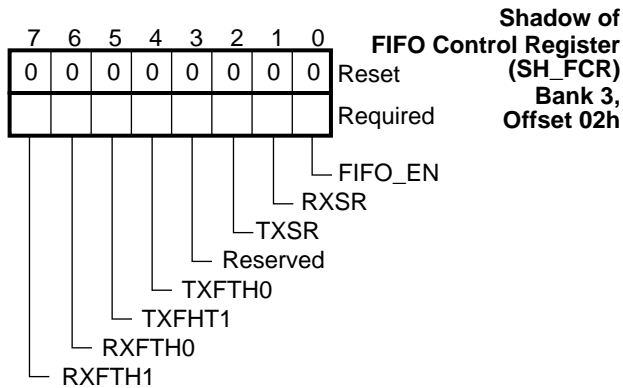


FIGURE 7-30. SH_LCR Register Bitmap

See “FIFO Control Register (FCR), Bank 0, Offset 02h” on page 145 for bit descriptions.

7.13.4 Link Control Register (LCR) and Bank Select Register (BSR), Bank 3, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.14 BANK 4 – IR MODE SETUP REGISTER

TABLE 7-20. Bank 4 Register Set

Offset	Register Name	Description
00-01h		Reserved
02h	IRCR1	Infrared Control Register 1
03h	LCR/BSR	Link Control/ Bank Select Registers
04-07h		Reserved

7.14.1 Reserved Registers, Bank 4, Offsets 00h and 01h

These registers are reserved.

7.14.2 Infrared Control Register 1 (IRCR1), Bank 4, Offset 02h

Enables the Sharp-IR or SIR infrared mode in the Non-Extended mode of operation.

Upon reset, all bits are set to 0.

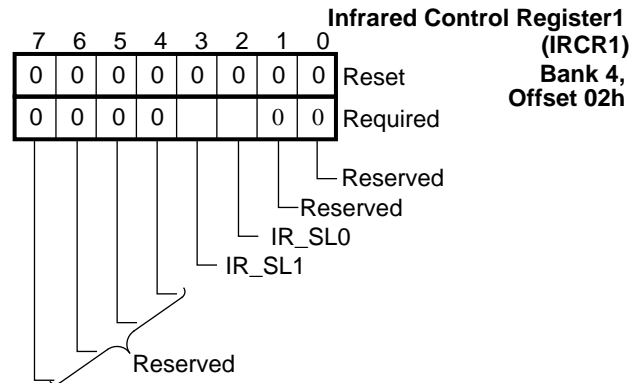


FIGURE 7-31. IRCR1 Register Bitmap

Bits 1,0 - Reserved

Read/Write 0.

Bits 3,2 - Sharp-IR or SIR Mode Select (IR_SL1,0), Non-Extended Mode Only

These bits enable Sharp-IR and SIR modes in Non-Extended mode. They allow selection of the appropriate infrared interface when Extended mode is not selected. These bits are ignored when Extended mode is selected. Before running the legacy application in Sharp-IR or SIR Mode, run a small enabling routine to set bits 3 and 2 to the appropriate mode, i.e., 10 or 11 (see Table 7-21). The infrared application can then be executed and this module will be pre-set for the appropriate mode.

Upon termination of the application these bits should be reset to 00 to switch back to a UART mode.

TABLE 7-21. Sharp-IR or SIR Mode Selection

IR_SL1	IR_SL0	Selected Mode
0	0	UART (Default)
0	1	Reserved
1	0	Sharp-IR
1	1	SIR

Bits 7-4 - Reserved

Read/Write 0.

7.14.3 Link Control Register (LCR) and Bank Select Register (BSR), Bank 4, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.14.4 Reserved Registers, Bank 4, Offsets 04h -07h

These registers are reserved.

7.15 BANK 5 – INFRARED CONTROL REGISTERS

TABLE 7-22. Bank 5 Registers

Offset	Register Name	Description
00-02h		Reserved
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h	IRCR2	Infrared Control Register 2
05h - 07h		Reserved

7.15.1 Reserved Registers, Bank 5, Offsets 00h -02h

These registers are reserved.

7.15.2 (LCR/BSR) Register, Bank 5, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.15.3 Infrared Control Register 2 (IRCR2), Bank 5, Offset 04h

This register controls the basic settings of the infrared modes. Upon reset, the content of this register is 02h.

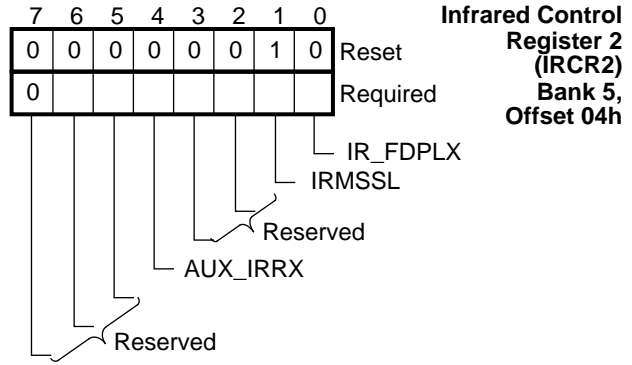


FIGURE 7-32. IRCR2 Register Bitmap

Bit 0 - Enable Infrared Full Duplex Mode (IR_FDPLX)

When set to 1, the infrared receiver is not masked during transmission.

Bit 1 - MSR Register Function Select in Infrared Mode (IRMSSL)

This bit selects the behavior of the Modem Status Register (MSR) and the Modem Status Interrupt (MS_EV) when any infrared mode is selected. When a UART mode is selected, the Modem Status Register and the Modem Status Interrupt function normally, and this bit is ignored.

0 - MSR register and modem status interrupt work in the IR modes as in the UART mode (Enables external circuitry to perform carrier detection and provide wake-up events).

1 - The MSR returns 30h, and the Modem Status Interrupt is disabled. (Default)

Bits 3,2 -Reserved

Read/Write 0.

Bit 4 - Auxiliary Infrared Input Select (AUX_IRRX)

When set to 1, the infrared signal is received from the auxiliary input. (Separate input signals may be desired for different front-end circuits). See Table 7-31 on page 165.

Bit 5-7 - Reserved

Read/Write 0.

7.15.4 Reserved Registers, Bank 5, Offsets 05h -07h

These registers are reserved.

7.16 BANK 6 – INFRARED PHYSICAL LAYER CONFIGURATION REGISTERS

This Bank of registers controls aspects of the framing and timing of the infrared modes.

TABLE 7-23. Bank 6 Register Set

Offset	Register Name	Description
00h	IRCR3	Infrared Control Register 3
01h		Reserved
02h	SIR_PW	SIR Pulse Width Control (≤ 115 Kbps)
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h - 07h		Reserved

7.16.1 Infrared Control Register 3 (IRCR3), Bank 6, Offset 00h

This Register enables/disables modulation in Sharp-IR mode.

Upon reset, the content of this register is 20h.

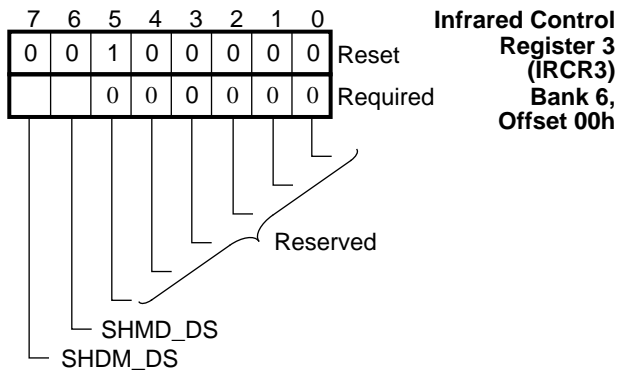


FIGURE 7-33. IRCR3 Register Bitmap

Bit 0-5 - Reserved

Read/Write 0.

Bit 6 - Sharp-IR Modulation Disable (SHMD_DS)

0 - Enables internal 500KHz transmitter modulation. (Default)

1 - Disables internal modulation.

Bit 7 - Sharp-IR Demodulation Disable (SHDM_DS)

0 - Enables internal 500 KHz receiver demodulation. (Default)

1 - Disables internal demodulation.

7.16.2 Reserved Register, Bank 6, Offset 01h

This register is reserved.

7.16.3 SIR Pulse Width Register (SIR_PW), Bank 6, Offset 02h

This register sets the pulse width for transmitted pulses in SIR operation mode. These setting do not affect the receiver. Upon reset, the content of this register is 00h, which defaults to a pulse width of 3/16 of the baud rate.

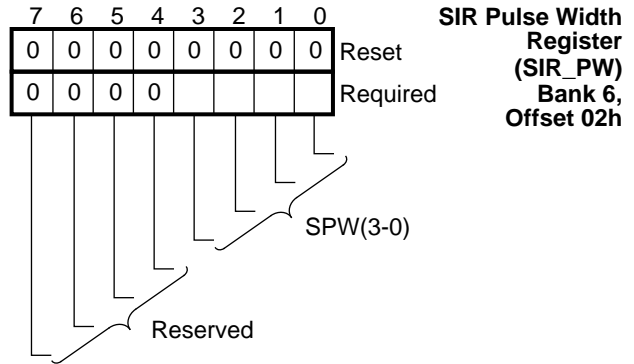


FIGURE 7-34. SIR_PW Register Bitmap

Bits 3-0 - SIR Pulse Width Register (SPW)

Two codes for setting the pulse width are available. All other values for this field are reserved.

0000 - Pulse width is 3/16 of the bit period. (Default)

1101 - Pulse width is 1.6 μsec.

Bits 7-4 - Reserved

Read/Write 0's.

7.16.4 Link Control Register (LCR) and Bank Select Register (BSR), Bank 6, Offset 03h

These registers are the same as the registers at offset 03h in Bank 0.

7.16.5 Reserved Registers, Bank 6, Offsets 04h-07h

These registers are reserved.

7.17 BANK 7 – CONSUMER-IR AND OPTICAL TRANSCEIVER CONFIGURATION REGISTERS

Bank 7 contains the registers that configure Consumer-IR functions and infrared transceiver controls. See Table 7-24.

TABLE 7-24. Bank 7 Register Set

Offset	Register Name	Description
00h	IRRXDC	Infrared Receiver Demodulator Control Register
01h	IRTXMC	Infrared Transmitter Modulator Control Register
02h	RCCFG	Consumer-IR Configuration Register
03h	LCR/BSR	Link Control Register/ Bank Select Register
04h	IRCFG1	Infrared Interface Configuration Register 1

Offset	Register Name	Description
05h		Reserved
06h	IRCFG3	Infrared Interface Configuration Register 3
07h	IRCFG4	Infrared Interface Configuration Register 4

The Consumer-IR utilizes two carrier frequency ranges (see also Table 7-28):

- Low range which spans from 30 KHz to 56 KHz, in 1 KHz increments, and
- High range which includes three frequencies: 400KHz, 450KHz or 480KHz.

High and low frequencies are specified independently to allow separate transmission and reception modulation settings. The transmitter uses the carrier frequency settings in Table 7-28.

The four registers at offsets 04h through 07h (the infrared transceiver configuration registers) are provided to configure the Infrared Interface (the transceiver). The transceiver mode is selected by up to three special output signals (IRSL2-0). When programmed as outputs these signals are forced to low when automatic configuration is enabled (AMCFG bit set to 1) and a UART mode is selected.

7.17.1 Infrared Receiver Demodulator Control Register (IRRXDC), Bank 7, Offset 0

This register controls settings for Sharp-IR and Consumer IR reception. After reset, the content of this register is 29h. This setting selects a subcarrier frequency in a range between 34.61 KHz and 38.26 KHz for the Consumer-IR mode, and from 480.0 to 533.3 KHz for the Sharp-IR mode. The value of this register is ignored in both modes if the receiver demodulator is disabled. The available frequency ranges for Consumer-IR and Sharp-IR modes are given in Tables 7-25 through 7-27.

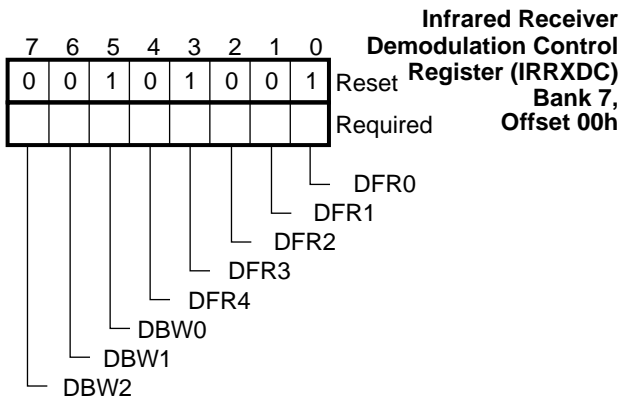


FIGURE 7-35. IRRXDC Register Bitmap

Bits 4-0 - Demodulator Frequency (DFR(4-0))

These bits select the subcarrier's center frequency for the Consumer-IR receiver demodulator. Table 7-25 shows the selection for low speed demodulation (bit 5 of

RCCFG=0, see page 163), and Table 7-26 shows the selection for high speed demodulation (bit 5 of RCCFG=1).

Bits 7-5 - Demodulator Bandwidth (DBW(2-0))

These bits set the demodulator bandwidth for the selected frequency range. The subcarrier signal frequency must fall within the specified frequency range in order to be accepted. Used for both Sharp-IR and Consumer-IR modes.

See Tables 7-25, 7-26 and bit 5 (RXHSC) of the Consumer-IR Configuration (RCCFG) Register on page 163.

7.17.2 Infrared Transmitter Modulator Control Register (IRTXMC), Bank 7, Offset 01h

This register controls modulation subcarrier parameters for Consumer-IR and Sharp-IR mode transmission. For Sharp-IR, only the carrier pulse width is controlled by this register - the carrier frequency is fixed at 500 KHz.

After reset, the value of this register is 69h, selecting a carrier frequency of 36 KHz and an IR pulse width of 7 μsec for Consumer-IR, or a pulse width of 0.8 μsec for Sharp-IR.

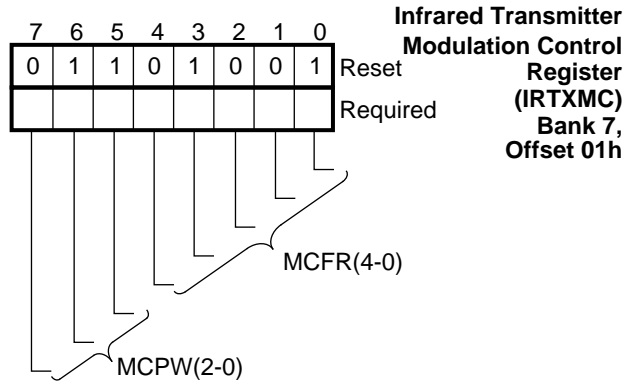


FIGURE 7-36. IRTXMC Register Bitmap

Bits 4-0 - Modulation Subcarrier Frequency (MCFR)

These bits set the frequency for the Consumer-IR modulation subcarrier. The encoding are defined in Table 7-28. Bits 7-5 - Modulation Subcarrier Pulse Width (MCPW)

Specify the pulse width of the subcarrier clock as shown in Table 7-29.

TABLE 7-25. Consumer-IR, Low Speed Demodulator (RXHSC = 0) (Frequency Ranges in KHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0
0 0 0 1 0	min	26.66	25.45	24.34	23.33	22.40	21.53
	max	29.47	31.11	32.94	35.00	37.33	40.00
0 0 0 1 1	min	28.57	27.27	26.08	25.00	24.00	23.07
	max	31.57	33.33	35.29	37.50	40.00	42.85
0 0 1 0 0	min	29.28	27.95	26.73	25.62	24.60	23.65
	max	32.37	34.16	36.17	38.43	41.00	43.92
0 0 1 0 1	min	30.07	28.68	27.43	26.29	25.24	24.27
	max	33.24	35.05	37.11	39.43	42.06	45.07
0 0 1 1 0	min	31.74	30.30	28.98	27.77	26.66	25.63
	max	35.08	37.03	39.21	41.66	44.44	47.61
0 0 1 1 1	min	32.60	31.13	29.78	28.54	27.40	26.34
	max	36.00	38.05	40.29	42.81	45.66	48.92
0 1 0 0 0	min	33.57	32.04	30.65	29.37	28.20	27.11
	max	37.10	39.16	41.47	44.06	47.00	50.35
0 1 0 0 1	min	34.61	33.04	31.60	30.29	29.08	27.96
	max	38.26	40.38	42.76	45.43	48.46	51.92
0 1 0 1 0	min	35.71	34.09	32.60	31.25	30.00	28.84
	max	39.47	41.66	44.11	46.87	50.00	53.57
0 1 0 1 1	min	36.85	35.18	33.65	32.25	30.96	29.76
	max	40.73	43.00	45.52	48.37	51.60	55.28
0 1 1 0 0	min	38.10	36.36	34.78	33.33	32.00	30.77
	max	42.10	44.44	47.05	50.00	53.33	57.14
0 1 1 0 1	min	39.40	37.59	36.00	34.45	33.08	31.80
	max	43.55	45.94	48.64	51.68	55.13	59.07
0 1 1 1 0	min	40.81	38.95	37.26	35.70	34.28	32.96
	max	45.11	47.61	50.41	53.56	57.13	61.21
1 0 0 1 0	min	42.32	40.40	38.64	37.03	35.55	34.18
	max	46.78	49.37	52.28	55.55	59.25	63.48
1 0 0 1 1	min	43.95	41.95	40.13	38.45	36.92	35.50
	max	48.58	51.27	54.29	57.68	61.53	65.92
1 0 1 0 1	min	45.71	43.63	41.74	40.00	38.40	36.92
	max	50.52	53.33	56.47	60.00	64.00	68.57
1 0 1 1 1	min	47.62	45.45	43.47	41.66	40.00	38.46
	max	52.63	55.55	58.82	62.50	66.66	71.42
1 1 0 1 0	min	49.66	47.40	45.34	43.45	41.72	40.11
	max	54.90	57.94	61.35	65.18	69.53	74.50
1 1 0 1 1	min	51.90	49.54	47.39	45.41	43.60	41.92
	max	57.36	60.55	64.11	68.12	72.66	77.85
1 1 1 0 1	min	54.38	51.90	49.65	47.58	45.68	43.92
	max	60.10	63.44	67.17	71.37	76.13	81.57

TABLE 7-26. Consumer IR, High Speed Demodulator (RXHSC = 1) (Frequency Ranges in kHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0
0 0 0 1 1	min	380.95	363.63	347.82	333.33	320.00	307.69
	max	421.05	444.44	470.58	500.00	533.33	571.42
0 1 0 0 0	min	436.36	417.39	400.00	384.00	369.23	355.55
	max	480.00	505.26	533.33	564.70	600.00	640.00
0 1 0 1 1	min	457.71	436.36	417.39	400.00	384.00	369.92
	max	502.26	533.33	564.70	600.00	640.00	685.57

TABLE 7-27. Sharp-IR Demodulator (Frequency Ranges in kHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	001	010	011	100	101	110
x x x x x x	min	480.0	457.1	436.4	417.4	400.0	384.0
	max	533.3	564.7	600.0	640.0	685.6	738.5

TABLE 7-28. Consumer-IR Carrier Frequency Encoding

Encoding MCFR Bits 43210	Low Frequency (TXHSC = 0)	High Frequency (TXHSC = 1)
00000	reserved	reserved
00001	reserved	reserved
00010	reserved	reserved
00011	30 KHz	400 KHz
00100	31 KHz	reserved
00101	32 KHz	reserved
00110	33 KHz	reserved
00111	34 KHz	reserved
01000	35 KHz	450 KHz
01001	36 KHz	reserved
01010	37 KHz	reserved
01011	38 KHz	480 KHz
01100	39 KHz	reserved
01101	40 KHz	reserved
01110	41 KHz	reserved
...
11010	53 KHz	reserved
11011	54 KHz	reserved

Encoding MCFR Bits 43210	Low Frequency (TXHSC = 0)	High Frequency (TXHSC = 1)
11100	55 KHz	reserved
11101	56 KHz	reserved
11110	56.9 KHz	reserved
11111	reserved	reserved

TABLE 7-29. Carrier Clock Pulse Width Options

Encoding MCPW Bits 7 6 5	Low Frequency (TXHSC = 0)	High Frequency (TXHSC = 1)
0 0 0	Reserved	Reserved
0 0 1	Reserved	Reserved
0 1 0	6 μsec	0.7 μsec
0 1 1	7 μsec	0.8 μsec
1 0 0	9 μsec	0.9 μsec
1 0 1	10.6 μsec	Reserved
1 1 0	Reserved	Reserved
1 1 1	Reserved	Reserved

7.17.3 Consumer-IR Configuration Register (RCCFG), Bank 7, Offset 02h

This register control the basic operation of the Consumer-IR mode. After reset, the content of this register is 00h.

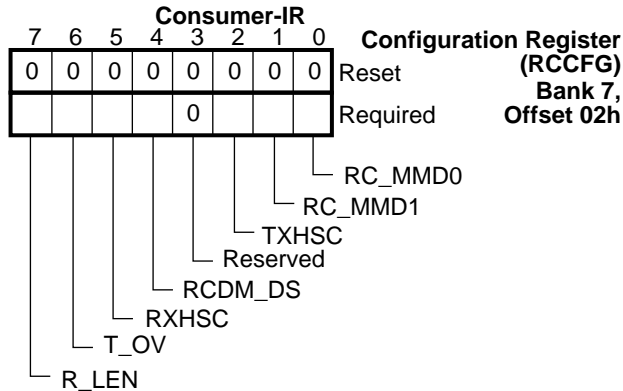


FIGURE 7-37. RCCFG Register Bitmap

Bits 1,0 - Transmitter Modulator Mode (RC_MMD(1,0))

Determines how infrared pulses are generated from the transmitted bit string. (see Table 7-30).

TABLE 7-30. Transmitter Modulation Mode Selection

RCCFG Bits	Modulation Mode
1 0	
0 0	C_PLS Modulation mode. Pulses are generated continuously for the entire logic 0 bit time.
0 1	8_PLS Modulation Mode. 8 pulses are generated each time one or more logic 0 bits are transmitted following a logic 1 bit.
1 0	6_PLS Modulation Mode. 6 pulses are generated each time one or more logic 0 bits are transmitted following a logic 1 bit.
1 1	Reserved. Result is indeterminate.

Bit 2 - Transmitter Subcarrier Frequency Select (TXHSC)

This bit selects the frequency range for the modulation carrier.

- 0 - Low frequency: 30-56.9 KHz
- 1 - High frequency: 400-480 KHz

Bit 3 - Reserved

Read/Write 0.

Bit 4 - Receiver Demodulation Disable (RCDM_DS)

When this bit is 1, the internal demodulator is disabled. The internal demodulator, when enabled, performs carrier frequency checking and envelope detection.

This bit must be set to 1 (disabled), when the demodulation is performed externally, or when oversampling mode is selected to determine the carrier frequency.

- 0 - Internal demodulation enabled.
- 1 - Internal demodulation disabled.

Bit 5 - Receiver Carrier Frequency Select (RXHSC)

This bit selects the frequency range for the receiver demodulator.

- 0 - Low frequency: 30-56.9 KHz
- 1 - High frequency: 400-480 KHz

Bit 6 - Receiver Sampling Mode Select(T_OV)

- 0 - Programmed-T-period sampling.
- 1 - Oversampling mode.

Bit 7 - Run Length Control (R_LEN)

Enables or disables run length encoding/decoding. The format of a run length code is:

YXXXXXXX

where, Y is the bit value and XXXXXXX is the number of bits minus 1 (Selects from 1 to 128 bits).

- 0 - Run Length Encoding/decoding is disabled.
- 1 - Run Length Encoding/decoding is enabled.

7.17.4 Link Control/Bank Select Registers (LCR/BSR), Bank 7, Offset 03h

These registers are the same as the registers at offset 03h in bank 0.

7.17.5 Infrared Interface Configuration Register 1 (IRCFG1), Bank 7, Offset 04h

This register holds the transceiver configuration data for Sharp-IR and SIR modes. It is also used to directly control the transceiver operation mode when automatic configuration is not enabled. The four least significant bits are also used to read the identification data of a Plug and Play infrared interface adaptor.

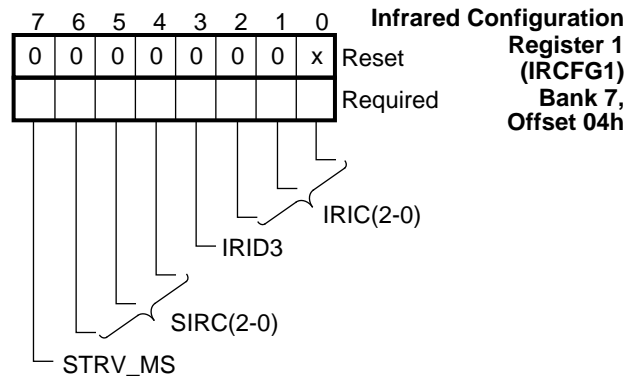


FIGURE 7-38. IRCFG1 Register Bitmap

Bit 0 - Transceiver Identification/Control Bit 0 (IRIC0)

The function of this bit depends on whether the ID0/IRSL0/IRRX2 pin is programmed as an input or an output.

If ID0/IRSL0/IRRX2 is programmed as an input (IRSL0_DS = 0) then:

- Upon read, this bit returns the logic level of the pin (allowing external devices to identify themselves).
- Data written to this bit position is ignored.

Bits 2-0 - Reserved

Read/write 0.

Bit 3- ID/IRSL(2-1) Pins' Direction Select (IRSL21_DS)

This bit determines the direction of the ID/IRSL2 and ID/IRSL1 pins.

- 0 - Pins' direction is input.
- 1 - Pins' direction is output.

Bit 4 - IRRX Signal Invert (RXINV)

This bit supports optical transceivers with receive signals of opposite polarity (active high instead of active low).

When set to 1 an inverter is put on the path of the input signal of the receiver.

Bit 5 - ID0/IRSL0/IRRX2 Pin Direction Select (IRSL0_DS)

This bit determines the direction of the ID0/IRSL0/IRRX2 pin. See Table 7-31 on page 165.

- 0 - Pin's direction is input.
- 1 - Pin's direction is output.

Bit 6 - Reserved

Read/write 0.

Bit 7 - Automatic Module Configuration (AMCFG)

When set to 1, this bit enables automatic infrared configuration.

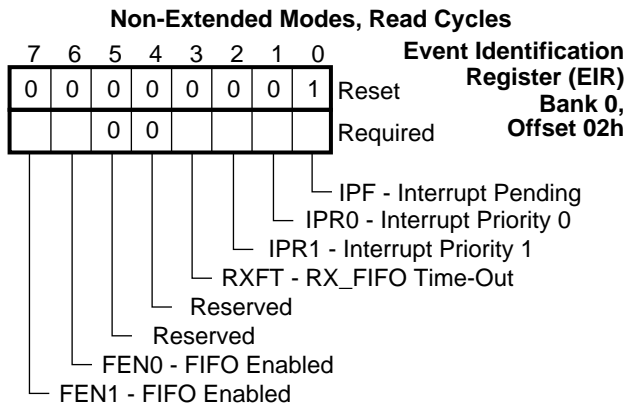
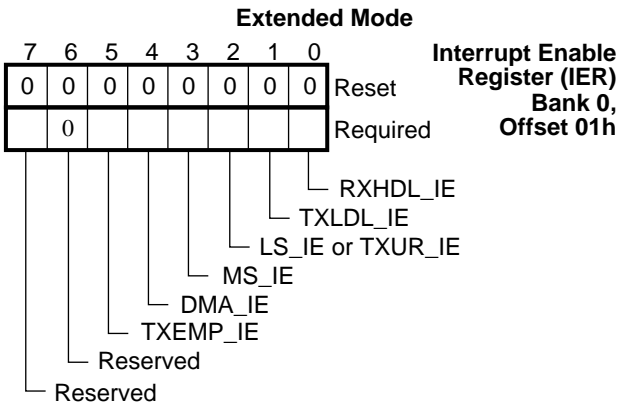
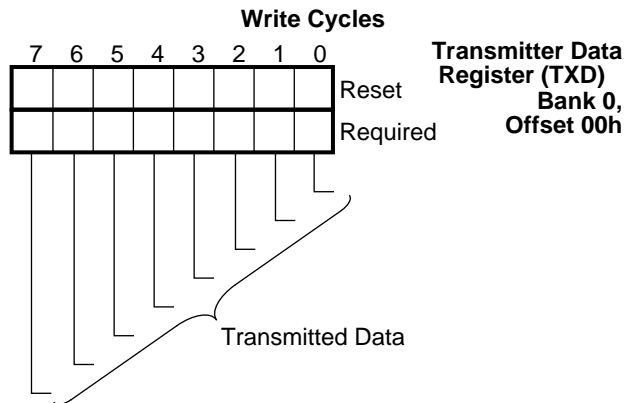
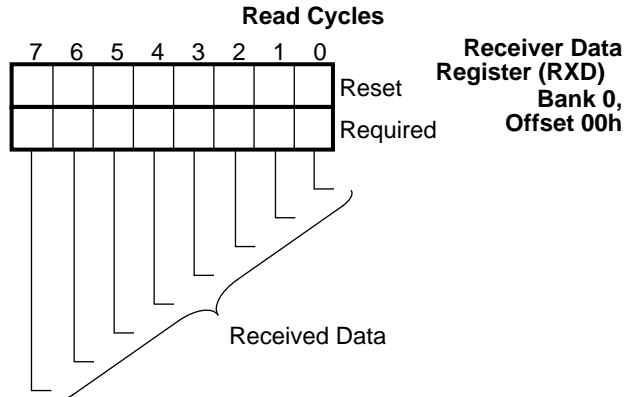
TABLE 7-31. Infrared Receiver Input Selection

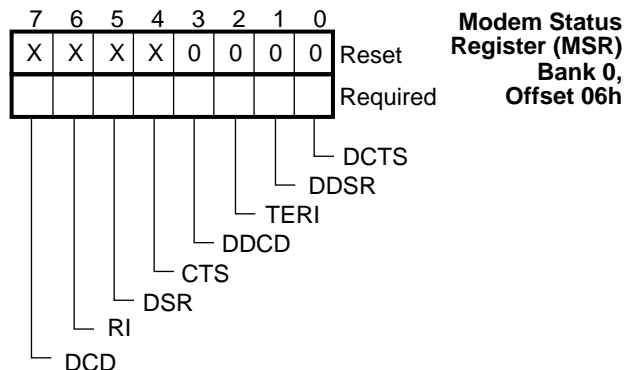
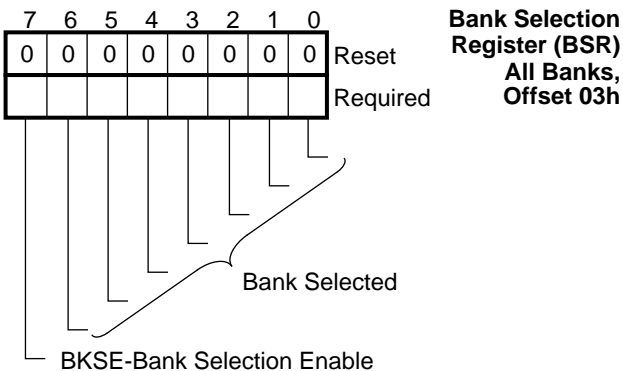
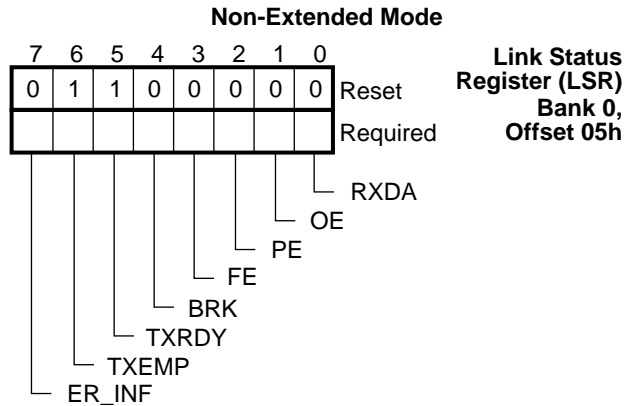
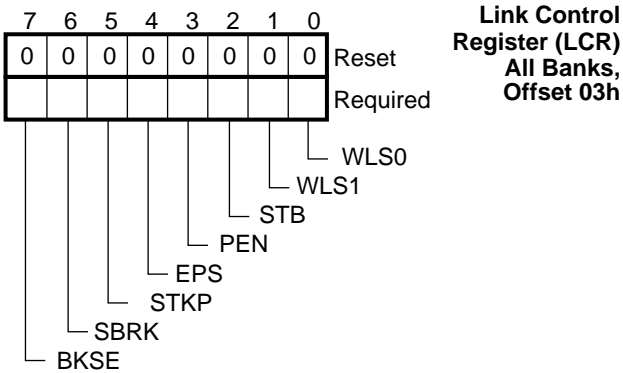
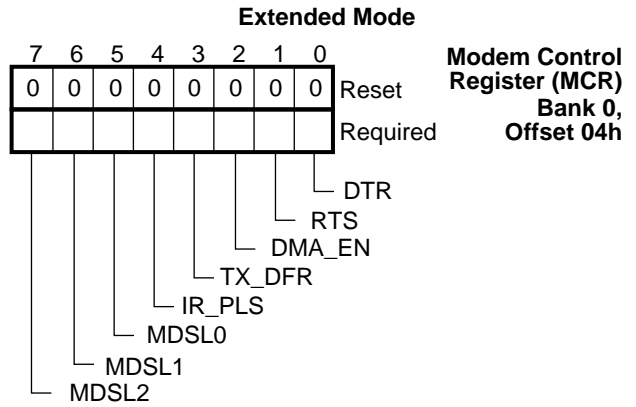
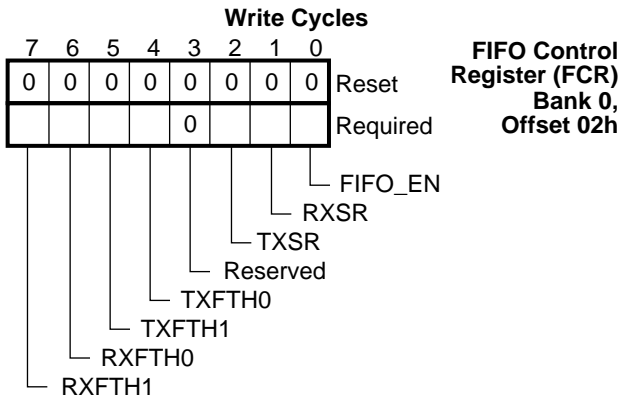
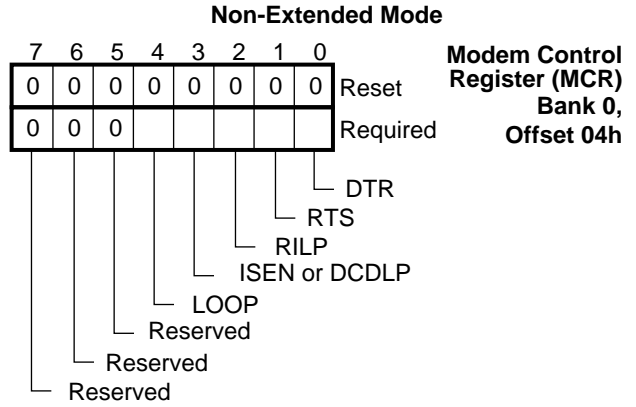
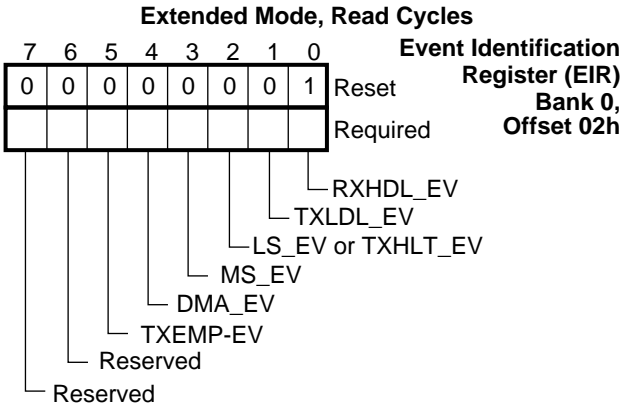
Bit 5 of IRCFG4 ^a (IRSL0_DS)	Bit 4 of IRCR2 (AUX_IRRX) ^b	Selected IRRX
0	0	IRRX1
0	1	IRRX2
1	0	IRRX1
1	1	1

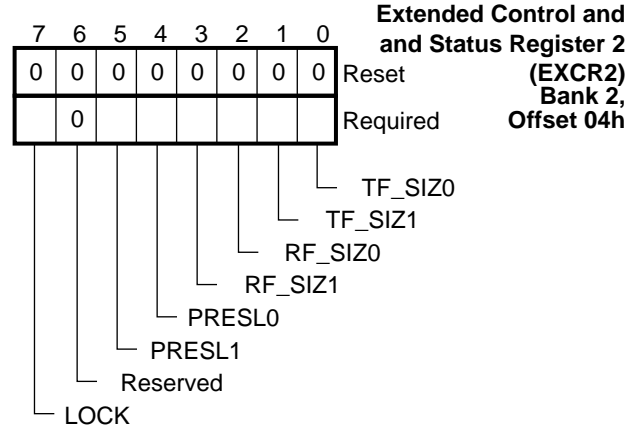
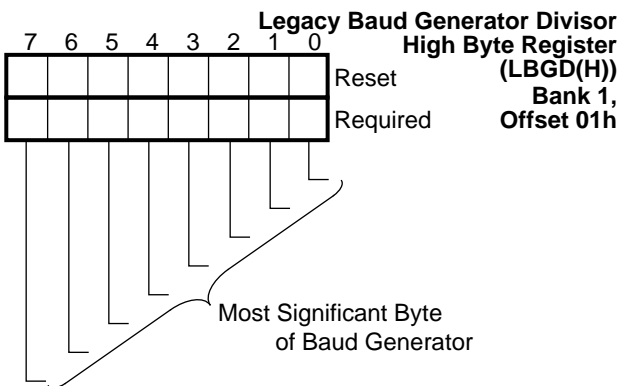
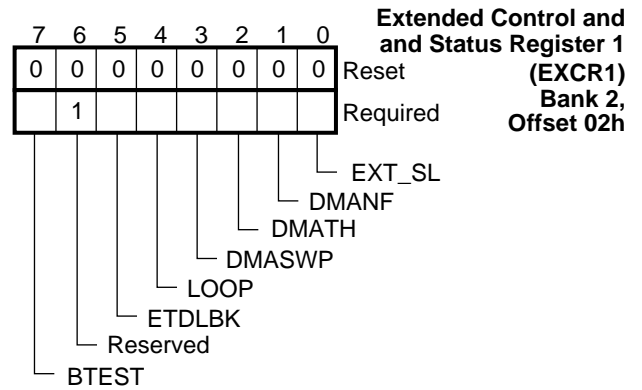
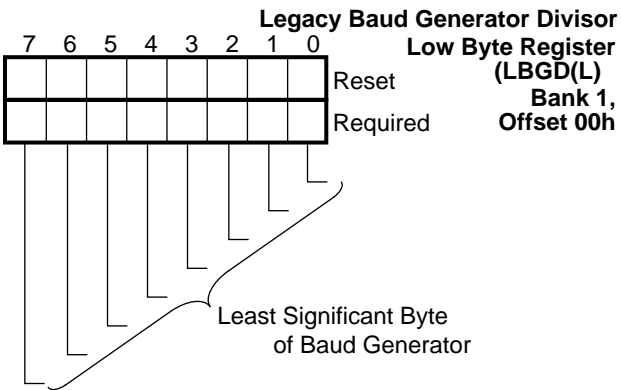
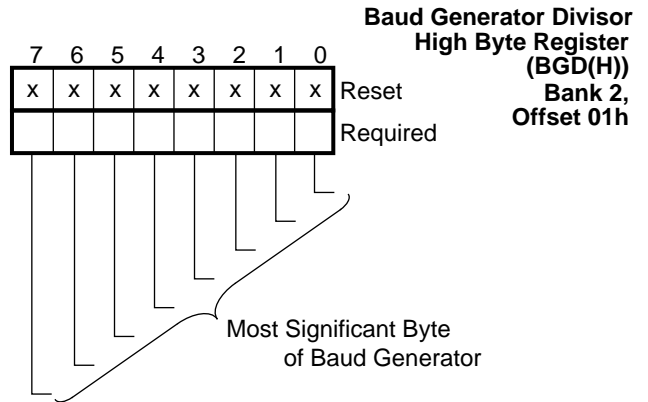
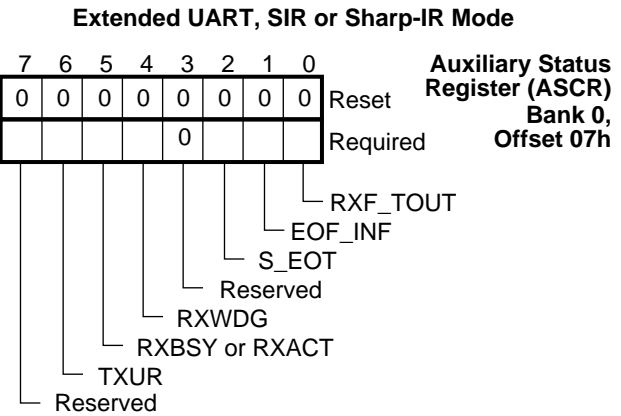
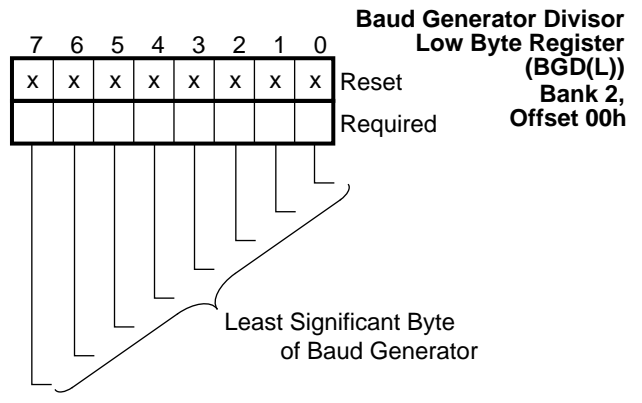
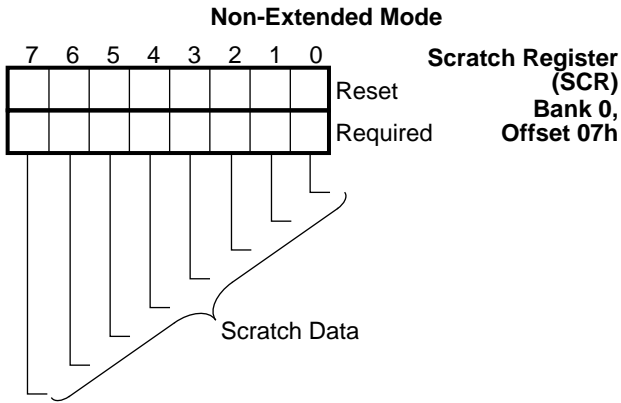
a. IRCFG4 is in bank 7, offset 07h. It is described on page 164.

b. AUX_IRRX (bit 4 of IRCR2) is described on page 158.

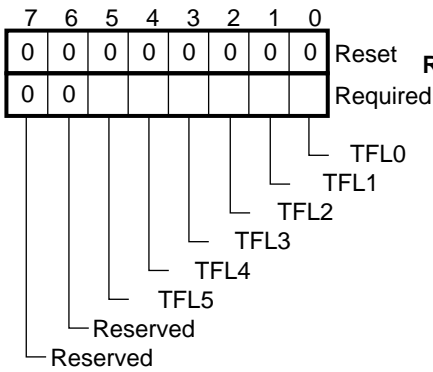
7.18 UART2 REGISTER WITH FAST IR REGISTER BITMAPS



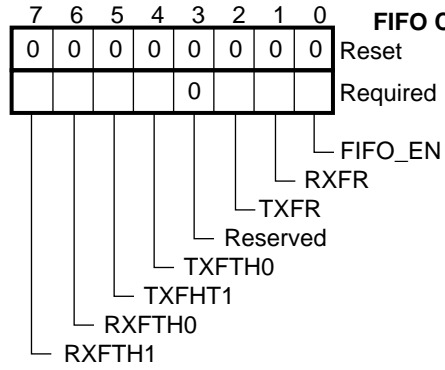




IrDA or Consumer-IR Modes

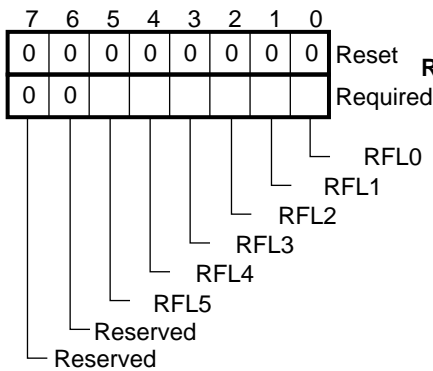


**TX_FIFO
Current Level
Register (TXFLV)
Bank 2,
Offset 06h**

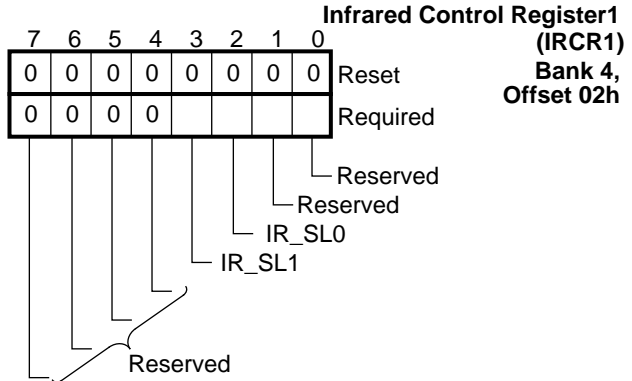


**Shadow of
FIFO Control Register
(SH_FCR)
Bank 3,
Offset 02h**

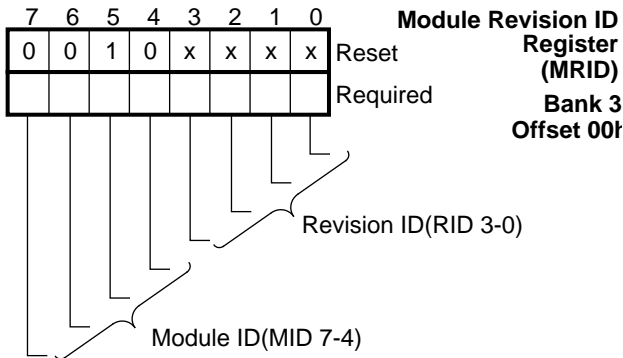
IrDA or Consumer-IR Modes



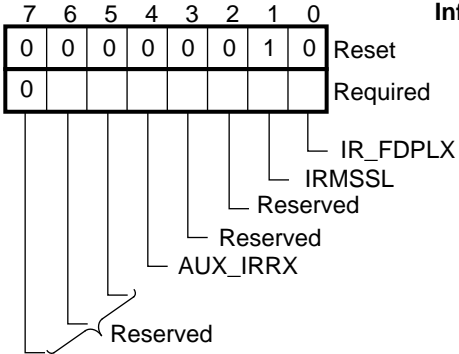
**RX_FIFO
Current Level
Register (RXFLV)
Bank 2,
Offset 07h**



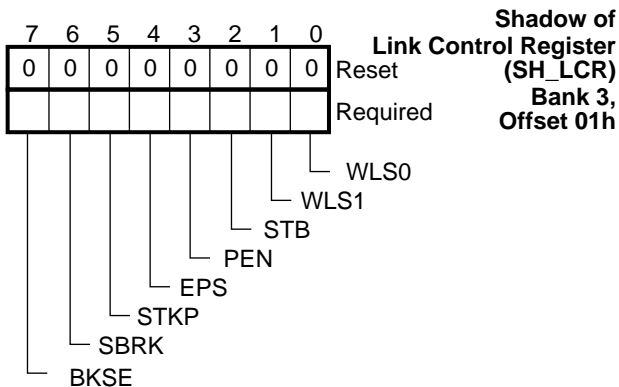
**Infrared Control Register1
(IRCR1)
Bank 4,
Offset 02h**



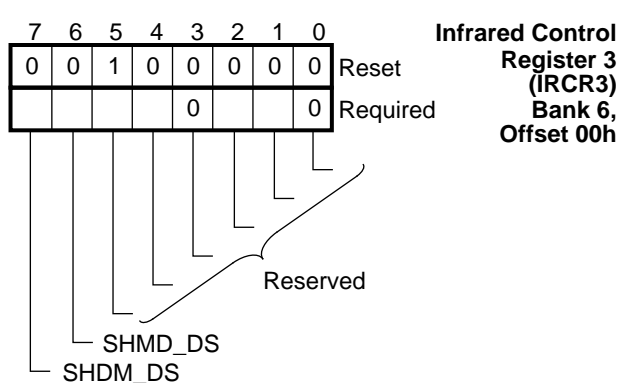
**Module Revision ID
Register (MRID)
Bank 3
Offset 00h**



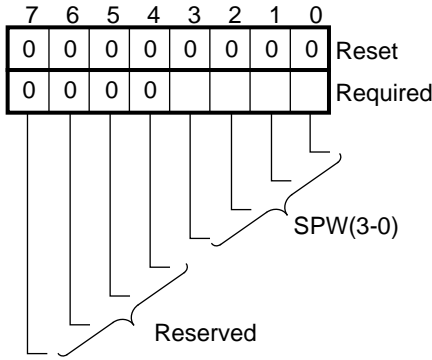
**Infrared Control
Register 2
(IRCR2)
Bank 5,
Offset 04h**



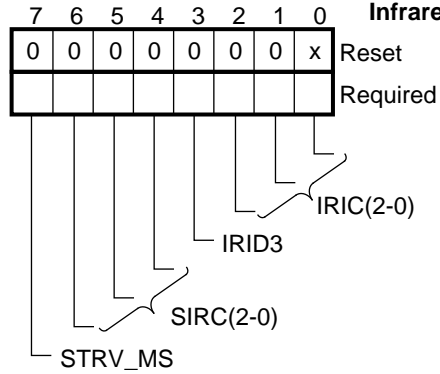
**Shadow of
Link Control Register
(SH_LCR)
Bank 3,
Offset 01h**



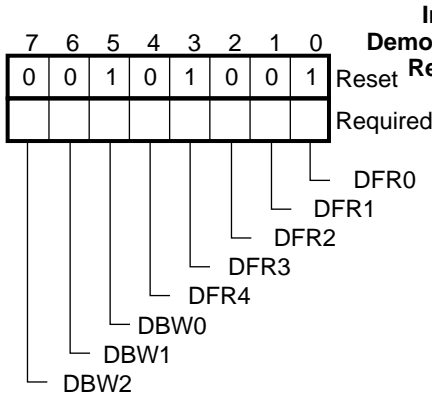
**Infrared Control
Register 3
(IRCR3)
Bank 6,
Offset 00h**



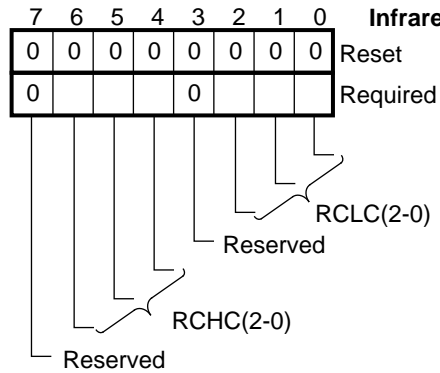
SIR Pulse Width Register (SIR_PW)
Bank 6, Offset 02h



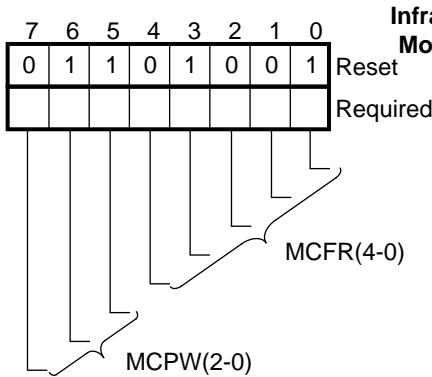
Infrared Configuration Register 1 (IRCFG1)
Bank 7, Offset 04h



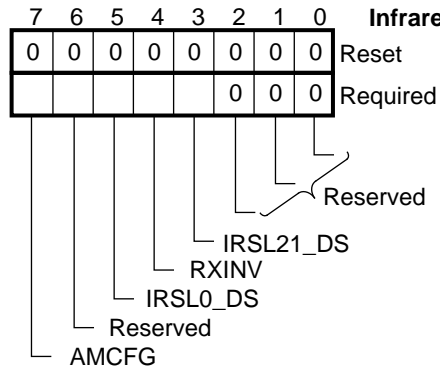
Infrared Receiver Demodulation Control Register (IRRXDC)
Bank 7, Offset 00h



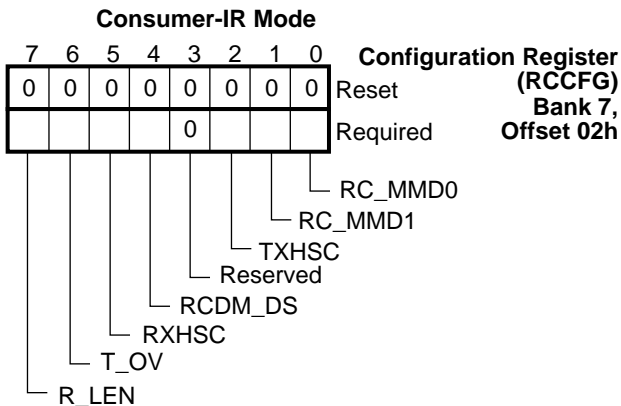
Infrared Configuration Register 3 (IRCFG3)
Bank 7, Offset 06h



Infrared Transmitter Modulation Control Register (IRTXMC)
Bank 7, Offset 01h



Infrared Configuration Register 4 (IRCFG4)
Bank 7, Offset 07h



Configuration Register (RCCFG)
Bank 7, Offset 02h

8.0 General Purpose Input and Output (GPIO) Ports (Logical Device 7) and Chip Select Output Signals

8.1 GENERAL PURPOSE INPUT AND OUTPUT (GPIO) PORTS

The part supports two identical General Purpose I/O (GPIO) ports.

Activation and deactivation (enable/disable) of GPIO ports is controlled by the Activate register (index 30h) of logical device 7 and by bit 7 of the Function Enable Register 2 (FER2) of the Power Management logical device. See Section 9.2.4 on page 173.

The base address of the GPIO ports is software configurable. It is controlled by two base address registers at indexes 60h and 61h1 of logical device 7. See Table 2-19 on page 33.

The registers that control the GPIO ports are in two banks. The active bank is selected by the GPIO Bank Select bit, bit 7 of SuperI/O Configuration 2 register. See section 2.4.4 on page 35.

Five registers control GPIO Port 1 and four registers control GPIO Port 2. The registers that control Port 1 are at offsets 00h through 03h from the base address in bank 0 and at offset 00h in bank 1. The registers that control Port 2 are at offsets 04h through 07h from the base address in bank 0. See Tables 8-1 and 8-2.

- Port Data registers at offsets 00h and 04h read or write the data bits of Ports 1 and 2, respectively.
- Port Direction registers at offsets 01h and 05h control the direction of each bit of Ports 1 and 2, respectively.
- Port Output Type registers at offsets 02h and 06h control the buffer type (open-drain or push-pull) of each bit of Ports 1 and 2, respectively.

- The GPIO ports have open-drain output signals with internal pull-ups and TTL input signals. Pull-up Control registers at offsets 03h and 07h enable or disable the internal pull-up capability of each bit of Ports 1 and 2, respectively.

Note that GPIO21 on pin 77 is unaffected by the output type or direction registers - it is always push-pull with no internal pullup.

The output type and pull-up settings for the GPIO17,16 signals can be locked by setting bits 7,6 of the Port 1 Lock register in bank 1.

Reading an output pin returns the internally latched bit value, not the pin value.

Writing to an input pin has no effect on the pin, except for internally latching the written value. The latched value is reflected on the pin when the direction changes to output. Upon reset the write latches are initialized to FFh.

The port pins are back-drive protected when the part is powered down and also when the port is inactive (disabled). AC and DC are the same as the STB pin, except for I_{OH}/I_{OL} of 4 mA.

The GPIO signals are multiplexed as follows:

- GPIO27-24 are multiplexed with the X-Bus Data Buffer (XDB) signals XD5-2, respectively.
- GPIO23 is multiplexed with \overline{RING} .
- GPIO22 is multiplexed with \overline{POR} .
- GPIO21 is multiplexed with IRSL0 and IRSL2.
- GPIO20 is multiplexed with IRSL1.
- GPIO17 is multiplexed with \overline{WDO}

A GPIO port must not be enabled at the same address as another accessible PC87307/PC97307 register. Undefined results will occur if a GPIO is configured in this way.

TABLE 8-1. The GPIO Registers, Bank 0

GPIO Register	Offset	Type	Hard Reset Value	Detailed Description
Port 1 Data	00h	R/W	FFh	Reads return the bit or pin value, according to the direction bit. Writes are saved in this register and affect the output pins.
Port 1 Direction	01h	R/W	00h	Each bit controls the direction of the corresponding port pin. 0 - Input. Reads of Port Data register return pin value. 1 - Output. Reads of Port Data register return bit value.
Port 1 Output Type	02h	R/W	00h	Each bit controls the type of the corresponding port pin. 0 - Open-drain. 1 - Push-pull.
Port 1 Pull-up Control	03h	R/W	FFh	Each bit controls the internal pull-up for the corresponding port pin. 0 - No internal pull-up. 1 - Internal pull-up.
Port 2 Data	04h	R/W	FFh	Same as Port 1 Data register.
Port 2 Direction	05h	R/W	00h	Same as Port 1 Direction register.
Port 2 Output Type	06h	R/W	00h	Same as Port 1 Output Type register.
Port 2 Pull-up Control	07h	R/W	FFh	Same as Port 1 Pull-up Control register.

TABLE 8-2. The GPIO Registers, Bank 1

GPIO Register	Offset	Type	Hard Reset Value	Detailed Description
Port 1 Lock Register	00h	R/W	00h	Bits 5-0 are reserved. Bits 7,6 lock the Port 1 control settings for bits GPIO17,16, respectively. Setting them to 1 locks the corresponding pin direction and pull-up bit settings. When configured as output, the pin value and buffer type are also locked. Only master reset unlocks these bits by setting them to 0s.
Reserved	01h-07h	-	-	-

8.2 PROGRAMMABLE CHIP SELECT OUTPUT SIGNALS

The part has three programmable chip select signals: $\overline{CS2}$ -0. $\overline{CS0}$ is an open drain output signal ($\overline{CS1}$ and $\overline{CS2}$ have push-pull buffers). $\overline{CS0}$ is in TRI-STATE when no V_{DD} is applied.

Activation and deactivation (enabling and disabling) of these chip select signals are controlled by the Function Enable Register 2 (FER2) of logical device 8 (see section 9.2.4 on page 173) and the configuration registers for $\overline{CS0}$, $\overline{CS1}$ and $\overline{CS2}$ at second level indexes 02h, 06h and 0Ah, respectively.

These registers are accessed using two index levels.

The first level index points to the Programmable Chip Select Index and Data registers, like other part configuration registers. See Sections 2.4.5 and 2.4.6 on page 36. The Programmable Chip Select Configuration Index and Data registers are at index 23h and 24h respectively.

The second level points to one of the three registers for each \overline{CS} pin. See "Programmable Chip Select Configuration Registers" on page 39. Each \overline{CS} pin is configured by the three registers assigned to it. One specifies the base address MSB. One specifies the base address LSB and one configures the \overline{CS} pin.

All 16 address bits are decoded, with five mask options to ignore (not decode) address bits A0, A1, A2, A3 and A4-11. Decoding of only address and AEN pins, without \overline{RD} or \overline{WR} pins, is also supported.

A \overline{CS} signal is asserted when an address match occurs and may be qualified by \overline{RD} or \overline{WR} signal(s). An address match occurs when the AEN signal is inactive (low) and the non-masked address pins match the corresponding base address bits.

9.0 Power Management (Logical Device 8)

9.1 POWER MANAGEMENT OPTIONS

The power management logical device provides configuration options and control of the WATCHDOG feature.

9.1.1 Configuration Options

Registers in this logical device enable activation of other logical devices, and set I/O characteristics for certain pins. (See Section 9.2)

9.1.2 The WATCHDOG Feature

The WATCHDOG feature lets you implement power saving strategies that power down the entire system if it is unused for a defined period of time. This feature is especially attractive for battery-powered systems.

The WATCHDOG function generates the \overline{WDO} output signal, which the system may use to implement power-down activities.

The WATCHDOG function is activated by setting the WATCHDOG Time-Out (WDTO) register to a value from 1 through 255 minutes. This defines a maximum countdown period. The WATCHDOG timer starts with this value and counts down to 0 unless a trigger event restarts the count.

The WATCHDOG Configuration register (WDCF) specifies the trigger events that cause reloading of the WATCHDOG time-out value into the timer and restart the countdown. See "WATCHDOG Configuration Register (WDCF), Index 06h" on page 175.

If the timer reaches zero, it is disabled, the \overline{WDO} signal becomes active (low) and the host system can use \overline{WDO} to trigger power down. You can monitor the state of the \overline{WDO} signal at any time by reading bit 1 of the WATCHDOG Status (WDST) register.

9.2 THE POWER MANAGEMENT REGISTERS

The power management registers are accessed via the Power Management Index and Data registers, which are located at base address and base address + 01h, respectively. The base address is indicated by the Base Address registers at indexes 60h and 61h of logical device 8, respectively. See Table 2-20 on page 34.

Table 9-1 lists the power management registers.

TABLE 9-1. The Power Management Registers

Index	Symbol	Description	Type
Base+0		Power Management Index Register	R/W
Base+1		Power Management Data Register	R/W
00h	FER1	Function Enable Register 1	R/W
01h	FER2	Function Enable Register 2	R/W
02h	PMC1	Power Management Control 1	R/W
03h	PMC2	Power Management Control 2	R/W
04h	PMC3	Power Management Control 3	R/W
05h	WDTO	WATCHDOG Time-Out Register	R/W
06h	WDCF	WATCHDOG Configuration Register	R/W
07h	WDST	WATCHDOG Status Register	R/W

9.2.1 Power Management Index Register, Base Address + 00h

This read/write register is reset by hardware to 00h. It points to one of the power management registers. Bits 7 through 3 are read only and return 00000 when read.

The data in the indicated register is accessed via the Power Management Data register at the base address + 01h.

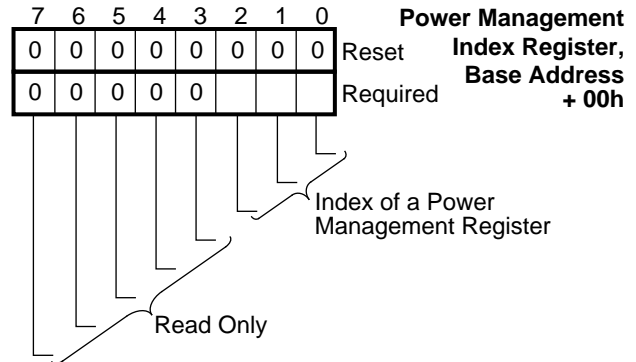


FIGURE 9-1. Power Management Index Register Bitmap

9.2.2 Power Management Data Register, Base Address + 01h

This read/write register contains the data in the register pointed to by the Power Management Index register at the base address. See Figure 9-2.

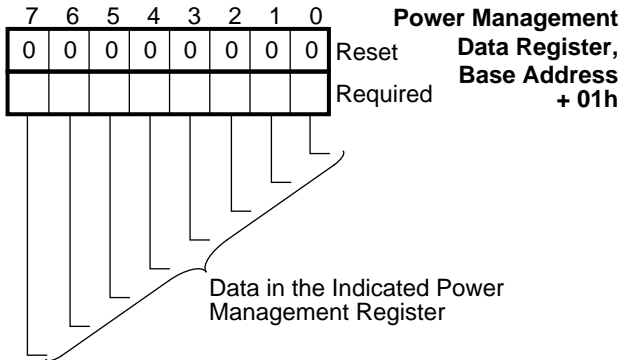


FIGURE 9-2. Power Management Data Register Bitmap

9.2.3 Function Enable Register 1 (FER1), Index 00h

Hardware resets this read/write register to FFh.

A set bit enables activation of the corresponding logical device via its Active register at index 30h.

A cleared bit disables the corresponding logical device regardless of the value in its Active register. Bit 0 of the Active register of a logical device is ignored when the corresponding FER1 bit is cleared. See Figure 9-3.

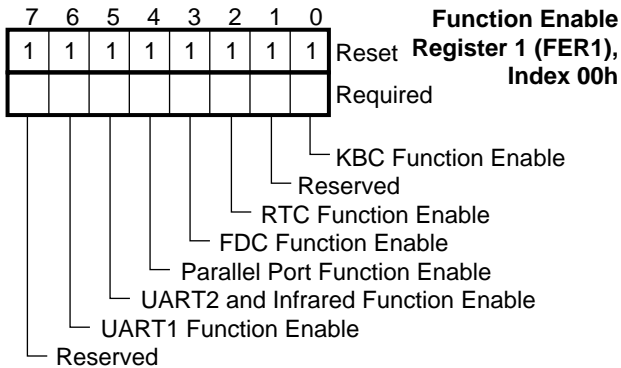


FIGURE 9-3. FER1 Register Bitmap

Bit 0 - KBC Function Enable

- 0 - Disabled.
- 1 - Enabled. (Default)

Bit 1 - Reserved

Reserved.

Bit 2 - RTC Function Enable

- 0 - Disabled.
- 1 - Enabled. (Default)

Bit 3 - FDC Function Enable

- 0 - Disabled.
- 1 - Enabled. (Default)

Bit 4 - Parallel Port Function Enable

- 0 - Disabled. (Default).
- 1 - Enabled.

Bit 5 - UART2 and Infrared Function Enable

- 0 - Disabled. (Default).
- 1 - Enabled.

Bit 6 - UART1 Function Enable

- 0 - Disabled. (Default)
- 1 - Enabled.

Bit 7 - Reserved

Reserved.

9.2.4 Function Enable Register 2 (FER2), Index 01h

Hardware resets this read/write register to FFh.

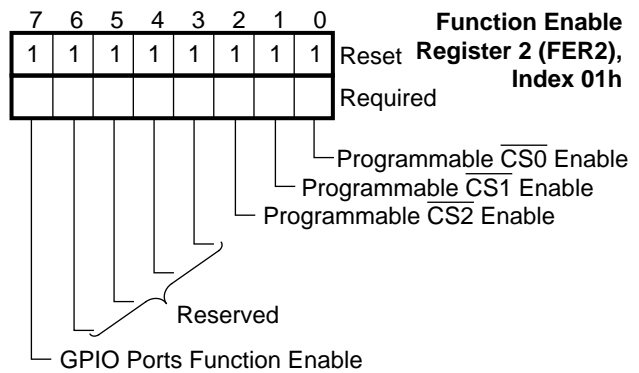


FIGURE 9-4. FER2 Register Bitmap

Bit 0 - Programmable $\overline{CS0}$ Function Enable

See $\overline{CS0}$ Configuration 0 register in Section 2.10.3 on page 39.

- 0 - $\overline{CS0}$ is disabled. $\overline{CS0}$ is not asserted; $\overline{CS0}$ configuration and base address registers are maintained.
- 1 - $\overline{CS0}$ is enabled. (Default)

Bit 1 - Programmable $\overline{CS1}$ Function Enable

See $\overline{CS1}$ Configuration 1 register in Section 2.10.7 on page 40.

- 0 - $\overline{CS1}$ is disabled. $\overline{CS1}$ signal is not asserted, $\overline{CS1}$ configuration and base address registers are maintained.
- 1 - $\overline{CS1}$ is enabled. (Default)

Bit 2 - Programmable $\overline{CS2}$ Function Enable

See $\overline{CS2}$ Configuration 2 register in Section 2.10.11 on page 40.

- 0 - $\overline{CS2}$ is disabled. The $\overline{CS2}$ signal is not asserted, $\overline{CS2}$ configuration and base address registers are maintained.
- 1 - $\overline{CS2}$ is enabled. (Default)

Bits 6-3 - Reserved

Reserved.

Bit 7 - GPIO Ports Function Enable

- 0 - GPIO Ports 1 and 2 are inactive (disabled). Reads and writes are ignored; registers and pins are maintained. Bit 0 of the Activate register (index 30h) of the GPIO Ports logical device is ignored. (Default)
- 1 - GPIO Ports 1 and 2 are active (enabled) when bit 0 of the Activate register (index 30h) of the GPIO Ports logical device is set.

9.2.5 Power Management Control 1 Register (PMC1), Index 02h

Hardware resets this read/write register to 00h. A set bit puts the signals of the corresponding inactive logical device in TRI-STATE (except IRQ and DMA pins) regardless of the value of bit 0 of the corresponding logical device register at index F0h. A cleared bit has no effect. In this case, the TRI-STATE status of signals is controlled by bit 0 of the corresponding logical device register at index F0h. This is an OR function between PMC1 and the register at index F0h of the corresponding logical device.

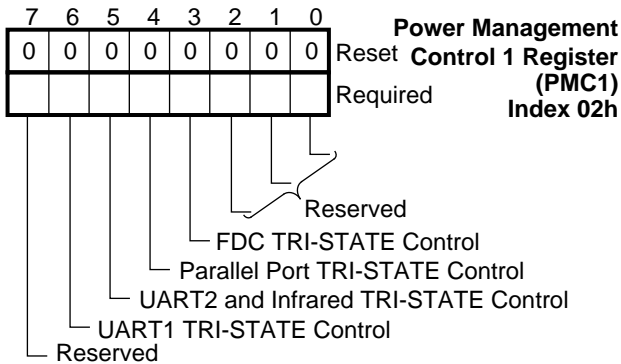


FIGURE 9-5. PMC1 Register Bitmap

Bits 2-0 - Reserved

These bits are reserved.

Bit 3 - FDC TRI-STATE Control

- 0 - No effect. TRI-STATE controlled by bit 0 of the SuperI/O FDC Configuration register. (Default) See Section 2.6.1 on page 36.
- 1 - FDC signals are in TRI-STATE.

Bit 4 - Parallel Port TRI-STATE Control

- 0 - No effect. TRI-STATE controlled by bit 0 of the SuperI/O Parallel Port Configuration register. (Default) See Section 2.7.1 on page 37.
- 1 - Parallel Port signals are in TRI-STATE.

Bit 5 - UART2 and Infrared TRI-STATE Control

- 0 - No effect. TRI-STATE controlled by bit 0 of the SuperI/O UART2 Configuration register. (Default) See Section 2.8.1 on page 38.
- 1 - UART2 signals are in TRI-STATE.

Bit 6 - UART1 TRI-STATE Control

- 0 - No effect. TRI-STATE controlled by bit 0 of the SuperI/O UART1 Configuration register. (Default) See Section 2.9.1 on page 38.
- 1 - UART1 signals are in TRI-STATE.

Bit 7 - Reserved

Reserved.

9.2.6 Power Management Control 2 Register (PMC2), Index 03h

Hardware resets this read/write register according to the CFG2 and CFG3 strap pins, the status of the multiplier clock and the hardware configuration. See Table 2-2 on page 25 and the description of the bits in this register.

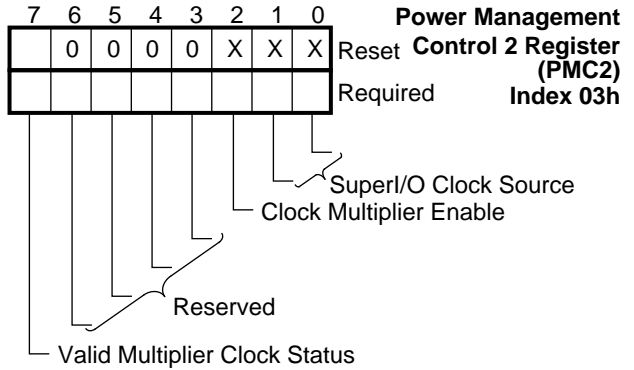


FIGURE 9-6. PMC2 Register Bitmap

Bits 1,0 - SuperI/O Clock Source

- Bit 0 is the Least Significant Bit (LSB).
- 00 - The 24 MHz clock is fed via the X1 pin.
- 01 - Reserved.
- 10 - The 48 MHz clock is fed via the X1 pin.
- 11 - The clock source is the on-chip clock multiplier.

Bit 2 - Clock Multiplier Enable

- 0 - On-chip clock multiplier is disabled.
- 1 - On-chip clock multiplier is enabled.

Bits 6-3 - Reserved

These bits are reserved.

Bit 7 - Valid Multiplier Clock Status

- This bit is read only.
- 0 - On-chip clock (clock multiplier output) is frozen.
- 1 - On-chip clock (clock multiplier output) is stable and toggling.

9.2.7 Power Management Control 3 Register (PMC3), Index 04h

Hardware resets this register to 0Eh.

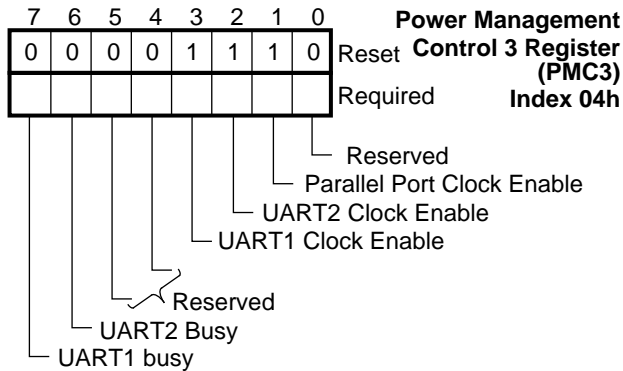


FIGURE 9-7. PMC3 Register Bitmap

Bit 0 - Reserved

This bit is reserved.

Bit 1 - Parallel Port Clock Enable

This bit is ANDed with bit 1 of the SuperI/O Parallel Port Configuration register at index F0h of logical device 4. If either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

0 - The clock is disabled.

1 - If bit 1 of the SuperI/O Parallel Port Configuration register is set to 1, the clock is enabled. (Default)

Bit 2 - UART2 Clock Enable

This bit is ANDed with bit 1 of the SuperI/O UART2 Configuration register at index F0h of logical device 5. If either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

0 - The clock is disabled.

1 - If bit 1 of the SuperI/O UART2 Configuration register is set to 1, the clock is enabled. (Default)

Bit 3 - UART1 Clock Enable

This bit is ANDed with bit 1 of the SuperI/O UART1 Configuration register at index F0h of logical device 6. If either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

0 - The clock is disabled.

1 - If bit 1 of the SuperI/O UART1 Configuration register is set to 1, the clock is enabled. (Default)

Bits 5,4 - Reserved

These bits are reserved.

Bit 6 - UART2 Busy

When set to 1, this read-only bit indicates the UART2 is busy. It is also accessed via the SuperI/O UART2 Configuration register at index F0h of logical device 5. See Section 2.8 on page 38.

Bit 7 - UART1 Busy

When set to 1, this read-only bit indicates the UART1 is busy. It is also accessed via the SuperI/O UART2 Configuration register at index F0h of logical device 6. See Section 2.9.1 on page 38.

9.2.8 Watchdog Time-Out (WDTO) Register, Index 05h

This read/write register specifies the WATCHDOG time-out period programmed by the user. It does not reflect the current count while a countdown is in progress. The time-out period may be from 1 to 255 minutes.

This register is cleared to 00h after reset. This register is also reset to zero and disabled when the Power Management device is activated.

See "The WATCHDOG Feature" on page 172 for more information.

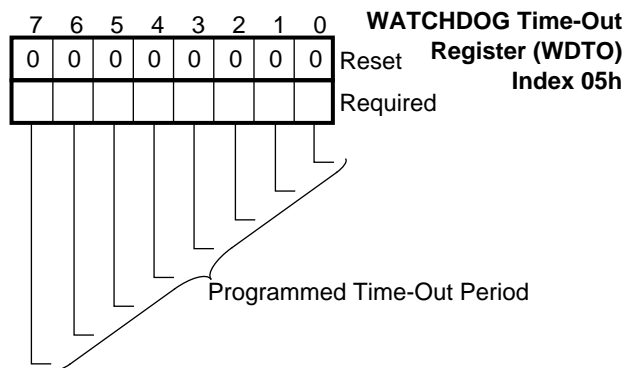


FIGURE 9-8. WDTO Register Bitmap

Bits 7-0 - Programmed Time-Out Period

These bits contain the programmed time-out period for the WATCHDOG timer. They do not reflect the current count while countdown is in progress.

Writing the value 00h resets the timer and deactivates the WDO signal. Hardware reset clears the register to 00h, and deactivates the WATCHDOG timer function and WDO. Software reset deactivates power management (logical device 8) and resets the WATCHDOG timer.

Values between 1 and 255 specify the countdown period, with one minute for each decrement.

When the timer reaches 00h, the \overline{WDO} signal is enabled (active low).

Writing a non-zero value to these bits resets the \overline{WDO} signal to 1 (inactive high).

9.2.9 WATCHDOG Configuration Register (WDCF), Index 06h

This register enables or masks the trigger events that restart the WATCHDOG timer.

When an enabled trigger event occurs, the programmed time-out value (the value in the WDTO register) is reloaded into the WATCHDOG timer. The WATCHDOG timer can reach zero and activate \overline{WDO} only if no trigger event occurs for an entire time-out period.

Trigger events are not affected by the polarity or type of the module interrupt.

Upon reset and upon activation of the power management device, all trigger events are disabled, i.e., bits are cleared to zero.

See “The WATCHDOG Feature” on page 172 for more information.

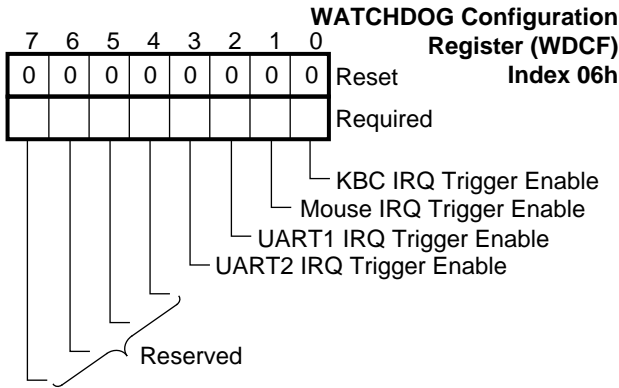


FIGURE 9-9. WDCF Register Bitmap

Bit 0 - KBC IRQ Trigger Enable

This bit enables the IRQ assigned to the KBC to trigger reloading of the WATCHDOG timer.

Reset clears this bit to 0.

0 - KBC IRQ trigger disabled. (Default)

1 - An active KBC IRQ signal triggers reloading of the WATCHDOG timer.

Bit 1 - Mouse IRQ Trigger Enable

This bit enables the IRQ assigned to the mouse to trigger reloading of the WATCHDOG timer.

Reset clears this bit to 0.

0 - Mouse IRQ trigger disabled. (Default)

1 - An active mouse IRQ signal triggers reloading of the WATCHDOG timer.

Bit 2 - UART1 IRQ Trigger Enable

This bit enables the IRQ assigned to UART1 to trigger reloading of the WATCHDOG timer.

Reset clears this bit to 0.

0 - UART1 IRQ trigger disabled. (Default)

1 - An active UART1 IRQ signal triggers reloading of the WATCHDOG timer.

Bit 3 - UART2 IRQ Trigger Enable

This bit enables the IRQ assigned to UART2 to trigger reloading of the WATCHDOG timer.

Reset clears this bit to 0.

0 - UART2 IRQ trigger disabled. (Default)

1 - An active UART2 IRQ signal triggers reloading of the WATCHDOG timer.

Bits 7-4 - Reserved

Reserved

9.2.10 WATCHDOG Status Register (WDST), Index 07h

Bit 1 of this register contains the value of the \overline{WDO} signal, for monitoring by software.

On reset or on PM logical device activation this register is initialized to 01h.

See “The WATCHDOG Feature” on page 172 for more information.

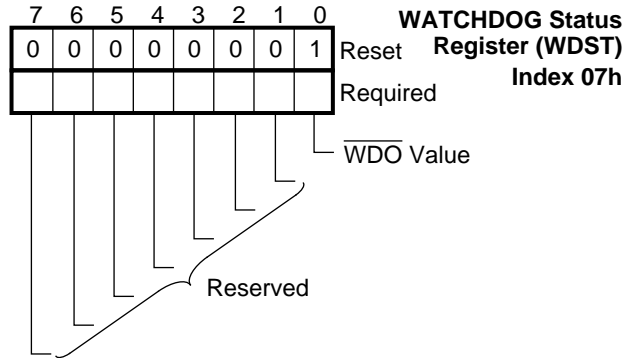


FIGURE 9-10. WDST Register Bitmap

Bit 0 - \overline{WDO} Value

This read-only bit reflects the value of \overline{WDO} . It is initialized to 1 by a hardware reset.

This bit reflects the status of the \overline{WDO} signal, even if \overline{WDO} is not configured for output by bit 6 of SuperI/O Configuration register 2, in which case the pin is used for GPIO17.

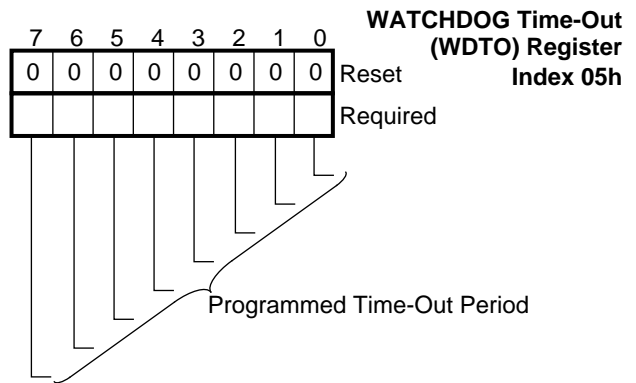
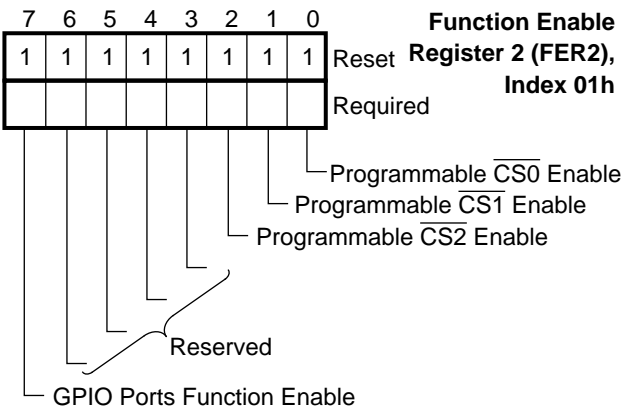
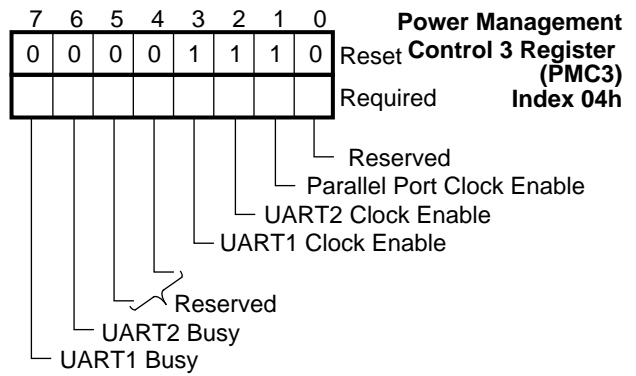
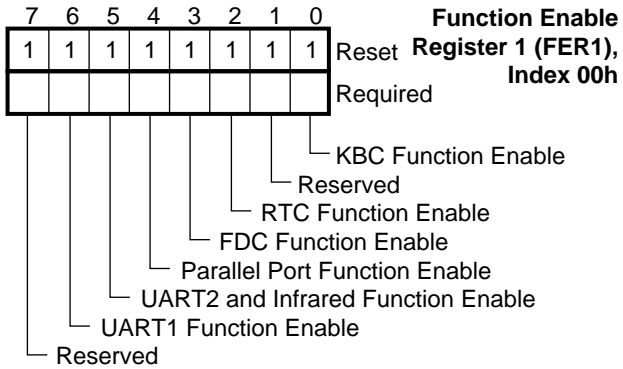
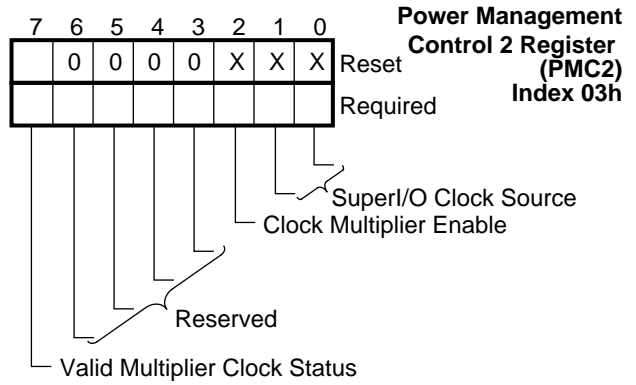
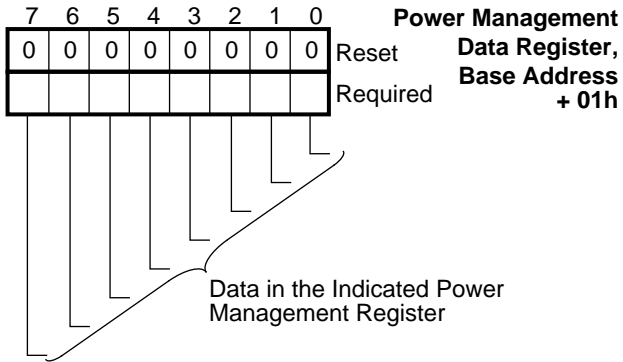
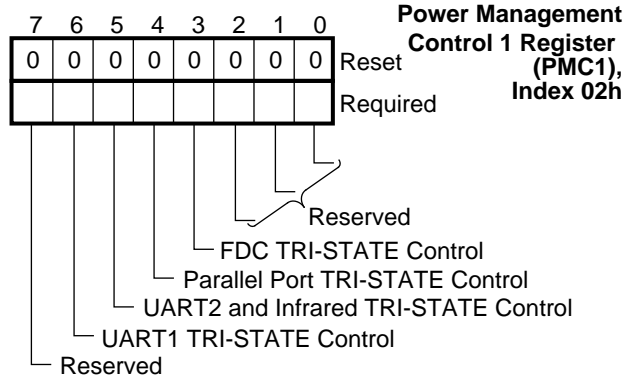
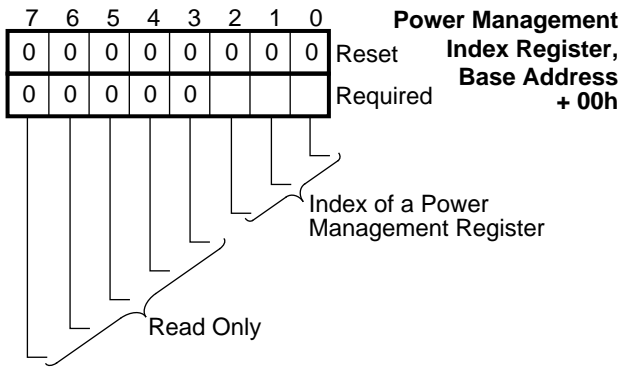
0 - \overline{WDO} is active.

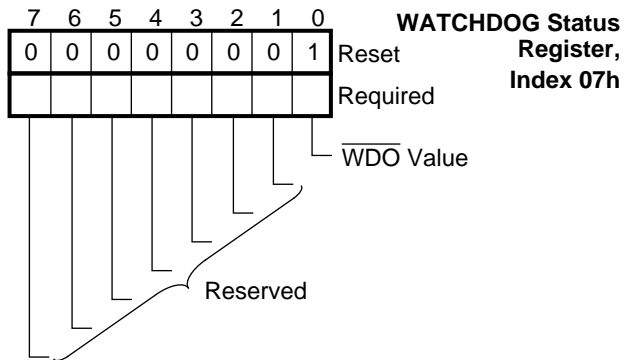
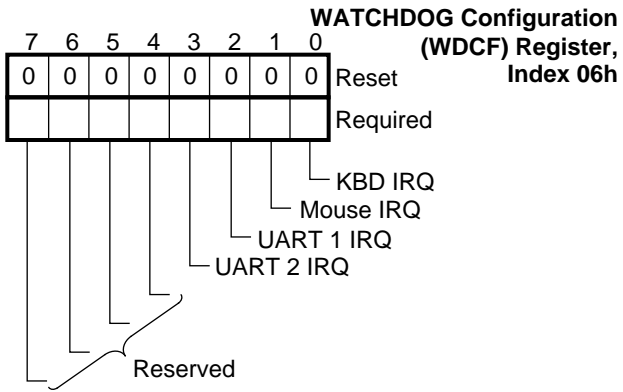
1 - \overline{WDO} is not active. (Default)

Bits 7-1 - Reserved

These bits are reserved.

9.3 POWER MANAGEMENT REGISTER BITMAPS





10.0 X-Bus Data Buffer

10.1 FUNCTIONAL OVERVIEW

The X-Bus Data Buffer (XDB) connects the 8-bit X data bus to the system data bus via the data bus of the PC87307/PC97307.

The XDB is selected by bit 4 of Super/O Chip Configuration 1 register (index 21h), as described in Section 2.4.3 on page 34. This bit is initialized according to the CFG1 strap pin value.

10.2 MAPPING

When XDB is not selected, these pins have alternate functions. See the XDB pin multiplexing in Table 1-2 on page 23.

When \overline{XDCS} is inactive, XD7-0 are neither driven nor gated to D7-0.

When \overline{XDCS} is active XD7-0, are linked to D7-0 as follows:

- D7-0 values are driven onto XD7-0 pins when \overline{XDRD} is inactive
- XD7-0 values are driven onto D7-0 pins when \overline{XDRD} is active.

11.0 The Internal Clock

11.1 THE CLOCK SOURCE

The source of the internal clock of the part can be 24 MHz or 48 MHz clock signals via the X1 pin, or an internal on-chip clock multiplier fed by the 32.768 KHz crystal of the Real-Time Clock (RTC). The clock source is determined by bits 1,0 of the Power Management Control 2 (PMC2) register of logical device 8. See Section 9.2.6 on page 174. These bits are initialized by the CFG2 and CFG3 strap pins.

Toggleing of the 32.768 KHz clock cannot be stopped while V_{CCH} is active. When the 32.768 KHz oscillator is not running, the internal circuit is blocked.

The internal on-chip clock multiplier generates 48 MHz and 24 MHz.

The Keyboard Controller (KBC) can operate at 8, 12 or 16 MHz. Selection of 8, 12 or 16 MHz for the KBC is done via the SuperI/O KBC Configuration register at index F0h of logical device 0. See Section 2.5.1 on page 36. 16 MHz is not supported when the clock source is 24 MHz via the X1 pin. The KBC clock source can be changed only when the KBC is inactive (disabled).

11.2 THE INTERNAL ON-CHIP CLOCK MULTIPLIER

Two events can trigger the internal on-chip clock multiplier. One is power-on while V_{DD} is active. The other is changing the multiplier enable bit (bit 2 of the PMC2 register of logical device 8) from 0 to 1. See Section 9.2.6 on page 174. This bit can also disable the clock multiplier and its output clock.

Once enabled, the output clock of the clock multiplier is frozen until the clock multiplier can provide an output clock that meets all requirements; then it starts. When the power is turned on, the part wakes up with the internal on-chip clock multiplier enabled, provided that it is selected by the CFG2,3 strap pins.

The 32.768 KHz and output clocks of the internal on-chip clock multiplier operate regardless of the status of the Master Reset (MR) signal. They can operate while MR is active.

The multiplier must have a 32.768 KHz input clock operating. Otherwise, the multiplier waits until this input clock starts operating.

Bit 7 of the PMC2 register of logical device 8 is the Valid Multiplier Clock status bit. When the 32.768 KHz clock toggles before MR becomes active, this bit is usually set to 1 before power-up reset ends (while MR is high, if MR is high for a few msec).

While it is stabilizing, the output clock is frozen and the status bit is cleared to 0 to indicate a frozen clock. When the clock multiplier becomes stable, the output clock starts toggling and the status bit is set to 1. A longer time is required to set the Valid Multiplier Clock status bit if the multiplier waits for a stable 32.768 KHz clock.

The Valid Multiplier Clock status bit indicates when the clock is operating. Software should poll this bit and activate (enable) the KBC, FDC, UART1, the UART2 and infrared interface (IR), and the Parallel Port according to its value.

The multiplier and its output clock do not use power when they are disabled.

11.3 SPECIFICATIONS

- Wake-up time (from the time V_{DD} becomes valid and the 32.768 KHz clock is operating, until the clock becomes stable) is a maximum of 1.5 msec.
- Tolerance (long term deviation) of the multiplier output clock, above the 32.768 KHz tolerance, is ± 110 ppm. Total tolerance is therefore $\pm (32.768 \text{ KHz clock tolerance} + 110 \text{ ppm})$.
- Cycle by cycle variance is a maximum of 0.1 ns.
- Power consumption is a maximum of 5 mA.

12.0 Interrupt and DMA Mapping

The standard Plug and Play Configuration registers map IRQs and DMA channels for the part. See Tables 2-8 and 2-9 starting on page 29.

12.1 IRQ MAPPING

The part allows connection of some logical devices to the 13 IRQ signals.

The polarity of an IRQ signal is controlled by bit 1 of the Interrupt Type registers (index 71h) of each logical device. The same bit also controls selection of push-pull or open-drain IRQ output. High polarity implies push-pull output. Low polarity implies open-drain output with strong pull-up for a short time, followed by weak pull-up.

The IRQ input signals of the KBC or mouse, and of the parallel port are not affected by this bit, i.e., bit 1 at index 71h of each logical device. This bit affects only the output buffer, not the input buffer.

Only UART1 and UART2 may map more than one logical device to any IRQ signal. Other devices may not do so.

An IRQ signal is in TRI-STATE when any of the following conditions is true:

- No logical device is mapped to the IRQ signal.
- The logical device mapped to the IRQ signal is inactive.
- The logical device mapped to the IRQ signal floats its IRQ signal.

12.2 DMA MAPPING

Although the part allows some logical devices to be connected to the four 8-bit DMA channels, it is illegal to map two logical devices to the same pair of DMA signals.

A DRQ signal is in TRI-STATE and the $\overline{\text{DACK}}$ input signal is blocked to 1 when any of the following conditions is true:

- No logical device is mapped to the DMA channel.
- The logical device mapped to the DMA channel is inactive.
- The logical device mapped to the DMA channel floats its DRQ signal.

13.0 Device Description

13.1 GENERAL DC ELECTRICAL CHARACTERISTICS

13.1.1 Recommended Operating Conditions

TABLE 13-1. Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Typical	Max	Unit
V_{DD}, V_{CCH}	Supply Voltage		4.5	5.0	5.5	V
V_{BAT}	Battery Backup Supply Voltage		2.4	3.0	3.6	V
T_A	Operating Temperature		0		+70	°C

13.1.2 Absolute Maximum Ratings

Absolute maximum ratings are values beyond which damage to the device may occur.

Unless otherwise specified, all voltages are relative to ground.

TABLE 13-2. Absolute Maximum Ratings

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	Supply Voltage		-0.5	6.5	V
V_I	Input Voltage		-0.5	$V_{DD} + 0.5$	V
V_O	Output Voltage		-0.5	$V_{DD} + 0.5$	V
T_{STG}	Storage Temperature		-65	+165	°C
P_D	Power Dissipation			1	W
T_L	Lead Temperature Soldering (10 sec.)			+260	°C
	ESD Tolerance	$C_{ZAP} = 100 \text{ pF}$ $R_{ZAP} = 1.5 \text{ K}\Omega^a$	1500		V

a. Value based on test complying with RAI-5-048-RA human body model ESD testing.

13.1.3 Capacitance

TABLE 13-3. Capacitance: $T_A = 25^\circ\text{C}$, $f = 1 \text{ MHz}$

Symbol	Parameter	Min	Typical	Max	Unit
C_{IN}	Input Pin Capacitance		5	7	pF
C_{IN1}	Clock Input Capacitance		8	10	pF
C_{IO}	I/O Pin Capacitance		10	12	pF
C_O	Output Pin Capacitance		6	8	pF

13.1.4 Power Consumption Under Recommended Operating Conditions

TABLE 13-4. Power Consumption

Symbol	Parameter	Conditions	Min	Typical	Max	Unit
I_{CC}	V_{DD} Average Main Supply Current ^a	$V_{IL} = 0.5\text{ V}$ $V_{IH} = 2.4\text{ V}$ No Load		32	50	mA
I_{CCSB}	V_{DD} Quiescent Main Supply Current in Low Power Mode	$V_{IL} = V_{SS}$ $V_{IH} = V_{DD}$ No Load		1.3	1.7	mA
I_{CCH}	V_{CCH} RTC/APC (Logical Device 2) Help Supply Current	$V_{CCH} = 5\text{ V} \pm 10\%$		2		mA
I_{BAT}	V_{BAT} Battery Supply Current	$V_{BAT} = 3\text{ V}$			2	μA

a. Do not permit V_{CCH} to ramp down at a rate exceeding 1 V/msec. If it does, it may reset the Valid RAM and Time (VRT) bit (bit 7) of the RTC Control Register D (CRD) at offset 0Dh of logical device 2.

13.2 DC CHARACTERISTICS OF PINS, BY GROUP

The following tables list the DC characteristics of all device pins described in Section 1.2. The pin list preceding each table lists the device pins to which the table applies.

13.2.1 Group 1

Pin List:

A15-0, AEN, $\overline{\text{ASTRXB}}$, $\overline{\text{CTS2,1}}$, $\overline{\text{DACK3-0}}$, $\overline{\text{DCD2,1}}$, $\overline{\text{DSKCHG}}$, $\overline{\text{DSR2,1}}$, ID3-0, $\overline{\text{INDEX}}$, $\overline{\text{IRRX2,1}}$, MR, $\overline{\text{RD}}$, $\overline{\text{RDATA}}$, $\overline{\text{SIN2,1}}$, TC, TRK0, WP, WR, XDRD

TABLE 13-5. DC Characteristics of Group 1 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD} ^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		-10	μA
V_H	Input Hysteresis		250		mV

a. Not tested. Guaranteed by design.

13.2.2 Group 2**Pin List:**

BUSY, PE, SLCT, $\overline{\text{WAIT}}$

Output from SLCT, PE and BUSY is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based FIFO and bit 4 of the Control2 parallel port register is 1. (See Table 6-1 on page 112.) Otherwise, output from these signals is level 2. External 4.7 k Ω pull-up resistors should be used. PE is controlled by bit 2 of PP Config0, and it is in Group 2 only if bit 2 of PP Config0 Register is "0". See Section 6.5.19 on page 127.

All group 2 pins are back-drive protected.

TABLE 13-6. DC Characteristics of Group 2 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		120	μA
		$V_{IN} = V_{SS}$		-10	μA

a. Not tested. Guaranteed by design.

13.2.3 Group 3**Pin List:**

$\overline{\text{ACK}}$, $\overline{\text{ERR}}$, PE

Output from $\overline{\text{ACK}}$ and $\overline{\text{ERR}}$ is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based FIFO and bit 4 of the Control2 parallel port register is 1. (See Table 6-1 on page 112.) Otherwise, output from these signals is level 2. External 4.7 k Ω pull-up resistors should be used. PE is controlled by bit 2 of PP Config0, and it is in Group 2 only if bit 2 of PP Config0 Register is "0". See section 6.5.19 on page 127.

All group 3 pins are back-drive protected.

TABLE 13-7. DC Characteristics of Group 3 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		-250	μA

a. Not tested. Guaranteed by design.

13.2.4 Group 4**Pin List:**

MSEN1,0, SELCS

SELCS is a CMOS input pin.

TABLE 13-8. DC Characteristics of Group 4 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
I_{IL}	Input Leakage Current	During Reset: $V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		-150	μA

a. Not tested. Guaranteed by design.

13.2.5 Group 5**Pin List:**

BADDR1,0, CFG3-0

These are CMOS input pins.

TABLE 13-9. DC Characteristics of Group 5 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.5	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	1.6	V
I_{IL}	Input Leakage Current	During Reset: $V_{IN} = V_{DD}$		150	μA
		$V_{IN} = V_{SS}$		-10	μA

a. Not tested. Guaranteed by design.

13.2.6 Group 6**Pin List:**

X1

TABLE 13-10. DC Characteristics of Group 6 Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
I_{XLKG}	X1 Leakage Current	$V_{IN} = V_{DD}$		400	μA
		$V_{IN} = V_{SS}$		-400	μA

a. Not tested. Guaranteed by design.

13.2.7 Group 7**Pin List:** $\overline{\text{RI1}}$, $\overline{\text{RI2}}$, $\overline{\text{RING}}$, $\overline{\text{SWITCH}}$, $\overline{\text{XDCS}}$ $\overline{\text{RING}}$ and $\overline{\text{XDCS}}$ are back-drive protected.**TABLE 13-11. DC Characteristics of Group 7 Pins**

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage ^a		2.0		V
V_{IL}	Input Low Voltage ^a			0.8	V
V_H	Hysteresis	$V_{BAT} = 3\text{ V}$	200		mV
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		100	μA
		$V_{IN} = V_{SS}$		-10 ^b	μA

a. Not tested. Guaranteed by design.

b. $\overline{\text{SWITCH}}$ has an internal pull-up resistor of 1M Ω .

13.2.8 Group 8**Pin List:**

D7-0

TABLE 13-12. DC Characteristics of Group 8 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD} ^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-13. DC Characteristics of Group 8 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -15$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 24$ mA		0.4	V

13.2.9 Group 9**Pin List:**CS2,1, XD7,6, XD1,0**TABLE 13-14. DC Characteristics of Group 9 Input Pins**

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD} ^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-15. DC Characteristics of Group 9 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -6$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 12$ mA		0.4	V

13.2.10 Group 10**Pin List:**GPIO27-10, XD5-2, $\overline{\text{WDO}}$

GPIO27-10 are back-drive protected.

TABLE 13-16. DC Characteristics of Group 10 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		100	μA
		$V_{IN} = V_{SS}$		-10 ^b	μA

a. Not tested. Guaranteed by design.

b. For GPIO pins the $I_{IL}(\text{Max}) = -550\mu\text{A}$.**TABLE 13-17. DC Characteristics of Group 10 Output Pins**

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -2 \text{ mA}^a$	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 2 \text{ mA}$		0.4	V

a. I_{OH} is valid for a GPIO signal only when it is not configured as open-drain.**13.2.11 Group 11****Pin List:**

KBCLK, KBDAT, MCLK, MDAT

Output from these signals is open-drain and cannot be forced high.

TABLE 13-18. DC Characteristics of Group 11 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-19. DC Characteristics of Group 11 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OL}	Output Low Voltage	$I_{OL} = 16 \text{ mA}$		0.4	V

13.2.12 Group 12**Pin List:**

P12, P16, P17, P20, P21.

TABLE 13-20. DC Characteristics of Group 12 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-21. DC Characteristics of Group 12 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -2 \text{ mA}^a$	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 2 \text{ mA}$		0.4	V

a. I_{OH} is driven for a period of 3 KBC clock periods (of 8 MHz, 12 MHz or 16 MHz) after the low-to-high transition, on pins P12, P16 and P17.**13.2.13 Group 13****Pin List:** \overline{AFD} , \overline{INIT} , \overline{SLIN} , \overline{STB} .

Group 13 pins are back-drive protected.

TABLE 13-22. DC Characteristics of Group 13 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-23. DC Characteristics of Group 13 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage ^a	$I_{OH} = -2 \text{ mA}$	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 2 \text{ mA}$		0.4	V

a. Output from \overline{STB} , \overline{AFD} , \overline{INIT} , \overline{SLIN} is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based (FIFO). (See Table 6-1 on page 112.) Otherwise, output from these signals is Level 2. External 4.7 K Ω pull-up resistors should be used.

13.2.14 Group 14**Pin List:**

PD7-0

Group 14 pins are back-drive protected.

TABLE 13-24. DC Characteristics of Group 14 Input Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{IH}	Input High Voltage		2.0	V_{DD}^a	V
V_{IL}	Input Low Voltage		-0.5 ^a	0.8	V
V_H	Hysteresis		250		mV

a. Not tested. Guaranteed by design.

TABLE 13-25. DC Characteristics of Group 14 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage ^a	$I_{OH} = -14$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 14$ mA		0.4	V

a. Output from PD7-0 is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based (FIFO) and bit 4 of the Control2 parallel port register is 1. (See Table 6-1 on page 112.) Otherwise, output from these signals is Level 2. External 4.7 K Ω pull-up resistors should be used.

13.2.15 Group 15**Pin List:**

IRQ1,3,4,5,6,7,8,9,10,11,12,14,15.

TABLE 13-26. DC Characteristics of Group 15 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -15$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 24$ mA		0.4	V
V_H	Hysteresis		250		mV

13.2.16 Group 16**Pin List:**DENSEL, \overline{DIR} , $\overline{DR1,0}$, \overline{HDSEL} , $\overline{MTR1,0}$, \overline{STEP} , \overline{WDATA} , \overline{WGATE} .**TABLE 13-27. DC Characteristics of Group 16 Output Pins**

Symbol	Parameter	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	$I_{OH} = -4$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 40$ mA		0.4	V

13.2.17 Group 17**Pin List:**

BOUT2,1, DTR2,1, IRSL2-0, RTS2,1, SOUT2,1.

TABLE 13-28. DC Characteristics of Group 17 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V _{OH}	Output High Voltage	I _{OH} = -6 mA	2.4		V
V _{OL}	Output Low Voltage	I _{OL} = 12 mA		0.4	V
V _H	Hysteresis		250		mV

13.2.18 Group 18**Pin List:**

DRQ3-0

TABLE 13-29. DC Characteristics of Group 18 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V _{OH}	Output High Voltage	I _{OH} = -15 mA	2.4		V
V _{OL}	Output Low Voltage	I _{OL} = 24 mA		0.4	V

13.2.19 Group 19**Pin List:**

IRTX

TABLE 13-30. DC Characteristics of Group 19 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V _{OH}	Output High Voltage	I _{OH} = -6mA	2.4		V
V _{OL}	Output Low Voltage	I _{OL} = 12 mA		0.4	V

13.2.20 Group 20**Pin List:**

DRATE0

TABLE 13-31. DC Characteristics of Group 20 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V _{OH}	Output High Voltage	I _{OH} = -6 mA	2.4		V
V _{OL}	Output Low Voltage	I _{OL} = 6 mA		0.4	V

13.2.21 Group 21**Pin List:**

CS0, CSOUT, POR

TABLE 13-32. DC Characteristics of Group 21 Output Pins

Parameter	Conditions	Min	Max	Units
Output High Voltage	Open-Drain			
Output Low Voltage	I _{OL} = 2 mA		0.4	V

13.2.22 Group 22

Pin List:

$\overline{IOCHRDY}$, \overline{ZWS}

TABLE 13-33. DC Characteristics of Group 22 Output Pins

Symbol	Parameter	Symbol	Conditions	Min	Max	Units
V_{OH}	Output High Voltage	V_{OH}	$I_{OH} = -15 \text{ mA}$	2.4		V
V_{OL}	Output Low Voltage	V_{OL}	$I_{OL} = 24 \text{ mA}$		0.4	V

13.2.23 Group 23

Pin List:

\overline{ONCTL}

This pin is back-drive protected and open-drain. V_{OH} is not tested for \overline{ONCTL} .

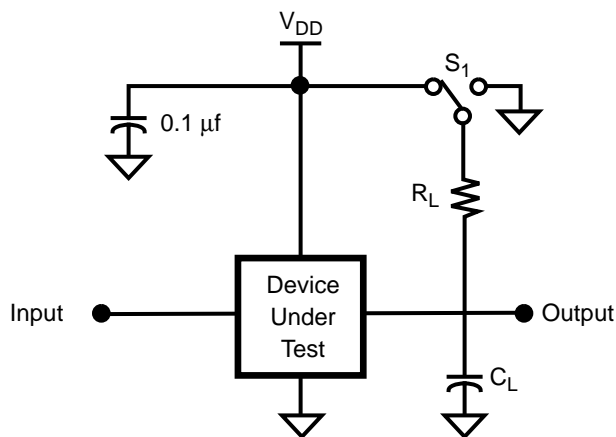
TABLE 13-34. DC Characteristics of Group 23 Output Pins

Symbol	Parameter	Conditions	Min	Max	Units
V_{OL}	Output Low Voltage	$I_{OL} = 14 \text{ mA}$		0.4	V

13.3 AC ELECTRICAL CHARACTERISTICS

13.3.1 AC Test Conditions $T_A = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$, $V_{DD} = 5.0 \text{ V} \pm 10\%$

Load Circuit (Notes 1, 2, 3)



AC Testing Input, Output Waveform

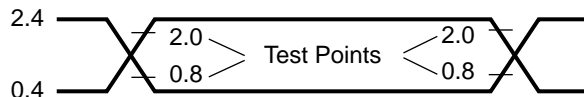


FIGURE 13-1. AC Test Conditions, $T_A = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$, $V_{DD} = 5.0 \text{ V} \pm 10\%$

Notes:

- $C_L = 100 \text{ pF}$, includes jig and scope capacitance.
- $S_1 = \text{Open}$ for push-pull output pins.
 $S_1 = V_{DD}$ for high impedance to active low and active low to high impedance measurements.
 $S_1 = \text{GND}$ for high impedance to active high and active high to high impedance measurements.
 $R_L = 1.0\text{K}\Omega$ for μP interface pins.
- For the FDC open-drive interface pins, $S_1 = V_{DD}$ and $R_L = 150\Omega$.

13.3.2 Clock Timing

TABLE 13-35. Clock Timing

Symbol	Parameter	24MHz		48MHz		Unit
		Min	Max	Min	Max	
t_{CH}	Clock High Pulse Width ^a	16		8.4		nsec
t_{CL}	Clock Low Pulse Width ^a	16		8.4		nsec
t_{CP}	Clock Period ^a	40	43	20	21.5	nsec
t_{ICP}	Internal Clock Period (See Table 13-36.)					
t_{DRP}	Data Rate Period (See Table 13-36.)					

a. Not tested. Guaranteed by design.

TABLE 13-36. Nominal t_{ICP} t_{DRP} Values

MFM Data Rate	t_{DRP}	t_{ICP}	Value	Unit
1 Mbps	1000	$3 \times t_{CP}$	125	nsec
500 Kbps	2000	$3 \times t_{CP}$	125	nsec
300 Kbps	3333	$5 \times t_{CP}$	208	nsec
250 Kbps	4000	$6 \times t_{CP}$	250	nsec

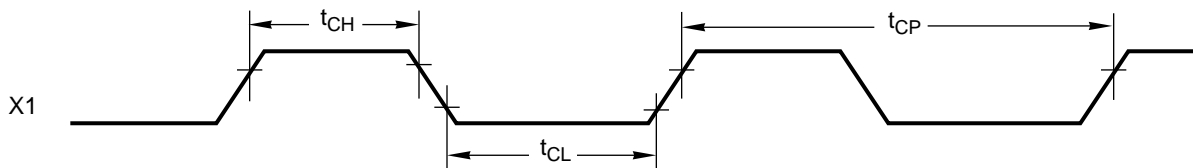


FIGURE 13-2. Clock Timing

13.3.3 Microprocessor Interface Timing

TABLE 13-37. Microprocessor Interface Timing

Symbol	Parameter	Min	Max	Unit
t_{AR}	Valid Address to Read Active	18		nsec
t_{AW}	Valid Address to Write Active	18		nsec
t_{DH}	Data Hold	0		nsec
t_{DS}	Data Setup	18		nsec
t_{HZ}	Read to Floating Data Bus ^a	13	25	nsec
t_{PS}	Port Setup	10		nsec
t_{RA}	Address Hold from Inactive Read	0		nsec
t_{RCU}	Read Cycle Update ^a	45		nsec
t_{RD}	Read Strobe Width	60		nsec
t_{RDH}	Read Data Hold	10		nsec
t_{RI}	Read Strobe to Clear FDC IRQ		55	nsec
t_{RVD}	Active Read to Valid Data		55	nsec
t_{WA}	Address Hold from Inactive Write	0		nsec
t_{WCU}	Write Cycle Update ^a	45		nsec
t_{WI}	Write Strobe to Clear FDC IRQ		55	nsec
t_{WO}	Write Data to Port Update		60	nsec
t_{WR}	Write Strobe Width	60		nsec
RC	Read Cycle = $t_{AR} + t_{RD} + t_{RCU}$ ^a	123		nsec
WC	Write Cycle = $t_{AW} + t_{WR} + t_{WC}$ ^a	123		nsec
t_{WRR}	\overline{RD} low after \overline{WR} high ^a	80		nsec

a. Not tested. Guaranteed by design.

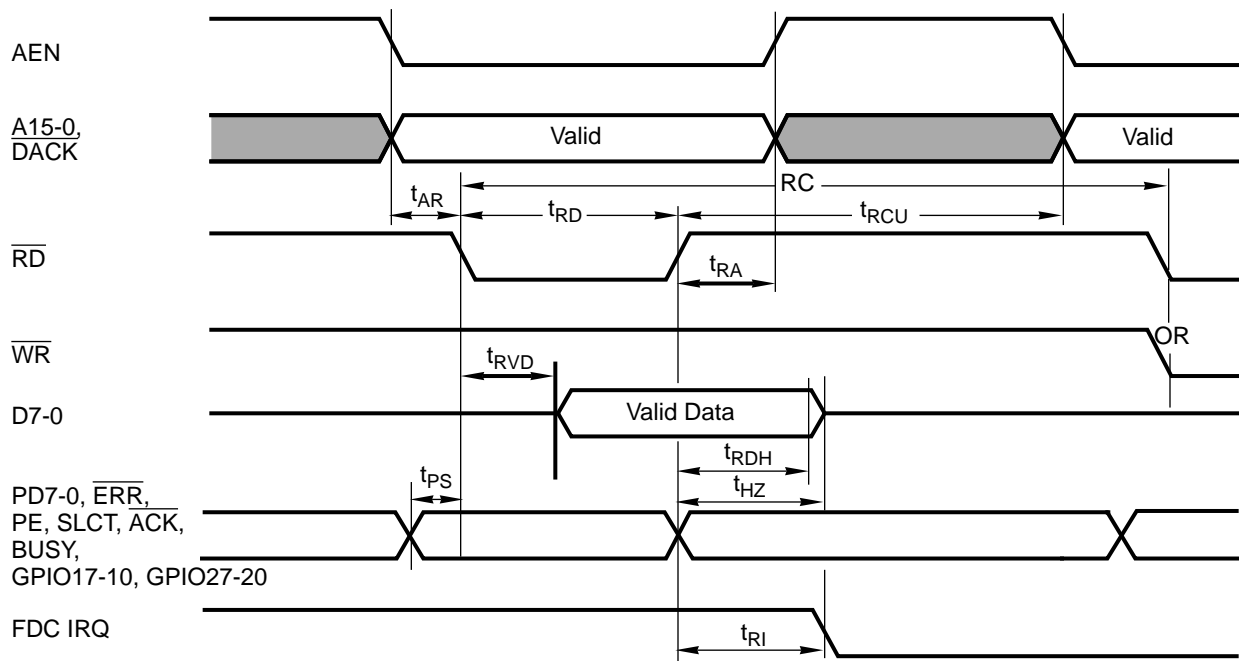


FIGURE 13-3. Microprocessor Read Timing

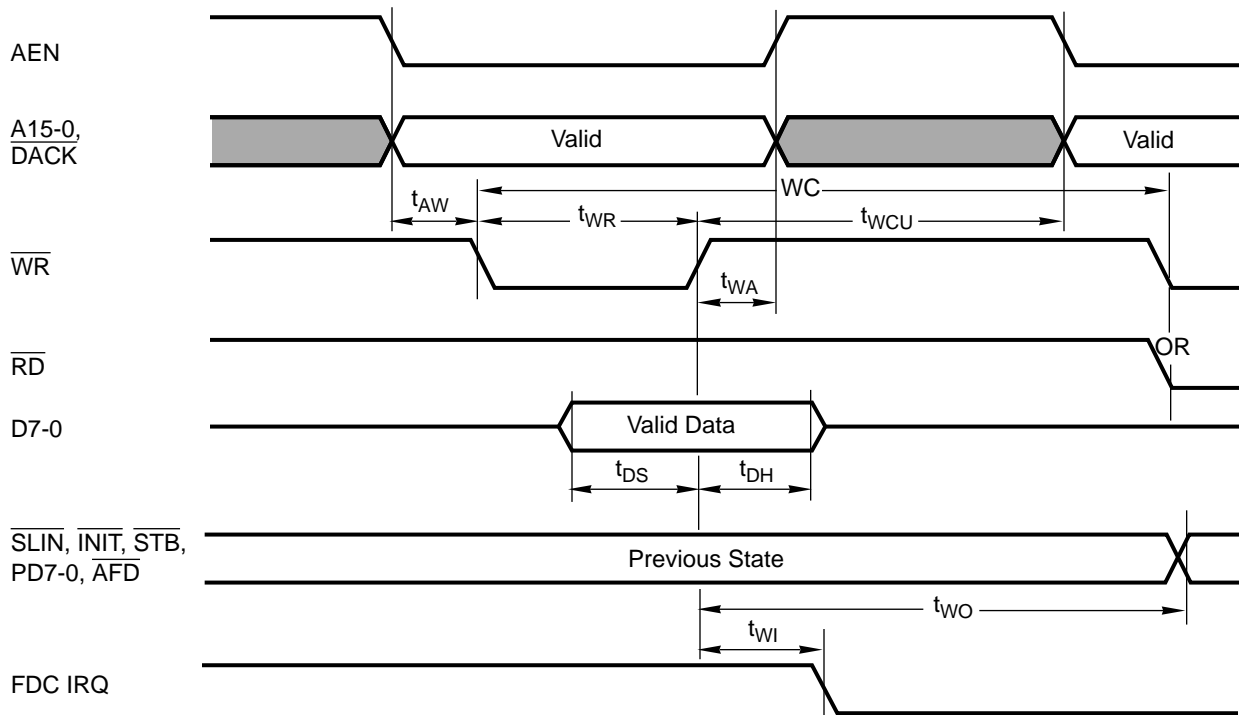


FIGURE 13-4. Microprocessor Write Timing

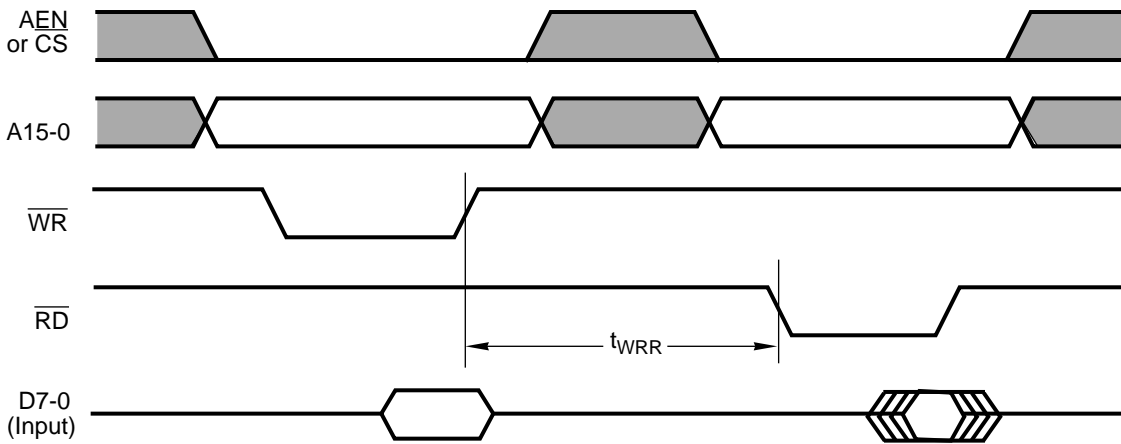


FIGURE 13-5. Read After Write Operation to All Registers and RAM

13.3.4 Baud Output Timing

TABLE 13-38. Baud Output Timing

Symbol	Parameter	Conditions	Min	Max	Unit
N	Baud Divisor		1	65535	nsec
t_{BHD}	Baud Output Positive Edge Delay ^a	CLK = 24 MHz/2, 100 pF load		56	nsec
t_{BLD}	Baud Output Negative Edge Delay ^a	CLK = 24 MHz/2, 100 pF load		56	nsec

a. Not tested. Guaranteed by design.

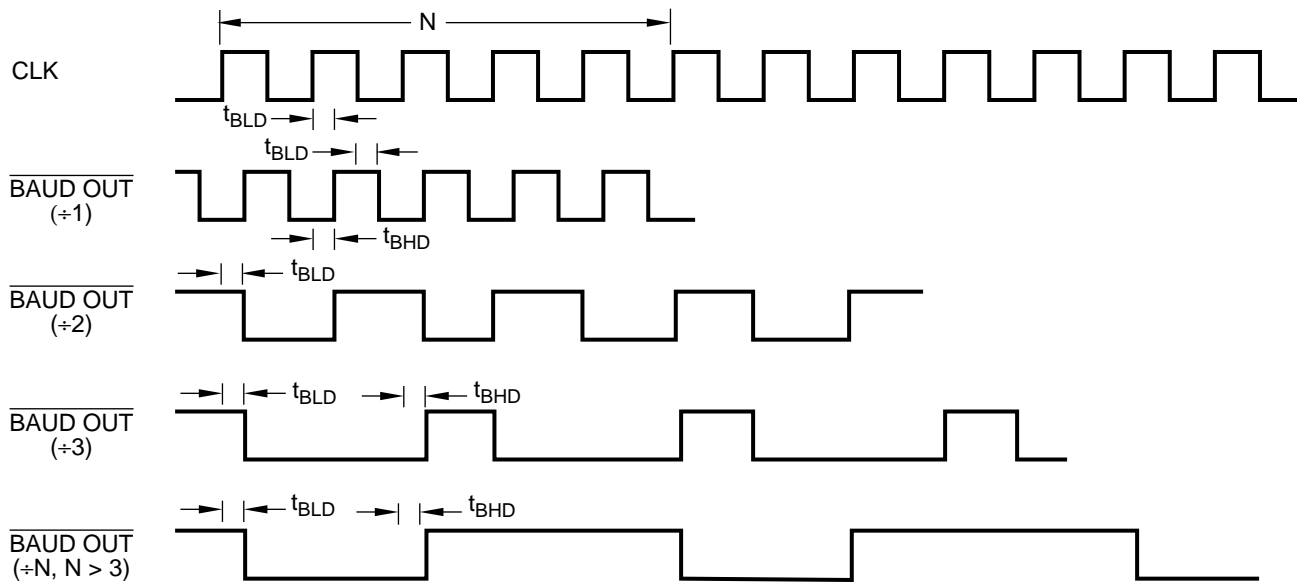


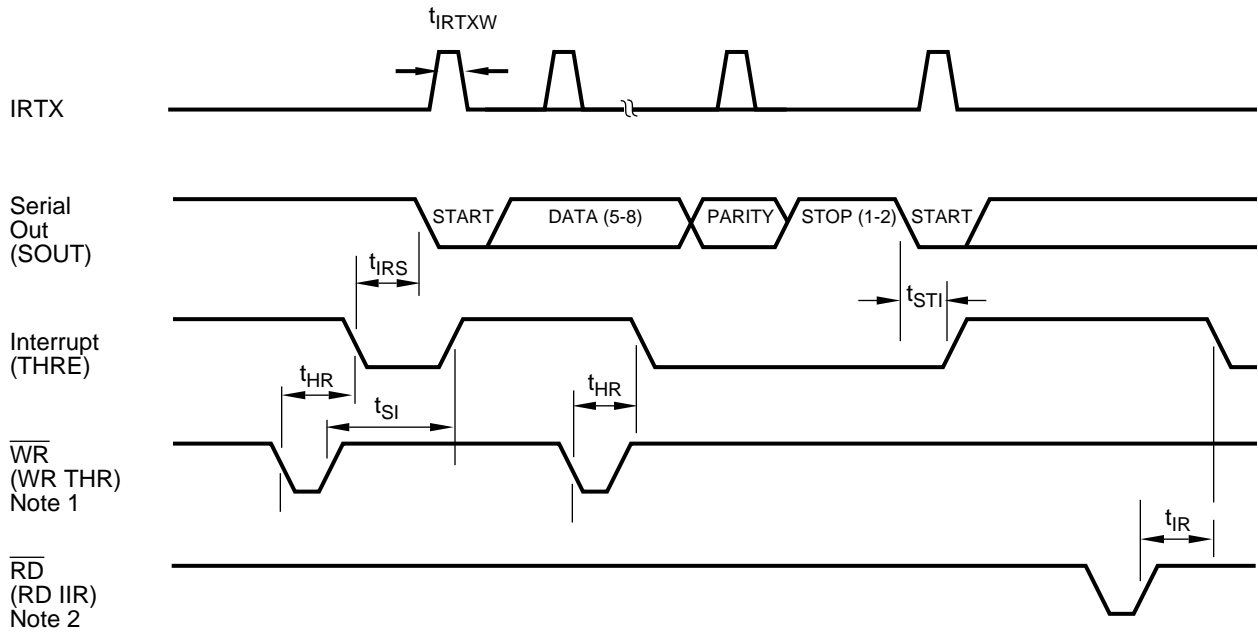
FIGURE 13-6. Baud Output Timing

13.3.5 Transmitter Timing

TABLE 13-39. Transmitter Timing

Symbol	Parameter	Min	Max	Unit
t_{IRTXW}	IRTX Pulse Width ^a	1.6 μ sec	$\frac{3}{16}$	Baud Output Cycles
t_{HR}	Delay from \overline{WR} (WR THR) to Reset IRQ		40	nsec
t_{IR}	Delay from \overline{RD} (RD IIR) to Reset IRQ (THRE)		55	nsec
t_{IRS}	Delay from Initial IRQ Reset to Transmit Start ^a	8	24	Baud Output Cycles
t_{SI}	Delay from Initial Write to IRQ ^a	16	24	Baud Output Cycles
t_{STI}	Delay from Start Bit to IRQ (THRE) ^a		8	Baud Output Cycles

a. Not tested. Guaranteed by design.



Notes:

1. See write cycle timing in Figure 13-4.
2. See read cycle timing in Figure 13-3.

FIGURE 13-7. Transmitter Timing

13.3.6 Receiver Timing

TABLE 13-40. Receiver Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t_{IRRXW}	IRRX Pulse Width ^a		1.6 μ sec	$6/16$	Baud Output Cycles
t_{RAI1}	Delay from Active Edge of \overline{RD} to Reset IRQ			78	nsec
t_{RAI2}	Delay from Active Edge of \overline{RD} to Reset IRQ			78	nsec
t_{RAI3}	Delay from Active Edge of \overline{RD} to Reset IRQ			78	nsec
t_{RINT}	Delay from Inactive Edge of \overline{RD} (RD LSR) to Reset IRQ			55	nsec
t_{SCD}	Delay from RCLK to Sample Time	b		41	nsec
t_{SINT}	Delay from Stop bit to Set Interrupt ^a			2	Baud Output Cycles

a. Not tested. Guaranteed by design.

b. This is internal timing and is therefore not tested.

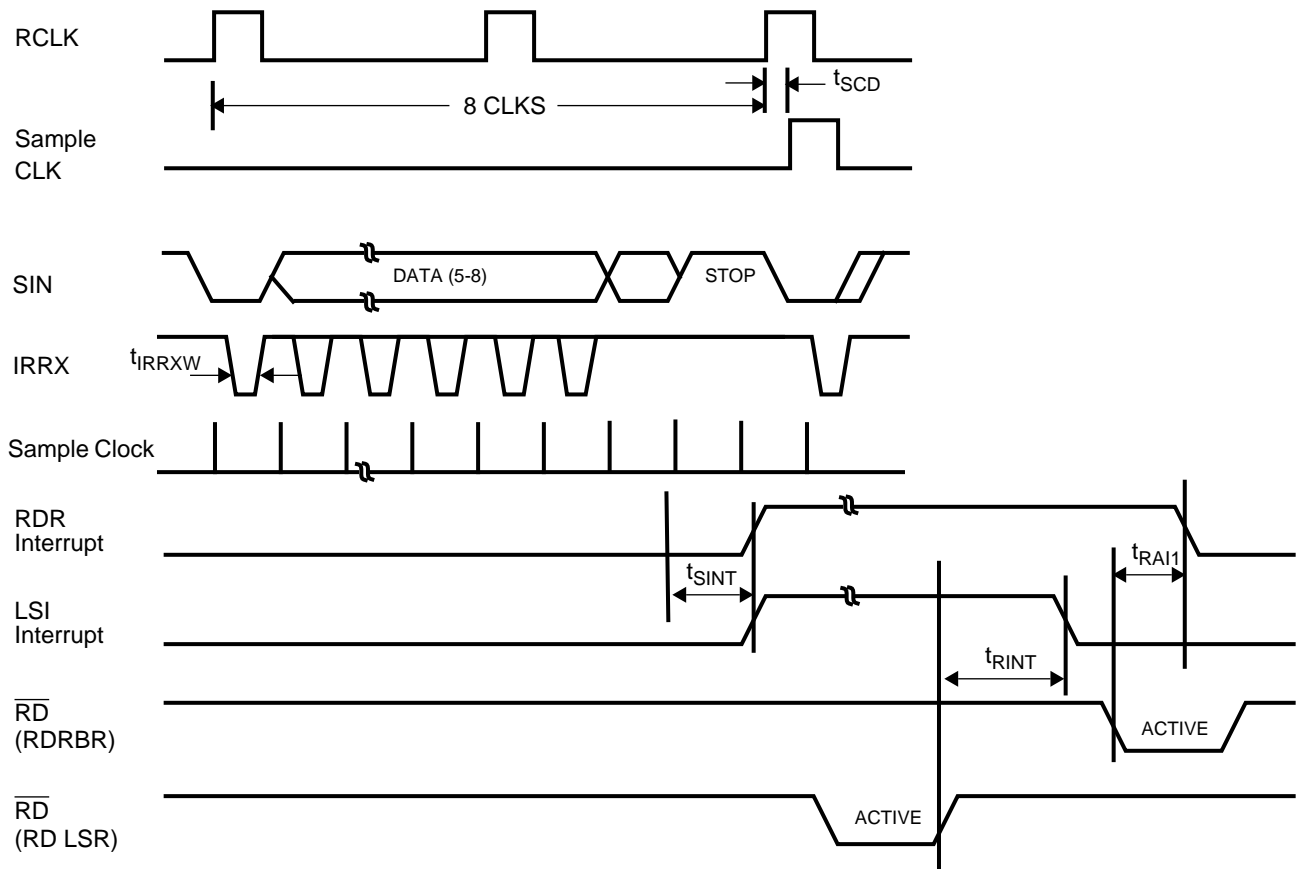
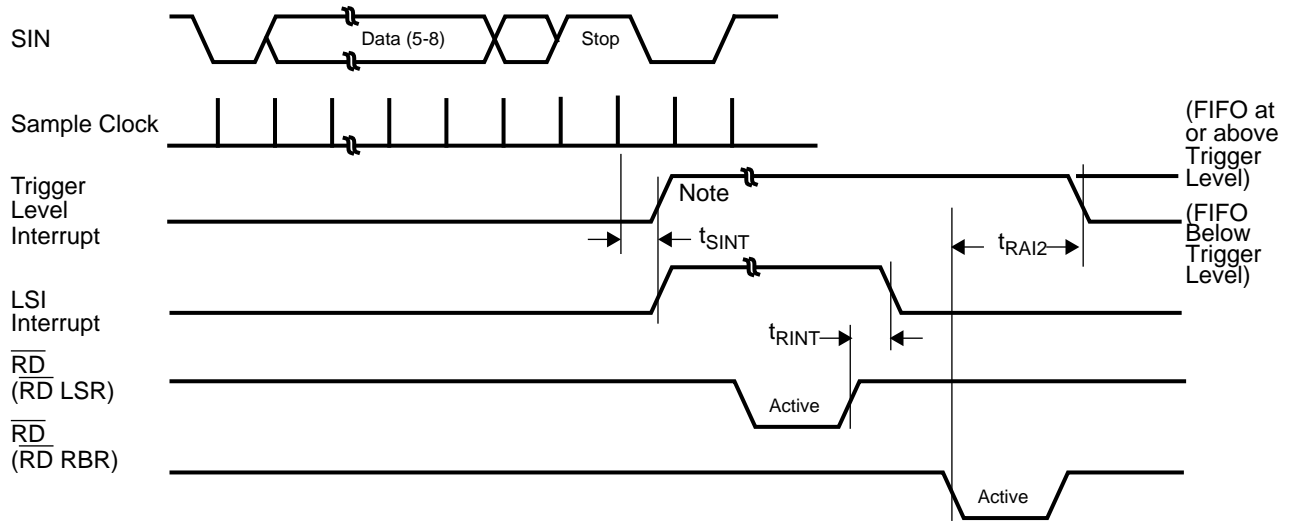


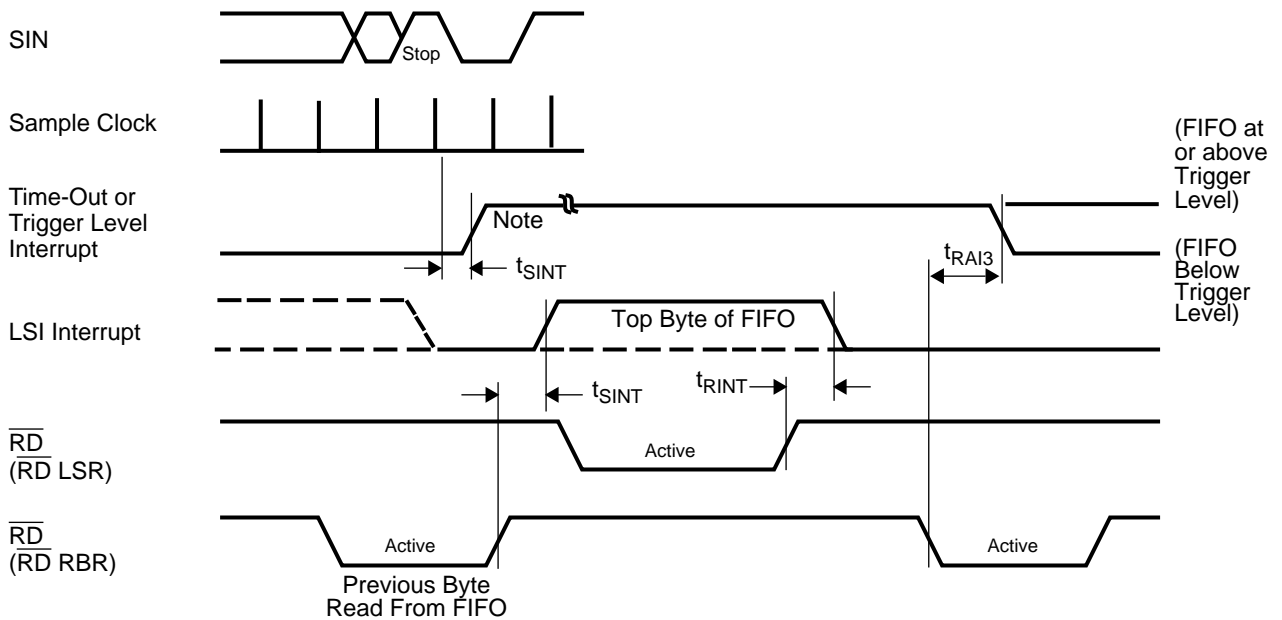
FIGURE 13-8. Receiver Timing



Note:

If $SCR0 = 1$, then $t_{SINT} = 3$ RCLKs. For a time-out interrupt, $t_{SINT} = 8$ RCLKs.

FIGURE 13-9. FIFO Mode Receiver Timing



Note:

If $SCR0 = 1$, then $t_{SINT} = 3$ RCLKs. For a time-out interrupt, $t_{SINT} = 8$ RCLKs

FIGURE 13-10. Time-Out Receiver Timing

13.3.7 UART, Sharp-IR and Consumer-IR Timing

TABLE 13-41. UART, Sharp-IR and Consumer Remote Control Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t_{BT}	Single Bit Time in UART and Sharp-IR	Transmitter	$t_{BTN} - 30^a$	$t_{BTN} + 30$	nsec
		Receiver	$t_{BTN} - 2\%$	$t_{BTN} + 2\%$	nsec
t_{CMW}	Modulation Signal Pulse Width in Sharp-IR and Consumer Remote Control	Transmitter	$t_{CWN} - 30^b$	$t_{CWN} + 30$	nsec
		Receiver	500		nsec
t_{CMP}	Modulation Signal Period in Sharp-IR and Consumer Remote Control	Transmitter	$t_{CPN} - 30^c$	$t_{CPN} + 30$	nsec
		Receiver	t_{MMIN}^d	t_{MMAX}^d	nsec

- a. t_{BTN} is the nominal bit time in UART, Sharp-IR, SIR and Consumer Remote Control modes. It is determined by the setting of the Baud Rate Generator Divisor registers BGD L and BGDH at offsets 00h and 01h, respectively.
- b. t_{CWN} is the nominal pulse width of the modulation signal for Sharp-IR and Consumer Remote Control modes. It is determined by the MCPW field (bits 7-5) of the IRTXMC register at offset 01h and the TXHSC bit (bit 2) in the RCCFG register at offset 02h. Both registers are in bank 7 of logical device 5.
- c. t_{CPN} is the nominal period of the modulation signal for Sharp-IR and Consumer Remote Control modes. It is determined by the MCFR field (bits 4-0) of the IRTXMC register at offset 01h and the TXHSC bit (bit 2) of the RCCFG register at offset 02h. Both registers are in bank 7 of logical device 5.
- d. t_{MMIN} and t_{MMAX} define the time range within which the period of the incoming carrier signal has to fall in order for the signal to be accepted by the receiver. These time values are determined by the content of register IRRXDC at offset 00h and the setting of the RXHSC bit (bit 5) in the RCCFG register at offset 02h. Both registers are in bank 7 of logical device 5.

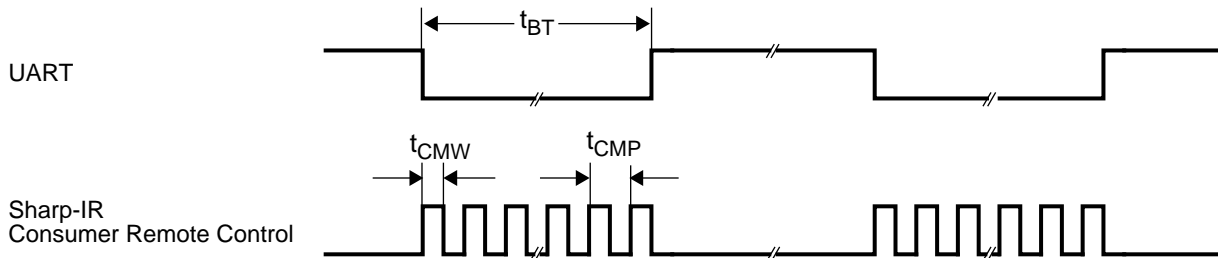


FIGURE 13-11. UART, Sharp-IR and Consumer Remote Control Timing

13.3.8 SIR Timing

TABLE 13-42. SIR Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t _{SPW}	SIR Signal Pulse Width	Transmitter, Variable	$(\sqrt[3]{16}) \times t_{\text{BTN}} - 15^a$	$(\sqrt[3]{16}) \times t_{\text{BTN}} + 15$	nsec
		Transmitter, Fixed	1.60	1.65	μsec
		Receiver	1		μsec
S _{DRT}	SIR Transmitter Data Rate Tolerance			± 0.87%	
t _{SJT}	SIR Receiver Edge Jitter, % of Nominal Bit Duration			± 6.5%	

a. t_{BTN} is the nominal bit time in UART, Sharp-IR, SIR and Consumer Remote Control modes.

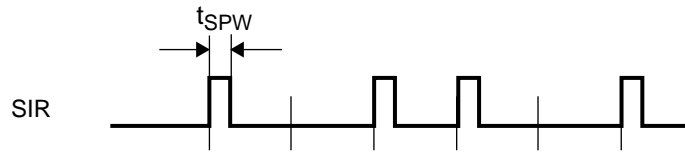


FIGURE 13-12. SIR Timing

13.3.9 IRSLn Write Timing

TABLE 13-43. IRSLn Write Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t _{WOD}	IRSLn Output Delay from Write Inactive			60	nsec

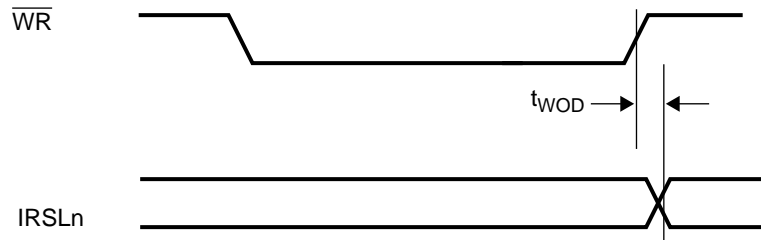
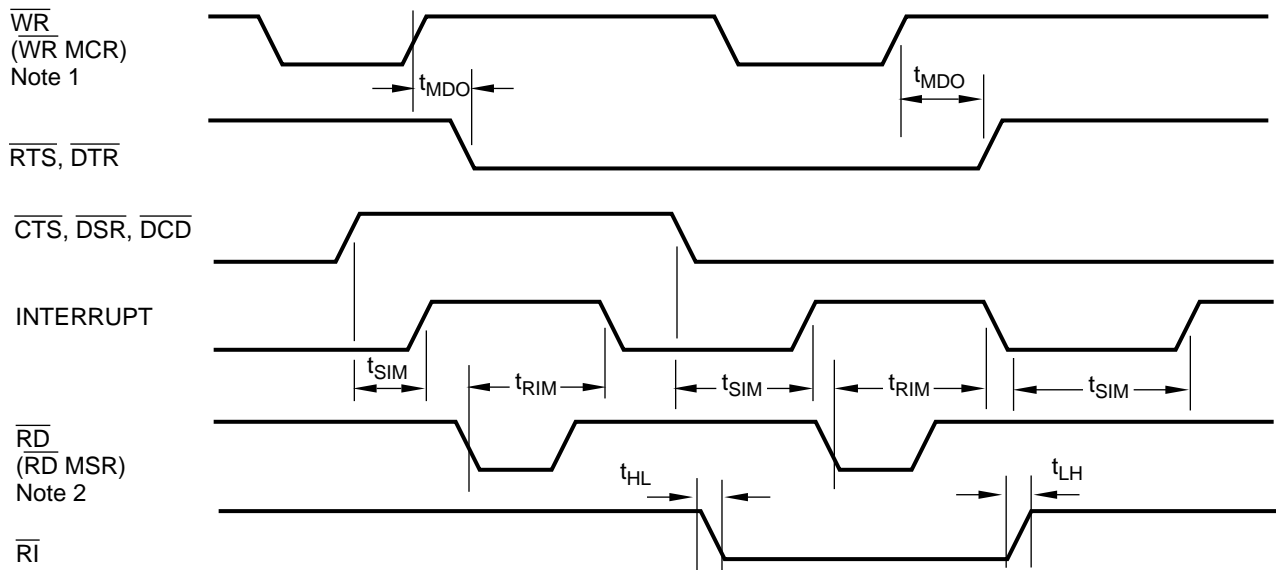


FIGURE 13-13. IRSLn Write Timing

13.3.10 Modem Control Timing

TABLE 13-44. Modem Control Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t_{HL}	RI2,1 High to Low Transition		10		nsec
t_{LH}	RI2,1 Low to High Transition		10		nsec
t_{MDO}	Delay from \overline{WR} (\overline{WR} MCR) to Output			40	nsec
t_{RIM}	Delay to Reset IRQ from \overline{RD} (\overline{RD} MSR)			78	nsec
t_{SIM}	Delay to Set IRQ from Modem Input			40	nsec



Notes:

1. See write cycle timing, Figure 13-4.
2. See read cycle timing, Figure 13-3.

FIGURE 13-14. Modem Control Timing

13.3.11 DMA Timing

TABLE 13-45. FDC DMA Timing

Symbol	Parameter	Min	Max	Unit
t_{KI}	\overline{DACK} Inactive Pulse Width	25		nsec
t_{KK}	\overline{DACK} Active Pulse Width	65		nsec
t_{KQ}	\overline{DACK} Active Edge to DRQ Inactive		65	nsec
t_{QK}	DRQ to \overline{DACK} Active Edge	10		nsec
t_{QP}	DRQ Period (Except Non-Burst DMA)	$8 \times t_{DRP}^a$		
t_{QQ}	DRQ Inactive Non-Burst Pulse Width	300	400 ^b	nsec
t_{QR}	DRQ to \overline{RD} , \overline{WR} Active	15		nsec
t_{QW}	DRQ to End of \overline{RD} , \overline{WR} (DRQ Service Time)		$(8 \times t_{DRP}) - (16 \times t_{ICP})^{a,c}$	
t_{QT}	DRQ to TC Active (DRQ Service Time)		$(8 \times t_{DRP}) - (16 \times t_{ICP})^{a,c}$	
t_{RQ}	\overline{RD} , \overline{WR} Active Edge to DRQ Inactive ^d		65	nsec
t_{TQ}	TC Active Edge to DRQ Inactive		75	nsec
t_{TT}	TC Active Pulse Width	50		nsec

- a. t_{DRP} and t_{ICP} are defined in Table 13-36.
- b. Only in case of pending DRQ.
- c. Values shown are with the FIFO disabled, or with FIFO enabled and THRESH = 0. For nonzero values of THRESH, add $(THRESH \times 8 \times t_{DRP})$ to the values shown.
- d. The active edge of \overline{RD} or \overline{WR} and TC is recognized only when \overline{DACK} is active.

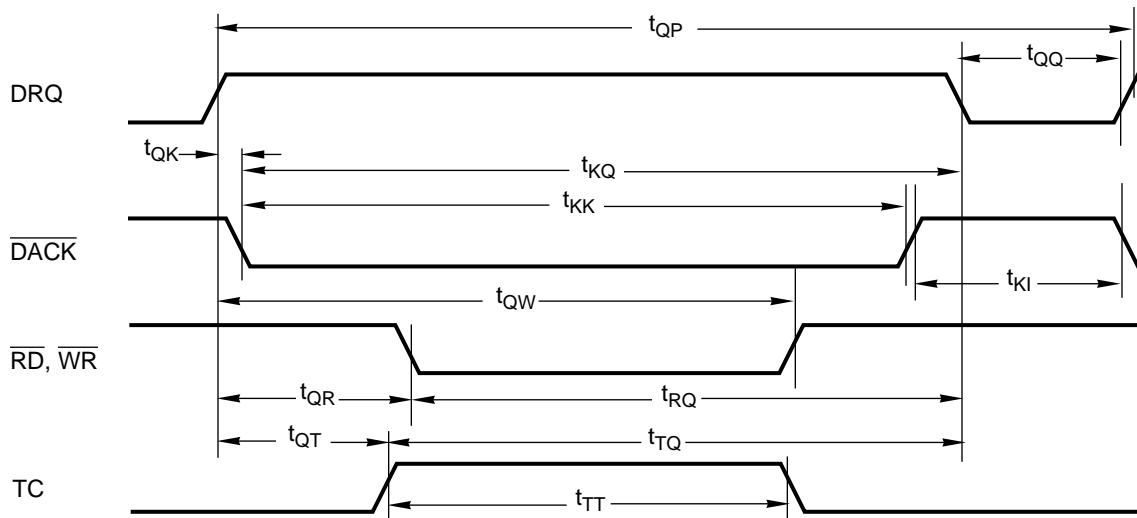


FIGURE 13-15. FDC DMA Timing

TABLE 13-46. ECP DMA Timing

Symbol	Parameter	Min	Max	Unit
t_{KIP}	\overline{DACK} Inactive Pulse Width	25		nsec
t_{KKP}	\overline{DACK} Active Pulse Width	65		nsec
t_{KQP}	\overline{DACK} Active Edge to DRQ Inactive ^{a b}		$65 + (6 \times 32 \times t_{CP})$	nsec
t_{QKP}	DRQ to \overline{DACK} Active Edge	10		nsec
t_{QPP}	DRQ Period	330		nsec
t_{QQP}	DRQ Inactive Non-Burst Pulse Width	300	400 ^c	nsec
t_{QRP}	DRQ to \overline{RD} , \overline{WR} Active	15		nsec
t_{RQP}	\overline{RD} , \overline{WR} Active Edge to DRQ Inactive ^d		65	nsec
t_{TQP}	TC Active Edge to DRQ Inactive		75	nsec
t_{TT}	TC Active Pulse Width	50		nsec

- a. One DMA transaction takes six clock cycles.
- b. t_{CP} is defined in Table 13-35.
- c. Only in case of pending DRQ.
- d. The active edge of \overline{RD} or \overline{WR} and TC is recognized only when \overline{DACK} is active.

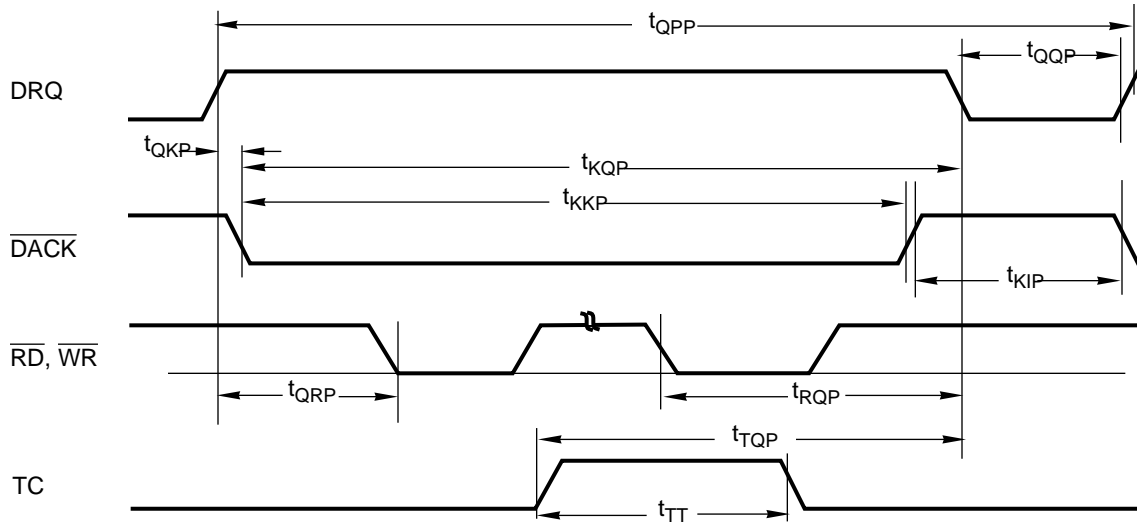


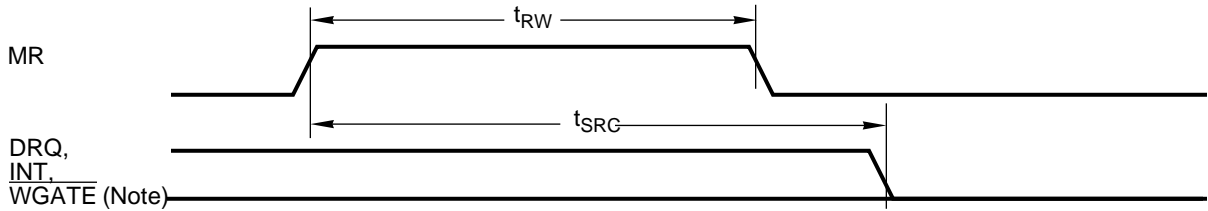
FIGURE 13-16. ECP DMA Timing

13.3.12 Reset Timing

TABLE 13-47. Reset Timing

Symbol	Parameter	Min	Max	Unit
t_{RW}	Reset Width ^a	100		μsec
t_{SRC}	Reset to Control Inactive ^b		300	nsec

- a. The software reset pulse width is 100 nsec.
- b. Not tested. Guaranteed by design.



Note:

In PC-AT mode, the DRQ and IRQ signals of the FDC are in TRI-STATE after time t_{SRC} .

FIGURE 13-17. Reset Timing

13.3.13 Write Data Timing

TABLE 13-48. Write Data Timing

Symbol	Parameter	Min	Max	Unit
t_{HDH}	$\overline{\text{HDSEL}}$ Hold from $\overline{\text{WGATE}}$ Inactive ^a	750		μsec
t_{HDS}	$\overline{\text{HDSEL}}$ Setup to $\overline{\text{WGATE}}$ Active ^a	100		μsec
t_{WDW}	Write Data Pulse Width	Table 13-49		

- a. Not tested. Guaranteed by design.

TABLE 13-49. Write Data Timing – Minimum t_{WDW} Values

Data Rate	t_{DRP}	t_{WDW}	t_{WDW} Value	Unit
1 Mbps	1000	$2 \times t_{ICP}$ ^a	250	nsec
500 Kbps	2000	$2 \times t_{ICP}$ ^a	250	nsec
300 Kbps	3333	$2 \times t_{ICP}$ ^a	375	nsec
250 Kbps	4000	$2 \times t_{ICP}$ ^a	500	nsec

- a. t_{ICP} is the internal clock period defined in Table 13-36.

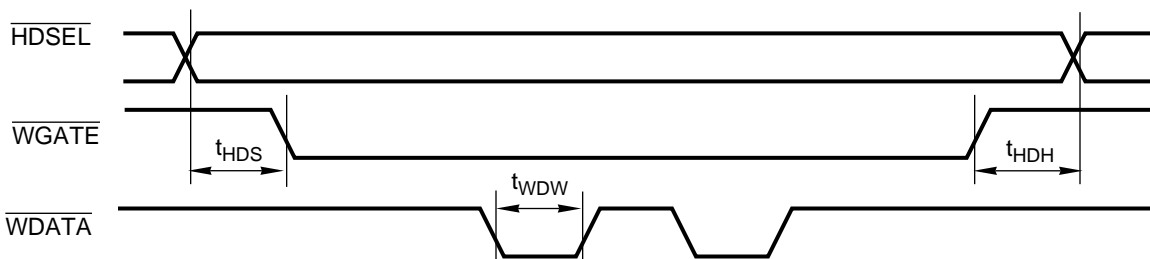


FIGURE 13-18. Write Data Timing

13.3.14 Drive Control Timing

TABLE 13-50. Drive Control Timing

Symbol	Parameter	Min	Max	Unit
t_{DRV}	$\overline{DR1,0}$ and $\overline{MTR1,0}$ from End of \overline{WR}		110	nsec
t_{DST}	\overline{DIR} Setup to \overline{STEP} Active ^a	6		μ sec
t_{IW}	Index Pulse Width	100		nsec
t_{STD}	\overline{DIR} Hold from \overline{STEP} Inactive	t_{STR}		msec
t_{STP}	\overline{STEP} Active High Pulse Width	8		μ sec
t_{STR}	\overline{STEP} Rate Time (See Table 5-26 on page 106.)	1		msec

a. Not tested. Guaranteed by design.

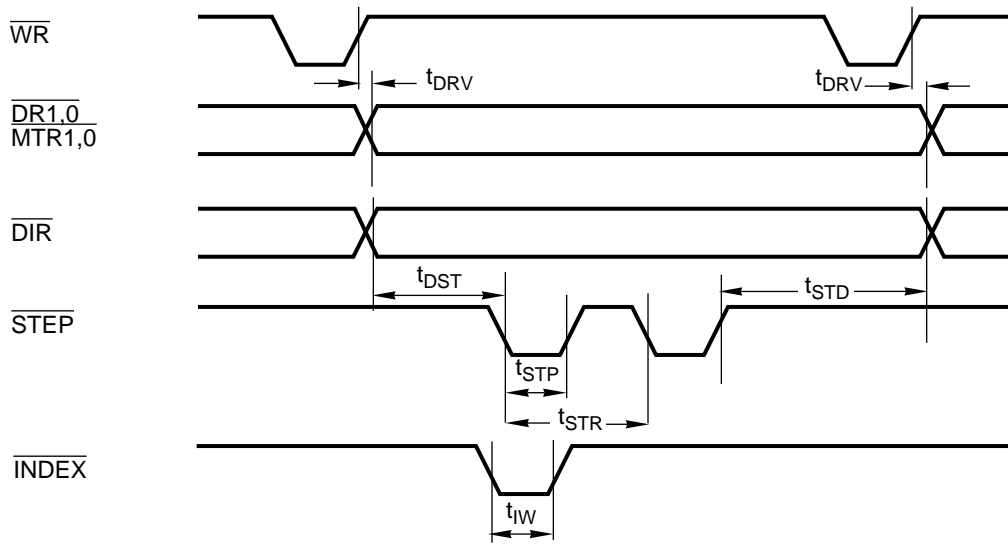


FIGURE 13-19. Drive Control Timing

13.3.15 Read Data Timing

TABLE 13-51. Read Data Timing

Symbol	Parameter	Min	Max	Unit
t_{RDW}	Read Data Pulse Width	50		nsec

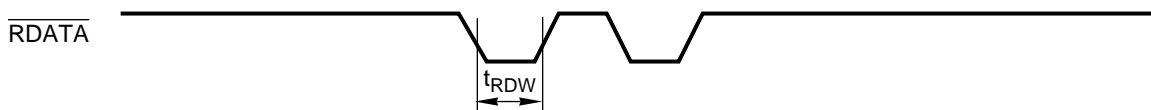


FIGURE 13-20. Read Data Timing

13.3.16 Parallel Port Timing

TABLE 13-52. Standard Parallel Port Timing

Symbol	Parameter	Conditions	Typical	Max	Unit
t_{PDH}	Port Data Hold	These times are system dependent and are therefore not tested.	500		nsec
t_{PDS}	Port Data Setup	These times are system dependent and are therefore not tested.	500		nsec
t_{PILa}	Port Active Low Interrupt, Active			33	nsec
t_{PIIa}	Port Active Low Interrupt, Inactive			33	nsec
t_{PIHa}	Port Active High Interrupt, Active			33	nsec
t_{PIHia}	Port Active High Interrupt, Inactive			33	nsec
t_{PIz}	Port Active High Interrupt, TRI-STATE			33	nsec
t_{SW}	Strobe Width	These times are system dependent and are therefore not tested.	500		nsec

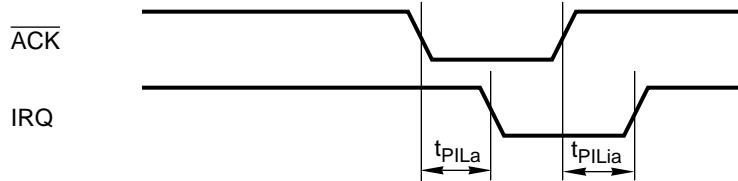


FIGURE 13-21. Parallel Port Interrupt Timing (Compatible Mode)

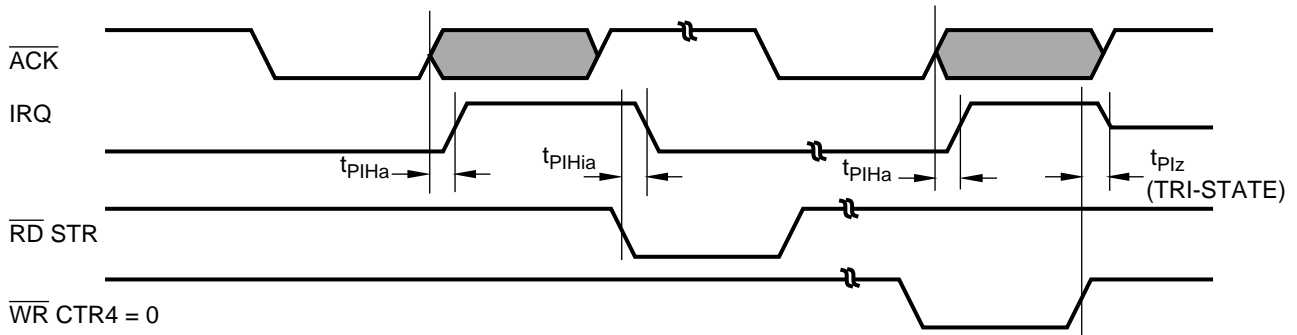


FIGURE 13-22. Parallel Port Interrupt Timing (Extended Mode)

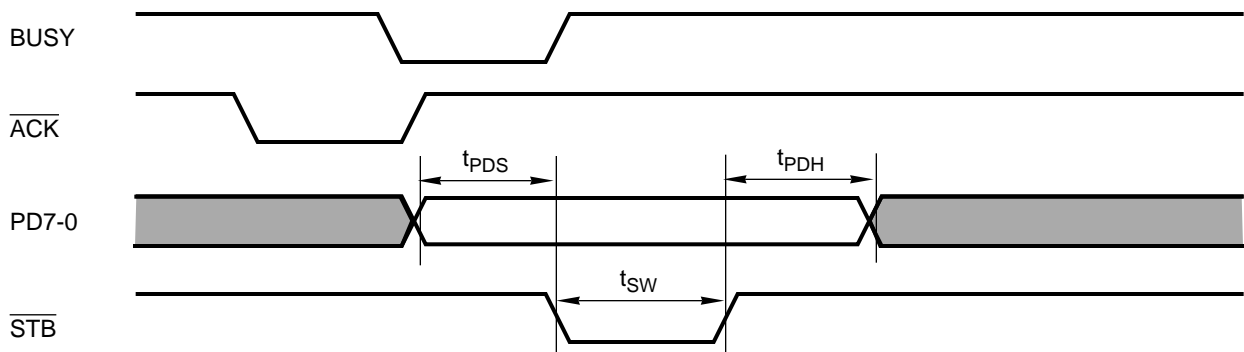


FIGURE 13-23. Typical Parallel Port Data Exchange

13.3.17 Enhanced Parallel Port 1.7 Timing

TABLE 13-53. Enhanced Parallel Port 1.7 Timing Parameters

Symbol	Parameter	Notes	Min	Max	Unit
t_{WW17}	WRITE Active or Inactive from WR Active or Inactive			45	nsec
t_{WST17}	DSTRB or ASTRB Active or Inactive from WR or RD Active or Inactive	a		45	nsec
t_{WEST17}	DSTRB or ASTRB Active after WRITE Becomes Active		0		nsec
t_{WPD17h}	PD7-0 Hold after WRITE Becomes Inactive		50		nsec
t_{HRW17}	IOCHRDY Active or Inactive after WAIT Becomes Active or Inactive			40	nsec
t_{WPDS17}	PD7-0 Valid after WRITE Becomes Active	b		15	nsec
t_{EPDW17}	PD7-0 Valid Width		80		nsec
t_{EPD17h}	PD7-0 Hold after DSTRB or ASTRB Becomes Inactive		0		nsec
t_{ZWS17a}	ZWS Valid after WR or RD Active			45	nsec
t_{ZWS17h}	ZWS Hold after WR or RD Inactive		0		nsec

- a. The design guarantees that WRITE will not change from low to high before DSTRB, or ASTRB, goes from low to high.
- b. D7-0 is stable 15 nsec before WR becomes active.

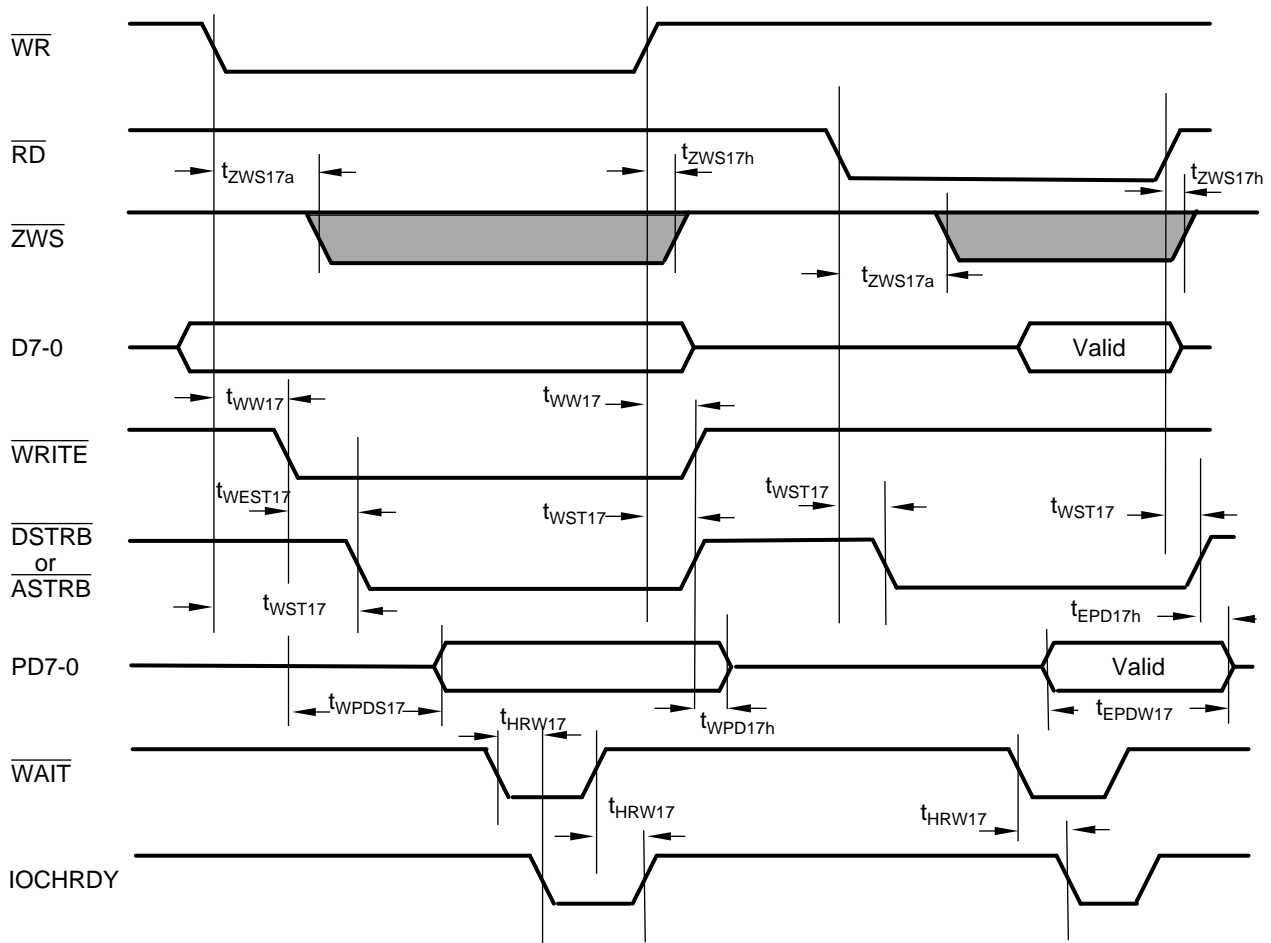


FIGURE 13-24. Enhanced Parallel Port 1.7 Timing

13.3.18 Enhanced Parallel Port 1.9 Timing

TABLE 13-54. Enhanced Parallel Port 1.9 Timing Parameters

Symbol	Parameter	Notes	Min	Max	Unit
t_{WW19a}	WRITE Active from \overline{WR} Active or \overline{WAIT} Low	a		45	nsec
t_{WW19ia}	WRITE Inactive from \overline{WAIT} Low			45	nsec
t_{WST19a}	\overline{DSTRB} or \overline{ASTRB} Active from \overline{WR} or \overline{RD} Active or \overline{WAIT} Low	a b		65	nsec
$t_{WST19ia}$	\overline{DSTRB} or \overline{ASTRB} Inactive from \overline{WR} or \overline{RD} High			45	nsec
t_{WEST19}	\overline{DSTRB} or \overline{ASTRB} Active after WRITE Active		10		nsec
t_{WPD19h}	PD7-0 Hold after \overline{WRITE} Inactive		0		nsec
t_{HRW19}	IOCHRDY Active after \overline{WR} or \overline{RD} Active or Inactive after \overline{WAIT} High			40	nsec
t_{WPDS19}	PD7-0 Valid after \overline{WRITE} Active	c		15	nsec
t_{EPDW19}	PD7-0 Valid Width		80		nsec
t_{EPD19h}	PD7-0 Hold after \overline{DSTRB} or \overline{ASTRB} Inactive		0		nsec
t_{ZWS19a}	\overline{ZWS} Valid after \overline{WR} or \overline{RD} Active			45	nsec
t_{ZWS19h}	\overline{ZWS} Hold after \overline{WR} or \overline{RD} Inactive		0		nsec

- a. When \overline{WAIT} is low, t_{WST19a} and t_{WW19a} are measured after \overline{WR} or \overline{RD} becomes active; else t_{WST19a} and t_{WW19a} are measured after \overline{WAIT} becomes low.
- b. The design guarantees that WRITE will not change from low to high before \overline{DSTRB} , or \overline{ASTRB} , goes from low to high.
- c. D7-0 is stable 15 nsec before \overline{WR} becomes active.

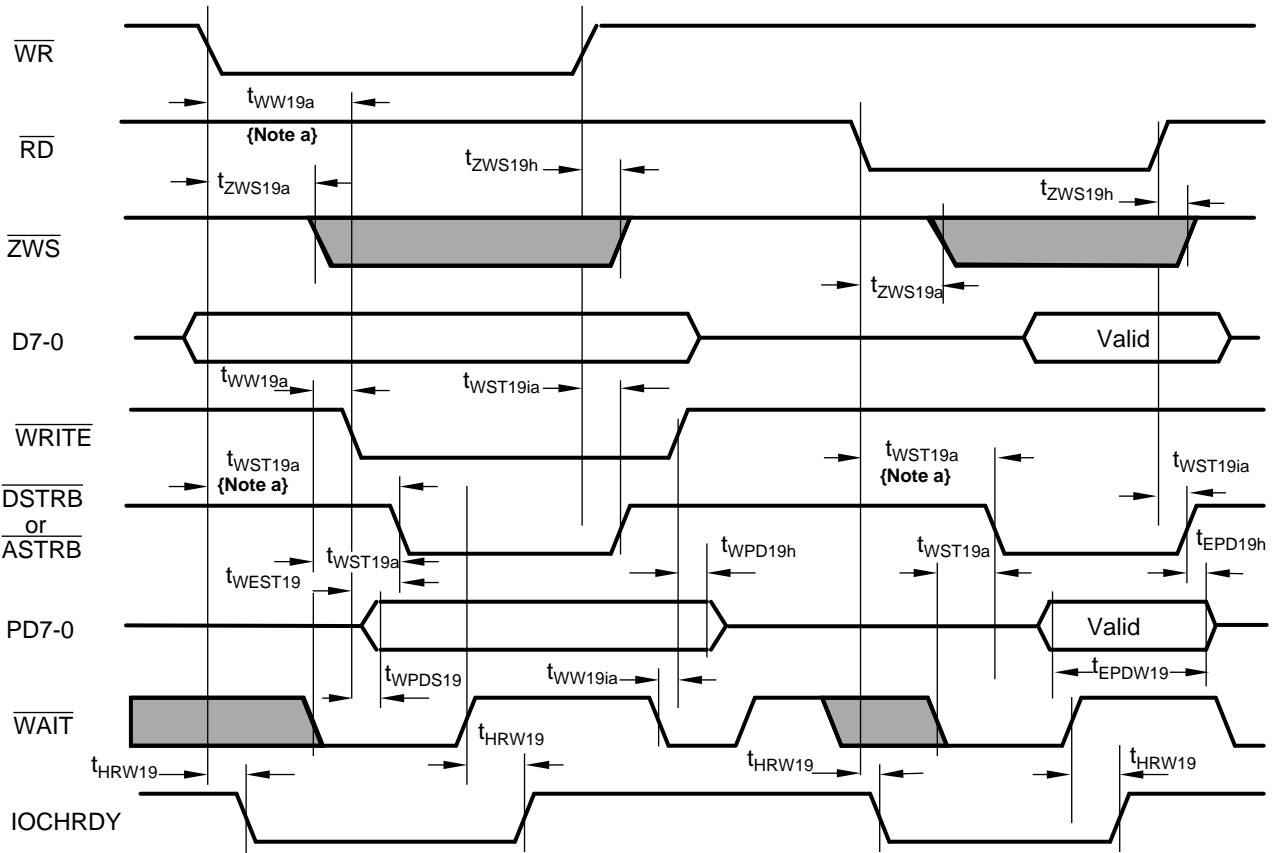


FIGURE 13-25. Enhanced Parallel Port 1.9 Timing

13.3.19 Extended Capabilities Port (ECP) Timing

TABLE 13-55. Extended Capabilities Port (ECP) Timing – Forward

Symbol	Parameter	Test Conditions	Min	Max	Unit
t_{ECDSF}	Data Setup before Strobe Active		0		nsec
t_{ECDHF}	Data Hold after BUSY		0		nsec
t_{ECLHF}	BUSY Setup after Strobe Active		75		nsec
t_{ECHHF}	Strobe Active after BUSY		0	1	sec
t_{ECHLF}	BUSY Setup after Strobe Inactive		0	35	msec
t_{ECLLF}	Strobe Active after BUSY		0		nsec

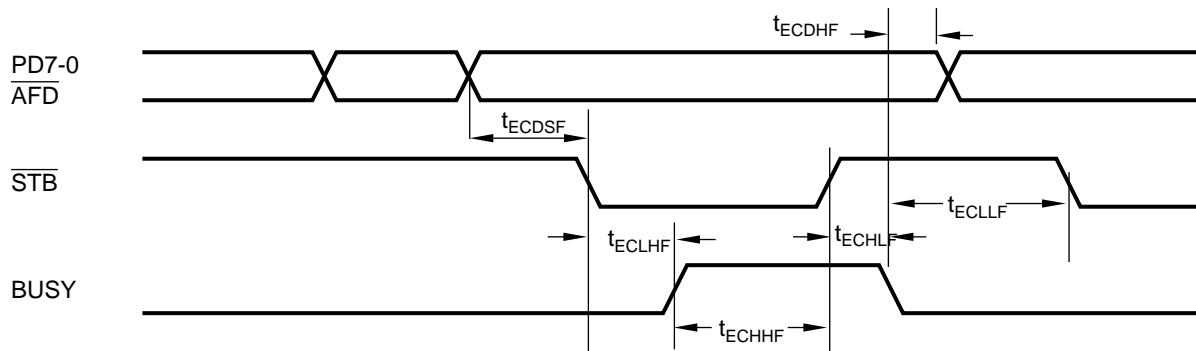


FIGURE 13-26. ECP Parallel Port Forward Timing Diagram

TABLE 13-56. Extended Capabilities Port (ECP) Timing – Backward

Symbol	Parameter	Test Conditions	Min	Max	Unit
t_{ECDSB}	Data Setup before Strobe Active		0		nsec
t_{ECDHB}	Data Hold after BUSY		0		nsec
t_{ECLHB}	BUSY Setup after Strobe Active		75		nsec
t_{ECHHB}	Strobe Active after BUSY		0	1	sec
t_{ECHLB}	BUSY Setup after Strobe Inactive		0	35	msec
t_{ECLLB}	Strobe Active after BUSY		0		nsec

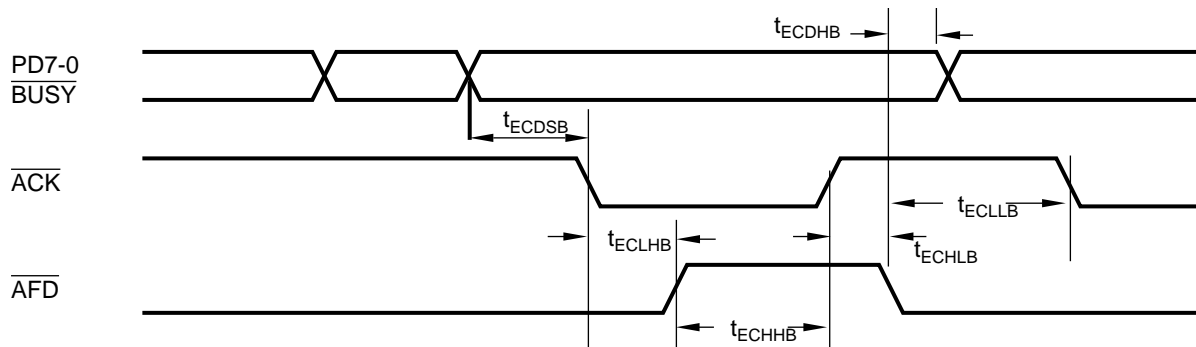


FIGURE 13-27. ECP Parallel Port Backward Timing Diagram

13.3.20 GPIO Write Timing

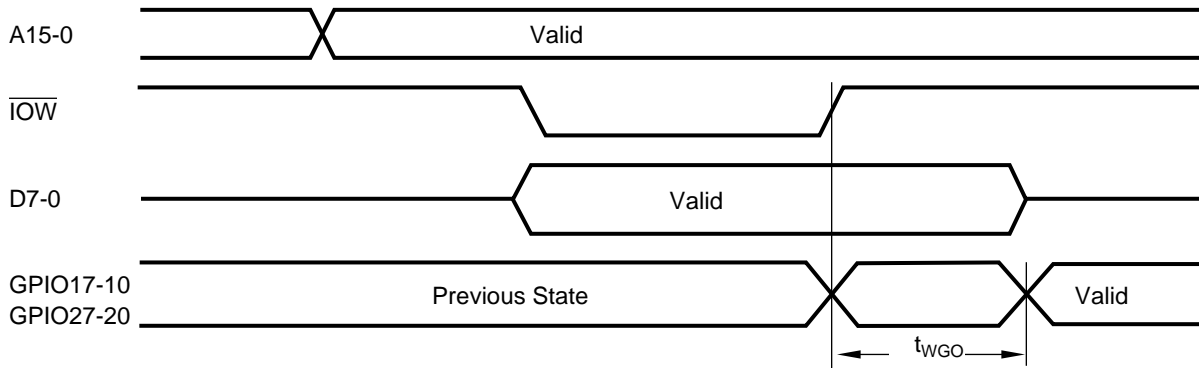


FIGURE 13-28. GPIO Write Timing Diagram

TABLE 13-57. GPIO Write Timing

Symbol	Parameter	Min	Max	Unit
t_{WGO}	Write Data to GPIO Update		300 ^a	nsec

a. Refer to "Microprocessor Interface Timing" on page 193 for read timing.

13.3.21 RTC Timing

TABLE 13-58. RTC Timing

Symbol	Parameter	Test Conditions	Min	Max	Unit
t_{RW}	\overline{IOR} to \overline{IRQ} TRI-STATE ^a			36	nsec
t_{RCI}	MR to \overline{IRQ} TRI-STATE ^a			25	nsec
t_{RCL}	MR High Time		100		μ sec
t_{VMR}	V_{CC} (4.5V) to MR ^a		10		msec

a. Not tested. Guaranteed by design.

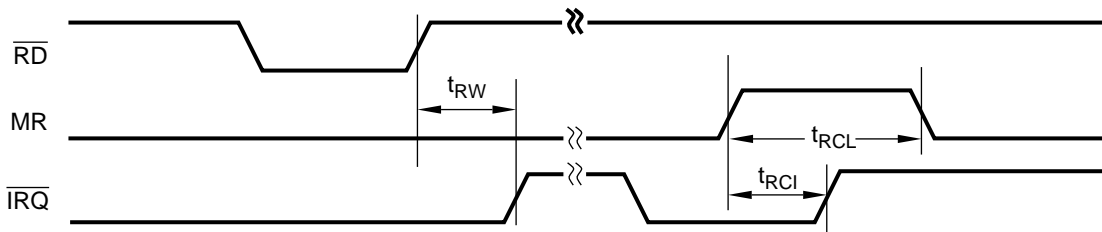


FIGURE 13-29. \overline{IRQ} Release Delay

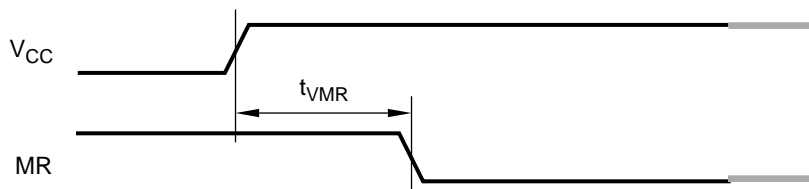


FIGURE 13-30. Master Reset (MR) Timing

13.3.22 APC Timing

TABLE 13-59. SWITCH Trigger and $\overline{\text{ONCTL}}$ Timing

Symbol	Parameter	Min	Max	Unit
t_{SWP}	SWITCH Pulse Width ^a	16		msec
t_{SWE}	Delay from SWITCH Events to $\overline{\text{ONCTL}}$, and from SWITCH Off Event to $\overline{\text{POR}}$ ^a	14	16	msec
t_{PORW}	$\overline{\text{POR}}$ Pulse Width (Edge Mode)	15	46	μsec
t_{PRL}	Delay from APCR1 Write to $\overline{\text{POR}}$ Inactive (Level Mode) ^a		25	nsec

a. Not tested. Guaranteed by design.

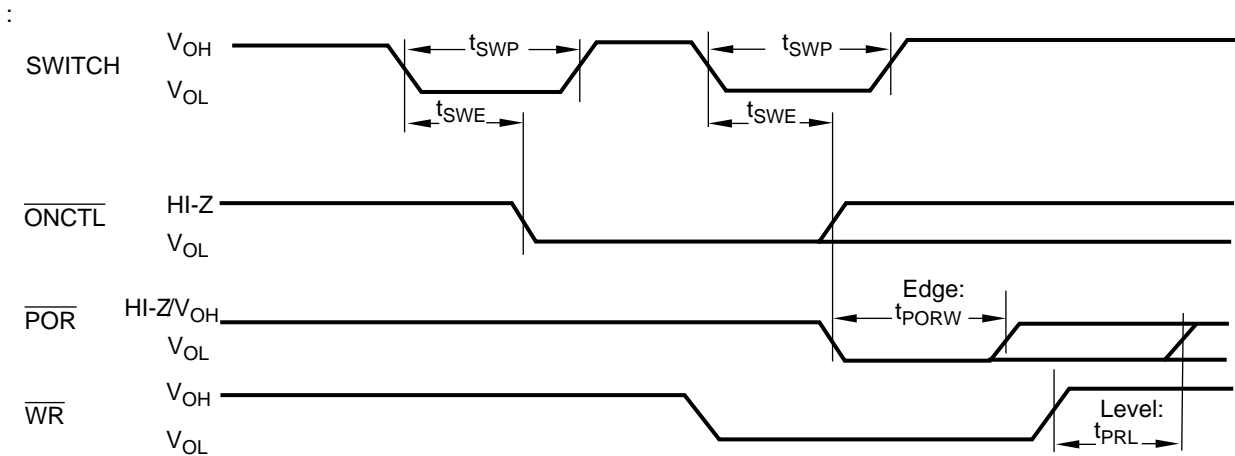


FIGURE 13-31. SWITCH Trigger and $\overline{\text{ONCTL}}$ Timing

TABLE 13-60. $\overline{\text{RI}}$ Trigger and $\overline{\text{ONCTL}}$ Timing

Symbol	Parameter	Min	Max	Unit
t_{RIO}	Delay from $\overline{\text{RI}}_{2,1}$ to $\overline{\text{ONCTL}}$		25	nsec
t_{RIW}	$\overline{\text{RI}}$ width	10	-	nsec

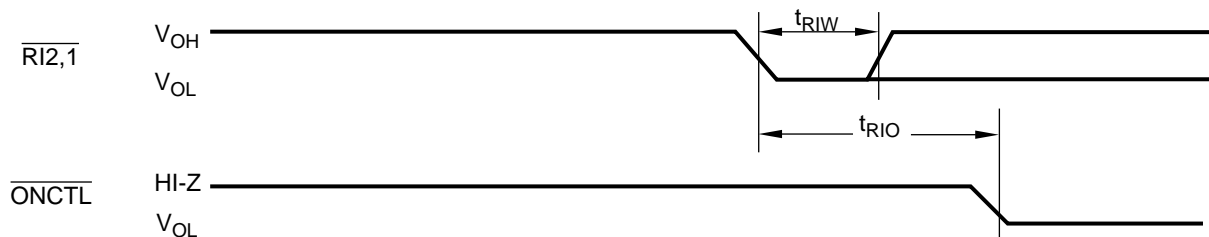


FIGURE 13-32. $\overline{\text{RI}}$ Trigger and $\overline{\text{ONCTL}}$ Timing

TABLE 13-61. $\overline{\text{RING}}$ Trigger and $\overline{\text{ONCTL}}$ Timing

Symbol	Parameter	Min	Max	Unit
t_{RPO}	Delay from $\overline{\text{RING}}$ Pulse to $\overline{\text{ONCTL}}$		25	nsec
t_{RTO}	Delay from $\overline{\text{RING}}$ Pulse Train to $\overline{\text{ONCTL}}$ ^a	0.125	0.190	sec
t_{RINW}	$\overline{\text{RING}}$ Width (High and Low Time), Single Pulse Mode	10		nsec
	$\overline{\text{RING}}$ Width (High and Low Time), Pulse Train Mode	50		μsec

a. Not tested. Guaranteed by design.

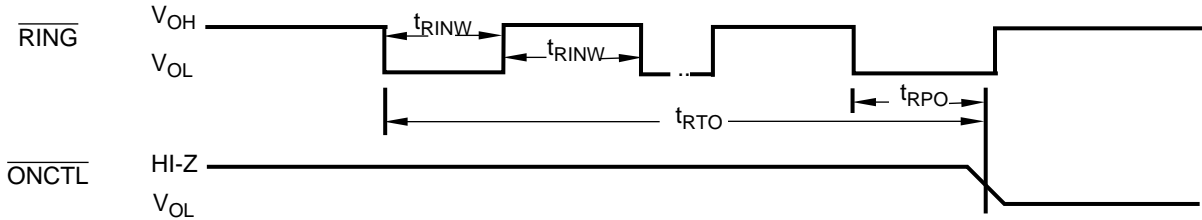


FIGURE 13-33. $\overline{\text{RING}}$ Trigger and $\overline{\text{ONCTL}}$ Timing

13.3.23 Chip Select Timing

TABLE 13-62. Chip Select Timing

Symbol	Parameter	Min	Max	Unit
t_{CE}	Delay from Command to Enable Chip Select	0	25	nsec
t_{CD}	Delay from Command to Disable Chip Select	0	25	nsec

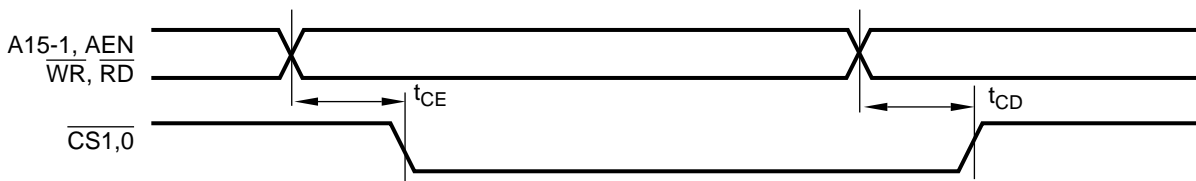


FIGURE 13-34. Chip Select Timing

Glossary

11-bit address mode

In this mode, the part decodes address lines A0-A10, A11-A15 are masked to 1, and UART2 is a fully featured 16550 UART. The mode is configured during reset, via CFG0 strap pin.

16-bit address mode

In this mode, the part decodes address lines A0-A15 and UART2 is a 16550 UART with SIN2/SOUT2 interface signals only. The mode is configured during reset, via CFG0 strap pin.

ABGDH and ABGDL

Alternate Baud rate Generator Divisor register (High and Low bytes) for UART2. (Logical device 5, bank 2, offsets 01h and 00h, respectively.)

ADDR

Address Register of the parallel port in EPP modes. (Logical device 4, offset 03h.)

AFIFO

Address FIFO for the parallel port in Extended Capabilities Port (ECP) mode 011. (Logical device 4, offset 000h.)

APC

Advanced Power Control.

APCR1 and APCR2

APC control registers 1 and 2. (Logical device 2, offsets 40h and 41h, respectively.)

APSR

Advanced Power Control (APC) status register. (Logical device 2, offset 42h.)

ASCR

Auxiliary Status and Control Register for UART2 in Extended operation modes. (Logical device 5, bank 0, offset 07h.)

ASK-IR

Amplitude Shift Keying Infrared.

BGDH and BGDL

Baud rate Generator Divisor buffer (High and Low bytes) for UART2. (Logical devices 5, bank 1, offsets 01h and 00h, respectively.)

BSR

Bank Selection Register for UART2, when enabled, i.e., when bit 7 of this register is 1. (Logical device 5, all banks, offset 03h.)

CCR

Configuration Control Register of the Floppy Disk Controller (FDC) for write operations. (Logical device 3, offset 07h.)

CFIFO

Parallel port data FIFO in Extended Capabilities Port (ECP) mode 010. (Logical device 4, offset 400h.)

CNFGA and CNFGB

Configuration registers A and B for the parallel port in Extended Capabilities Port (ECP) mode 111. (Logical device 4, offsets 400h and 401h, respectively.)

Config0

See PP Config0.

Consumer Remote Control Mode

This UART mode supports all four protocols currently used in remote-controlled home entertainment equipment. Also called TV-Remote mode.

Control0, Control2 and Control4

Internal configuration registers of the parallel port in Extended Capabilities Port (ECP) modes. (Logical device 4, second level offsets 00h, 02h and 04h.)

CSN

Card Select Number register - an 8-bit register with a unique value that identifies an ISA card.

CRA, CRB, CRC, CRD

Control Registers of the Real-Time Clock (RTC). (Logical device 2, offsets 0Ah, 0Bh, 0Ch and 0Dh, respectively.)

CTR

Control Register of the parallel port in SPP modes. (Logical device 4, offset 02h.)

DASK-IR

Digital Amplitude Shift Keying Infrared.

Data

The Data register contains the data in the register indicated by the corresponding Index register.

DATA0, DATA1, DATA2 and DATA3

Data Registers of the parallel port in EPP modes. (Logical device 4, offsets 04h, 05h, 06h and 07h, respectively.)

DATAR

Data Register for the parallel port in Extended Capability Port (ECP) modes 000 and 001. (Logical device 4, offset 000h.)

DCR

Data Control Register for the parallel port in Extended Capabilities Port (ECP) modes. (Logical device 4, offset 002h.)

Device

Any circuit that performs a specific function, such as a parallel port.

DFIFO

ECP Data FIFO in Extended Capabilities Port (ECP) mode 011. (Logical device 4, offset 400h.)

DID

Device ID register for UART2. (Logical device 5, bank 3, offset 00h.)

DIR

Digital Input Register of the Floppy Disk Controller (FDC) for read operations. (Logical device 3, offset 07h.)

DOR

Digital Output Register of the Floppy Disk Controller (FDC). (Logical device 3, offset 2h.)

DSR	Data rate Select Register of the Floppy Disk Controller (FDC) for write operations (logical device 3, offset 4h) and the Data Status Register in Extended Capabilities Port (ECP) modes (logical device 4, offset 001h).	IER	The Interrupt Enable Register for UART1 (logical device 6, offset 01h, divisor latch registers not accessible, bit 7 of LCR = 0) and for UART2 (logical device 5, bank 0, offset 01h).
DTR	Data Register of the parallel port in SPP or EPP modes. (Logical device 4, offset 00h.)	IIR	The Interrupt Identification Register for UART1. (Logical device 6, offset 02h.)
EAR	Extended Auxiliary Register of the parallel port in Extended Capabilities Port (ECP) modes. (Logical device 4, offset 405h.)	Index	The Index register is a pointer that is used to address other registers.
ECP	Extended Capabilities Port.	IR	InfraRed.
ECR	Extended Control Register for the parallel port in Extended Capabilities Port (ECP) modes. (Logical device 4, offset 402h.)	IRCFG1, IRCFG3 and IRCFG4	Infrared module Configuration registers for UART2. (Logical device 5, bank 7, offsets 04h, 06h and 07h, respectively.)
EDR	Extended Data Register for the parallel port in extended Capabilities Port (ECP) modes. (Logical device 4, offset 404h.)	IRCR1, IRCR2 and IRCR3	Infrared Module Control Registers 1, 2 and 3 for UART2. (Logical device 5. IRCR1 is in bank 4, offset 02h; IRCR2 is in bank 5, offset 04h; IRCR3 is in bank 6, offset 00h.)
EIR	Extended Index Register of the parallel port Extended Capabilities Port (ECP) modes (logical device 4, offset 403h) and Event Identification Register for UART1 (logical device 6, offset 01h, divisor latch registers not accessible, bit 7 of LCR = 0) and for UART2 for read cycles (logical device 5, bank 0, offset 02h).	IrDA	Infrared Data Association.
Extended UART Operation Mode	This UART operation mode supports standard 16450 and 16550A UART operations plus additional interrupts and DMA features. It does not include infrared or Consumer Remote Control modes.	IrDA-2 mode	In this mode, the part provides the Infrared Data Association standard compliant interface.
EPP	Enhanced Parallel Port.	IRQ	Interrupt Request.
EXCR1 and EXCR2	Extended Control Registers 1 and 2 for UART2. (Logical device 5, bank 2, offsets 02h and 04h, respectively.)	IRRXDC	Infrared Receiver Demodulator Control register for UART2. (Logical device 5, bank 7, offset 00h.)
FCR	The FIFO Control Register for UART1 (logical device 6, offset 02h) and for UART2 for write cycles (logical device 5, bank 0, offset 02h).	IRTXMC	Infrared Transmitter Modulator Control register for UART2. (Logical device 5, bank 7, offset 01h.)
FDC	Floppy Disk Controller.	ISA	Industry Standard Architecture for the PC bus.
FDD	Floppy Disk Drive.	LCR	Line Control Register for UART1 (logical device 6, offset 03h) and for UART2 when enabled, i.e., when bit 7 of this register is 0 (logical device 5, all banks, offset 03h).
FER1 and FER2	Function Enable Registers of the Power Management device (Logical device 8, offsets 00h and 01h, respectively.).	Legacy	Usually refers to older devices or systems that are not Plug and Play compatible.
FIFO	Data register (FIFO queue) of the Floppy Disk Controller (FDC). (Logical device 3, offset 05h.)	Legacy Mode	In this mode, the interrupts and the base addresses of the FDC, UARTs, KBC, RTC and the parallel port of the part are configured as in earlier Super/I/O chips.
GPIO	General Purpose I/O - I/O pins available for general use.	LFSR	The Linear Feedback Shift Register. In Plug and Play mode, this register is used to prepare the chip for operation in Plug and Play (PnP) mode.
		LSB	Least Significant Byte or Bit.
		LSR	Line Status Register for UART1 (logical device 6, offset 05h) and for UART2 in Non-Extended modes only (logical device 5, bank 0, offset 05h).

MCR

Modem Control Register for UART1 (logical device 6, offset 04h) and for UART2 (logical device 5, bank 0, offset 04h).

MSB

Most Significant Byte or Bit.

MSR

Main Status Register of the Floppy Disk Controller (FDC) (logical device 3, offset 4h) and Modem Status Register for UART1 for read operations (logical device 6, offset 06h) and for UART2 (logical device 5, bank 0, offset 06h).

Non-Extended UART Operation Modes

These UART operation modes support only UART operations that are standard for 15450 or 16550A devices.

NVM

Non-volatile memory.

P_BGDH and P_BGDL

Pipeline Baud rate Generator Divisor buffer (High and Low bytes) for UARTs. (Logical devices 5 and 6, bank 5, offsets 01h and 00h, respectively.)

PIO

Programmable Input/Output.

P_MDR

Pipeline Mode Register for UARTs. (Logical devices 5 and 6, bank 5, offset 02h.)

Plug and Play

A design philosophy and a set of specifications that describe hardware and software changes to the PC and its peripherals that automatically identify and arbitrate resource requirements among all devices and buses on the system. Plug and Play is sometimes abbreviated as PnP.

PM

Power Management.

PMC1, PMC2 and PMC3

Power Management Control registers of logical device 8 at offsets 02h, 03h and 04h, respectively.

PnP

Sometimes used to indicate Plug and Play.

PnP Mode

In this mode, the interrupts, the DMA channels and the base address of the FDC, UARTs, KBC, RTC, GPIO, APC and the Parallel Port of the part are fully Plug and Play.

PP Config0

Internal configuration register of the Parallel Port in Extended Capabilities Port (ECP) modes. (Logical device 4, second level offset 05h.)

Precompensation

Also called write precompensation, is a way of pre-conditioning the WDATA output signal to adjust for the effects of bit shift on the data as it is written to the disk surface.

RBR

Receiver Buffer Register for UART1, read operations only (logical device 6, offset 00h, divisor latch registers not accessible, bit 7 of LCR = 0).

RCCFG

Consumer Remote Control Configuration register for UART2. (Logical device 5, bank 7, offset 02h.)

RLC

Run Length Count byte for parallel ports.

RLE

Run Length Expander for parallel ports.

RLR

RAM Lock Register for Advanced Power Control (APC). (Logical device 2, offset 47h.)

RSR

Internal Receiver Shift Register for UART1.

RTC

Real-Time Clock.

RXDR

Receiver Data Register for read cycles for UART2. (Logical device 5, bank 0, offset 00h.)

RXFLV

Reception FIFO Level for UART2. (Logical device 5, bank 2, offset 07h.)

SCR

Scratch Register for UART1 (logical device 6, offset 07h) and for UART2 in UART operation mode (logical device 5, bank 0, offset 07h).

SH_FCR

Shadow of the FIFO Control Register (FCR) for UART2 for read operations. (Logical device 5, bank 3, offset 02h.)

SH_LCR

Shadow of the Line Control Register (LCR) for UART2 for read operations. (Logical device 5, bank 3, offset 01h.)

Sharp IR

Sharp Infrared.

Sharp IR Mode

In this mode, the part supports a Sharp Infrared interface.

SIO

SuperI/O, sometimes used to refer to a chip that has SuperI/O capabilities, e.g., the PC87307/PC97307 VUL device.

SIR

Serial Infrared.

SIR_PW

SIR Pulse Width control for UART2. (Logical device 5, bank 6, offset 02h.)

SPP

The Standard Parallel Port configuration of the Parallel Port device (Logical device 4) supports the Compatible SPP mode and the Extended PP mode.

SRA and SRB

Status Registers A and B of the Floppy Disk Controller (FDC). (Logical device 3, offsets 0h and 1h, respectively.)

ST0, ST1, ST2 and ST3

Status registers 0, 1, 2 and 3 of the Floppy Disk Controller (FDC).

STR

Status Register of the parallel port in SPP modes. (Logical device 4, offset 01h.)

TDR

Tape Drive Register of the Floppy Disk Controller (FDC). (Logical device 3, offset 03h.)

THR

Transmitter Holding Register for UART1 write operations only. (Logical device 6, offset 00h, divisor latch registers not accessible, bit 7 of LCR = 0.)

TFIFO

Test FIFO for the parallel port in Extended Capabilities Port (ECP) mode 110. (Logical device 4, offset 400h.)

TSR

Internal Transmitter Shift Register for UART1.

TV-Remote Mode

See Consumer Remote Control mode.

TXDR

Transmitter Data Register for write cycles for UART2. (Logical device 5, bank 0, offset 00h.)

TXFLV

Transmission FIFO Level for UART2. (Logical devices 5, bank 2, offset 06h.)

UART

Universal Asynchronous Receiver Transmitter. The part supports two UARTs, UART1 and UART2. They are identical in UART modes; UART2 includes infrared and DMA support.

WDCF

WATCHDOG Configuration register for Power Management module. (Logical device 8 at offset 06h.)

WDST

WATCHDOG Status register for Power Management. (Logical device 8 at offset 07h.)

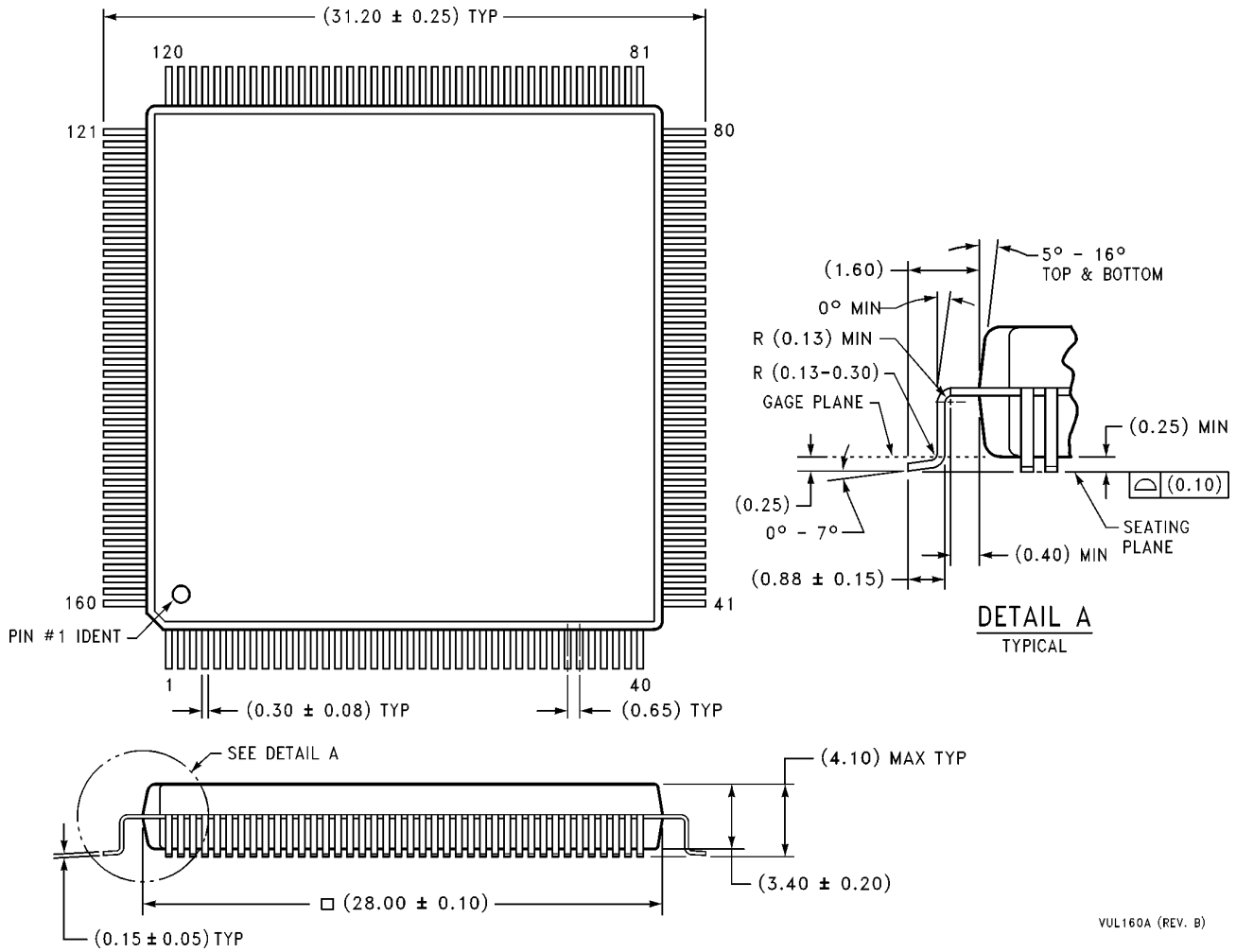
WDTO

WATCHDOG Time-Out register for Power Management. (Logical device 8 at offset 05h.)

XDB

X-Bus Data Buffer.

Physical Dimension inches (millimeters)



VUL160A (REV. B)

PlasticQuad Flatpack (PQFP), EIAJ
Order Number PC87307VUL/PC97307VUL
NS Package Number VUL160A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

	National Semiconductor Corporation Fax: 1-800-737-7018 Email: support@nsc.com Tel: 1-800-272-9959	National Semiconductor Europe Fax: (+49) 0-180-530 85 86 Email: europe.support@nsc.com Deutsch Tel: (+49) 0-180-530 85 85 English Tel: (+49) 0-180-532 78 32	National Semiconductor Asia Pacific Customer Response Group Fax: 65-250-4466 Email: sea.support@nsc.com Tel: 65-254-4466	National Semiconductor Japan Ltd. Fax: 81-3-5620-6179 Tel: 81-3-5620-6175
---	---	---	--	--