



## GENERAL DESCRIPTION



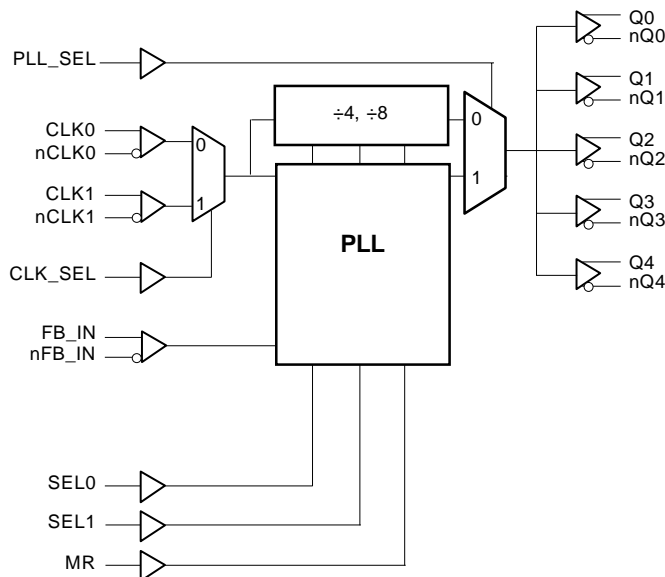
The ICS8624I is a high performance, 1-to-5 Differential-to-LVHSTL zero delay buffer and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The ICS8624I has two selectable clock input pairs.

The CLK0, nCLK0 and CLK1, nCLK1 pair can accept most standard differential input levels. The VCO operates at a frequency range of 250MHz to 630MHz. Utilizing one of the outputs as feedback to the PLL, output frequencies up to 630MHz can be regenerated with zero delay with respect to the input. Dual reference clock inputs support redundant clock or multiple reference applications.

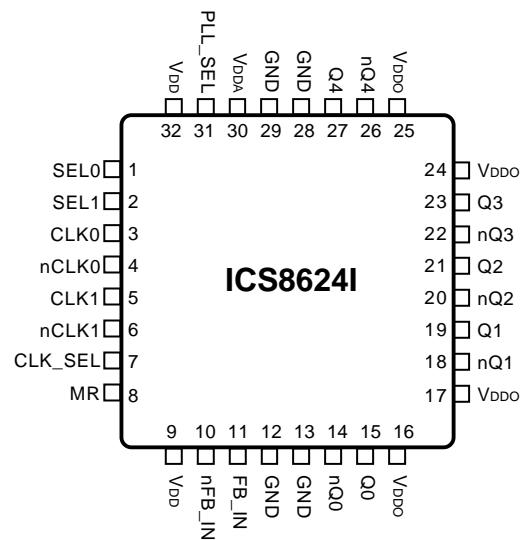
## FEATURES

- Fully integrated PLL
- 5 differential LVHSTL compatible outputs
- Selectable differential CLKx, nCLKx input pairs
- CLKx, nCLKx pairs can accept the following differential input levels: LVDS, LVPECL, LVHSTL, SSTL, HCSL
- Output frequency range: 31.25MHz to 630MHz
- Input frequency range: 31.25MHz to 630MHz
- VCO range: 250MHz to 630MHz
- External feedback for “zero delay” clock regeneration
- Cycle-to-cycle jitter: 35ps (maximum)
- Output skew: 50ps (maximum)
- Static phase offset: 30ps ±125ps
- 3.3V core, 1.8V output operating supply
- -40°C to 85°C ambient operating temperature

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**32-Lead LQFP**  
7mm x 7mm x 1.4mm body package  
**Y Package**  
Top View



**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1	SEL0	Input	Pulldown	Determines the input and output frequency range noted in Table 3. LVCMOS / LVTTTL interface levels.
2	SEL1	Input	Pulldown	Determines the input and output frequency range noted in Table 3. LVCMOS / LVTTTL interface levels.
3	CLK0	Input	Pulldown	Non-inverting differential clock input.
4	nCLK0	Input	Pullup	Inverting differential clock input.
5	CLK1	Input	Pulldown	Non-inverting differential clock input.
6	nCLK1	Input	Pullup	Inverting differential clock input.
7	CLK_SEL	Input	Pulldown	Clock select input. When LOW, selects CLK0, nCLK0. When HIGH, selects CLK1, nCLK1 inputs. LVCMOS / LVTTTL interface levels.
8	MR	Input	Pulldown	Active HIGH Master Reset. When logic is HIGH, the internal dividers are reset. When LOW, the Master Reset is disabled. LVCMOS / LVTTTL interface levels.
9, 32	V <sub>DD</sub>	Power		Core supply pins.
10	nFB_IN	Input	Pullup	Feedback input to phase detector for regenerating clocks with "zero delay".
11	FB_IN	Input	Pulldown	Feedback input to phase detector for regenerating clocks with "zero delay".
12, 13 28, 29	GND	Power		Power supply ground.
14, 15	nQ0, Q0	Output		Differential clock outputs. 50Ω typical output impedance. LVHSTL interface levels.
16, 17, 24, 25	V <sub>DDO</sub>	Power		Output supply pins.
18, 19	nQ1, Q1	Output		Differential clock outputs. 50Ω typical output impedance. LVHSTL interface levels.
20, 21	nQ2, Q2	Output		Differential clock outputs. 50Ω typical output impedance. LVHSTL interface levels.
22, 23	nQ3, Q3	Output		Differential clock outputs. 50Ω typical output impedance. LVHSTL interface levels.
26, 27	nQ4, Q4	Output		Differential clock outputs. 50Ω typical output impedance. LVHSTL interface levels.
30	V <sub>DDA</sub>	Power		Analog supply pin.
31	PLL_SEL	Input	Pullup	Selects between the PLL and clock as the input to the dividers. When HIGH, selects PLL. When LOW, selects reference clock. LVCMOS / LVTTTL interface levels.

NOTE 1: *Pullup* and *Pulldown* refer to internal input resistors. See Table 2, Pin Characteristics, for typical values.



**TABLE 2. PIN CHARACTERISTICS**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C <sub>IN</sub>	Input Capacitance				4	pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		KΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		KΩ

**TABLE 3A. CONTROL INPUT FUNCTION TABLE**

Inputs			Outputs PLL_SEL = 1 PLL Enable Mode
SEL1	SEL0	Reference Frequency Range (MHz)*	Q0:Q4, nQ0:nQ4
0	0	250 - 630	÷ 1
0	1	125 - 315	÷ 1
1	0	62.5 - 157.5	÷ 1
1	1	31.25 - 78.75	÷ 1

\*NOTE: VCO frequency range for all configurations above is 250MHz to 630MHz.

**TABLE 3B. PLL BYPASS FUNCTION TABLE**

Inputs		Outputs PLL_SEL = 0 PLL Bypass Mode
SEL1	SEL0	Q0:Q4, nQ0:nQ4
0	0	÷ 4
0	1	÷ 4
1	0	÷ 4
1	1	÷ 8



**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{DDx}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $V_O$	-0.5V to $V_{DDO} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	47.9°C/W (0 lfpm)
Storage Temperature, $T_{STG}$	-65°C to 150°C

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

**TABLE 4A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Core Supply Voltage		3.135	3.3	3.465	V
$V_{DDA}$	Analog Supply Voltage		3.135	3.3	3.465	V
$V_{DDO}$	Output Supply Voltage		1.6	1.8	2.0	V
$I_{DD}$	Power Supply Current				120	mA
$I_{DDA}$	Analog Supply Current				15	mA
$I_{DDO}$	Output Supply Current	No Load		0		mA

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage		2		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage		-0.3		0.8	V
$I_{IH}$	Input High Current	SELO, SEL1, CLK_SEL, MR	$V_{DD} = V_{IN} = 3.465V$		150	$\mu A$
		PLL_SEL	$V_{DD} = V_{IN} = 3.465V$		5	$\mu A$
$I_{IL}$	Input Low Current	SELO, SEL1, CLK_SEL, MR	$V_{DD} = 3.465V, V_{IN} = 0V$	-5		$\mu A$
		PLL_SEL	$V_{DD} = 3.465V, V_{IN} = 0V$	-150		$\mu A$

**TABLE 4C. DIFFERENTIAL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	CLK0, CLK1, FB_IN	$V_{DD} = V_{IN} = 3.465V$		150	$\mu A$
		nCLK0, nCLK1, nFB_IN	$V_{DD} = V_{IN} = 3.465V$		5	$\mu A$
$I_{IL}$	Input Low Current	CLK0, CLK1, FB_IN	$V_{DD} = 3.465V, V_{IN} = 0V$	-5		$\mu A$
		nCLK0, nCLK1, nFB_IN	$V_{DD} = 3.465V, V_{IN} = 0V$	-150		$\mu A$
$V_{PP}$	Peak-to-Peak Input Voltage		0.15		1.3	V
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		0.5		$V_{DD} - 0.85$	V

NOTE 1: For single ended applications, the maximum input voltage for CLKx, nCLKx is  $V_{DD} + 0.3V$ .

NOTE 2: Common mode voltage is defined as  $V_{IH}$ .



**TABLE 4D. LVHSTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		1.0		1.4	V
$V_{OL}$	Output Low Voltage; NOTE 1		0		0.4	V
$V_{OX}$	Output Crossover Voltage		$40\% \times (V_{OH} - V_{OL}) + V_{OL}$		$60\% \times (V_{OH} - V_{OL}) + V_{OL}$	V
$V_{SWING}$	Peak-to-Peak Output Voltage Swing		0.6		1.1	V

NOTE 1: Outputs terminated with  $50\Omega$  to ground.

**TABLE 5. INPUT FREQUENCY CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units	
$f_{IN}$	Input Frequency	CLK0, nCLK0, CLK1, nCLK1	PLL_SEL = 1	31.25		630	MHz
			PLL_SEL = 0			630	MHz

**TABLE 6. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $V_{DDO} = 1.8V \pm 0.2V$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{MAX}$	Output Frequency				630	MHz
$t_{PD}$	Propagation Delay; NOTE 1	$f \leq 630\text{MHz}$	3.4	3.9	4.5	ns
$t(\emptyset)$	Static Phase Offset; NOTE 2, 5	PLL_SEL = 3.3V	-95	30	155	ps
$t_{sk(o)}$	Output Skew; NOTE 3, 5				50	ps
$f_{jit(cc)}$	Cycle-to-Cycle Jitter; NOTE 5, 6				35	ps
$f_{jit(\emptyset)}$	Phase Jitter; NOTE 4, 5, 6				$\pm 50$	ps
$t_L$	PLL Lock Time				1	ms
$t_R$	Output Rise Time	20% to 80%	300		700	ps
$t_F$	Output Fall Time	20% to 80%	300		700	ps
$t_{PW}$	Output Pulse Width		tPeriod/2 - 85	tPeriod/2	tPeriod/2 + 85	ps

All parameters measured at  $f_{MAX}$  unless noted otherwise.

NOTE 1: Measured from the differential input crossing point to the differential output crossing point.

NOTE 2: Defined as the time difference between the input reference clock and the averaged feedback input signal across all conditions, when the PLL is locked and the input reference frequency is stable.

NOTE 3: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at output differential cross points.

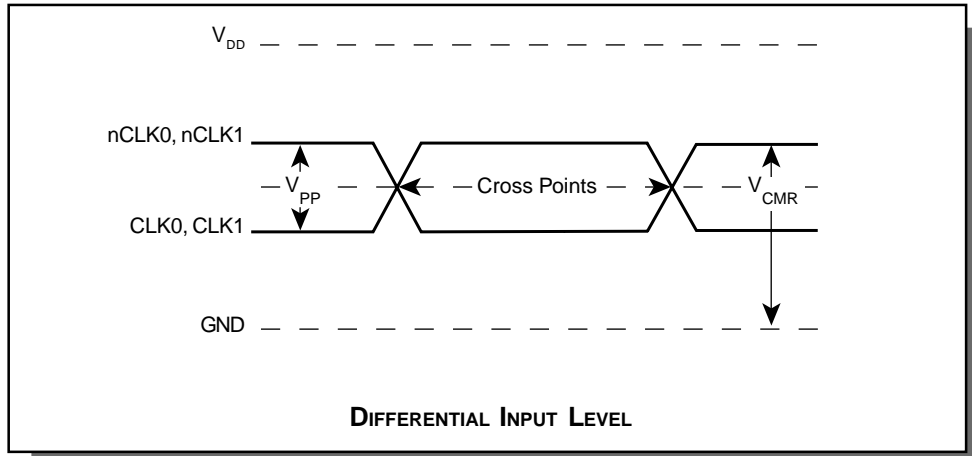
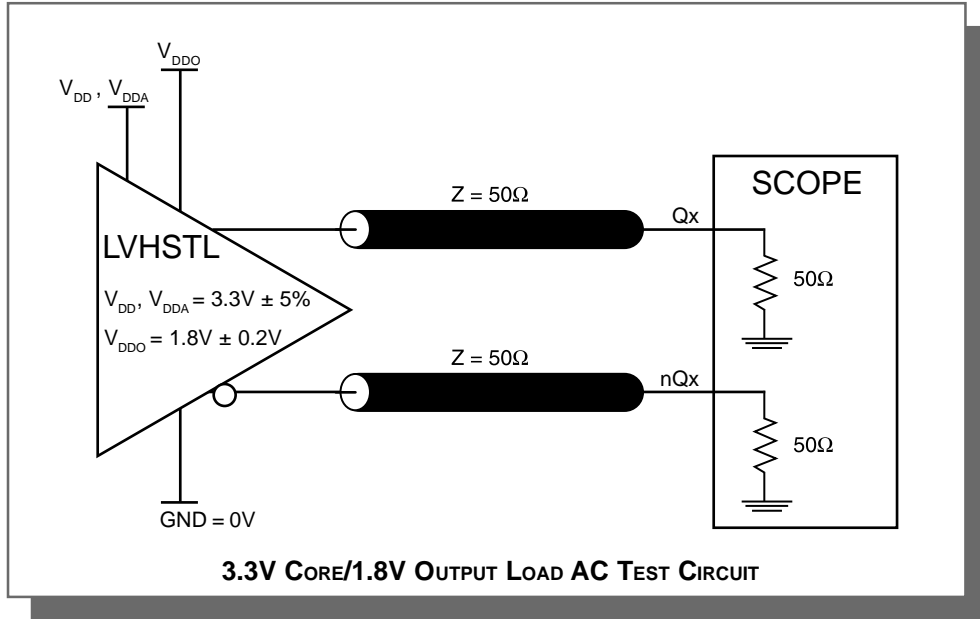
NOTE 4: Phase jitter is dependent on the input source used.

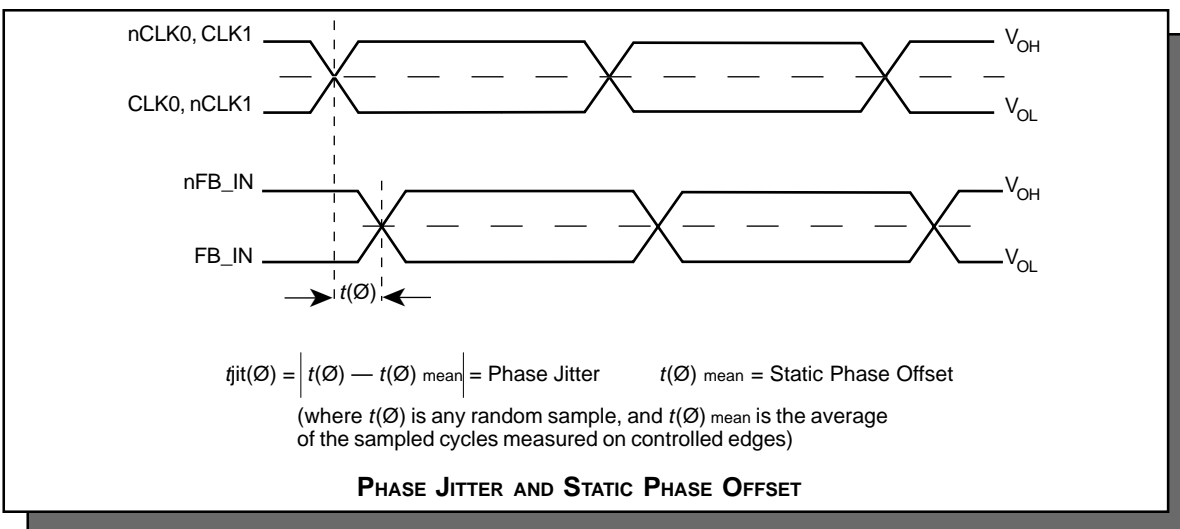
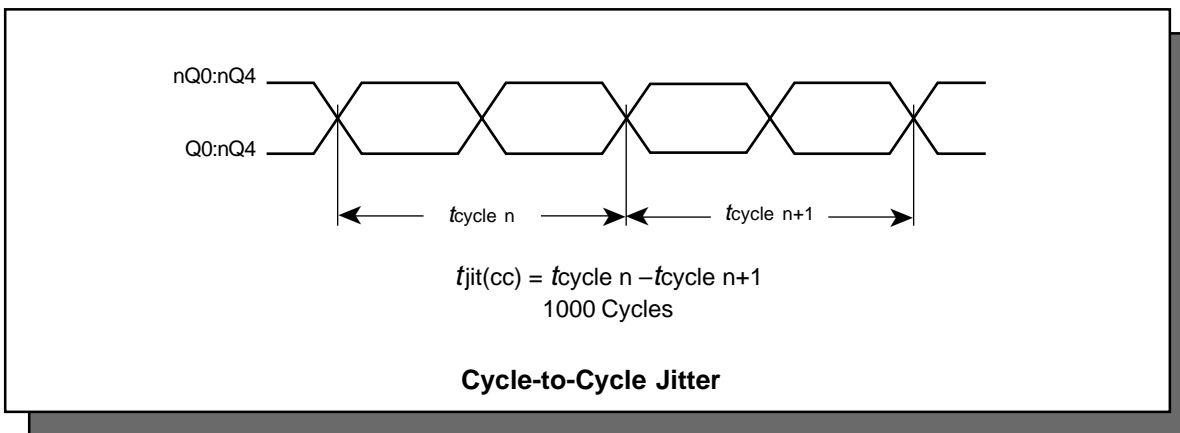
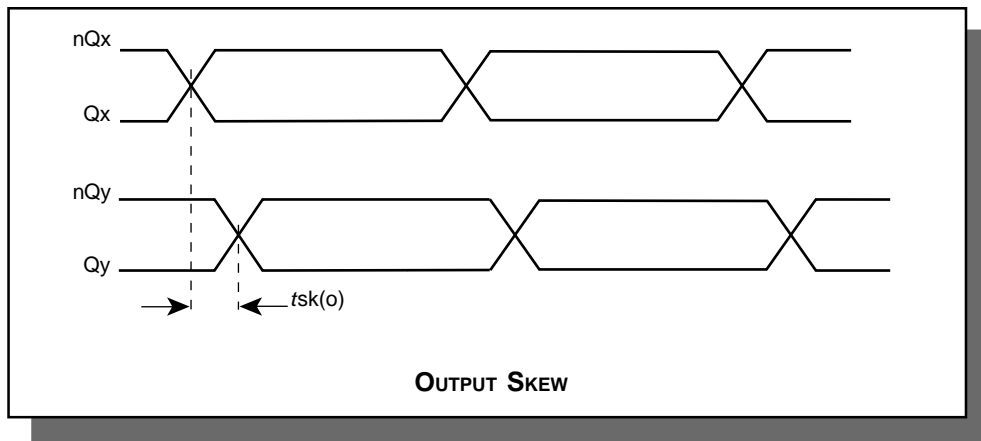
NOTE 5: This parameter is defined in accordance with JEDEC Standard 65.

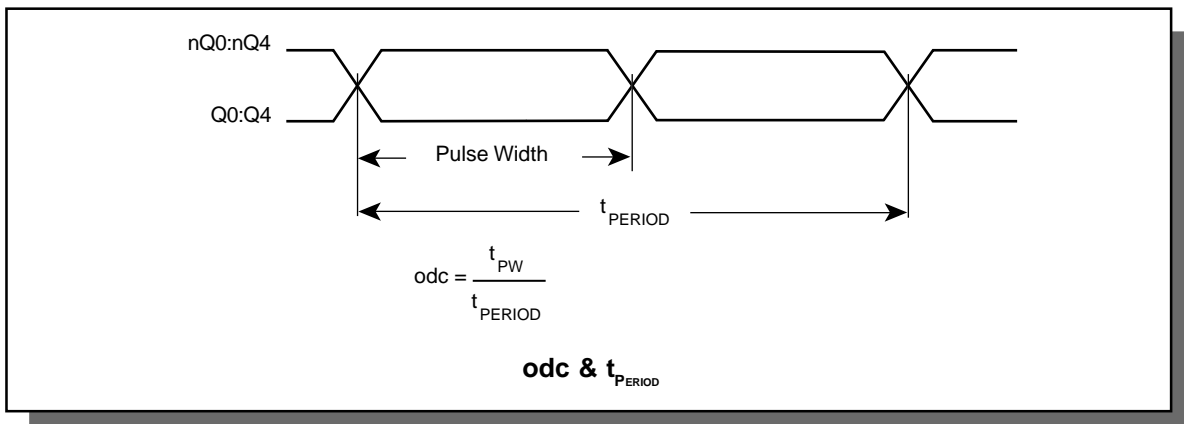
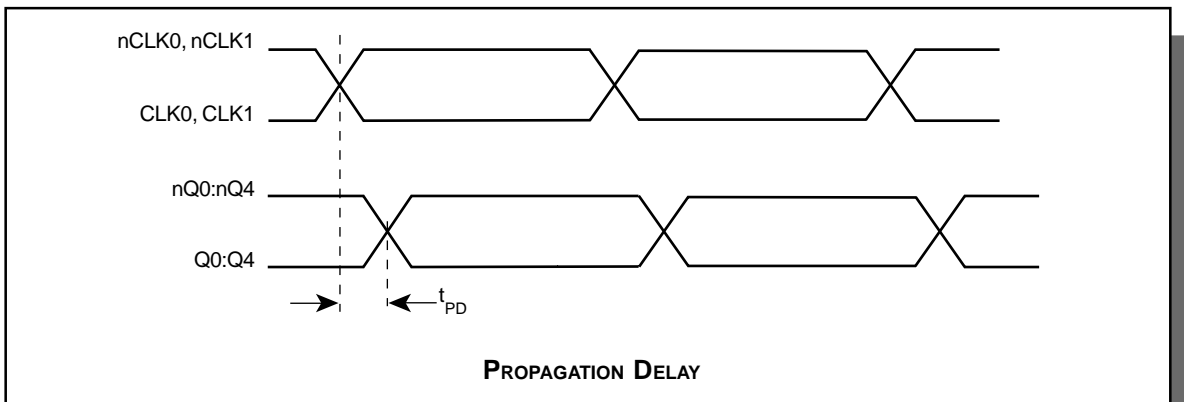
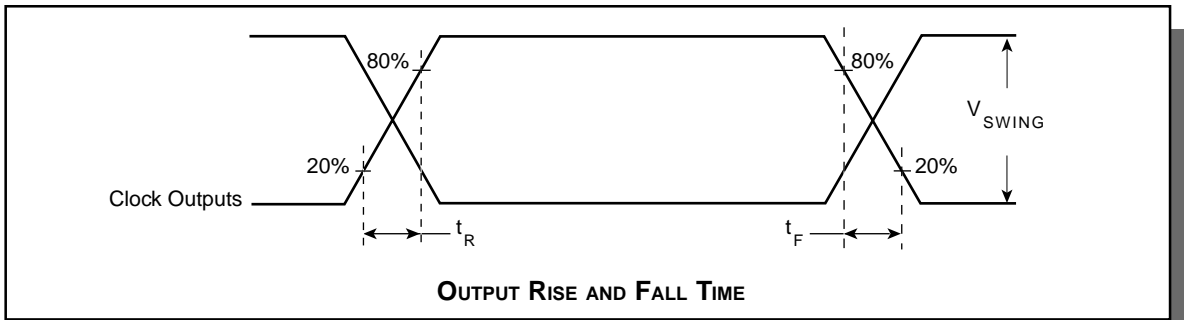
NOTE 6: Characterized at VCO frequency of 622MHz.



**PARAMETER MEASUREMENT INFORMATION**











## APPLICATION INFORMATION

### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS8624I provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA1}$ , and  $V_{DDO}$  should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 1* illustrates how a  $10\Omega$  resistor along with a  $10\mu F$  and a  $.01\mu F$  bypass capacitor should be connected to each  $V_{DDA}$  pin.

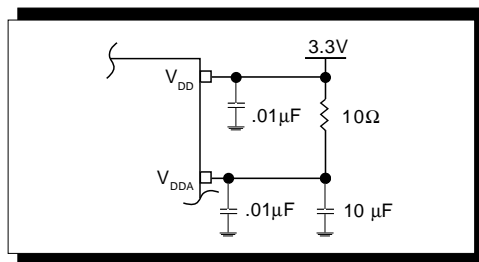


FIGURE 1 - POWER SUPPLY FILTERING

### WIRING THE DIFFERENTIAL INPUT TO ACCEPT SINGLE ENDED LEVELS

*Figure 2* shows how the differential input can be wired to accept single ended levels. The reference voltage  $V_{REF} = V_{DD}/2$  is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio of R1 and R2 might need to be adjusted to position the  $V_{REF}$  in the center of the input voltage swing. For example, if the input clock swing is only 2.5V and  $V_{DD} = 3.3V$ ,  $V_{REF}$  should be 1.25V and  $R2/R1 = 0.609$ .

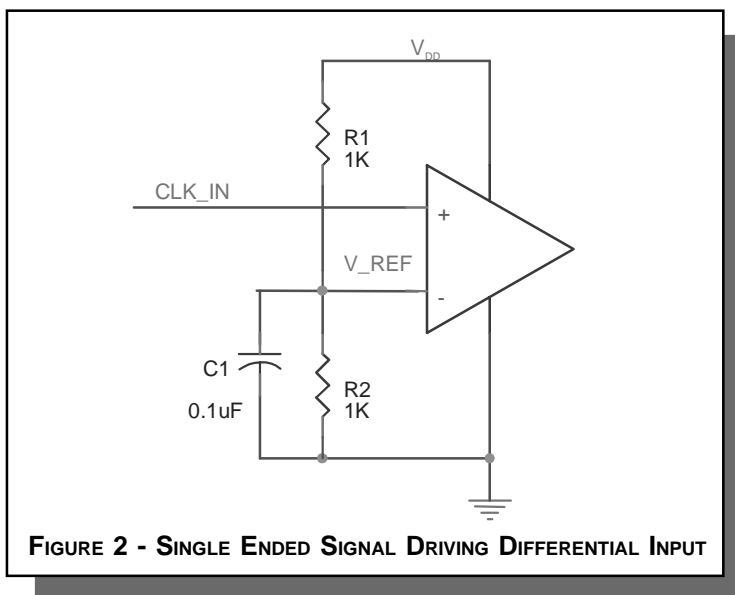


FIGURE 2 - SINGLE ENDED SIGNAL DRIVING DIFFERENTIAL INPUT



### LAYOUT GUIDELINE

The schematic of the ICS8624I layout example is shown in *Figure 3A*. The ICS8624I recommended PCB board layout for this example is shown in *Figure 3B*. This layout example is used as a general guideline. The layout in the actual system will depend on the selected component types, the density of the components, the density of the traces, and the stacking of the P.C. board.

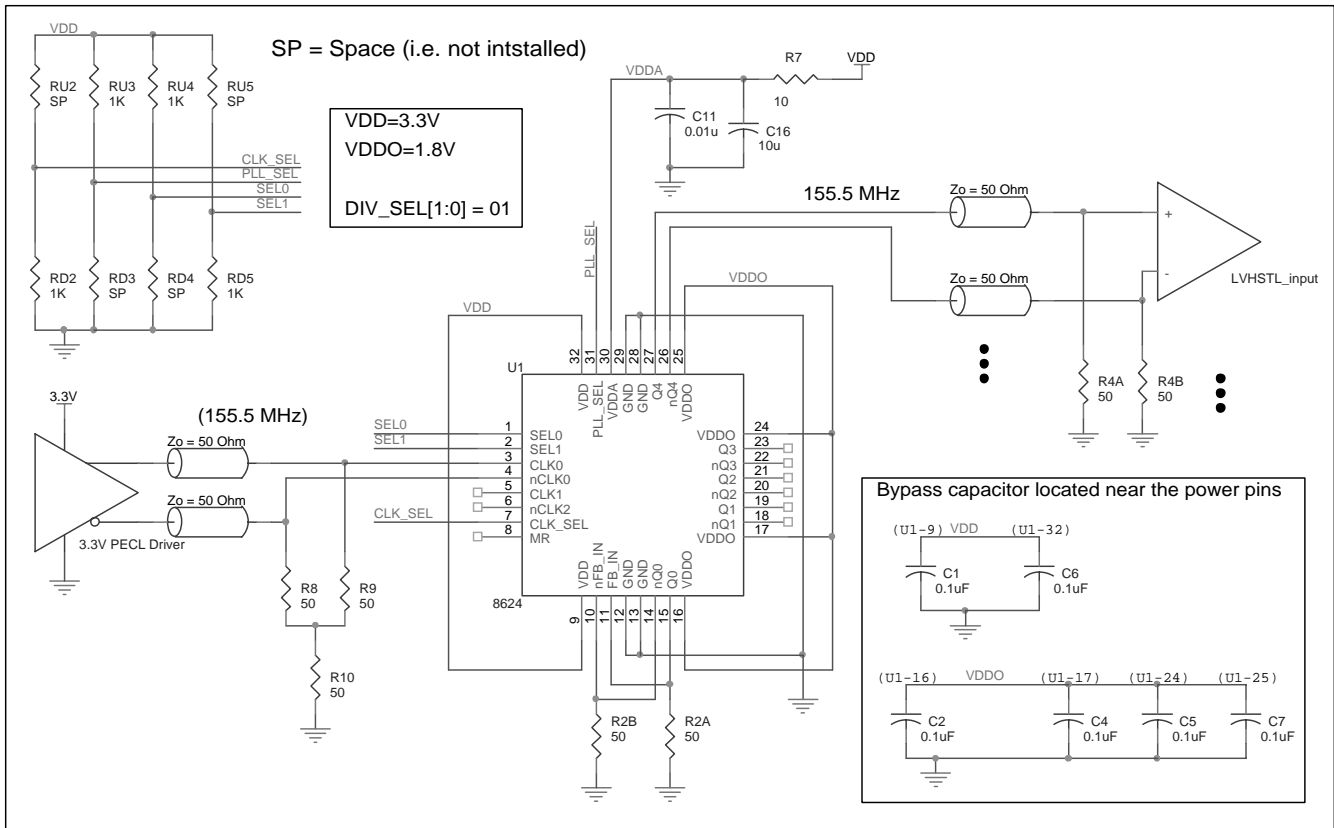


FIGURE 3A - ICS8624I LVHSTL ZERO DELAY BUFFER SCHEMATIC EXAMPLE



The following component footprints are used in this layout example:

All the resistors and capacitors are size 0603.

**POWER AND GROUNDING**

Place the decoupling capacitors C1, C6, C2, C4, and C5, as close as possible to the power pins. If space allows, placement of the decoupling capacitor on the component side is preferred. This can reduce unwanted inductance between the decoupling capacitor and the power pin caused by the via.

Maximize the power and ground pad sizes and number of vias capacitors. This can reduce the inductance between the power and ground planes and the component power and ground pins.

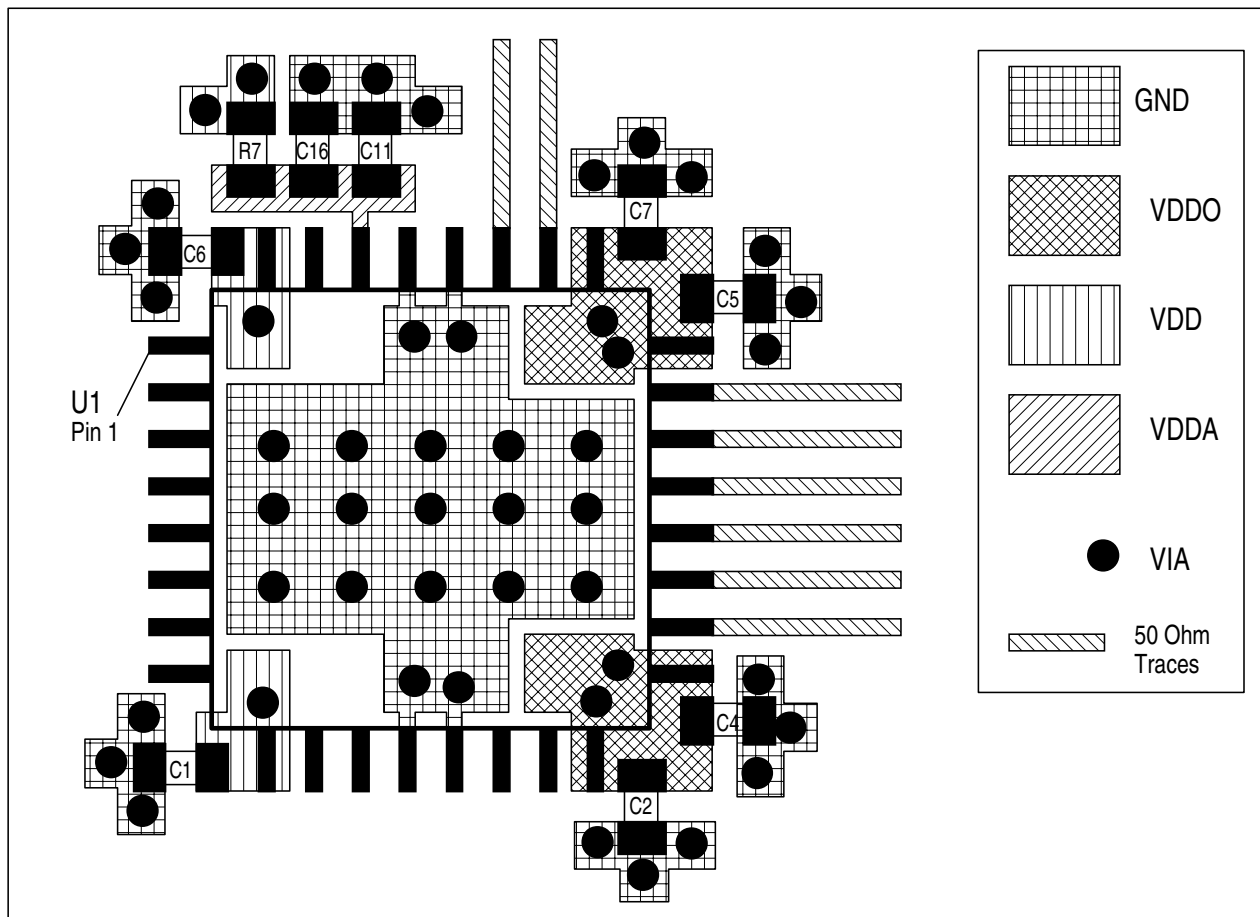
The RC filter consisting of R7, C11, and C16 should be placed as close to the  $V_{DDA}$  pin as possible.

**CLOCK TRACES AND TERMINATION**

Poor signal integrity can degrade the system performance or cause system failure. In synchronous high-speed digital systems, the clock signal is less tolerant to poor signal integrity than other signals. Any ringing on the rising or falling edge or excessive ring back can cause system failure. The shape of the trace and the

trace delay might be restricted by the available space on the board and the component location. While routing the traces, the clock signal traces should be routed first and should be locked prior to routing other signal traces.

- The differential 50Ω output traces should have same length.
- Avoid sharp angles on the clock trace. Sharp angle turns cause the characteristic impedance to change on the transmission lines.
- Keep the clock traces on the same layer. Whenever possible, avoid placing vias on the clock traces. Placement of vias on the traces can affect the trace characteristic impedance and hence degrade signal integrity.
- To prevent cross talk, avoid routing other signal traces in parallel with the clock traces. If running parallel traces is unavoidable, allow a separation of at least three trace widths between the differential clock trace and the other signal trace.
- Make sure no other signal traces are routed between the clock trace pair.
- The matching termination resistors should be located as close to the receiver input pins as possible.



**FIGURE 3B - PCB BOARD LAYOUT FOR ICS8624I**



## POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS8624I. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS8624I is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{DD} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

**NOTE:** Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * I_{DD\_MAX} = 3.465V * 135mA = 467.8mW$
- Power (outputs)<sub>MAX</sub> = **32.8mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $5 * 32.8mW = 164mW$

$$\text{Total Power}_{MAX} (3.465V, \text{ with all outputs switching}) = 467.8mW + 164mW = 631.8mW$$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad and directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS™ devices is 125°C.

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$Pd\_total$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 42.1°C/W per Table 7 below. Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ C + 0.632W * 42.1^\circ C/W = 111.6^\circ C. \text{ This is well below the limit of } 125^\circ C$$

This calculation is only an example.  $T_j$  will obviously vary depending on the number of loaded outputs, supply voltage, air flow, and the type of board (single layer or multi-layer).

**TABLE 7. THERMAL RESISTANCE  $\theta_{JA}$  FOR 32-PIN LQFP, FORCED CONVECTION**

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°C/W

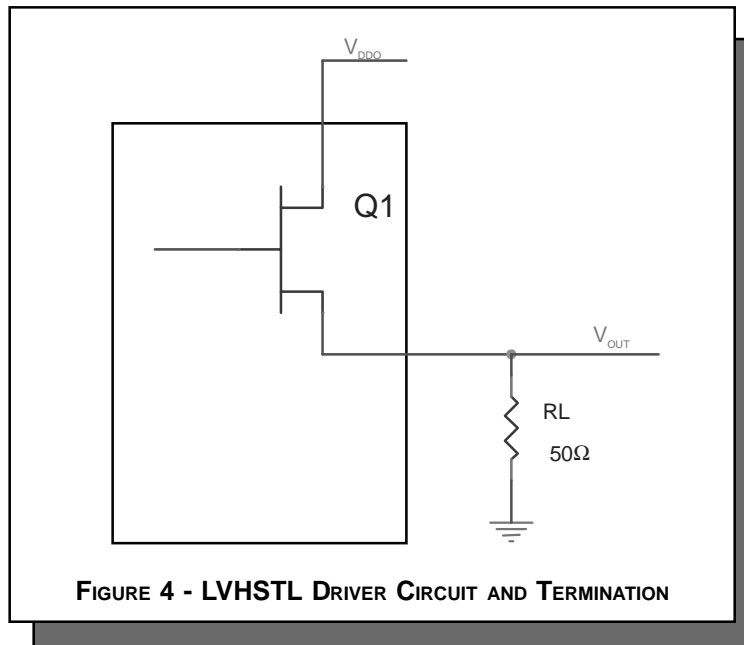
**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.



### 3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

LVHSTL output driver circuit and termination are shown in *Figure 4*.



To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load.

Pd\_H is power dissipation when the output drives high.  
Pd\_L is the power dissipation when the output drives low.

$$Pd\_H = (V_{OH\_MAX} / R_L) * (V_{DD\_MAX} - V_{OH\_MAX})$$

$$Pd\_L = (V_{OL\_MAX} / R_L) * (V_{DD\_MAX} - V_{OL\_MAX})$$

$$Pd\_H = (1V/50\Omega) * (2V - 1V) = \mathbf{20mW}$$

$$Pd\_L = (0.4V/50\Omega) * (2V - 0.4V) = \mathbf{12.8mW}$$

$$\text{Total Power Dissipation per output pair} = Pd\_H + Pd\_L = \mathbf{32.8mW}$$



## RELIABILITY INFORMATION

TABLE 8.  $\theta_{JA}$  VS. AIR FLOW TABLE

$\theta_{JA}$ by Velocity (Linear Feet per Minute)			
	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	67.8°C/W	55.9°C/W	50.1°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	47.9°C/W	42.1°C/W	39.4°C/W

**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

### TRANSISTOR COUNT

The transistor count for ICS8624I is: 1565



PACKAGE OUTLINE - Y SUFFIX

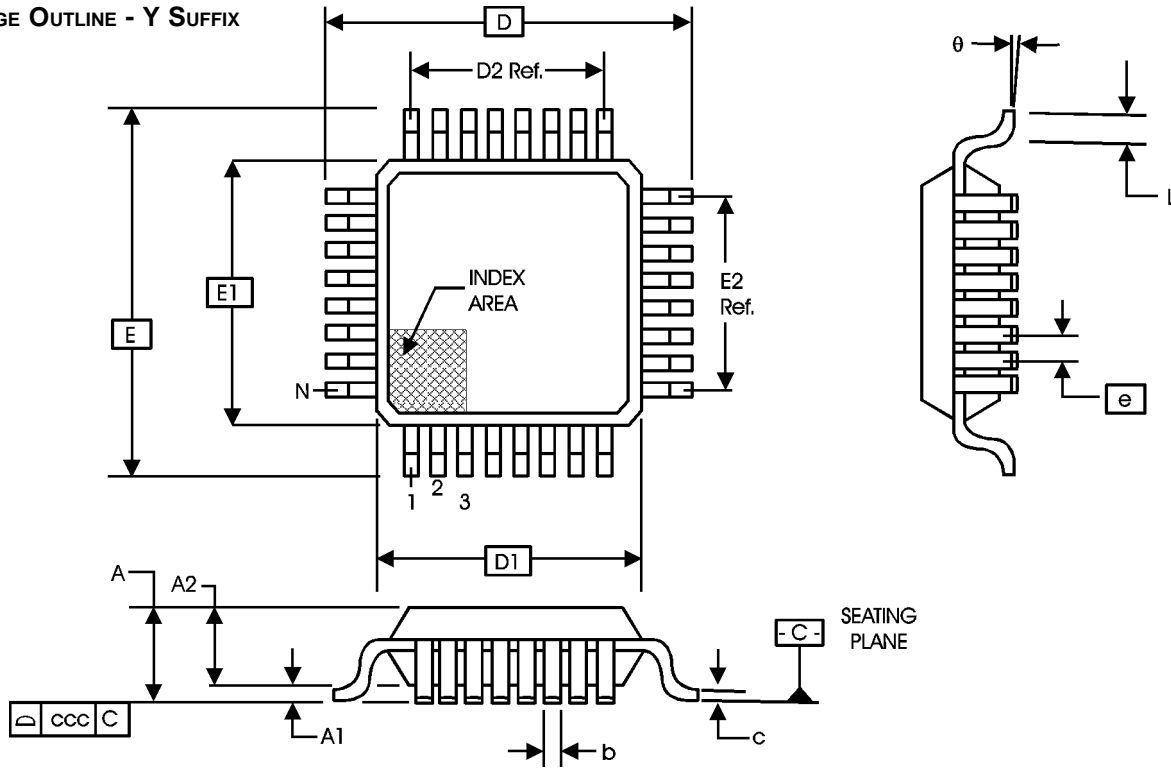


TABLE 9. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	BBA		
	MINIMUM	NOMINAL	MAXIMUM
N	32		
A			1.60
A1	0.05		0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
c	0.09		0.20
D		9.00 BASIC	
D1		7.00 BASIC	
D2		5.60	
E		9.00 BASIC	
E1		7.00 BASIC	
E2		5.60	
e		0.80 BASIC	
L	0.45	0.60	0.75
θ	0°		7°
ccc			0.10

Reference Document: JEDEC Publication 95, MS-026



Integrated  
Circuit  
Systems, Inc.

**ICS8624I**  
LOW SKEW, 1-TO-5  
DIFFERENTIAL-TO-LVHSTL ZERO DELAY BUFFER

**TABLE 10. ORDERING INFORMATION**

Part/Order Number	Marking	Package	Count	Temperature
ICS8624BYI	ICS8624BYI	32 Lead LQFP	250 per tray	-40°C to 85°C
ICS8624BYIT	ICS8624BYI	32 Lead LQFP on Tape and Reel	1000	-40°C to 85°C

While the information presented herein has been checked for both accuracy and reliability, Integrated Circuit Systems, Incorporated (ICS) assumes no responsibility for either its use or for infringement of any patents or other rights of third parties, which would result from its use. No other circuits, patents, or licenses are implied. This product is intended for use in normal commercial and industrial applications. Any other applications such as those requiring high reliability, or other extraordinary environmental requirements are not recommended without additional processing by ICS. ICS reserves the right to change any circuitry or specifications without notice. ICS does not authorize or warrant any ICS product for use in life support devices or critical medical instruments.





REVISION HISTORY SHEET				
Rev	Table	Page	Description of Change	Date
A		11 - 12	Revised Figures 3A & 3B.	8/13/02
A	T1	2	Pin Description Table - revised $V_{DD}$ description to <i>Core supply pins</i> from <i>Positive supply pins</i> .	10/8/02
	T3A	3	Control Input Function Table - corrected note to read ...250MHz to 630MHz from ...250 to 700MHz.	
	T4A	4	Power Supply Table - revised $V_{DD}$ Parameter description to read <i>Core Supply Voltage</i> from <i>Positive Supply Voltage</i> .	
		13	Corrected power dissipation equation. Replaced $V_{OH\_MIN}$ with $V_{OH\_MAX}$ .	