

HID & SYSTEM MANAGEMENT PRODUCTS, MOUSECODER® FAMILY

DESCRIPTION

The PixiPoint® SH1201 mouse encoder is a cost-effective, high-functionality IC that interfaces a force-stick sensor to a PS/2 or serial port. Ideal for laptop or palmtop use, the low-power PixiPoint® uses an advanced algorithm for enhanced motion control. The IC can be configured as a standard 3-button mouse or as a wheel mouse. The IC provides an extra port for hot-plug connection of an external PS/2 mouse, including one with wheel function. The embedded sensor and the external device can operate concurrently.

The PixiPoint® includes a signal conditioning circuit for a low cost, simple and real estate-saving implementation. Just a few low-tolerance external components are needed.

Typically consuming less than 4.5 mA, the PixiPoint® is ideal for battery-operated systems.

PS/2 communication is bidirectional at 10 Kbps. The PixiPoint® returns up to 100 mouse reports per second, and is compatible with the standard two-button mouse protocol, the standard three-button mouse protocol, and the standard wheel mouse protocols. It implements all commands from and to the system (as defined in the IBM PS/2 mouse communication protocol).

The PixiPoint® also implements most of the IBM force stick extended commands, and works with most IBM force stick drivers.

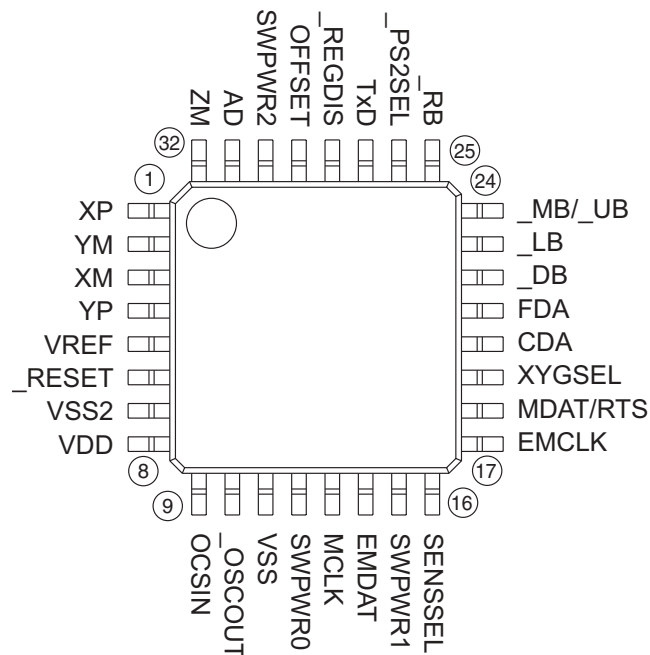
FEATURES

- Advanced motion control algorithm provides accurate cursor control
- Can be configured for PS/2 or RS232 serial communication with the host
- Can be configured as a standard 3-button mouse or a wheel mouse
- Complies with the Microsoft® *Plug and Play External COM Device* specification
- Click (select), double-click (execute), and slow drag are implemented in the IC – no special driver support is required
- Provides built-in profiles to interface popular force-stick sensors from several manufacturers
- Supports hot-plug connection of a standard external PS/2 mouse, with or without wheel function
- Works with standard Windows® mouse drivers
- Works with most IBM force stick drivers
- CleanStop™ feature means cursor stops where it should
- In PS/2 mode, supports all standard PS/2 commands
- Royalty-free and cost-effective
- Low power consumption: 4.5 mA (typical)
- 2.7 V–5.5 V operation over extended temperature range

APPLICATIONS

- Notebooks/laptops
- Handhelds
- Keyboards
- Instrumentation

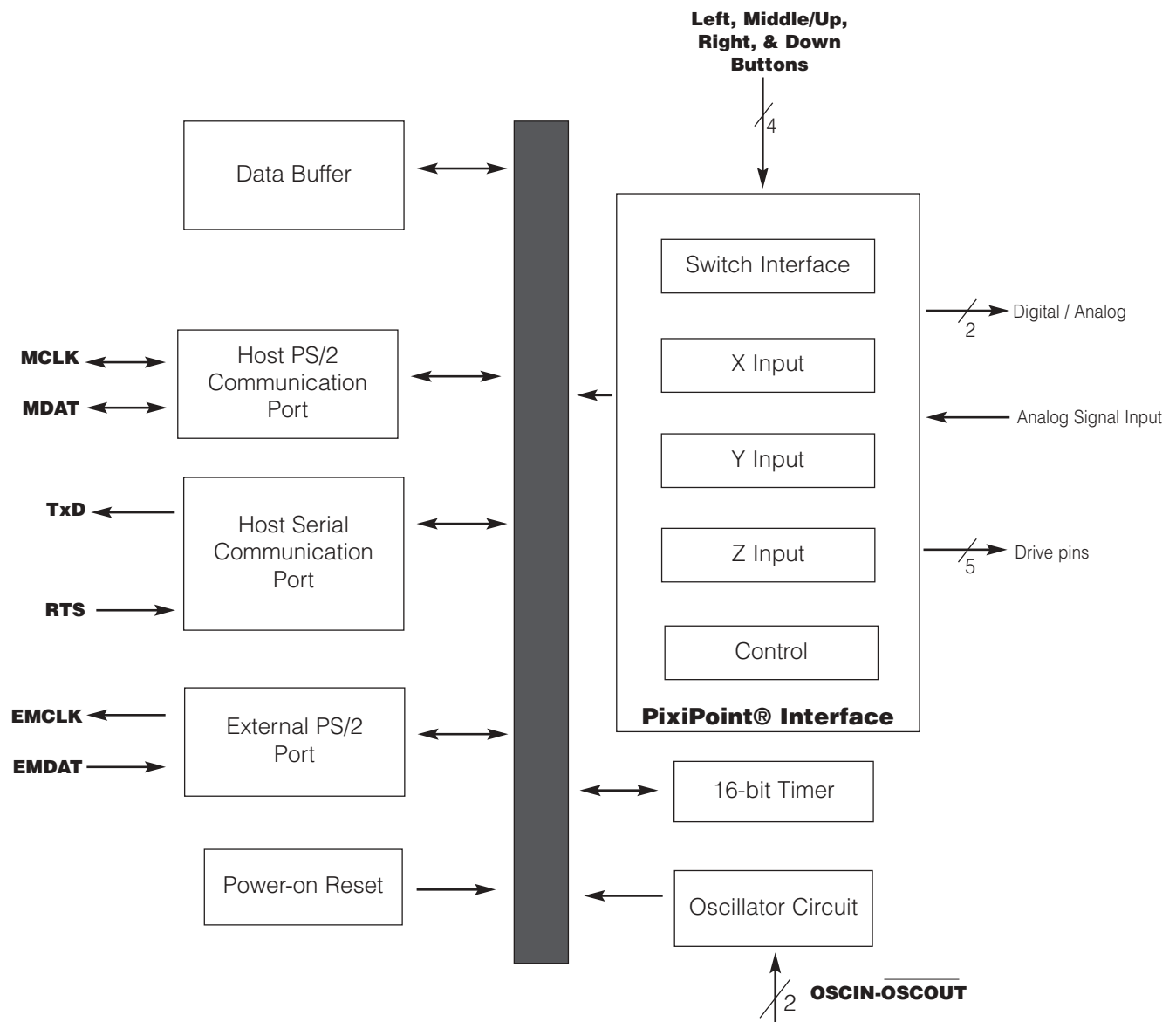
PIN ASSIGNMENTS



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ORDERING CODE

| | |
|--------------|--|
| SH1201-FG | LQFP 32-pin, 0.8 mm pitch |
| sh1201tr.pdf | Document: <i>PixiPoint® Technical Reference (Extended PS/2 Protocol)</i> |

BLOCK DIAGRAM




FUNCTIONAL DESCRIPTION

The SH1201 consists functionally of several major sections (see the block diagram on the previous page). These include the PixiPoint® interface, the 16-bit timer, the oscillator circuit, the host PS/2 communication port, the host serial communication port, and the external PS/2 port. All sections communicate with each other and operate concurrently.

SENSOR SUPPORT

The SH1201 has built-in profiles to interface with several sensors, some of which are listed here. A profile is selected by tying the SENSSEL line (pin 16) to the indicated line.

- CTS 106 - floating
- CTS 109 - ground
- CTS 105 - XP (pin 1)
- K-Tech 3.2 - YM (pin 2)

SENSOR Z-AXIS SUPPORT

The SH1201 has built-in Z-axis functionality to recognize click and double-click on the force stick itself.

Z-axis functionality depends on an appropriate resistor Rz at the sensor input (R4 in the mode schematics, R4, R12, or R11 in the evaluation board schematic in this data sheet) whose value is one half the resistance of one strain gauge of the sensor. Omitting this resistor and leaving this connection open disables Z-axis functionality. Rz values:

- CTS 106 - 1.6 KΩ
- CTS 109 - 1.24 KΩ
- CTS 105 - 1.6 KΩ
- K-Tech 3.2 - 1.6 KΩ

PIN DEFINITIONS

| Mnemonic | Pin # | Type | Name and Function |
|----------|-------|----------|--|
| Vdd | 8 | P | Power supply: 2.7 V–5.5 V (depends on host interface mode) |
| Vss | 11 | P | Ground |
| Vss2 | 7 | P | Ground |
| _RESET | 6 | I | Reset: apply 0V for orderly start-up |
| _OSCOUT | 10 | O | Oscillator output: open for external clock input or one side of the ceramic resonator with built-in load capacitors |
| OSCIN | 9 | I | Oscillator input: external clock input or one side of the ceramic resonator with built-in load capacitors |
| MCLK | 13 | I/O (nd) | Host PS/2 clock |
| MDAT/RTS | 18 | I/O (nd) | Host PS/2 data / serial request-to-send input external mouse |
| EMCLK | 17 | I/O (nd) | External mouse clock: PS/2 clock signal from external mouse |
| EMDAT | 14 | I/O (nd) | External mouse data: PS/2 data signal from external mouse |
| TxD | 27 | O | Serial transmit to host: idle high |
| _DB | 22 | I/O (nd) | Down button: active low, strobed sampling |
| _LB | 23 | I/O (nd) | Left button: active low, strobed sampling |
| _MB/_UB | 24 | I/O (nd) | Middle/up button: active low, strobed sampling |
| _RB | 25 | I/O (nd) | Right button: active low, strobed sampling |
| AD | 31 | AI | Analog to digital converter input |
| SENSSEL | 16 | I/O (nd) | Sensor select pin: normally left floating |
| _REGDIS | 28 | I/O (nd) | Regulator disable/enable (low = disable) |
| VREF | 5 | AI | Reference voltage for built-in A/D |
| XM | 3 | I/O | X minus drive pin |
| XP | 1 | I/O | X plus drive pin |
| YM | 2 | I/O | Y minus drive pin |
| YP | 4 | I/O | Y plus drive pin |
| ZM | 32 | I/O | Z minus drive pin |
| XYGSEL | 19 | I | XY gain 100% floating, 75% tied to ground, 50% tied to SWPWR2, 125% tied to REGDIS |
| CDA | 20 | O | Coarse digital-to-analog |
| FDA | 21 | O | Fine digital-to-analog |
| _PS2SEL | 26 | I | Interface select: tie to ground for PS/2 host, tie to power (Vcc) for serial host |
| OFFSET | 29 | I/O | Offset: resets the offset circuit during inactivity |
| SWPWR0 | 12 | I/O | Switched power driver |
| SWPWR1 | 15 | I/O | Switched power driver: connect to SPWR0 |
| SWPWR2 | 30 | I/O | Switched power driver: connect to SPWR0 |

Note: An underscore before a pin mnemonic denotes an active low signal.
Pin types legend: P = power, AI = analog input; I = input; O = output; I/O = input or output; I/O (nd) = input or output with N-channel open drain driver

POWER AND EXTERNAL PS/2 SPEED BY HOST INTERFACE

High-speed PS/2 host interface
 4 V–5.5 V power supply
 external PS/2 port speed:
 100 reports/second maximum

Low-speed PS/2 host interface
 2.7 V–5.5 V power supply
 external PS/2 port speed:
 60 reports/second maximum

Serial host interface
 2.7 V–5.5 V power supply
 external PS/2 port speed:
 60 reports/second maximum

Note: Embedded (internal) pointer speed is 100 reports/second maximum for all interface types



HOST INTERFACE

The PixiPoint® communicates with the host system using high-speed PS/2, low-speed PS/2, or serial.

The state of the interface select pin (PS2SEL, pin 26) determines which interface is used. If the pin is tied to ground, high-speed PS/2 is used; if it is tied to SWPWR2 (pin 30), low-speed PS/2 is used; if it is tied to power (Vcc), serial is used.

BUILT-IN FEATURES

The PixiPoint® provides the following built-in functions:

Tap — Select.

Double Tap — Execute.

Press Hold — Drag.

EasyDrag™ — reduces the speed of the cursor when the user is dragging an object on the desktop, making it simple to accurately handle the object.

CleanStop™ — ensures that the cursor stops precisely.

POWER CONSUMPTION

The SH1201 typically consumes less than 4.5 mA. Low-power consumption makes it ideal for use in battery-operated systems.

SIGNAL CONDITIONING CIRCUIT

The PixiPoint® interfaces with a sensor that has four strain gauges – one on each of the sides. If force is applied precisely in the X direction, it produces a change of resistance of only the two X gauges. Force in the Y direction causes changes only in the Y gauges. One of the pair of gauges increases, while the other decreases in resistance.

If the user presses on the sensor from the top (Z axis), all of the strain gauges decrease in resistance.

When the test current is passed through the gauges, these resistance changes are converted into voltage changes. These signals are very small, typically under 1 mV Full Scale.

The signal conditioning circuit balances and amplifies the incoming signals for digitizing by a built-in A/D converter.

Semtech's circuit can correct a significant imbalance between the gauges in each X and Y pair ($\pm 12.5\%$), allowing relaxed manufacturing tolerances for the sensors and cabling. There is no performance degradation over the full operating temperature range, and no degradation for large temperature gradients between the paired gauges.

MOUSE EMULATION

The PixiPoint® emulates either a standard 3-button mouse or a standard wheel mouse. The mouse type emulated depends on the state of the down button pin (DB, pin 22).

For standard 3-button mouse operation, leave DB floating.

For standard wheel mouse operation, if the host interface is PS/2, tie DB to TxD (pin 27)

For standard wheel mouse operation, if the host interface is serial, tie DB to MCLK (pin 13)

In 3-button mode, the left, right and middle buttons are implemented.

In wheel mode, the left, right, up, and down buttons are implemented; pressing up and down buttons together emulates a middle-button press.



SERIAL HARDWARE

The TxD and RTS lines are CMOS logic-level signals, suitable for direct connection to the pins of an UART. Interfacing via the RS-232 port requires an addition of an inverting driver and receiver. A simple one-transistor inverting driver and receiver can be used.

SERIAL COMMUNICATION

Communication through the serial port is uni-directional at a fixed speed of 1200 Baud, 7N1 protocol (7 data bits, 1 stop bit, no parity check).

The host can reset the device at any time by setting the RTS line high. When RTS is set low after a delay of at least 100 ms, the PixiPoint® responds in one of two ways as shown below. Its response depends on its mode: wheel mode or 3-button mode, as determined by the state of the down button pin (DB, pin 22).

Wheel mode

When the PixiPoint® is in wheel mode, and RTS is set low after a delay of at least 100 ms, the PixiPoint® responds with the two identification characters "MZ" (0x4D, 0x5A); they are followed by a zero motion report consisting of the four bytes 0x40, 0x00, 0x00, 0x00, and then by the plug-and-play string:

```
vvSTH1201\MOUSE\PNP0F0A\PIXIPOINTcc
```

This plug-and-play string is a sequence of ASCII characters with their codes reduced by 0x20. Note that vv represents a 2-byte version number, and cc is a 2-byte checksum. For further information, please refer to the *Plug and Play External COM Device Specification*, available from Microsoft. See the following web page (subject to change):
<http://www.microsoft.com/hwdev/resources/specs/pnpcom.asp>

3-button mode

When the PixiPoint® is in 3-button mode, and RTS is set low after a delay of at least 100 ms, the PixiPoint® responds with the two identification characters "M3" (0x4D, 0x33); they are followed by a zero motion report consisting of the four bytes 0x40, 0x00, 0x00, 0x00, and then by the plug-and-play string:

```
vvSTH1201\MOUSE\PNP0F0A\PIXIPOINTcc
```

This plug-and-play string is a sequence of ASCII characters with their codes reduced by 0x20. Note that vv represents a 2-byte version number, and cc is a 2-byte checksum. For further information, please refer to the *Plug and Play External COM Device Specification*, available from Microsoft. See the following web page (subject to change):
<http://www.microsoft.com/hwdev/resources/specs/pnpcom.asp>



SERIAL DATA REPORTS

In wheel mode, data reports are always four bytes long.

In 3-button mode, data reports are four bytes long only if the middle button is depressed or changing state; otherwise, data reports are three bytes long.

A data report is sent if motion is detected, or if buttons are pressed or released. X and Y motion is reported relative to the last report sent, in a two's complement form with 8-bit resolution. Therefore, motion values can range from -128 to +127.

Z3-Z0 is Z-displacement (wheel value), a 4-bit two's complement value from -8 to +7.

| Byte 1 | |
|--|------------------------------------|
| b0 | X6 |
| b1 | X7: MSB of X Data |
| b2 | Y6 |
| b3 | Y7: MSB of Y Data |
| b4 | Right button status, 1 = depressed |
| b5 | Left button status, 1 = depressed |
| b6 | Always=1 |
| Byte 2 | |
| b0 | X0: LSB of X data |
| b1 | X1 |
| b2 | X2 |
| b3 | X3 |
| b4 | X4 |
| b5 | X5 |
| b6 | Always=0 |
| Byte 3 | |
| b0 | Y0: LSB of Y data |
| b1 | Y1 |
| b2 | Y2 |
| b3 | Y3 |
| b4 | Y4 |
| b5 | Y5 |
| b6 | Always=0 |
| Byte 4 (wheel mode) | |
| b0 | Z0: LSB of Z data |
| b1 | Z1 |
| b2 | Z2 |
| b3 | Z3: MSB of Z data |
| b4 | Middle button status; 1=depressed |
| b5 | Always=0 |
| b6 | Always=0 |
| Byte 4 (3-button mode, only when middle button is depressed or changing state) | |
| b0 | Always=0 |
| b1 | Always=0 |
| b2 | Always=0 |
| b3 | Always=0 |
| b4 | Always=0 |
| b5 | Middle button status; 1=depressed |
| b6 | Always=0 |



PS/2 COMMUNICATION

At start-up or reset, the PixiPoint® waits between 300 and 500 milliseconds, then sends 0xAA to the host, followed by a device ID of 0x00. Then the IC sets itself to its default values, i.e. incremental stream mode with 1:1 scaling, and a report rate of 100 Hz. The IC then disables itself until a command is received from the host.

PS/2 REPORTS

The adjacent list shows the PS/2 report formats.

In the data report, each of the two position values (X and Y) is expressed as a 9-bit two's complement integer with the most significant bit (the sign bit) stored separately in byte 1. Z value (wheel or scroll) is expressed as an 8-bit two's complement integer.

If there is an overflow of the accumulator, the maximum positive or negative count is reported and the corresponding overflow bit is set.

PS/2 ERROR HANDLING

For every correct command or parameter received from the host, the SH1201 sends an acknowledge (0xFA). If an invalid command or parameter is received, the SH1201 issues a resend request (0xFE). If an invalid input is again received, the device transmits an error code (0xFC) to the host. Both error and resend request responses are sent by the device within 25 milliseconds. The host may not issue any new commands until either the PixiPoint® has responded or 25 milliseconds have elapsed.

PS/2 DATA REPORT

| | | |
|---|-----------------------------|---------------|
| Byte 1 | | |
| b0 | Left Button status | 1 = depressed |
| b1 | Right Button Status | 1 = depressed |
| b2 | Middle Button Status | 1 = depressed |
| b3 | Reserved | Always = 1 |
| b4 | X8: MSB of X data, sign bit | 1 = negative |
| b5 | Y8: MSB of Y data, sign bit | 1 = negative |
| b6 | X data overflow | 1 = overflow |
| b7 | Y data overflow | 1 = overflow |
| Byte 2 | | |
| b0 | X0: LSB of X data | |
| b1 | X1 | |
| b2 | X2 | |
| b3 | X3 | |
| b4 | X4 | |
| b5 | X5 | |
| b6 | X6 | |
| b7 | X7 | |
| Byte 3 | | |
| b0 | Y0: LSB of Y data | |
| b1 | Y1 | |
| b2 | Y2 | |
| b3 | Y3 | |
| b4 | Y4 | |
| b5 | Y5 | |
| b6 | Y6 | |
| b7 | Y7 | |
| Byte 4 (for wheel function; sent only if output of Z data is enabled by the driver) | | |
| b0 | Z0: LSB of Z data | |
| b1 | Z1 | |
| b2 | Z2 | |
| b3 | Z3 | |
| b4 | Z4 | |
| b5 | Z5 | |
| b6 | Z6 | |
| b7 | Z7: MSB of Z data, sign bit | |

PS/2 STATUS REPORT

| | | |
|--------|--------------------------------|---------------|
| Byte 1 | | |
| b0 | Right button | 1 = depressed |
| b1 | Middle button | 1 = depressed |
| b2 | Left button | 1 = depressed |
| b3 | Reserved | Always = 0 |
| b4 | Scaling - 1:1 (0) / 2:1 (1) | |
| b5 | Disable - (0) / enable (1) | |
| b6 | Stream - (0) / prompt (1) mode | |
| b7 | | Always = 0 |
| Byte 2 | | |
| b0 - 1 | Current resolution setting | |
| b2 - 7 | | Always = 0 |
| Byte 3 | | |
| b0-7 | Current sampling rate | |



PS/2 MODE COMMANDS

When the **Reset Command (0xFF)** is received, the SH1201 sets the following default parameters: incremental stream mode, 1:1 scaling, report rate of 100 Hz, and disabled. It then sends 0xAA to the host followed by a device ID of 0x00.

The host sends the **Resend Last Data Stream Command (0xFE)** when it detects an error in any SH1201 transmission. The device then resends the last output data packet to the host. This transmission occurs after a PixiPoint® transmission, and before the host enables the interface allowing the next PixiPoint® output.

The **Set Default Status Command (0xF6)** re-initializes the device to its condition at power-up.

The **Disable Command (0xF5)** stops the device from transmitting all reports. However, the mode does not change; the PixiPoint® is still able to respond to commands. If the disable command is issued while the device is transmitting a report, the SH1201 immediately stops the transmission and disables itself.

The **Reset Echo Mode Command (0xEC)** returns the device to its previous mode, and disables it.

The **Set Prompt (Remote) Mode Command (0xF0)** sets the device to Prompt Mode. Data values are then only reported in response to a **Read Report Command (0xEB)**.

If the **Set Echo Mode Command (0xEE)** is received, the PixiPoint® immediately returns any data bytes except 0xFF or 0xEC.

If the PixiPoint® is in incremental stream mode, the **Enable Command (0xF4)** allows it to begin data transmission. If the device is in prompt mode, the enable command only updates the internal status of the PixiPoint®.

The PixiPoint® responds to the **Set Sampling Rate Command (0xF3)** in both stream and prompt Modes but only updates its internal status if this command is enacted while the device is in stream mode.

The SH1201 responds to the **Read Device Type Command (0xF2)** with the device ID of 0x00.

The **Read Report Command (0xEB)** prompts the PixiPoint® for a report. The report occurs even if the device has not moved or if the status of the switches did not change.

The **Set Incremental Stream Mode Command (0xEA)** sets the PixiPoint® to stream mode and disables the device.

The **Status Request Command (0xE9)** returns a 3-byte status report.

The **Set Resolution Command (0xE8)** controls resolution, the **Set 2:1 Scaling Command (0xE7)** enables a coarse/fine tracking response, and the **Set 1:1 Scaling Command (0xE6)** enables the values of movements to be transmitted to the host without any scaling. Due to Semtech's advanced motion algorithm, set resolution and scaling commands are acknowledged and reported as activated, but their contents are ignored.

PIXIPOINT® EXTENDED PS/2 PROTOCOL

The PixiPoint® supports some extended PS/2 commands. The functions of these commands include adjusting sensitivity and gain parameters, and retrieving extended status information from the PixiPoint®. For details, see the PixiPoint® *Technical Reference Manual (PixiPoint® Extended PS/2 Protocol)* document, available on the Semtech web site (<http://www.semtech.com/>).



CIRCUIT NOTES

Power Circuit

The SH1201 reference design uses the SC431 shunt regulator, which is recommended. The SC431 works with the REGDIS pin to reduce power consumption.

Operational amplifier

For a power supply above 4 V, a lower cost op amp like the LM358/2904 can be used instead of the LMV321.

Integration circuit

The integration capacitor is 180 pF. A greater capacitance would reduce X, Y, Z axis sampling gain.

Compensation capacitors

C6 (56 pF) compensates for capacitance of sensor drive pins and layout. Measure waveforms at AD (pin 31). If the initial value of the six sampling waveform is not half of op amp output swing, use a different-valued capacitor here. Greater capacitance yields a smaller initial sampling value.

Low-impedance sensors

A low-impedance force stick requires resistors to boost total device impedance above 600 Ω .

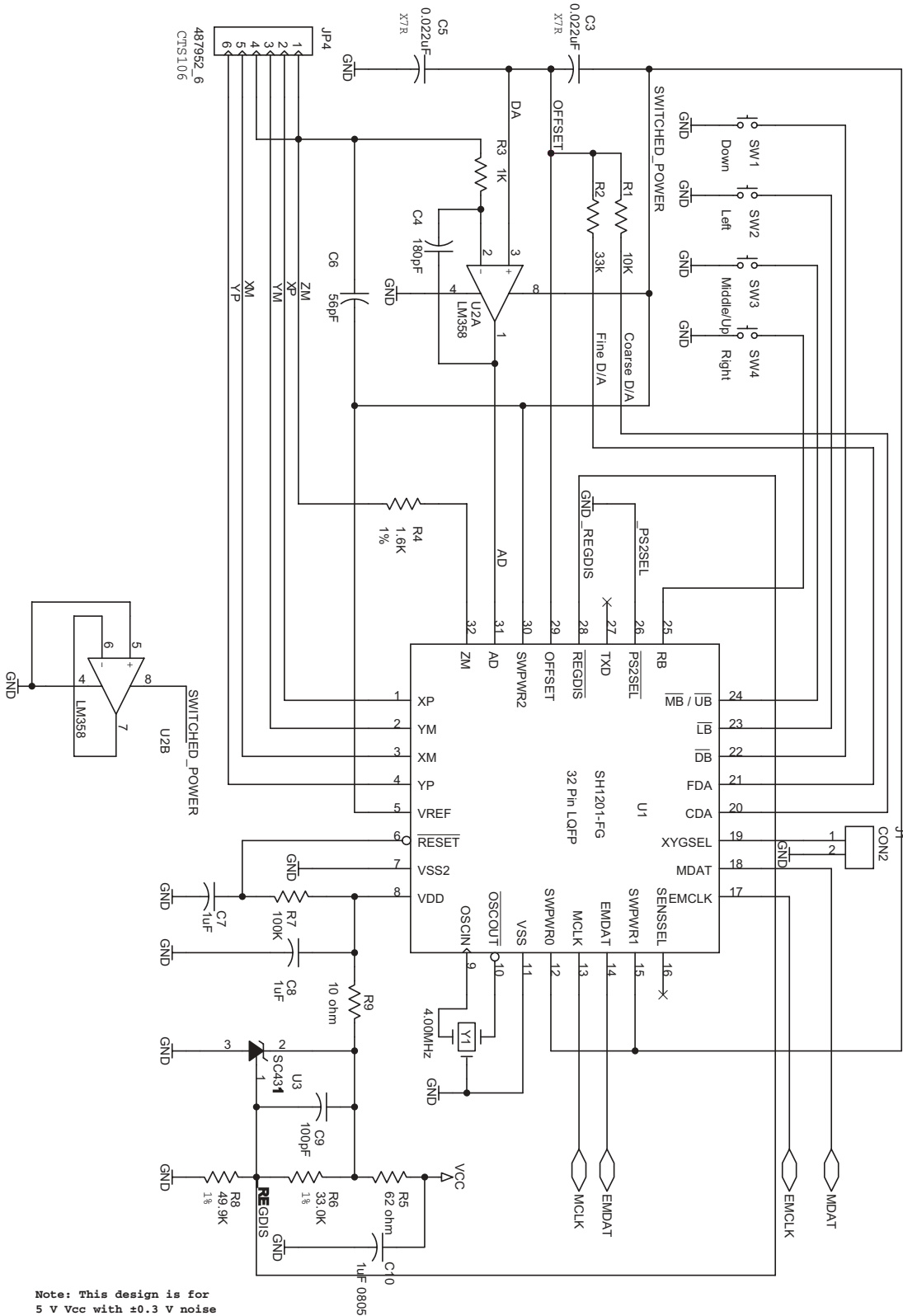
External PS/2

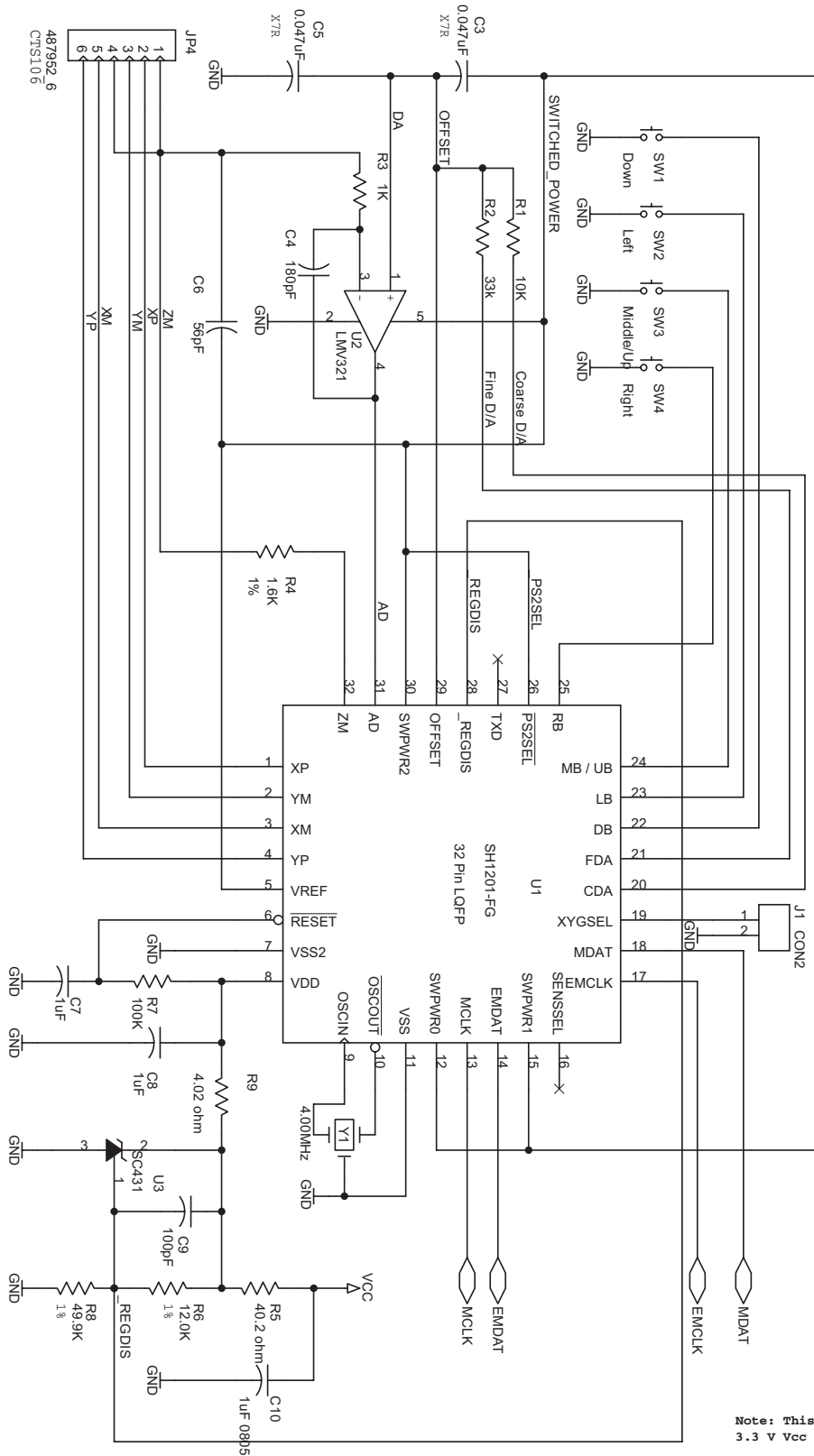
L1 limits surge current from hot-plug of external mouse.

Clock generator

4 MHz resonator with built-in load capacitors
or external clock or crystal
or Semtech SH300x MicroBuddy™

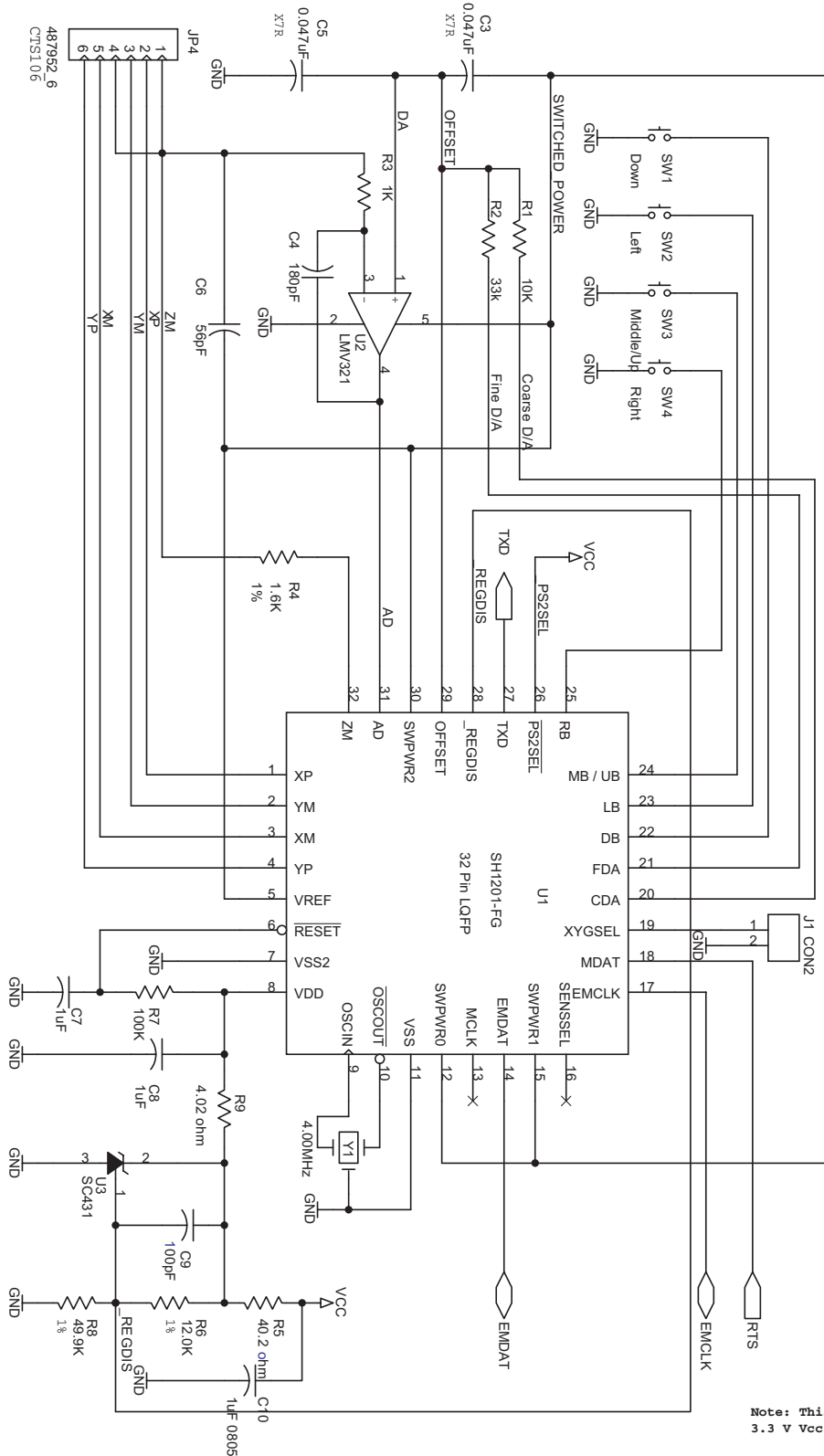
HIGH-SPEED PS/2 MODE SCHEMATIC FOR THE PIXIPOINT® SH1201-FG



LOW-SPEED PS/2 MODE SCHEMATIC FOR THE PIXIPPOINT® SH1201-FG


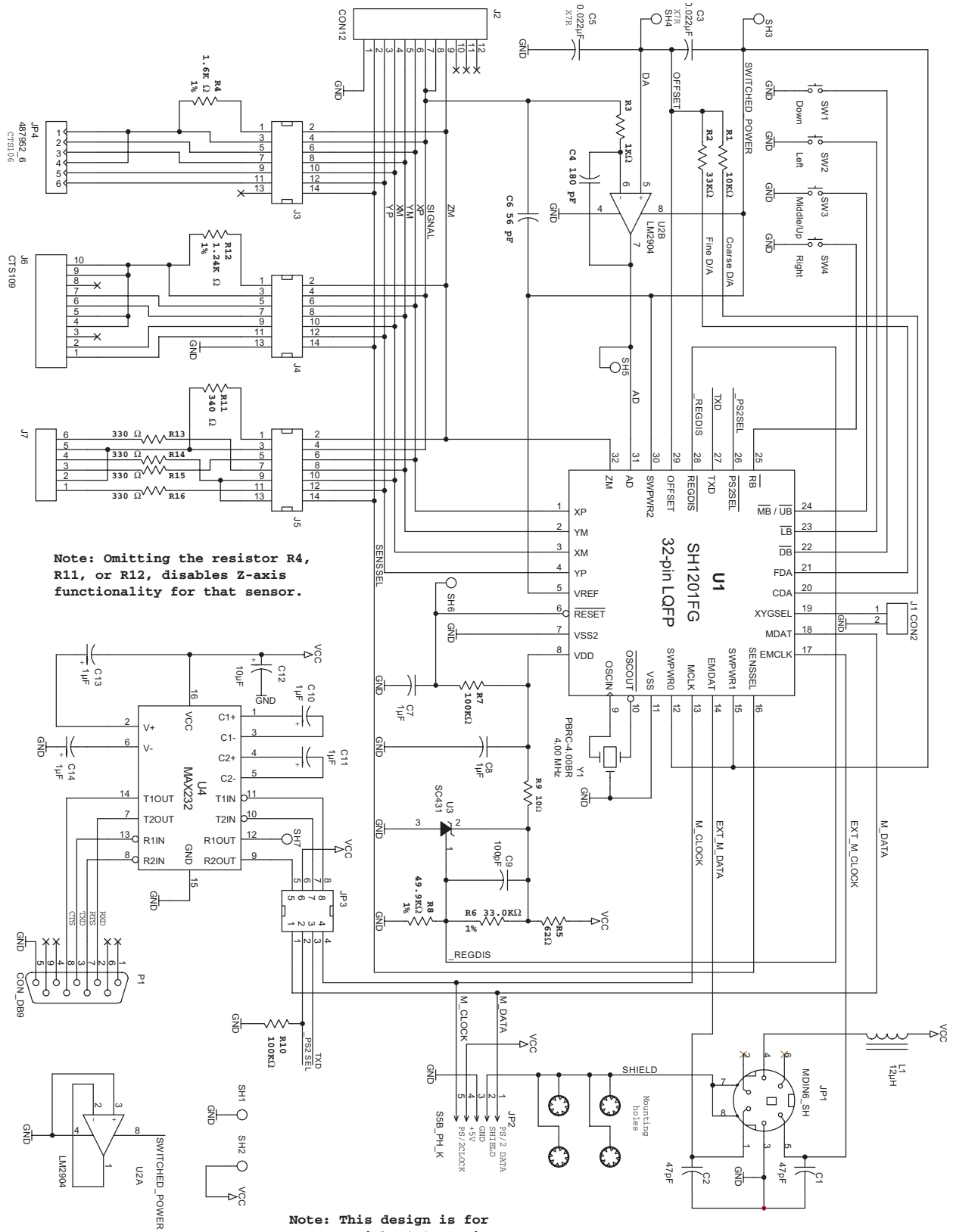
Note: This design is for 3.3 V Vcc with ± 0.3 V noise

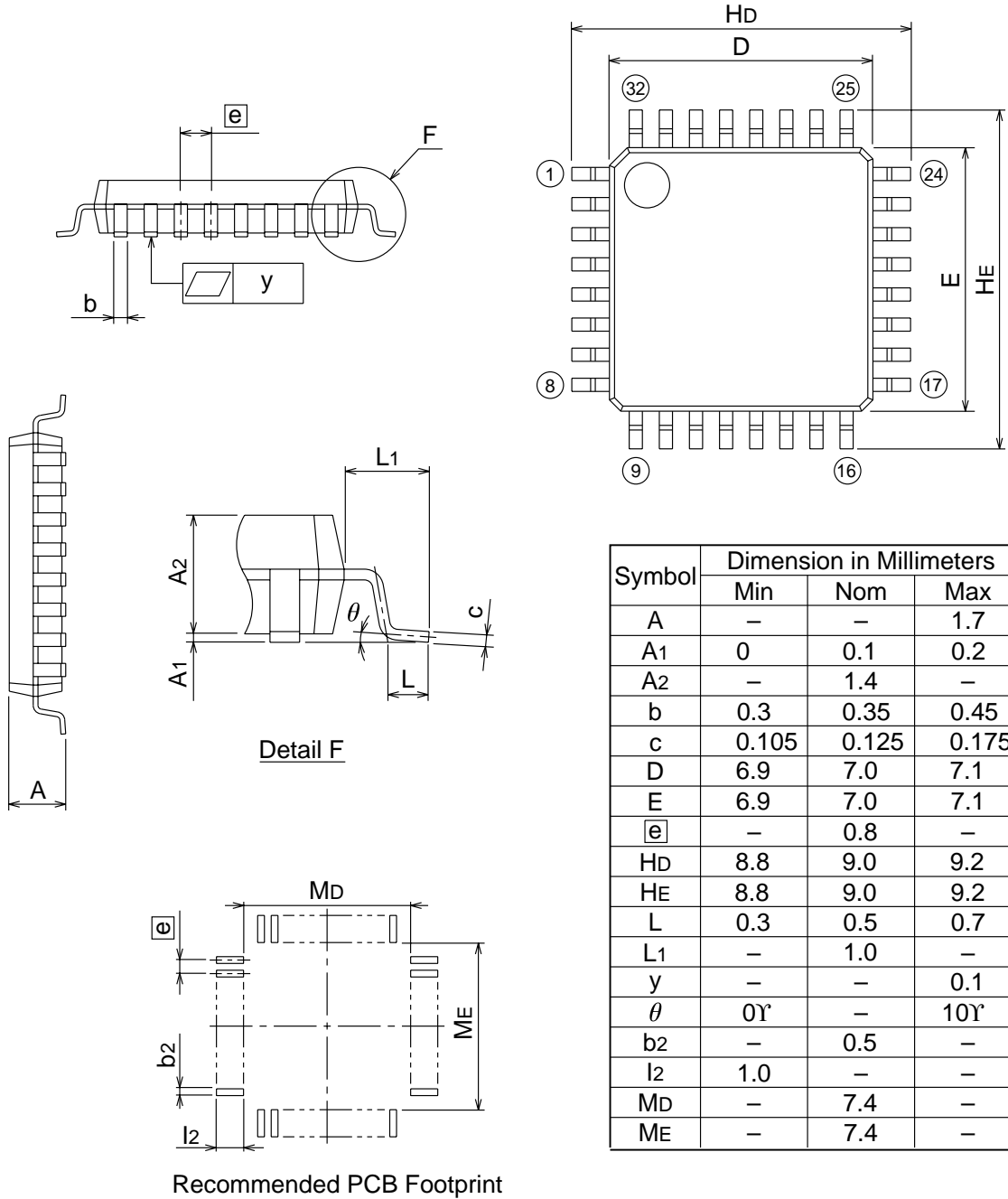
SERIAL MODE SCHEMATIC FOR THE PIXIPOINT® SH1201-FG



Note: This design is for 3.3 V Vcc with ±0.3 V noise

EVALUATION BOARD SCHEMATIC FOR THE PIXIPOINT® SH1201-FG







ELECTRICAL SPECIFICATIONS

Absolute maximum ratings

| Ratings | Symbol | Value | Unit |
|--|------------------|--|------|
| Supply voltage | V _{DD} | -0.3 to 7.0 | V |
| Input voltage | V _{IN} | V _{SS} - 0.3 to V _{DD} + 0.3 | V |
| Current drain per pin (not including V _{SS} or V _{DD}) | I | 20 | mA |
| Operating temperature | T _A | T _{LOW} to T _{HIGH} | °C |
| SH1201 | | -20 to +85 | °C |
| Storage temperature range | T _{STG} | -40 to +125 | °C |
| ESD rating (human body model) | V _{ESD} | 2.0 | KV |

DC electrical characteristics, temperature range = T_{LOW} to T_{HIGH} unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|--|-----------------|-----------------------|-----|--------------------|------|
| Supply voltage | | 2.7 | 5.0 | 5.5 | V |
| Output voltage (10 μA load) | V _{OH} | V _{DD} - 0.1 | | | V |
| | V _{OL} | | | 0.1 | V |
| Input high voltage | V _{IH} | 0.8V _{DD} | | V _{DD} | V |
| Input low voltage | V _{IL} | V _{SS} | | 0.2V _{DD} | V |
| Input current | I _{IN} | | | +/- 1 | μA |
| Supply current (V _{DD} =5.0Vdc +/-10%, V _{SS} =0) | I _{DD} | | 3.0 | TBD | mA |

Control timing (V_{DD} = 5.0 Vdc +/-10%, V_{SS} = 0 Vdc, temperature range = T_{LOW} to T_{HIGH} unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|-------------------------|------------------|-----|-----|-----|------|
| Frequency of operation | f _{osc} | | | | |
| ■ Crystal option | | | 4.0 | | MHz |
| ■ External clock option | | | 4.0 | | MHz |

Sensor characteristics

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|----------------------------------|-------|-----|------|------|
| Resistance | R _x | 0.6 K | | 10 K | Ohms |
| Matching | R _{x1} /R _{x2} | 75 | | 125 | % |
| | R _{y1} /R _{y2} | 75 | | 125 | % |



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