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# USB1T1103

## Universal Serial Bus Peripheral Transceiver with Voltage Regulator

### Features

- Complies with Universal Serial Bus Specification 2.0
- Integrated 5V to 3.3V voltage regulator for powering VBus
- Utilizes digital inputs and outputs to transmit and receive USB cable data
- Supports full speed (12Mbps/s) data rates
- Ideal for portable electronic devices
- MLP technology package (16 terminal) with HBCC footprint
- 15kV contact HBM ESD protection on bus terminals

### Description

This chip provides a USB Transceiver functionality with a voltage regulator that is compliant to USB Specification Rev 2.0. this integrated 5V to 3.3V regulator allows interfacing of USB Application specific devices with supply voltages ranging from 1.65V to 3.6V with the physical layer of Universal Serial Bus. It is capable of operating at 12Mbps/s (full speed) data rates and hence is fully compliant to USB Specification Rev 2.0. The Vbusmon terminal allows for monitoring the Vbus line.

The USB1T1103 also provides exceptional ESD protection with 15kV contact HBM on D+,D- terminals

### Applications

- PDA
- PC Peripherals
- Cellular Phones
- MP3 Players
- Digital Still Camera
- Information Appliance



### Ordering Information

| Part Number  | Package Number | Product code Top Mark | Pb-Free | Package Description                                                  | Packing Method            |
|--------------|----------------|-----------------------|---------|----------------------------------------------------------------------|---------------------------|
| USB1T1103MPX | MLP14D         | \$Y&Z&2&T<br>USB1103  | Yes     | 14-Terminal Molded Leadless Package (MLP), 2.5mm Square              | 3K Units on Tape and Reel |
| USB1T1103MHX | MLP16HB        | \$Y&Z&2&T<br>USB1103  | Yes     | 16-Terminal Molded Leadless Package (MHBCC), JEDEC MO-217,3mm Square | 3K Units on Tape and Reel |

Pb-Free package per JEDEC J-STD-020B.

## Typical Application

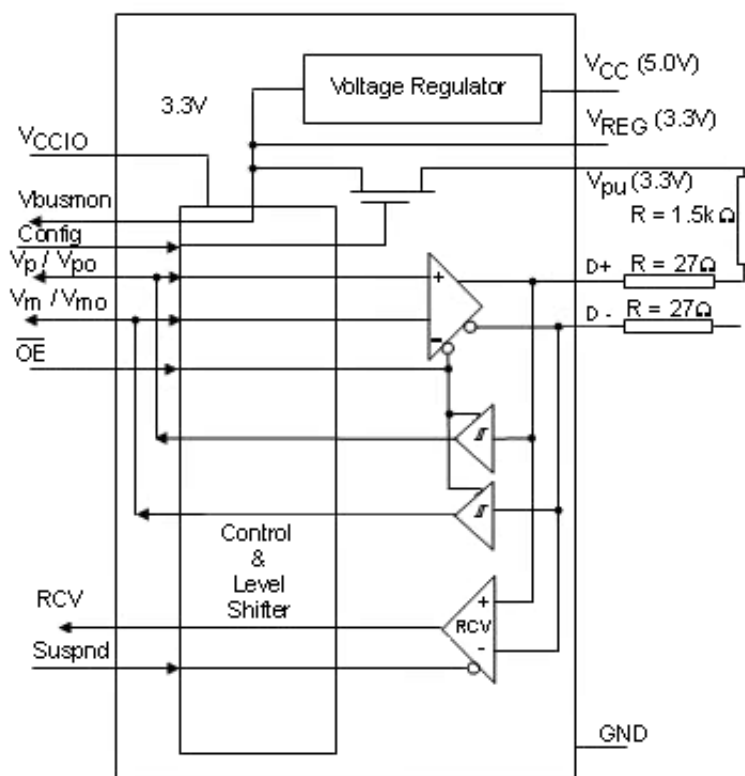


Figure 1. Logic Diagram

## Connection Diagrams

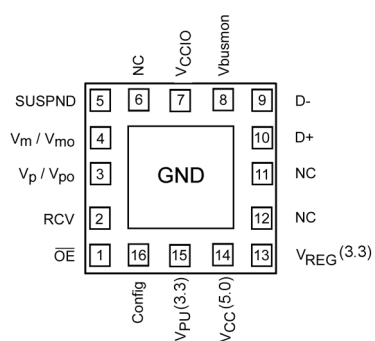


Figure 2. MLP16 GND Exposed Diepad  
(Bottom View)

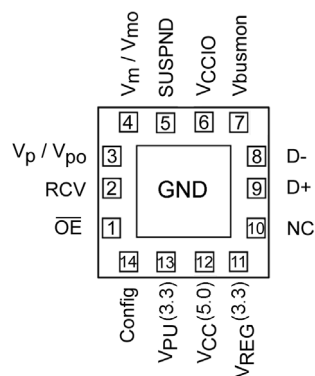


Figure 3. MLP14 GND Exposed Diepad  
(Bottom View)

# Terminal Descriptions

| Terminal Number |                | Terminal Name    | I/O  | Terminal Description                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------|----------------|------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MLP14           | MLP16          |                  |      |                                                                                                                                                                                                                                                                                                                                                                                                |
| 1               | 1              | OE               | I    | Output Enable:<br>Active LOW enables the transceiver to transmit data on the bus. When not active the transceiver is in the receive mode (CMOS level is relative to $V_{CCIO}$ )                                                                                                                                                                                                               |
| 2               | 2              | RCV              | O    | Receive Data Output:<br>Non-inverted CMOS level output for USB differential Input (CMOS output level is relative to $V_{CCIO}$ ). Driven LOW when SUSPN is HIGH; RCV output is stable and preserved during SE0 condition.                                                                                                                                                                      |
| 3               | 3              | $V_p/V_{po}$     | I/O  | Single-ended D+ receiver output $V_p$ (CMOS level relative to $V_{CCIO}$ ):<br>Used for external detection of SE0, error conditions, speed of connected device; Terminal also acts as drive data input $V_{po}$ (see Table 1 and Table 2).<br>Output drive is 4 mA buffer.                                                                                                                     |
| 4               | 4              | $V_m/V_{mo}$     | I/O  | Single-ended D- receiver output $V_m$ (CMOS level relative to $V_{CCIO}$ ):<br>Used for external detection of SE0, error conditions, speed of connected device; Terminal also acts as drive data input $V_{mo}$ (see Table 1 and Table 2).<br>Output drive is 4 mA buffer.                                                                                                                     |
| 5               | 5              | SUSPND           | I    | Suspend:<br>Enables a low power state (CMOS level is relative to $V_{CCIO}$ ). While the SUSPND terminal is active (HIGH) it will drive the RCV terminal to logic "0" state.                                                                                                                                                                                                                   |
| —               | 6              | NC               |      | No Connect                                                                                                                                                                                                                                                                                                                                                                                     |
| 6               | 7              | $V_{CCIO}$       |      | Supply Voltage for digital I/O terminals (1.65V to 3.6V):<br>When not connected the D+ and D- terminals are in 3-STATE. This supply bus is totally independent of $V_{CC}$ (5V) and $V_{REG}$ (3.3V), and must never exceed the $V_{REG}$ (3.3) voltage. For $V_{CCIO}$ disconnected the O+/O- terminals are HIGH Impedance and the $V_{PU}$ (3.3V) is turned off.                             |
| 7               | 8              | Vbusmon          | O    | Vbus monitor output (CMOS level relative to $V_{CCIO}$ ):<br>When Vbus > 4.1V then Vbusmon = HIGH and when Vbus < 3.6V then Vbusmon = LOW. If SUSPND = HIGH then Vbusmon is pulled HIGH.                                                                                                                                                                                                       |
| 9, 8            | 10, 9          | D+, D-           | AI/O | Data +, Data -:<br>Differential data bus conforming to the USB standard. Terminals are HIGH Impedance for bus powered mode when Vbus < 3.6V. For ByPass Mode then HIGH Impedance when $V_{REG}/V_{bus} < V_{REG}$ minimum.                                                                                                                                                                     |
| 10              | 11             | NC               |      | No Connect                                                                                                                                                                                                                                                                                                                                                                                     |
| —               | 12             | NC               |      | No Connect                                                                                                                                                                                                                                                                                                                                                                                     |
| 11              | 13             | $V_{REG}$ (3.3V) |      | Internal Regulator Option:<br>Regulated supply output voltage (3.0V to 3.6V) during 5V operation;<br>decoupling capacitor of at least 0.1 $\mu$ F is required.<br>Regulator ByPass Option:<br>Used as supply voltage input for 3.3V operation.                                                                                                                                                 |
| 12              | 14             | $V_{CC}$ (5.0V)  |      | Internal Regulator Option:<br>Used as supply voltage input (4.0V to 5.5V); can be connected directly to USB line Vbus.<br>Regulator ByPass Option:<br>Connected to $V_{REG}$ (3.3V)                                                                                                                                                                                                            |
| 13              | 15             | $V_{PU}$ (3.3V)  |      | Pull-up Supply Voltage ( $3.3V \pm 10\%$ ):<br>Connect an external 1.5k $\Omega$ resistor on D+ (FS data rate);<br>Terminal function is controlled by Config input terminal:<br>Config = LOW - $V_{PU}$ (3.3V) is floating (HIGH Impedance) for zero pull-up current.<br>Config = HIGH - $V_{PU}$ (3.3V) = 3.3V; internally connected to $V_{REG}$ (3.3V).<br>$V_{PU}$ is OFF in disable mode. |
| 14              | 16             | Config           | I    | USB connect or disconnect software control input.<br>Configures 3.3V to external 1.5k $\Omega$ resistor on D+ when HIGH.                                                                                                                                                                                                                                                                       |
| Exposed Diepad  | Exposed Diepad | GND              | GND  | GND supply down bonded to exposed diepad to be connected to the PCB GND.                                                                                                                                                                                                                                                                                                                       |

## Functional Description

The USB1T1103 transceiver is designed to convert CMOS data into USB differential bus signal levels and to convert USB differential bus signal to CMOS data.

To minimize EMI and noise the outputs are edge rate controlled with the rise and fall times controlled and defined for full speed data rates only (12Mbps/s). The rise, fall times are balanced between the differential terminals to minimize skew.

The USB1T1103 differs from earlier USB Transceiver in that the  $V_p/V_m$  and  $V_{po}/V_{mo}$  terminals are now I/O termi-

nals rather than discrete input and output terminals. Table 1 describes the specific terminal functionality selection. Table 2 and Table 3 describe the specific Truth Tables for Driver and Receiver operating functions.

The USB1T1103 also has the capability of various power supply configurations, including a disable mode for  $V_{CCIO}$  disconnected, to support mixed voltage supply applications (see Table 4) and Section 2.1 for detailed descriptions.

## Functional Tables

**Table 1. Function Select**

| SUSPND | OE | D+, D-                   | RCV                     | $V_p/V_{po}$   | $V_m/V_{mo}$   | Function                                                |
|--------|----|--------------------------|-------------------------|----------------|----------------|---------------------------------------------------------|
| L      | L  | Driving & Receiving      | Active                  | $V_{po}$ Input | $V_{mo}$ Input | Normal Driving (Differential Receiver Active)           |
| L      | H  | Receiving <sup>(1)</sup> | Active                  | $V_p$ Output   | $V_m$ Output   | Receiving                                               |
| H      | L  | Driving                  | Inactive <sup>(2)</sup> | $V_{po}$ Input | $V_{mo}$ Input | Driving during Suspend (Differential Receiver Inactive) |
| H      | H  | 3 STATE <sup>(1)</sup>   | Inactive <sup>(2)</sup> | $V_p$ Output   | $V_m$ Output   | Low Power State                                         |

### Notes:

- Signal levels is function of connection and/or pull-up/pull-down resistors.
- For SUSPND = HIGH mode the differential receiver is inactive and the output RCV is forced LOW. The out-of-suspend signaling (K) is detected via the single-ended receivers of the  $V_p/V_{po}$  and  $V_m/V_{mo}$  terminals.

**Table 2. Driver Function ( $\overline{OE} = L$ ) using Differential Input Interface**

| $V_m/V_{mo}$ | $V_p/V_{po}$ | Data (D+ / D-)       |
|--------------|--------------|----------------------|
| L            | L            | SE0 <sup>(3)</sup>   |
| L            | H            | Differential Logic 1 |
| H            | L            | Differential Logic 0 |
| H            | H            | Illegal State        |

### Notes:

- SE0 = Single Ended Zero

**Table 3. Receiver Function ( $\overline{OE} = H$ )**

| D+, D-               | RCV | $V_p/V_{po}$ | $V_m/V_{mo}$ |
|----------------------|-----|--------------|--------------|
| Differential Logic 1 | H   | H            | L            |
| Differential Logic 0 | L   | L            | H            |
| SE0                  | X   | L            | L            |

### Notes:

- X = Don't Care
- RCV(0) denotes the signal level on output RCV just prior to the SE0 or SE1 event. This level is stable during the SE0 or SE1 event period.

## Power Supply Configurations and Options

The three modes of power supply operation are:

### Normal Mode: Regulated Output and Regulator Bypass

1. Regulated Output:  $V_{CCIO}$  is connected and  $V_{CC}(5.0)$  is connected to 5V (4.0V to 5.5V) and the internal voltage regulator then produces 3.3V for the USB connections.
2. Internal Regulator Bypass Mode:  $V_{CCIO}$  is connected and both  $V_{CC}(5.0)$  and  $V_{REG}(3.3)$  are connected to a 3.3V source (3.0V to 3.6V).

In both cases, for normal mode, the  $V_{CCIO}$  is an independent voltage source (1.65V to 3.6V) that is a function of the external circuit configuration.

**Sharing Mode:**  $V_{CCIO}$  is only supply connected.  $V_{CC}$  and  $V_{REG}$  are not connected. In this mode, the D+ and D- terminals are 3-STATE and the USB1T1103 allows

external signals up to 3.6V to share the D+ and D- bus lines. Internally the circuitry limits leakage from D+ and D- terminals (maximum 10 $\mu$ A) and  $V_{CCIO}$  such that device is in low power (suspended) state. Terminals Vbusmon and RCV are forced LOW as an indication of this mode with Vbusmon being ignored during this state.

**Disable Mode:**  $V_{CCIO}$  is not connected.  $V_{CC}$  is connected, or  $V_{CC}$  and  $V_{REG}$  are connected. 0V to 3.3V in this mode D+ and D- are 3-STATE and  $V_{PU}$  is HIGH Impedance (switch is turned off). The USB1T1103 allows external signals up to 3.6V to share the D+ and D- bus lines. Internally the circuitry limits leakage from D+ and D- pins (maximum 10 $\mu$ A).

A summary of the Supply Configurations is described in Table 4.

**Table 4. Power Supply Configuration Options**

| Terminals                | Disable                               | Sharing                | Normal<br>(Regulated Output)          | Normal<br>(Regulator Bypass)                                         |
|--------------------------|---------------------------------------|------------------------|---------------------------------------|----------------------------------------------------------------------|
| $V_{CC}(5V)$             | Connected to 5V source                | Not Connected or <3.6V | Connected to 5V Source                | Connected to $V_{REG}(3.3V)$<br>[Max Drop of 0.3V]<br>(2.7V to 3.6V) |
| $V_{REG}(3.3V)$          | 3.3V, 300 $\mu$ A<br>Regulated Output | Not Connected          | 3.3V, 300 $\mu$ A<br>Regulated Output | Connected to 3.3V Source                                             |
| $V_{CCIO}$               | $\leq 0.5V$                           | 1.65V to 3.6V Source   | 1.65V to 3.6V Source                  | 1.65V to 3.6V Source                                                 |
| $V_{PU}(3.3V)$           | 3-STATE (off)                         | 3-STATE (off)          | 3.3V Available if<br>Config = HIGH    | 3.3V Available if<br>Config = HIGH                                   |
| D+, D-                   | 3-STATE (off)                         | 3-STATE                | Function of<br>Mode Set Up            | Function of<br>Mode Set Up                                           |
| $V_p/V_{po}, V_m/V_{mo}$ | Invalid [I]                           | L                      | Function of<br>Mode Set Up            | Function of<br>Mode Set Up                                           |
| RCV                      | Invalid [I]                           | L                      | Function of<br>Mode Set Up            | Function of<br>Mode Set Up                                           |
| Vbusmon                  | Invalid [I]                           | L                      | Function of<br>Mode Set Up            | Function of<br>Mode Set Up                                           |
| OE, SUSPND, Config       | Hi-Z                                  | Hi-Z                   | Function of<br>Mode Set Up            | Function of<br>Mode Set Up                                           |

### Notes:

6. Invalid [I] I/O are to be 3-STATE, outputs to be LOW.

## ESD Protection

### ESD Performance of the USB1T1103

- HBM D+/D-: 15.0kV
- HBM, all other terminals (Mil-Std 883E): 6.5kV

### ESD Protection: D+/D- Terminals

Since the differential terminals of a USB transceiver may be subjected to extreme ESD voltages, additional immunity has been included in the D+ and D- terminals without compromising performance. The USB1T1103 differential terminals have ESD protection to the following limits:

- 15kV using the contact Human Body Model
- 8kV using the Contact Discharge method as specified in IEC 61000-4-2

## Human Body Model

Figure 3 shows the schematic representation of the Human Body Model ESD event. Figure 4 is the ideal waveform representation of the Human Body Model.

### IEC 61000-4-2, IEC 60749-26 and IEC 60749-27

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment and evaluates the equipment in its entirety for ESD immunity. Fairchild Semiconductor has evaluated this device using the IEC 6100-4-2 representative system model depicted in Figure 5. Under the additional standards set forth by the IEC, this device is also compliant with IEC 60749-26 (HBM) and IEC 60749-27 (MM).

### Additional ESD Test Conditions

For additional information regarding our product test methodologies and performance levels, please contact Fairchild Semiconductor.

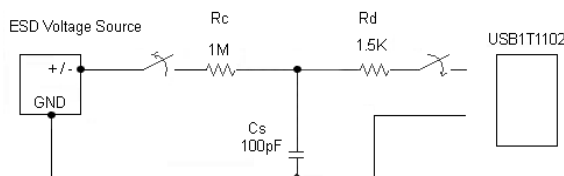


Figure 3. Human Body ESD Test Model

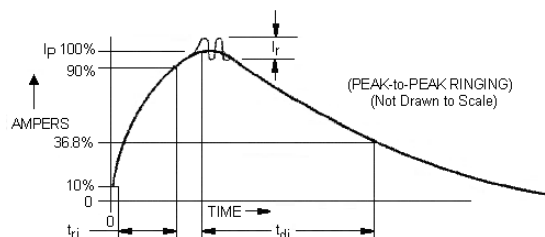


Figure 4. HBM Current Waveform

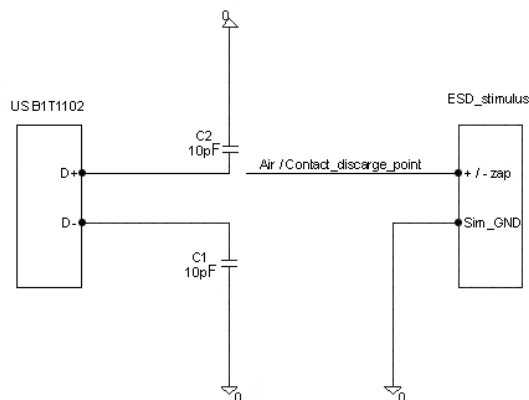


Figure 5. IEC 61000-4-2 ESD Test Model

## Absolute Maximum Ratings

The “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The “Recommended Operating Conditions” table defines the conditions for actual device operation.

| Symbol            | Parameter                                            | Min. | Max.             | Unit |
|-------------------|------------------------------------------------------|------|------------------|------|
| $V_{CC}$ (5V)     | Supply Voltage                                       | -0.5 | +6.0             | V    |
| $V_{CCIO}$        | I/O Supply Voltage                                   | -0.5 | +4.6             | V    |
| $I_{LU}$          | Latch-up Current, $V_I = -1.8V$ to $+5.4V$           |      | 150              | mA   |
| $I_{IK}$          | DC Input Current, $V_I < 0$                          |      | -18              | mA   |
| $V_I$             | DC Input Voltage <sup>(4)</sup>                      | -0.5 | $V_{CCIO} + 0.5$ | V    |
| $I_{OK}$          | DC Output Diode Current, $V_O > V_{CC}$ or $V_O < 0$ |      | $\pm 18$         | mA   |
| $V_O$             | DC Output Voltage <sup>(5)</sup>                     | -0.5 | $V_{CCIO} + 0.5$ | V    |
| $I_O$             | Output Source or Sink Current, $V_O + 0$ to $V_{CC}$ |      |                  |      |
|                   | Current for D+, D- Terminals                         |      | $\pm 12$         | mA   |
|                   | Current for RCV, $V_M/V_P$                           |      | $\pm 12$         | mA   |
| $I_{CC}, I_{GND}$ | DC $V_{CC}$ or GND Current                           |      | $\pm 100$        | mA   |
| $V_{ESD}$         | ESD Immunity Voltage                                 |      |                  |      |
|                   | Contact HBM                                          |      |                  |      |
|                   | Terminals D+, D-, $I_{LI} < 1\mu A$                  |      | $\pm 15$         | kV   |
|                   | All other Terminals $I_{LI} < 1\mu A$                |      | $\pm 6.5$        | kV   |
| $T_{STG}$         | Storage Temperature                                  | -40  | +150             | °C   |
| $P_{TOT}$         | Power Dissipation                                    |      |                  |      |
|                   | $I_{CC}$ (5V)                                        |      | 48               | mW   |
|                   | $I_{CCIO}$                                           |      | 9                | mW   |

### Notes:

7. IO Absolute Maximumun Rating must be observed.
8. Per ESD Methodology described on page 6.

## Recommended Operation Conditions

| Symbol     | Parameter                                   | Min. | Max.             | Unit |
|------------|---------------------------------------------|------|------------------|------|
| $V_{CC}$   | Supply Voltage                              | 4.0  | 5.5              | V    |
| $V_{CC10}$ | I/O DC Voltage                              | 1.65 | 3.6              | V    |
| $V_I$      | DC Input Voltage Range                      | 0    | $V_{CCIO} + 5.5$ | V    |
| $V_{AI/O}$ | DC Input Range for AI/O, Terminal D+ and D- | 0    | 3.6              | V    |
| $T_A$      | Operating Ambient Temperature               | -40  | +85              | °C   |

## DC Electrical Characteristics

### Supply Terminals

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).

$V_{CC}$  (5V) = 4.0V to 5.5V or  $V_{REG}$  (3.3V) = 3.0V to 3.6V,  $V_{CCIO}$  = 1.65V to 3.6V.

| Symbol                                          | Parameter                                                   | Conditions                                                                                                  | Limits                 |                     |                      | Units |
|-------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------|---------------------|----------------------|-------|
|                                                 |                                                             |                                                                                                             | -40°C to +85°C         |                     |                      |       |
|                                                 |                                                             |                                                                                                             | Min.                   | Typ.                | Max.                 |       |
| V <sub>REG</sub> (3.3V)                         | Regulated Supply Output                                     | Internal Regulator Option; I <sub>LOAD</sub> ≤300 μA                                                        | 3.0 <sup>(9)(10)</sup> | 3.3                 | 3.6                  | V     |
| I <sub>CC</sub>                                 | Operating Supply Current (V <sub>CC</sub> 5.0)              | Transmitting and Receiving at 12 Mb/s; C <sub>LOAD</sub> = 50 pF (D+, D-)                                   |                        | 4.0 <sup>(11)</sup> | 8.0                  | mA    |
| I <sub>CCIO</sub>                               | I/O Operating Supply Current                                | Transmitting and Receiving at 12 Mb/s                                                                       |                        | 1.0 <sup>(11)</sup> | 2.0                  | mA    |
| I <sub>CC</sub> (IDLE)                          | Supply Current during FS IDLE and SE0 (V <sub>CC</sub> 5.0) | IDLE: V <sub>D+</sub> + ≤2.7V, V <sub>D-</sub> ≤ 0.3V; SE0: V <sub>D+</sub> + ≤ 0.3V, V <sub>D-</sub> ≤0.3V |                        |                     | 300 <sup>(12)</sup>  | μA    |
| I <sub>CCIO</sub> (STATIC)                      | I/O Static Supply Current                                   | IDLE, SUSPEND or SE0                                                                                        |                        |                     | 20.0                 | μA    |
| I <sub>CC</sub> (DISABLE)                       | Disable Supply Current                                      | V <sub>CCIO</sub> = 0V<br>V <sub>CC</sub> Connected                                                         |                        |                     | 25.0                 | μA    |
| I <sub>CC</sub> (SUSPEND)                       | Suspend Supply Current<br>USB1T1103                         | SUSPEND = HIGH<br>OE = HIGH<br>V <sub>m</sub> = V <sub>p</sub> = OPEN                                       |                        |                     | 25.0 <sup>(12)</sup> | μA    |
| I <sub>CCIO</sub> (SHARING)                     | I/O Sharing Mode Supply Current                             | V <sub>CC</sub> (5V) Not Connected                                                                          |                        |                     | 20.0                 | μA    |
| ID+ (SHARING)<br>I <sub>D</sub> +/-             | Sharing Mode Load Current on D+/D- Terminals                | V <sub>CC</sub> (5V) Not Connected<br>Config = LOW; V <sub>D±</sub> = 3.6V                                  |                        |                     | 10.0                 | μA    |
| I <sub>D+</sub> (DISABLE)<br>I <sub>D</sub> +/- | Disable Mode Load Current on D+/D- Terminals                | V <sub>CCIO</sub> Not Connected or 0V<br>Config = V <sub>D</sub> ± = 3.6V LOW or HIGH                       |                        |                     | 10.0                 | μA    |
| V <sub>CCTH</sub>                               | V <sub>CC</sub> Threshold Detection Voltage                 | 1.65V ≤ V <sub>CCIO</sub> ≤3.6V                                                                             |                        |                     |                      | V     |
|                                                 |                                                             | Supply Lost                                                                                                 |                        |                     | 3.6                  |       |
|                                                 |                                                             | Supply Present                                                                                              | 4.1                    |                     |                      |       |
| V <sub>CCHYS</sub>                              | V <sub>CC</sub> Threshold Detection Hysteresis Voltage      | V <sub>CCIO</sub> = 1.8V                                                                                    |                        | 70.0                |                      | mV    |
| V <sub>CCIO</sub> TH                            | V <sub>CCIO</sub> Threshold Detection Voltage               | 2.7V ≤ V <sub>REG</sub> ≤ 3.6V                                                                              |                        |                     |                      | V     |
|                                                 |                                                             | Supply Lost                                                                                                 |                        |                     | 0.5                  |       |
|                                                 |                                                             | Supply Present                                                                                              | 1.4                    |                     |                      |       |
| V <sub>CCIO</sub> HYS                           | V <sub>CCIO</sub> Threshold Detection Hysteresis Voltage    | V <sub>REG</sub> = 3.3V                                                                                     |                        | 450                 |                      | mV    |
| V <sub>REG</sub> TH                             | Regulated Supply Threshold Detection Voltage                | 1.65V ≤ V <sub>CCIO</sub> ≤ V <sub>REG</sub><br>2.7V ≤ V <sub>REG</sub> ≤ 3.6V                              |                        |                     |                      | V     |
|                                                 |                                                             | Supply Lost                                                                                                 |                        |                     | 0.8                  |       |
|                                                 |                                                             | Supply Present                                                                                              | 2.4 <sup>(14)</sup>    |                     |                      |       |
| V <sub>REG</sub> HYS <sup>(15)</sup>            | Regulated Supply Threshold Detection Hysteresis Voltage     | V <sub>CCIO</sub> = 1.8V                                                                                    |                        | 450                 |                      | mV    |

#### Notes:

9.  $I_{LOAD}$  includes the pull-up resistor current via terminal  $V_{PU}$

10. The minimum voltage in Suspend mode is 2.7V.

11. Not tested in production, value based on characterization.

12. Excludes any current from load and  $V_{PU}$  current to the 1.5k $\Omega$  resistor.

13. Includes current between  $V_{pu}$  and the 1.5k internal pull-up resistor.

14. When  $V_{CCIO} < 2.7V$ , minimum value for  $V_{REG TH} = 2.0V$  for supply present condition.

15. DC electrical measurements should be taken with unused inputs and I/O pins connected to a valid logic level. This applies for all modes of device operation defined in the Functional Tables on Page 4.

## DC Electrical Characteristics

### Digital Terminals – excludes D+, D- Terminals

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).

$V_{CCIO} = 1.65V$  to  $3.6V$ .

| Symbol                             | Parameter                 | Conditions                        | Limits                              |                       | Units |
|------------------------------------|---------------------------|-----------------------------------|-------------------------------------|-----------------------|-------|
|                                    |                           |                                   | -40C° to +85°C                      |                       |       |
|                                    |                           |                                   | Min.                                | Max.                  |       |
| Input Levels                       |                           |                                   |                                     |                       |       |
| V <sub>IL</sub>                    | LOW Level Input Voltage   |                                   |                                     | 0.3*V <sub>CCIO</sub> | V     |
| V <sub>IH</sub>                    | HIGH Level Input Voltage  |                                   | 0.6*V <sub>CCIO</sub>               |                       | V     |
| Output Levels                      |                           |                                   |                                     |                       |       |
| V <sub>OL</sub>                    | LOW Level Output Voltage  | I <sub>OL</sub> = 2 mA            |                                     | 0.4                   | V     |
|                                    |                           | I <sub>OL</sub> = 100 =μA         |                                     | 0.15                  |       |
| V <sub>OH</sub>                    | HIGH Level Output Voltage | I <sub>OH</sub> = 2 mA            | V <sub>CCIO</sub> - <sup>0.4</sup>  |                       | V     |
|                                    |                           | I <sub>OH</sub> = 100 =μA         | V <sub>CCIO</sub> - <sup>0.15</sup> |                       |       |
| Leakage Current                    |                           |                                   |                                     |                       |       |
| I <sub>LI</sub>                    | Input Leakage Current     | V <sub>CCIO</sub> = 1.65V to 3.6V |                                     | ±1.0 <sup>(16)</sup>  | μA    |
| Capacitance                        |                           |                                   |                                     |                       |       |
| C <sub>IN</sub> , C <sub>I/O</sub> | Input Capacitance         | Terminal to GND                   |                                     | 10.0                  | pF    |

#### Notes:

16. If  $V_{CCIO} \geq V_{REG}$ , leakage current is higher than specified.

## DC Electrical Characteristics

### Analog I/O Terminals – D+, D- Terminals

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).

$V_{CC} = 4.0V$  to  $5.5V$  or  $V_{REG} = 3.0V$  to  $3.6V$ .

| Symbol                               | Parameter                                 | Conditions                              | Limits         |      |      | Units |
|--------------------------------------|-------------------------------------------|-----------------------------------------|----------------|------|------|-------|
|                                      |                                           |                                         | -40°C to +85°C |      |      |       |
|                                      |                                           |                                         | Min.           | Typ. | Max. |       |
| Input Levels – Differential Receiver |                                           |                                         |                |      |      |       |
| V <sub>DI</sub>                      | Differential Input Sensitivity            | V <sub>I(D+)</sub> - V <sub>I(D-)</sub> | 0.2            |      |      | V     |
| V <sub>CM</sub>                      | Differential Common Mode Voltage          |                                         | 0.8            |      | 2.5  | V     |
| Input Levels – Single-ended Receiver |                                           |                                         |                |      |      |       |
| V <sub>IL</sub>                      | LOW Level Input Voltage                   |                                         |                |      | 0.8  | V     |
| V <sub>IH</sub>                      | HIGH Level Input Voltage                  |                                         | 2.0            |      |      | V     |
| V <sub>HYS</sub>                     | Hysteresis Voltage                        |                                         | 0.30           |      | 0.7  | V     |
| Output Levels                        |                                           |                                         |                |      |      |       |
| V <sub>OL</sub>                      | LOW Level Output Voltage                  | R <sub>L</sub> = 1.5kΩ to 3.6V          |                |      | 0.3  | V     |
| V <sub>OH</sub>                      | HIGH Level Output Voltage <sup>(17)</sup> | R <sub>L</sub> = 15kΩ to GND            | 2.8            |      | 3.6  | V     |
| Leakage Current                      |                                           |                                         |                |      |      |       |
| I <sub>OFF</sub>                     | Input Leakage Current Off State           |                                         |                |      | ±1.0 | μA    |
| CAPACITANCE                          |                                           |                                         |                |      |      |       |
| C <sub>I/O</sub>                     | I/O Capacitance                           | Terminal to GND                         |                |      | 20.0 | pF    |
| Resistance                           |                                           |                                         |                |      |      |       |

| Symbol            | Parameter                               | Conditions                    | Limits         |      |      | Units |
|-------------------|-----------------------------------------|-------------------------------|----------------|------|------|-------|
|                   |                                         |                               | -40°C to +85°C |      |      |       |
|                   |                                         |                               | Min.           | Typ. | Max. |       |
| Z <sub>DRV</sub>  | Driver Output Impedance <sup>(18)</sup> |                               | 34.0           | 41.0 | 44.0 | Ω     |
| Z <sub>IN</sub>   | Driver Input Impedance                  |                               | 10.0           |      |      | MΩ    |
| R <sub>SW</sub>   | Switch Resistance                       |                               |                |      | 10.0 | Ω     |
| V <sub>TERM</sub> | Termination Voltage <sup>(19)(20)</sup> | R <sub>PU</sub> Upstream Port | 3.0            |      | 3.6  | V     |

**Notes:**

17. If V<sub>OH</sub> minimum = V<sub>REG</sub> - 0.2V.

18. Includes external resistors of 27Ω on both D+ and D- terminals.

19. This voltage is available at terminal V<sub>PU</sub> and V<sub>REG</sub>.

20. Minimum voltage is 2.7V in the suspend mode.

## AC Electrical Characteristics

### A I/O Terminals Full Speed

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).

V<sub>CC</sub> = 4.0V to 5.5V or V<sub>REG</sub> = 3.0V to 3.6V, V<sub>CCIO</sub> = 1.65V to 3.6V, C<sub>L</sub> = 50 pF; R<sub>L</sub> = 1.5K on D+ to V<sub>PU</sub>.

| Symbol                 | Parameter                                                                      | Conditions                                                                   | Limits         |      |       | Unit |
|------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------|------|-------|------|
|                        |                                                                                |                                                                              | -40°C to +85°C |      |       |      |
|                        |                                                                                |                                                                              | Min.           | Typ. | Max.  |      |
| Driver Characteristics |                                                                                |                                                                              |                |      |       |      |
| t <sub>R</sub>         | Output Rise Time                                                               | C <sub>L</sub> = 50 - 125 pF<br>10% to 90%                                   | 4.0            |      | 20.0  | ns   |
| t <sub>F</sub>         | Output Fall Time                                                               | Figure 8, 12                                                                 | 4.0            |      | 20.0  |      |
| t <sub>RFM</sub>       | Rise/Fall Time Match                                                           | t <sub>F</sub> / t <sub>R</sub> Excludes First Transition<br>from Idle State | 90.0           |      | 111.1 | %    |
| V <sub>CRS</sub>       | Output Signal Crossover Voltage <sup>(21)</sup>                                | Excludes First Transition from<br>Idle State see Waveform                    | 1.3            |      | 2.0   | V    |
| Driver Timing          |                                                                                |                                                                              |                |      |       |      |
| t <sub>PLH</sub>       | Propagation Delay                                                              | Figures 9,12                                                                 |                |      | 18.0  | ns   |
| t <sub>PHL</sub>       | (V <sub>p</sub> /V <sub>po</sub> , V <sub>m</sub> /V <sub>mo</sub> to D+/D-)   |                                                                              |                |      |       |      |
| t <sub>PHZ</sub>       | Driver Disable Delay                                                           | Figures 11,12                                                                |                |      | 15.0  | ns   |
| t <sub>PLZ</sub>       | (OE to D+/D-)                                                                  |                                                                              |                |      |       |      |
| t <sub>PZH</sub>       | Driver Enable Delay                                                            | Figures 11,13                                                                |                |      | 15.0  | ns   |
| t <sub>PZL</sub>       | (OE to D+/D-)                                                                  |                                                                              |                |      |       |      |
| Receiver Timing        |                                                                                |                                                                              |                |      |       |      |
| t <sub>PLH</sub>       | Propagation Delay (Diff)                                                       | Figures 10,14                                                                |                |      | 15.0  | ns   |
| t <sub>PHL</sub>       | (D+/D- to Rev)                                                                 |                                                                              |                |      |       |      |
| t <sub>PLH</sub>       | Single-Ended Receiver Propagation Delay                                        | Figures 10,14                                                                |                |      | 18.0  | ns   |
| t <sub>PHL</sub>       | (D+/D- to V <sub>p</sub> / V <sub>po</sub> , V <sub>m</sub> /V <sub>mo</sub> ) |                                                                              |                |      |       |      |

**NOTES:**

21. Not production tested; limits guaranteed by design.

## Typical Application Configurations

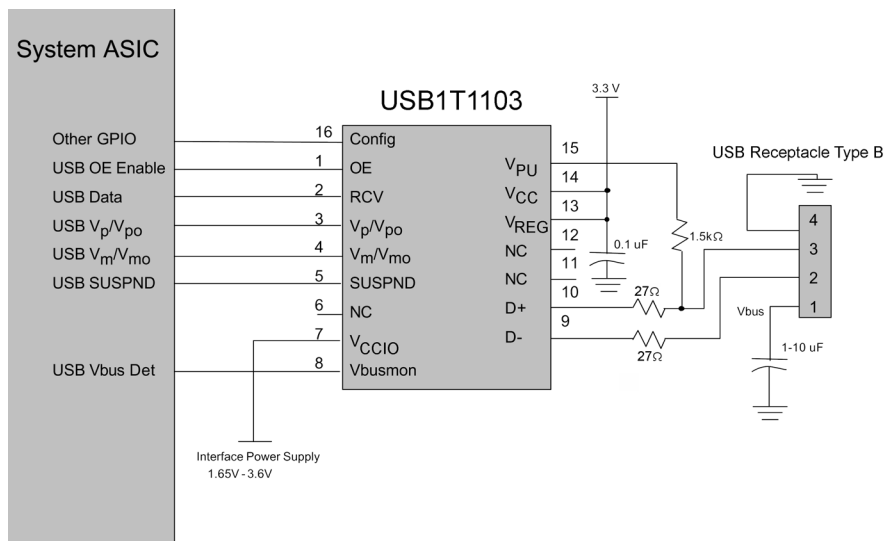


Figure 6. Upstream Connection in Bypass Mode with Differential Outputs

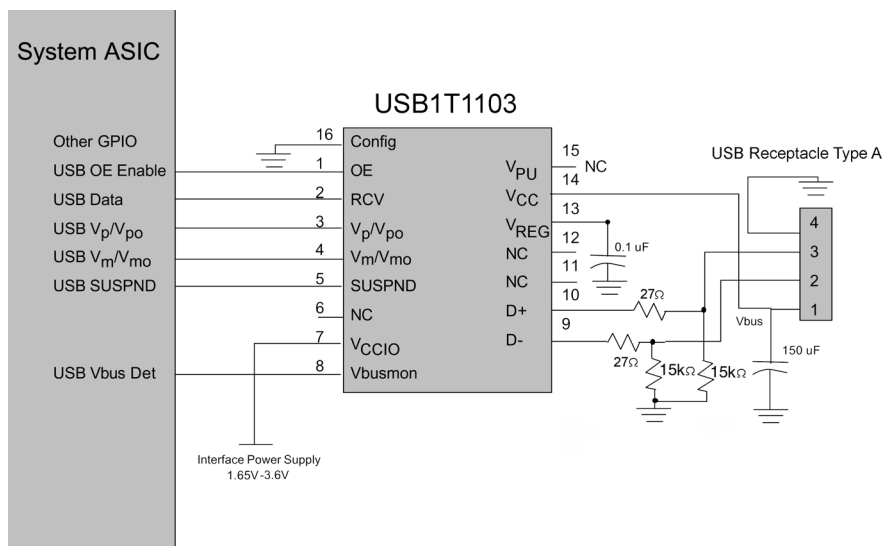


Figure 7. Downstream Connection in Normal Mode with Differential Outputs

## AC Waveforms

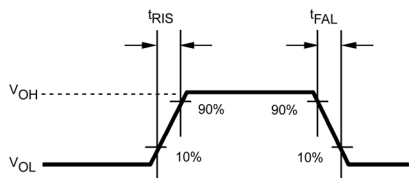


Figure 8. Rise and Fall Times

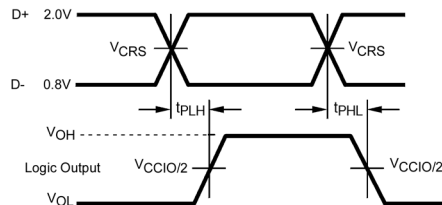


Figure 10. D+/D- to  $R_{CV}$ ,  $V_{po}/V_p$  and  $V_{mo}/V_m$

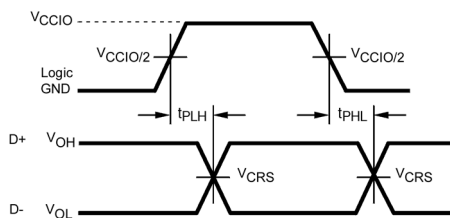


Figure 9.  $V_{po}$ ,  $V_{mo}$  to D+/D-

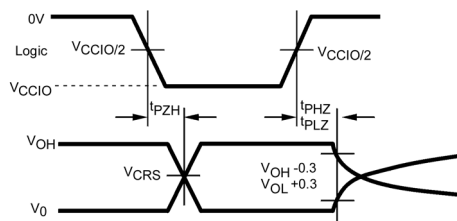
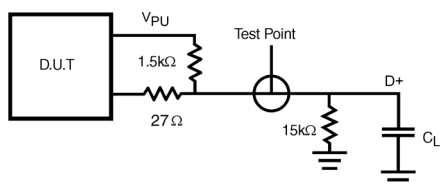


Figure 11.  $\overline{OE}$  to D+/D-

## Test Circuits and Waveforms



$C_L = 50$  pF Full Speed Propagation Delays

$C_L = -125$  pF Edge Rates only

Figure 12. Load for D+/D-

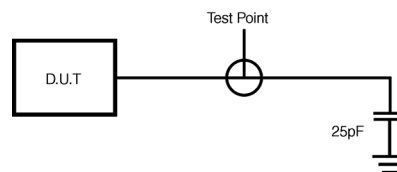
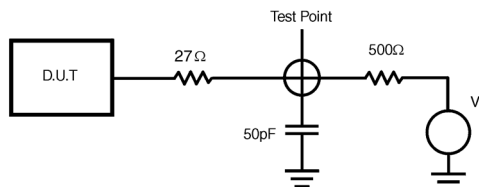


Figure 14. Load for  $V_m/V_{mo}$ ,  $V_p/V_{po}$  and  $R_{CV}$



$V = 0$  for  $t_{PZH}$ ,  $t_{PHZ}$

$V = V_{REG}$  for  $t_{PZL}$

Figure 13. Load for Enable and Disable Times

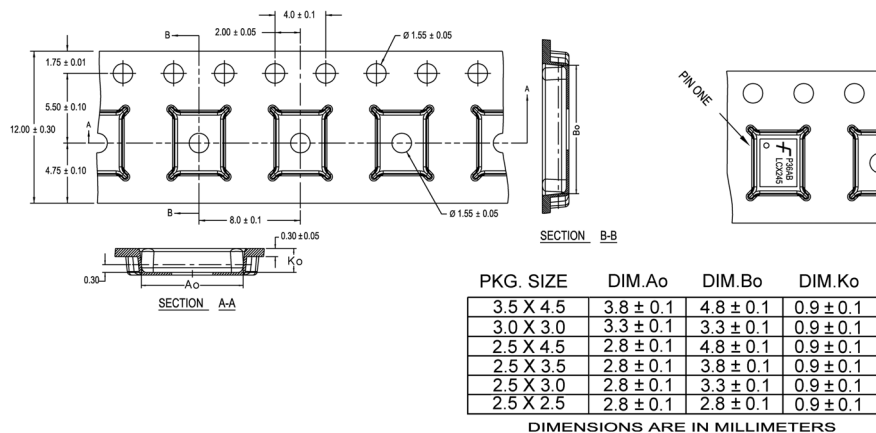
## Tape and Reel Specification

### Tape Format for MHBCC and MLP

| Package Designator | Tape Section       | Number Cavities | Cavity Status | Cover Tape Status |
|--------------------|--------------------|-----------------|---------------|-------------------|
| MHX/MPX            | Leader (Start End) | 125 (typ)       | Empty         | Sealed            |
|                    | Carrier            | 2500/3000       | Filled        | Sealed            |
|                    | Trailer (Hub End)  | 75 (typ)        | Empty         | Sealed            |

### TAPE DIMENSIONS

Dimensions are in inches (millimeters) unless otherwise specified.

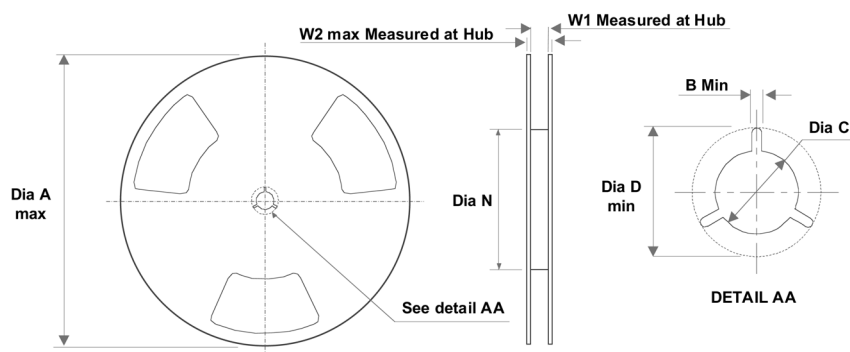


NOTES: unless otherwise specified

1. Cumulative pitch for feeding holes and cavities (chip pockets) not to exceed 0.008[0.20] over 10 pitch span.
2. Smallest allowable bending radius.
3. Thru hole inside cavity is centered within cavity.
4. Tolerance is  $\pm 0.002[0.05]$  for these dimensions on all 12mm tapes.
5. Ao and Bo measured on a plane 0.120[0.30] above the bottom of the pocket.
6. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
7. Pocket position relative to sprocket hole measured as true position of pocket. Not pocket hole.
8. Controlling dimension is millimeter. Dimension in inches rounded.

### REEL DIMENSIONS

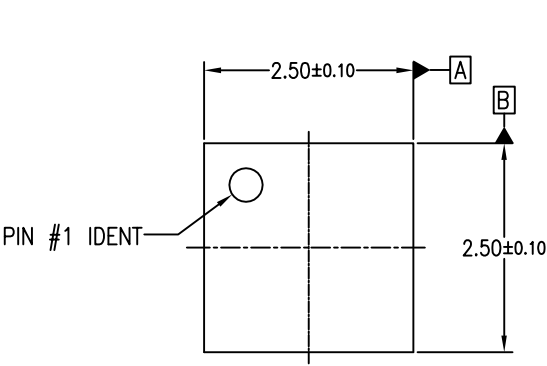
Dimensions are in inches (millimeters) unless otherwise specified.



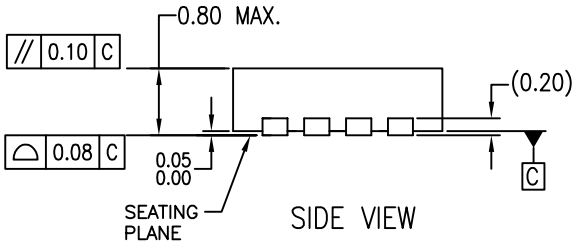
| Tape Size | A    | B      | C       | D       | N     | W1     | W2     |
|-----------|------|--------|---------|---------|-------|--------|--------|
| 12 mm     | 13.0 | 0.059  | 0.512   | 0.795   | 7.008 | 0.488  | 0.724  |
|           | 330  | (1.50) | (13.00) | (20.20) | (178) | (12.4) | (18.4) |

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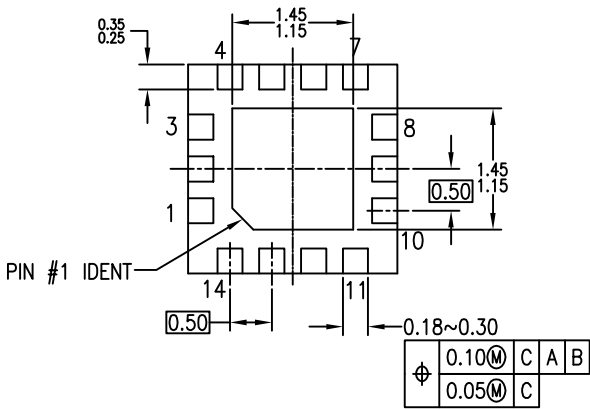
| REVISIONS |                             |      |           |          |
|-----------|-----------------------------|------|-----------|----------|
| LTR       | DESCRIPTION                 | EDCN | DATE      | BY/APP'D |
| A         | RELEASE TO DOCUMENT CONTROL |      | 25-2-2004 | FEITAN   |



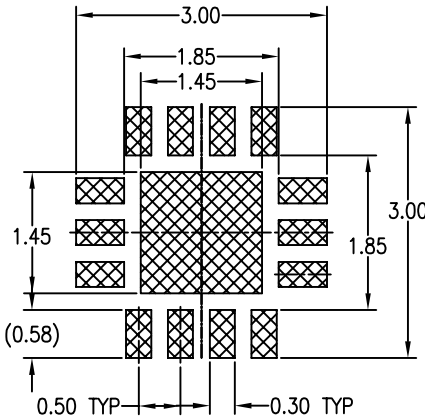
TOP VIEW



SIDE VIEW



BOTTOM VIEW



RECOMMENDED LAND PATTERN

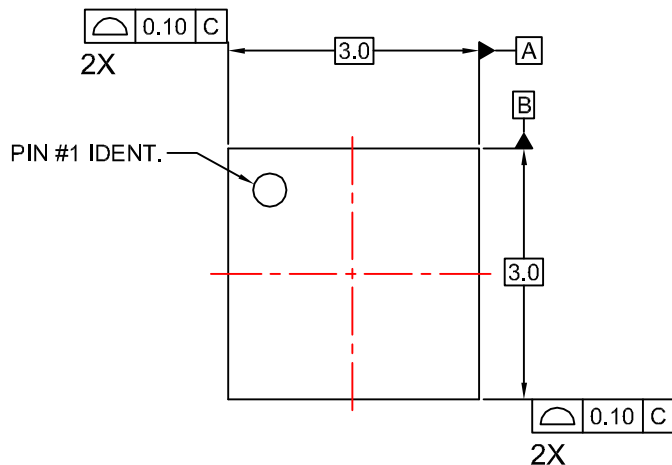
NOTES:

- A. NO JEDEC REGISTRATION
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

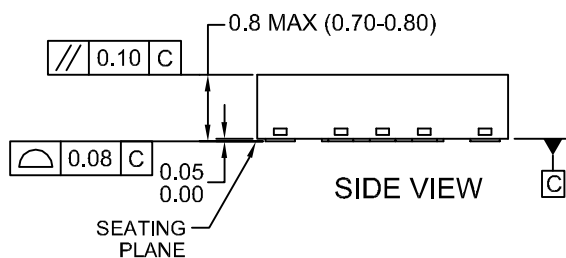
MLP14DrevA

|                                                                                                                                               |  |        |  |                                                                                              |      |                |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------|--|--------|--|----------------------------------------------------------------------------------------------|------|----------------|--------------|
| APPROVALS                                                                                                                                     |  | DATE   |  | <div>FAIRCHILD</div> <div>Bayan Lepas, FIZ,<br/>SEMICONDUCTOR 11900, Penang, Malaysia.</div> |      |                |              |
| DRAWN                                                                                                                                         |  | FEITAN |  |                                                                                              |      |                |              |
| DFTG. CHK.                                                                                                                                    |  |        |  |                                                                                              |      |                |              |
| ENGR. CHK.                                                                                                                                    |  |        |  |                                                                                              |      |                |              |
|                                                                                                                                               |  |        |  |                                                                                              |      |                |              |
|                                                                                                                                               |  |        |  | 14LD, MLP, 2.5MM SQUARE                                                                      |      |                |              |
| <div>PROJECTION</div> <div></div> <div>INCH<br/>[MM]</div> |  |        |  | SCALE                                                                                        | SIZE | DRAWING NUMBER | REV          |
|                                                                                                                                               |  |        |  | N/A                                                                                          | N/A  | MKT-MLP14D     | A            |
|                                                                                                                                               |  |        |  | DO NOT SCALE DRAWING                                                                         |      |                | SHEET 1 of 1 |

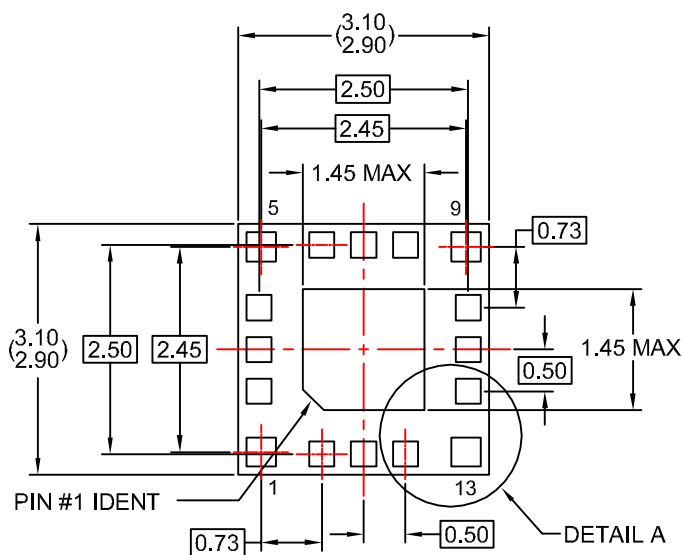
| REVISIONS |                                                                              |            |            |
|-----------|------------------------------------------------------------------------------|------------|------------|
| NBR       | DESCRIPTION                                                                  | DATE       | DRAWN/SITE |
| A         | RELEASE TO DOCUMENT CONTROL                                                  | 14-11-2003 | FEITAN     |
| 2         | UPDATED DRAWING AND ADDED NON ASME TOLERANCE REFERENCE VALUES FOR BODY DIMS. | 12-3-2008  | L. England |
| 3         | Fixed min package thickness typo in side view.                               | 4-29-2009  | L. England |
| 4         | Removed extra squares on Bottom View.                                        | 7-6-2009   | L. England |



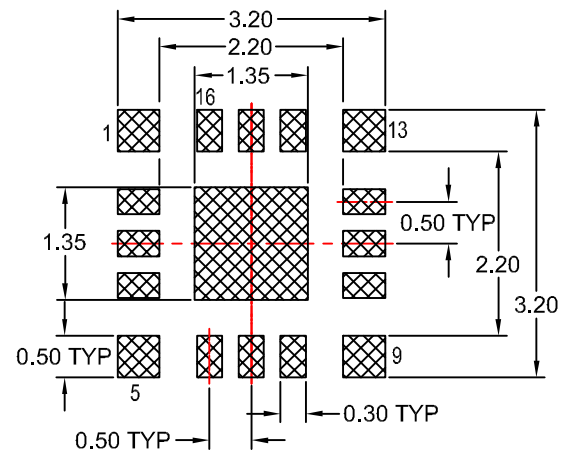
TOP VIEW



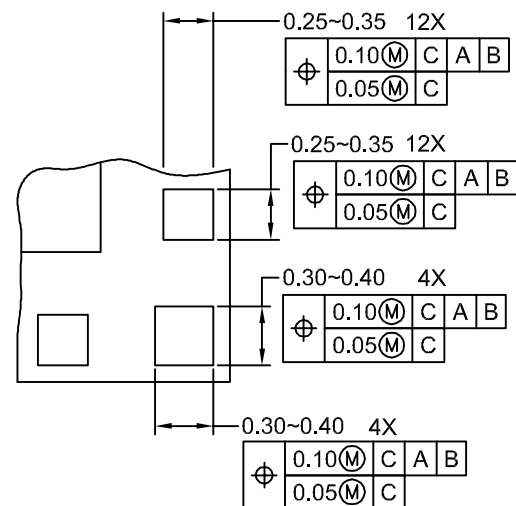
SIDE VIEW



BOTTOM VIEW



RECOMMENDED LAND PATTERN



DETAIL A

# NOTES:

- A. SIMILAR TO JEDEC REGISTRATION MO-217,
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994
- D. LANDPATTERN RECOMMENDATION IS PER FSC INTERNAL DESIGN
- E. DRAWING FILENAME: MLP16HBrev4

|                                                                                                                                                                    |            |          |                                                   |      |                |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------|---------------------------------------------------|------|----------------|-----|
| APPROVALS                                                                                                                                                          |            | DATE     | <div>FAIRCHILD</div> SEMICONDUCTOR®               |      |                |     |
| DRAWN                                                                                                                                                              | L. England | 7-6-2009 | 16LD, MLP, JEDEC MO-217<br>EQUIVALENT, 3MM SQUARE |      |                |     |
| DFTG. CHK.                                                                                                                                                         | S. Martin  | 7-6-2009 |                                                   |      |                |     |
| ENGR. CHK.                                                                                                                                                         |            |          |                                                   |      |                |     |
|                                                                                                                                                                    |            |          |                                                   |      |                |     |
|                                                                                                                                                                    |            |          |                                                   |      |                |     |
| <div><div><div></div><div></div><div></div><div></div></div><div>PROJECTION</div><div><div></div><div></div><div></div><div></div></div><div>INCH (MM)</div></div> |            |          | SCALE                                             | SIZE | DRAWING NUMBER | REV |
|                                                                                                                                                                    |            |          | N/A                                               | N/A  | MKT-MLP16HB    | 4   |
|                                                                                                                                                                    |            |          | DO NOT SCALE DRAWING                              |      | SHEET 1 of 1   |     |



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| AccuPower™                                                                                   | FRFET®                                                                              | PowerTrench®                                                                                       | The Power Franchise®                                                                        |
| Auto-SPM™                                                                                    | Global Power Resource™                                                              | PowerXS™                                                                                           | the power franchise                                                                         |
| Build it Now™                                                                                | Green FPS™                                                                          | Programmable Active Droop™                                                                         | TinyBoost™                                                                                  |
| CorePLUS™                                                                                    | Green FPS™ e-Series™                                                                | QFET®                                                                                              | TinyBuck™                                                                                   |
| CorePOWER™                                                                                   | Gmax™                                                                               | QS™                                                                                                | TinyCalc™                                                                                   |
| CROSSVOLT™                                                                                   | GTO™                                                                                | Quiet Series™                                                                                      | TinyLogic®                                                                                  |
| CTL™                                                                                         | IntelliMAX™                                                                         | RapidConfigure™                                                                                    | TINYOPTO™                                                                                   |
| Current Transfer Logic™                                                                      | ISOPLANAR™                                                                          |  ™                | TinyPower™                                                                                  |
| DEUXPEED®                                                                                    | MegaBuck™                                                                           | Saving our world, 1mW/W/kW at a time™                                                              | TinyPWM™                                                                                    |
| Dual Cool™                                                                                   | MICROCOUPLER™                                                                       | SignalWise™                                                                                        | TinyWire™                                                                                   |
| EcoSPARK®                                                                                    | MicroFET™                                                                           | SmartMax™                                                                                          | TriFault Detect™                                                                            |
| EfficientMax™                                                                                | MicroPak™                                                                           | SMART START™                                                                                       | TRUECURRENT™*                                                                               |
|  Fairchild® | MicroPak2™                                                                          | SPM®                                                                                               | µSerDes™                                                                                    |
| Fairchild Semiconductor®                                                                     | MillerDrive™                                                                        | STEALTH™                                                                                           |  SerDes™ |
| FACT Quiet Series™                                                                           | MotionMax™                                                                          | SuperFET™                                                                                          | UHC®                                                                                        |
| FACT®                                                                                        | Motion-SPM™                                                                         | SuperSOT™-3                                                                                        | Ultra FRFET™                                                                                |
| FAST®                                                                                        | OptoHiT™                                                                            | SuperSOT™-6                                                                                        | UniFET™                                                                                     |
| FastvCore™                                                                                   | OPTOLOGIC®                                                                          | SuperSOT™-8                                                                                        | VCX™                                                                                        |
| FETBench™                                                                                    | OPTOPLANAR®                                                                         | SupreMOS™                                                                                          | VisualMax™                                                                                  |
| FlashWriter®*                                                                                |  ™ | SyncFET™                                                                                           | XS™                                                                                         |
| FPS™                                                                                         | PDP SPM™                                                                            | Sync-Lock™                                                                                         |                                                                                             |
| F-PFS™                                                                                       | Power-SPM™                                                                          |  SYSTEM GENERAL®* |                                                                                             |

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2. A critical component in 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.

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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

| Datasheet Identification | Product Status        | Definition                                                                                                                                                                                          |
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