

# USB1T1104

## Universal Serial Bus Peripheral Transceiver with Voltage Regulator

### General Description

The USB1T1104 is an Universal Serial Bus Specification Rev 2.0 compliant transceiver. The device provides an USB interface for Full-Speed (12Mbit/s) USB applications. The USB1T1104 provides excellent flexibility, allowing differential and single ended inputs while an integrated voltage regulator sets the I/O level to 1.65V to 3.6V. Utilizing an integrated 5.0V to 3.3V voltage regulator, the part can be powered directly from the USB host ( $V_{BUS}$ ) to minimize the power consumed from the local sources while used in devices with low supply voltages.

The USB1T1104 provides 15kV ESD protection on the USB bus pins (D+/D-). This eliminates the need for any external ESD devices while providing excellent protection to larger and more expensive ASICs and USB controllers.

### 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 12Mbits/s speed data rates
- Ideal for portable electronic devices
- 15kV contact HBM ESD protection on bus pins
- 3.3mm leadless package
- Industry standard HBCC footprint is lead-free

### Applications

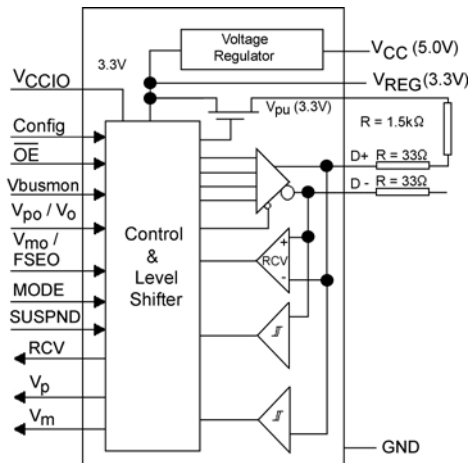
- Cell phone
- Digital camera
- MP3

### Ordering Code:

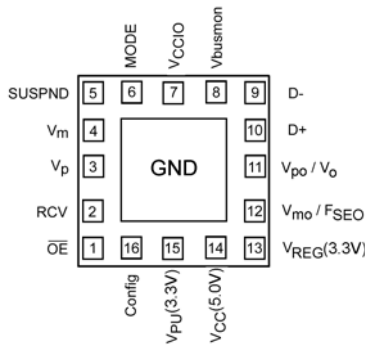
| Order Number | Package Number | Package Description   |
|--------------|----------------|---|
| USB1T1104MHX | MLP16HB        | Pb-Free 16-Terminal Molded Leadless Package (MHBCC), JEDEC MO-217, 3mm Square |

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

### Logic Diagram



## Connection Diagram



(Bottom View)

## Terminal Descriptions

| Terminal Number | Terminal Name      | I/O   | Terminal Description  |
|-----------------|--------------------|-------|---|
| 1               | $\overline{OE}$    | I     | Output Enable: 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               | RCV                | O     | Receive Data Output: 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 SEO condition.  |
| 3               | $V_p$              | O     | Single-ended D+ receiver output $V_p$ (CMOS level relative to $V_{CCIO}$ ): Used for external detection of SEO, error conditions, speed of connected device; Driven HIGH when no supply connected to $V_{CC}$ and $V_{REG}$ .   |
| 4               | $V_m$              | O     | Single-ended D- receiver output $V_m$ (CMOS level relative to $V_{CCIO}$ ): Used for external detection of SEO, error conditions, speed of connected device; Driven HIGH when no supply connected to $V_{CC}$ and $V_{REG}$ .   |
| 5               | SUSPND             | I     | Suspend: Enables a low power state (CMOS level is relative to $V_{CCIO}$ ). While the SUSPND pin is active (HIGH) it will drive the RCV pin to logic "0" state.   |
| 6               | MODE               | I     | MODE input (CMOS level is relative to $V_{CCIO}$ ). A HIGH selects the differential input MODE ( $V_{po}$ , $V_{mo}$ ) whereas a LOW enables the single-ended MODE ( $V_o$ , $V_{FSEO}$ ) see Table 2 and Table 4   |
| 7               | $V_{CCIO}$         |       | Supply Voltage for digital I/O pins (1.65V to 3.6V): When not connected the D+ and D- pins are in 3-STATE. This supply bus is totally independent of $V_{CC}$ (5V) and $V_{REG}$ (3.3V).  |
| 8               | Vbusmon            | O     | Vbus monitor output (CMOS level relative to $V_{CCIO}$ ): When $V_{bus} > 4.1V$ then $V_{busmon} = HIGH$ and when $V_{bus} < 3.6V$ then $V_{busmon} = LOW$ .  |
| 10, 9           | D+, D-             | A/I/O | Data +, Data -: Differential data bus conforming to the USB standard.   |
| 11              | $V_{po} / V_o$     | I     | Driver Data Input (CMOS level is relative to $V_{CCIO}$ ); Schmitt trigger input; see Table 2 and Table 3   |
| 12              | $V_{mo} / F_{SEO}$ | I     | Driver Data Input (CMOS level is relative to $V_{CCIO}$ ); Schmitt trigger input; see Table 2 and Table 3   |
| 13              | $V_{REG}$ (3.3V)   |       | Internal Regulator Option: Regulated supply output voltage (3.0V to 3.6V) during 5V operation; decoupling capacitor of at least 0.1 $\mu F$ is required.  |
| 14              | $V_{CC}$ (5.0V)    |       | Internal Regulator Option: Used as supply voltage input (4.0V to 5.5V); can be connected directly to USB line Vbus.   |
| 15              | $V_{PU}$ (3.3V)    |       | Pull-up Supply Voltage (3.3V $\pm$ 10%): Connect an external 1.5k $\Omega$ resistor on D+ (FS data rate); Pin function is controlled by Config input pin:<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). |
| 16              | Config             | I     | USB connect or disconnect software control input. Configures 3.3V to external 1.5k $\Omega$ resistor on D+ when HIGH.   |

| Terminal Number | Terminal Name | I/O | Terminal Description   |
|-----------------|---------------|-----|--|
| Exposed Diepad  | GND           | GND | GND supply down bonded to exposed diepad to be connected to the PCB GND. |

## Functional Description

The USB1T1104 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. The rise, fall times are balanced between the differential pins to minimize skew.

Table 1 describes the specific pin functionality selection. Table 2, Table 3, and Table 4 describe the specific Truth Tables for Driver and Receiver operating functions.

The USB1T1104 also has the capability of various power supply configurations to support mixed voltage supply applications (see Table 5) and Power Supply Configurations and Options for detailed descriptions.

## Functional Tables

**TABLE 1. Function Select**

| SUSPND | $\overline{OE}$ | D+, D-              | RCV               | $V_p/V_m$ | Function  |
|--------|-----------------|---------------------|-------------------|-----------|---|
| L      | L               | Driving & Receiving | Active            | Active    | Normal Driving (Differential Receiver Active)           |
| L      | H               | Receiving (Note 1)  | Active            | Active    | Receiving   |
| H      | L               | Driving             | Inactive (Note 2) | Active    | Driving during Suspend (Differential Receiver Inactive) |
| H      | H               | 3-STATE (Note 1)    | Inactive (Note 2) | Active    | Low Power State   |

**Note 1:** Signal levels is function of connection and/or pull-up/pull-down resistors.

**Note 2:** For SUSPND = HIGH mode the differential receiver is inactive and the output RCV output is forced LOW. The out-of-suspend signaling (K) is detected via the single-ended receiver outputs of the  $V_p$  and  $V_m$  pins.

**TABLE 2. Driver Function ( $\overline{OE} = L$ ) using Differential Input Interface Mode Pin = H**

| $V_{mo}$ | $V_{po}$ | Data                 |
|----------|----------|----------------------|
| L        | L        | SE0 (Note 3)         |
| L        | H        | Differential Logic 1 |
| H        | L        | Differential Logic 0 |
| H        | H        | Illegal State        |

**Note 3:** SE0 = Single Ended Zero

**TABLE 3. Driver Function ( $\overline{OE} = L$ ) using Single-ended Input Interface Mode Pin = L**

| FSE0 | $V_o$ | Data                 |
|------|-------|----------------------|
| L    | L     | Differential Logic 0 |
| L    | H     | Differential Logic 1 |
| H    | L     | SE0 (Note 4)         |
| H    | H     | SE0 (Note 4)         |

**Note 4:** SE0 = Single Ended Zero

TABLE 4. Receiver Function ( $\overline{OE} = H$ )

| D+, D-               | RCV | V <sub>p</sub> | V <sub>m</sub> |
|----------------------|-----|----------------|----------------|
| Differential Logic 1 | H   | H              | L              |
| Differential Logic 0 | L   | L              | H              |
| SE0                  | X   | L              | L              |
| Sharing Mode         | L   | H              | H              |

X = Don't Care

### Power Supply Configurations and Options

The three modes of power supply operation are:

- Normal Mode: Regulated Output

1. Regulated Output. V<sub>CCIO</sub> is connected and V<sub>CC</sub> (5.0) is connected to 5V (4.0V to 5.5V) and the internal voltage regulator then produces 3.3V for the USB connections.

For normal mode the V<sub>CCIO</sub> is an independent voltage source (1.65V to 3.6V) that is a function of the external circuit configuration.

- Sharing Mode: V<sub>CCIO</sub> is only supply connected. V<sub>CC</sub> and V<sub>REG</sub> are not connected. In this mode the D+ and D- pins are

3-STATE and the USB1T1104 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 μA) and V<sub>CCIO</sub> such that device is in low power (suspended) state. Pins Vbusmon and RCV are forced LOW as an indication of this mode with Vbusmon being ignored during this state.

- Disable Mode: V<sub>CCIO</sub> is not connected and V<sub>CC</sub>(5V) is connected. In this mode the D+ and D- pins are 3-STATE and the device is in low power state.

A summary of the Supply Configurations is described in Table 5.

TABLE 5. Power Supply Configuration Options

| Pins  | Power Supply Mode Configuration |                                  |                                    |
|---|---------------------------------|----------------------------------|------------------------------------|
|   | Sharing                         | Disable                          | Normal (Regulated Output)          |
| V <sub>CC</sub> (5V)  | < 3.6V                          | Connected to 5V Source           | Connected to 5V Source             |
| V <sub>REG</sub> (3.3V)   | Pulled LOW<br>Regulator OFF     | 3.3V, 300 μA<br>Regulated Output | 3.3V, 300 μA<br>Regulated Output   |
| V <sub>CCIO</sub>   | 1.65V to 3.6V Source            | Not Connected                    | 1.65V to 3.6V Source               |
| V <sub>PU</sub> (3.3V)  | 3-STATE (Off)                   | 3-STATE (Off)                    | 3.3V Available if<br>Config = HIGH |
| D+, D-  | 3-STATE                         | 3-STATE                          | Function of<br>Mode Set Up         |
| V <sub>p</sub> , V <sub>m</sub>   | H                               | Invalid                          | Function of<br>Mode Set Up         |
| RCV   | L                               | Invalid                          | Function of<br>Mode Set Up         |
| OE, SUSPND, Config,<br>V <sub>po</sub> /V <sub>o</sub> , V <sub>mo</sub> /F <sub>SEO</sub> , MODE | Hi-Z                            | Hi-Z                             | Function of<br>Mode Set Up         |

Note 5: Hi-Z or forced LOW.

## Absolute Maximum Ratings (Note 6)

|   |                            |
|---|----------------------------|
| Supply Voltage ( $V_{CC}$ )(5V)         | -0.5V to +6.0V             |
| I/O Supply Voltage ( $V_{CCIO}$ )       | -0.5V to +4.6V             |
| Latch-up Current ( $I_{LU}$ )           |                            |
| $V_I = -1.8V$ to +5.4V                  | 150 mA                     |
| DC Input Current ( $I_{IK}$ )           |                            |
| $V_I < 0$                               | -18 mA                     |
| DC Input Voltage ( $V_I$ )              |                            |
| (Note 7)                                | -0.5V to $V_{CCIO} + 0.5V$ |
| DC Output Diode Current ( $I_{OK}$ )    |                            |
| $V_O > V_{CC}$ or $V_O < 0$             | $\pm 18$ mA                |
| DC Output Voltage ( $V_O$ )             |                            |
| (Note 7)                                | -0.5V to $V_{CCIO} + 0.5V$ |
| Output Source or Sink Current ( $I_O$ ) |                            |
| $V_O = 0$ to $V_{CC}$                   |                            |
| Current for D+, D- Pins                 | $\pm 12$ mA                |
| Current for RCV, $V_m/V_p$              | $\pm 12$ mA                |
| DC $V_{CC}$ or GND Current              |                            |
| ( $I_{CC}$ , $I_{GND}$ )                | $\pm 100$ mA               |
| ESD Immunity Voltage ( $V_{ESD}$ ):     |                            |
| Contact HBM                             |                            |
| Pins D+, D-, and GND                    | 15kV                       |
| All Other Pins                          | 2.5kV                      |
| Storage Temperature ( $T_{STO}$ )       | -40°C to + 125°C           |
| Power Dissipation ( $P_{TOT}$ )         |                            |
| $I_{CC}$ (5V)                           | 48 mW                      |
| $I_{CCIO}$                              | 9 mW                       |

## Recommended Operating Conditions

|   |                         |
|---|-------------------------|
| DC Supply Voltage $V_{CC}$ (5V)         | 4.0V to 5.5V            |
| I/O DC Voltage $V_{CCIO}$               | 1.65V to 3.6V           |
| DC Input Voltage Range ( $V_I$ )        | 0V to $V_{CCIO} + 0.5V$ |
| DC Input Range for A/I/O ( $V_{IA/O}$ ) | 0V to 3.6V              |
| Pins D+ and D-                          | 0V to 3.6V              |
| Operating Ambient Temperature           |                         |
| ( $T_{AMB}$ )                           | -40°C to +85°C          |

**Note 6:** 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 Characteristic tables are not guaranteed at the absolute maximum rating. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

**Note 7:** IO Absolute Maximum Rating must be observed.

## DC Electrical Characteristics (Supply Pins)

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               |         |
| $V_{REG}$ (3.3V)     | Regulated Supply Output                                  | Internal Regulator Option;<br>$I_{LOAD} \leq 300 \mu A$   | 3.0<br>(Note 8)(Note 9) | 3.3              | 3.6               | V       |
| $I_{CC}$             | Operating Supply Current ( $V_{CC5.0}$ )                 | Transmitting and Receiving at<br>12 Mbits/s; $C_{LOAD} = 50$ pF (D+, D-)                        |                         | 4.0<br>(Note 10) | 8.0               | mA      |
| $I_{CCIO}$           | I/O Operating Supply Current                             | Transmitting and Receiving at<br>12 Mbits/s   |                         | 1.0<br>(Note 10) | 2.0               | mA      |
| $I_{CC}$ (IDLE)      | Supply Current during<br>FS IDLE and SE0 ( $V_{CC5.0}$ ) | IDLE: $V_{D+} \geq 2.7V$ , $V_{D-} \leq 0.3V$ ;<br>SE0: $V_{D+} \leq 0.3V$ , $V_{D-} \leq 0.3V$ |                         |                  | 500<br>(Note 11)  | $\mu A$ |
| $I_{CCIO}$ (STATIC)  | I/O Static Supply Current                                | IDLE, SUSPND or SE0   |                         |                  | 20.0              | $\mu A$ |
| $I_{CC}$ (SUSPND)    | Suspend Supply Current<br>USB1T1104                      | SUSPND = HIGH<br>$\overline{OE} = HIGH$<br>$V_m = V_p = OPEN$                                   |                         |                  | 25.0<br>(Note 11) | $\mu A$ |
| $I_{CCIO}$ (SHARING) | I/O Sharing Mode Supply Current                          | $V_{CC}$ (5V) Not Connected   |                         |                  | 20.0              | $\mu A$ |

### DC Electrical Characteristics (Continued)

| Symbol                   | Parameter  | Conditions   | Limits         |      |      | Units |
|--------------------------|--|--|----------------|------|------|-------|
|                          |  |  | -40°C to +85°C |      |      |       |
|                          |  |  | Min            | Typ  | Max  |       |
| I <sub>Dz(ShARING)</sub> | Sharing Mode Load Current on D+/D- Pins                  | V <sub>CC</sub> (5V) Not Connected<br>Config = LOW; V <sub>Dz</sub> = 3.6V |                |      | 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>CCIOTh</sub>      | 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>CCIOHYS</sub>     | V <sub>CCIO</sub> Threshold Detection Hysteresis Voltage | V <sub>REG</sub> = 3.3V  |                | 450  |      | mV    |

**Note 8:** I<sub>LOAD</sub> includes the pull-up resistor current via pin V<sub>PU</sub>

**Note 9:** The minimum voltage in Suspend mode is 2.7V.

**Note 10:** Not tested in production, value based on characterization.

**Note 11:** Excludes any current from load and V<sub>PU</sub> current to the 1.5kΩ resistor.

**Note 12:** Includes current between V<sub>pu</sub> and the 1.5k internal pull-up resistor.

**Note 13:** When V<sub>CCIO</sub> < 2.7V, minimum value for V<sub>REGTh</sub> = 2.0V for supply present condition.

### DC Electrical Characteristics (Digital Pins – excludes D+, D- Pins)

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted). V<sub>CCIO</sub> = 1.6V to 3.6V

| Symbol                            | Parameter                    | Test Conditions  | Limits                   |                   | Units |
|-----------------------------------|------------------------------|--|--------------------------|-------------------|-------|
|                                   |                              |  | -40°C to +85°C           |                   |       |
|                                   |                              |  | Min                      | Max               |       |
| <b>Input Levels</b>               |                              |  |                          |                   |       |
| V <sub>IL</sub>                   | LOW Level Input Voltage      |  |                          | 0.3               | V     |
| V <sub>IH</sub>                   | HIGH Level Input Voltage     |  | 0.6*V <sub>CCIO</sub>    |                   | V     |
| V <sub>HYS</sub>                  | Hysteresis Voltage P11 + P12 | Pins V <sub>pu</sub> /V <sub>mo</sub> , V <sub>CCIO</sub> = 3.3V | 0.30                     | 0.7               | V     |
| <b>Output Levels</b>              |                              |  |                          |                   |       |
| 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> - 0.4  |                   | V     |
|                                   |                              | I <sub>OH</sub> = 100 μA   | V <sub>CCIO</sub> - 0.15 |                   |       |
| <b>Leakage Current</b>            |                              |  |                          |                   |       |
| I <sub>LI</sub>                   | Input Leakage Current        | V <sub>CCIO</sub> = 1.65V to 3.6V                                |                          | ±1.0<br>(Note 14) | μA    |
| <b>Capacitance</b>                |                              |  |                          |                   |       |
| C <sub>IN</sub> , C <sub>IO</sub> | Input Capacitance            | Pin to GND   |                          | 10.0              | pF    |

**Note 14:** If V<sub>CCIO</sub> ≥ V<sub>REG</sub> then leakage current will be higher than specified.

## DC Electrical Characteristics (Analog I/O Pins – D+, D– Pins)

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                        | Test Condition               | Limits                        |                   |           | Units     |
|---|----------------------------------|------------------------------|-------------------------------|-------------------|-----------|-----------|
|   |                                  |                              | –40°C to +85°C                |                   |           |           |
|   |                                  |                              | Min                           | Typ               | Max       |           |
| <b>Input Levels – Differential Receiver</b> |                                  |                              |                               |                   |           |           |
| $V_{DI}$                                    | Differential Input Sensitivity   | $ V_{I(D+)} - V_{I(D-)} $    | 0.2                           |                   |           | V         |
| $V_{CM}$                                    | Differential Common Mode Voltage |                              | 0.8                           |                   | 2.5       | V         |
| <b>Input Levels – Single-ended Receiver</b> |                                  |                              |                               |                   |           |           |
| $V_{IL}$                                    | LOW Level Input Voltage          |                              |                               |                   | 0.8       | V         |
| $V_{IH}$                                    | HIGH Level Input Voltage         |                              | 2.0                           |                   |           | V         |
| $V_{HYS}$                                   | Hysteresis Voltage               |                              | 0.4                           |                   | 0.7       | V         |
| <b>Output Levels</b>                        |                                  |                              |                               |                   |           |           |
| $V_{OL}$                                    | LOW Level Output Voltage         | $R_L = 1.5k\Omega$ to $3.6V$ |                               |                   | 0.3       | V         |
| $V_{OH}$                                    | HIGH Level Output Voltage        | $R_L = 15k\Omega$ to GND     | 2.8<br>(Note 15)              |                   | 3.6       | V         |
| <b>Leakage Current</b>                      |                                  |                              |                               |                   |           |           |
| $I_{LZ}$                                    | Input Leakage Current Off State  | $\overline{OE} = H$          |                               |                   | $\pm 1.0$ | $\mu A$   |
| <b>Capacitance</b>                          |                                  |                              |                               |                   |           |           |
| $C_{I/O}$                                   | I/O Capacitance                  | Pin to GND                   |                               |                   | 20.0      | pF        |
| <b>Resistance</b>                           |                                  |                              |                               |                   |           |           |
| $Z_{DRV}$                                   | Driver Output Impedance          |                              | 34.0                          | 41.0<br>(Note 16) | 44.0      | $\Omega$  |
| $Z_{IN}$                                    | Driver Input Impedance           |                              | 10.0                          |                   |           | $M\Omega$ |
| $R_{SW}$                                    | Switch Resistance                |                              |                               |                   | 10.0      | $\Omega$  |
| $V_{TERM}$                                  | Termination Voltage              | $R_{PU}$ Upstream Port       | 3.0<br>(Note 17)<br>(Note 18) |                   | 3.6       | V         |

**Note 15:**  $V_{OH \text{ min.}} = V_{REG} - 0.2V$ .

**Note 16:** Includes external resistors of  $29\Omega$  on both D+ and D– pins.

**Note 17:** This voltage is available at pin  $V_{PU}$  and  $V_{REG}$ .

**Note 18:** Minimum voltage is  $2.7V$  in the suspend mode.

## AC Electrical Characteristics (A I/O Pins Full Speed)

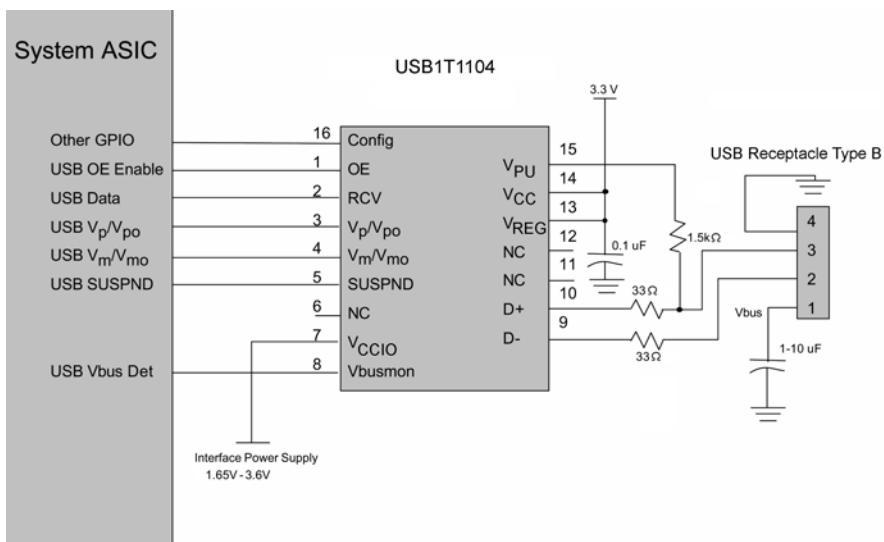
Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).  
 $V_{CC} = 4.0V$  to  $5.5V$  or  $V_{REG} = 3.0V$  to  $3.6V$ ,  $V_{CCIO} = 1.65V$  to  $3.6V$ ,  $C_L = 50$  pF;  $R_L = 1.5K$  on D+ to  $V_{PU}$

| Symbol                        | Parameter                               | Test Conditions   | Limits         |     |       | Unit |
|-------------------------------|---|---|----------------|-----|-------|------|
|                               |   |   | -40°C to +85°C |     |       |      |
|                               |   |   | Min            | Typ | Max   |      |
| <b>Driver Characteristics</b> |   |   |                |     |       |      |
| $t_{FR}$                      | Output Rise Time                        | $C_L = 50 - 125$ pF<br>10% to 90%                         | 4.0            |     | 20.0  | ns   |
| $t_{FF}$                      | Output Fall Time                        | Figures 1, 5  | 4.0            |     | 20.0  | ns   |
| $f_{RFM}$                     | Rise/Fall Time Match                    | $t_F / t_R$ Excludes First Transition from Idle State     | 90.0           |     | 111.1 | %    |
| $V_{CRS}$<br>(Note 19)        | Output Signal Crossover Voltage         | Excludes First Transition from Idle State<br>see Waveform | 1.3            |     | 2.0   | V    |
| <b>Driver Timing</b>          |   |   |                |     |       |      |
| $t_{PLH}$                     | Propagation Delay                       | Figures 2, 5  |                |     | 18.0  | ns   |
| $t_{PHL}$                     | ( $V_P/V_{PO}$ , $V_M/V_{MO}$ to D+/D-) |   |                |     |       |      |
| $t_{PHZ}$                     | Driver Disable Delay                    | Figures 4, 6  |                |     | 15.0  | ns   |
| $t_{PLZ}$                     | ( $\overline{OE}$ to D+/D-)             |   |                |     |       |      |
| $t_{PZH}$                     | Driver Enable Delay                     | Figures 4, 6  |                |     | 15.0  | ns   |
| $t_{PZL}$                     | ( $\overline{OE}$ to D+/D-)             |   |                |     |       |      |
| <b>Receiver Timing</b>        |   |   |                |     |       |      |
| $t_{PLH}$                     | Propagation Delay (Diff)                | Figures 3, 7  |                |     | 15.0  | ns   |
| $t_{PHL}$                     | (D+/D- to Rev)                          |   |                |     |       |      |
| $t_{PLH}$                     | Single Ended Receiver Propagation Delay | Figures 3, Figure 7                                       |                |     | 18.0  | ns   |
| $t_{PHL}$                     | (D+/D- to $V_P/V_{PO}$ , $V_M/V_{MO}$ ) |   |                |     |       |      |

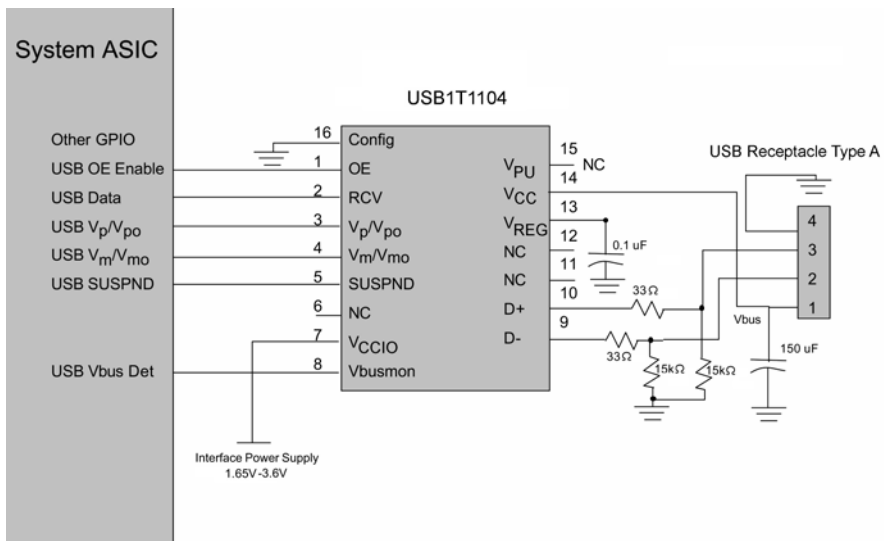
**Note 19:** Not production tested, guaranteed by characterization.



## Typical Application Configurations



Upstream Connection in Bypass Mode with Differential Outputs



Downstream Connection in Normal Mode with Differential Outputs

### AC Waveforms

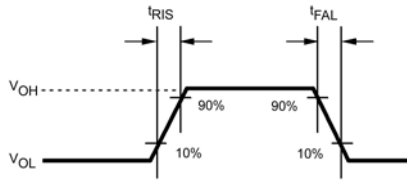


FIGURE 1. Rise and Fall Times

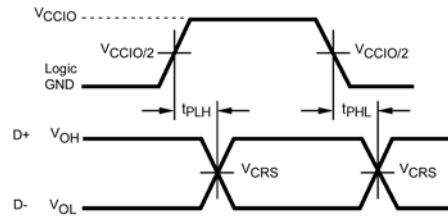


FIGURE 2.  $V_{po}/V_o$ ,  $V_{mo}/V_{SEO}$  to D+/D-

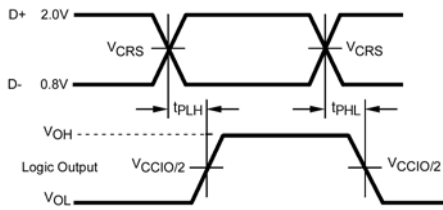


FIGURE 3. D+/D- to  $R_{CV}$ ,  $V_p$  and  $V_m$

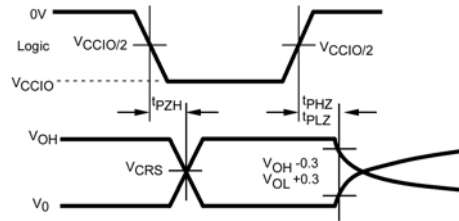
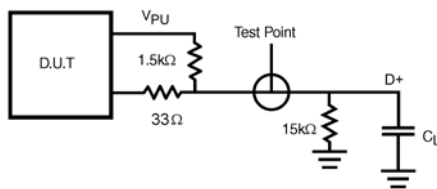


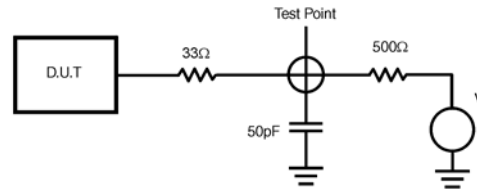
FIGURE 4.  $\overline{OE}$  to D+/D-

### Test Circuits and Waveforms



$C_L = 50$  pF Full Speed Propagation Delays  
 $C_L = -125$  pF Edge Rates only

FIGURE 5. Load for D+/D-



$V = 0$  for  $t_{PZH}$ ,  $t_{PHZ}$   
 $V = V_{REG}$  for  $t_{PZL}$

FIGURE 6. Load for Enable and Disable Times

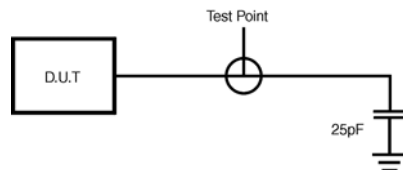


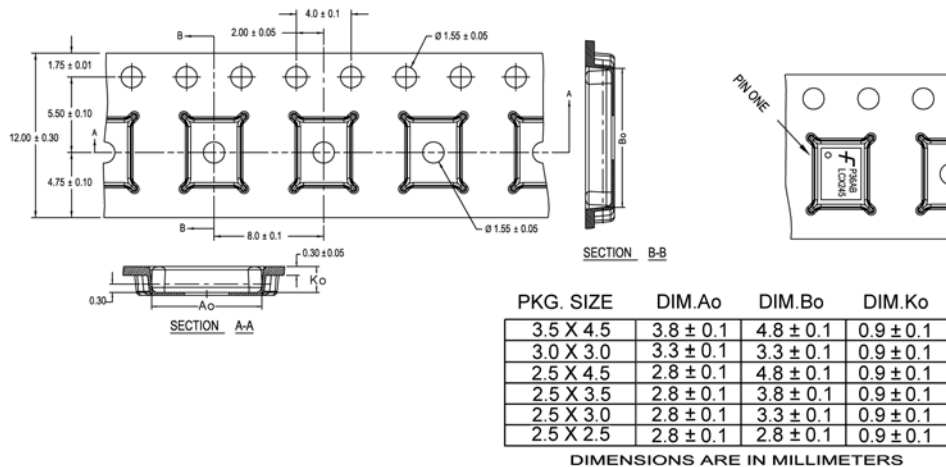
FIGURE 7. Load for  $V_m/V_{mo}$ ,  $V_p/V_{po}$  and  $R_{CV}$

# Tape and Reel Specification

## Tape Format for MHBCC

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

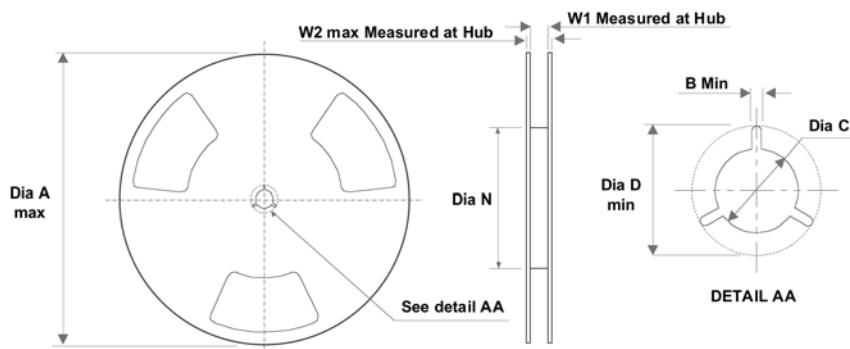
## TAPE DIMENSIONS inches (millimeters)



NOTES: unless otherwise specified

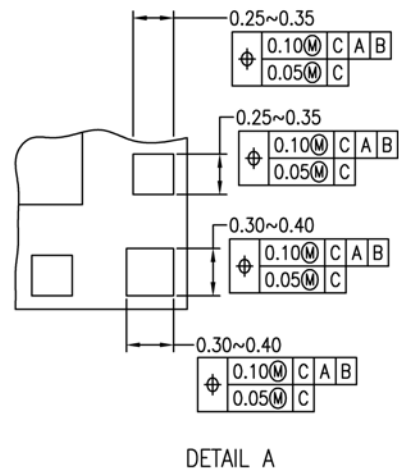
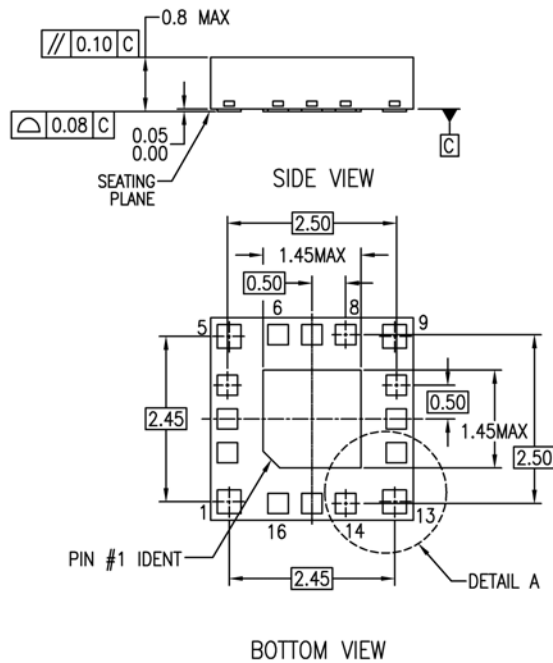
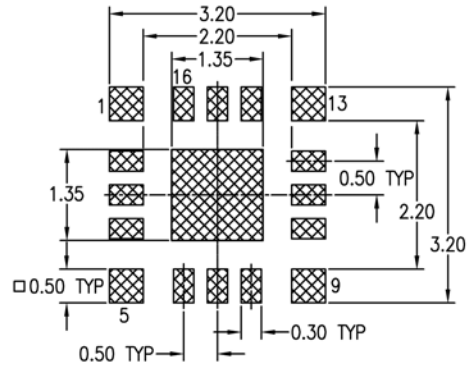
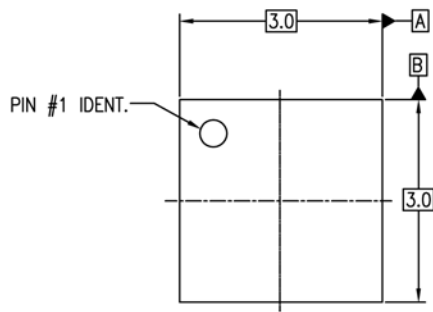
1. Cumulative pitch for feeding holes and cavities (chip pockets) not to exceed 0.008[0.20] over 10 pitch span.
2. Smallest allowable bending radius.
3. Thru hole inside cavity is centered within cavity.
4. Tolerance is  $\pm 0.002[0.05]$  for these dimensions on all 12mm tapes.
5. Ao and Bo measured 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 inches (millimeters)



| 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) |

**Physical Dimensions** inches (millimeters) unless otherwise noted



NOTES:

- A. SIMILAR TO JEDEC REGISTRATION MO-217, DATED 11/2001
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

MLP16HBrevA

**Pb-Free 16-Terminal Molded Leadless Package (MHBCC), JEDEC MO-217, 3mm Square Package Number MLP16HB**

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provided in the labeling, can be reasonably expected to result in significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

Definition of terms

| Datasheet Identification | Product Status         | Definition  |
|--------------------------|------------------------|---|
| Advance Information      | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.  |
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