

# 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
- Supports disable mode and is functionally equivalent to Philips ISP1102

### Applications

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

### 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



### Ordering Information

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

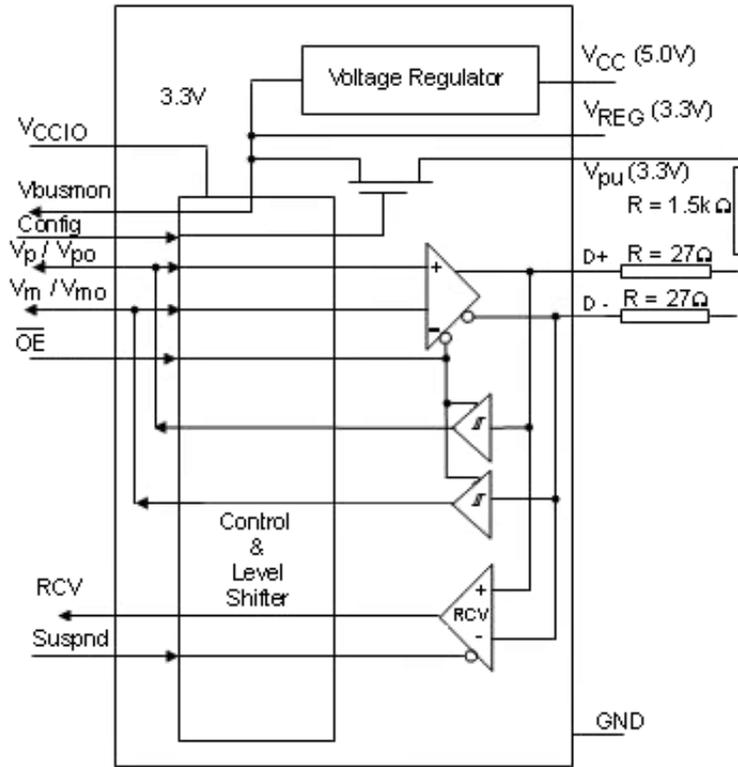


Figure 1. Logic Diagram

### Connection Diagrams

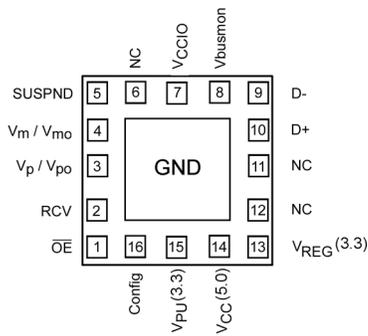


Figure 2. MLP16 GND Exposed Diepad (Bottom View)

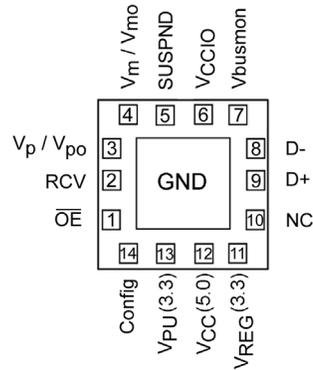


Figure 3. MLP14 GND Exposed Diepad (Bottom View)

## Terminal Descriptions

Terminal Number		Terminal Name	I/O	Terminal Description
MLP14	MLP16			
1	1	OE	I	Output Enable: 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: 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 $V_{CCIO}$ ): 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). 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 $V_{CCIO}$ ): 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). Output drive is 4 mA buffer.
5	5	SUSPND	I	Suspend: 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): 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 $V_{CCIO}$ ): 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-	A/I/O	Data +, Data -: 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 $V_{REG}/Vbus < V_{REG}$ minimum.
10	11	NC		No Connect
—	12	NC		No Connect
11	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. Regulator ByPass Option: Used as supply voltage input for 3.3V operation.
12	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. Regulator ByPass Option: Connected to $V_{REG}$ (3.3V)
13	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); Terminal function is controlled by Config input terminal: Config = LOW - $V_{PU}$ (3.3V) is floating (HIGH Impedance) for zero pull-up current. Config = HIGH - $V_{PU}$ (3.3V) = 3.3V; internally connected to $V_{REG}$ (3.3V). $V_{PU}$ is OFF in disable mode.
14	16	Config	I	USB connect or disconnect software control input. 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 (12Mbits/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 (Regulated Output)	Normal (Regulator Bypass)
$V_{CC}(5V)$	Connected to 5V source	Not Connected or <3.6V	Connected to 5V Source	Connected to $V_{REG}(3.3V)$ [Max Drop of 0.3V] (2.7V to 3.6V)
$V_{REG}(3.3V)$	3.3V, 300 $\mu$ A Regulated Output	Not Connected	3.3V, 300 $\mu$ A 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 Config = HIGH	3.3V Available if Config = HIGH
D+, D-	3-STATE (off)	3-STATE	Function of Mode Set Up	Function of Mode Set Up
$V_p/V_{po}, V_m/V_{mo}$	Invalid [!]	L	Function of Mode Set Up	Function of Mode Set Up
RCV	Invalid [!]	L	Function of Mode Set Up	Function of Mode Set Up
Vbusmon	Invalid [!]	L	Function of Mode Set Up	Function of Mode Set Up
OE, SUSPND, Config	Hi-Z	Hi-Z	Function of Mode Set Up	Function of Mode Set Up

### Notes:

6. Invalid [!] 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.

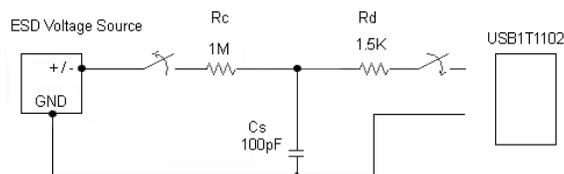


Figure 3. Human Body ESD Test Model

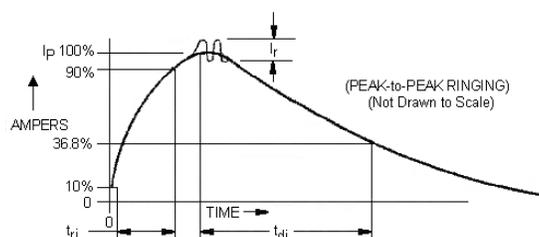


Figure 4. HBM Current Waveform

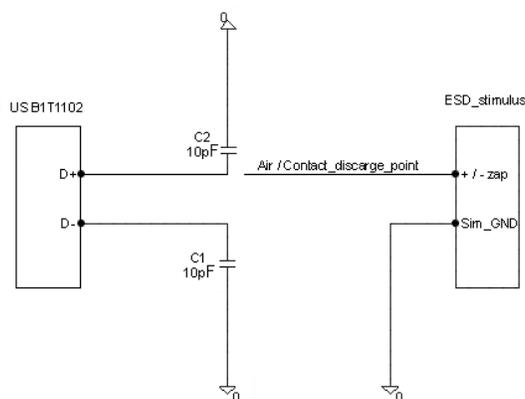


Figure 5. IEC 61000-4-2 ESD Test Model

## 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	+125	C
$P_{TOT}$	Power Dissipation			
	$I_{CC}$ (5V)		48	mW
	$I_{CCIO}$		9	mW

### Notes:

- IO Absolute Maximum Rating must be observed.
- 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.	
$V_{REG}$ (3.3V)	Regulated Supply Output	Internal Regulator Option; $I_{LOAD} \leq 300 \mu A$	3.0 <sup>(9)(10)</sup>	3.3	3.6	V
$I_{CC}$	Operating Supply Current ( $V_{CC}$ 5.0)	Transmitting and Receiving at 12 Mb/s; $C_{LOAD} = 50$ pF (D+, D-)		4.0 <sup>(11)</sup>	8.0	mA
$I_{CCIO}$	I/O Operating Supply Current	Transmitting and Receiving at 12 Mb/s		1.0 <sup>(11)</sup>	2.0	mA
$I_{CC}$ (IDLE)	Supply Current during FS IDLE and SE0 ( $V_{CC}$ 5.0)	IDLE: $V_{D+} \leq 2.7V$ , $V_{D-} \leq 0.3V$ ; SE0: $V_{D+} \leq 0.3V$ , $V_{D-} \leq 0.3V$			300 <sup>(12)</sup>	$\mu A$
$I_{CCIO}$ (STATIC)	I/O Static Supply Current	IDLE, SUSPEND or SE0			20.0	$\mu A$
$I_{CC}$ (DISABLE)	Disable Supply Current	$V_{CCIO} = 0V$ $V_{CC}$ Connected			25.0	$\mu A$
$I_{CC}$ (SUSPEND)	Suspend Supply Current USB1T1103	SUSPEND = HIGH $\overline{OE} = HIGH$ $V_m = V_p = OPEN$			25.0 <sup>(12)</sup>	$\mu A$
$I_{CCIO}$ (SHARING)	I/O Sharing Mode Supply Current	$V_{CC}$ (5V) Not Connected			20.0	$\mu A$
$I_{D+}$ (SHARING) $I_{D+/-}$	Sharing Mode Load Current on D+/D- Terminals	$V_{CC}$ (5V) Not Connected Config = LOW; $V_{D\pm} = 3.6V$			10.0	$\mu A$
$I_{D+}$ (DISABLE) $I_{D+/-}$	Disable Mode Load Current on D+/D- Terminals	$V_{CCIO}$ Not Connected or 0V Config = $V_{D\pm} = 3.6V$ LOW or HIGH			10.0	$\mu A$
$V_{CC}$ TH	$V_{CC}$ Threshold Detection Voltage	$1.65V \leq V_{CCIO} \leq 3.6V$				V
		Supply Lost			3.6	
		Supply Present	4.1			
$V_{CC}$ HYS	$V_{CC}$ Threshold Detection Hysteresis Voltage	$V_{CCIO} = 1.8V$		70.0		mV
$V_{CCIO}$ TH	$V_{CCIO}$ Threshold Detection Voltage	$2.7V \leq V_{REG} \leq 3.6V$				V
		Supply Lost			0.5	
		Supply Present	1.4			
$V_{CCIO}$ HYS	$V_{CCIO}$ Threshold Detection Hysteresis Voltage	$V_{REG} = 3.3V$		450		mV
$V_{REG}$ TH	Regulated Supply Threshold Detection Voltage	$1.65V \leq V_{CCIO} \leq V_{REG}$				V
		$2.7V \leq V_{REG} \leq 3.6V$				
		Supply Lost			0.8	
$V_{REG}$ HYS <sup>(15)</sup>	Regulated Supply Threshold Detection Hysteresis Voltage	$V_{CCIO} = 1.8V$				mV
					2.4 <sup>(14)</sup>	

#### 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  $V_{REGTH} = 2.0V$  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
			-40°C to +85°C		
			Min.	Max.	
<b>Input Levels</b>					
$V_{IL}$	LOW Level Input Voltage			$0.3 \cdot V_{CCIO}$	V
$V_{IH}$	HIGH Level Input Voltage		$0.6 \cdot V_{CCIO}$		V
<b>Output Levels</b>					
$V_{OL}$	LOW Level Output Voltage	$I_{OL} = 2 \text{ mA}$		0.4	V
		$I_{OL} = 100 \text{ } \mu\text{A}$		0.15	
$V_{OH}$	HIGH Level Output Voltage	$I_{OH} = 2 \text{ mA}$	$V_{CCIO} - 0.4$		V
		$I_{OH} = 100 \text{ } \mu\text{A}$	$V_{CCIO} - 0.15$		
<b>Leakage Current</b>					
$I_{LI}$	Input Leakage Current	$V_{CCIO} = 1.65V$ to $3.6V$		$\pm 1.0^{(16)}$	$\mu\text{A}$
<b>Capacitance</b>					
$C_{IN}, C_{IO}$	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.	
<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		0.30		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 <sup>(17)</sup>	$R_L = 15k\Omega$ to GND	2.8		3.6	V
<b>Leakage Current</b>						
$I_{OFF}$	Input Leakage Current Off State				$\pm 1.0$	$\mu\text{A}$
<b>CAPACITANCE</b>						
$C_{I/O}$	I/O Capacitance	Terminal to GND			20.0	pF
<b>Resistance</b>						

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>PJ</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>PJ</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

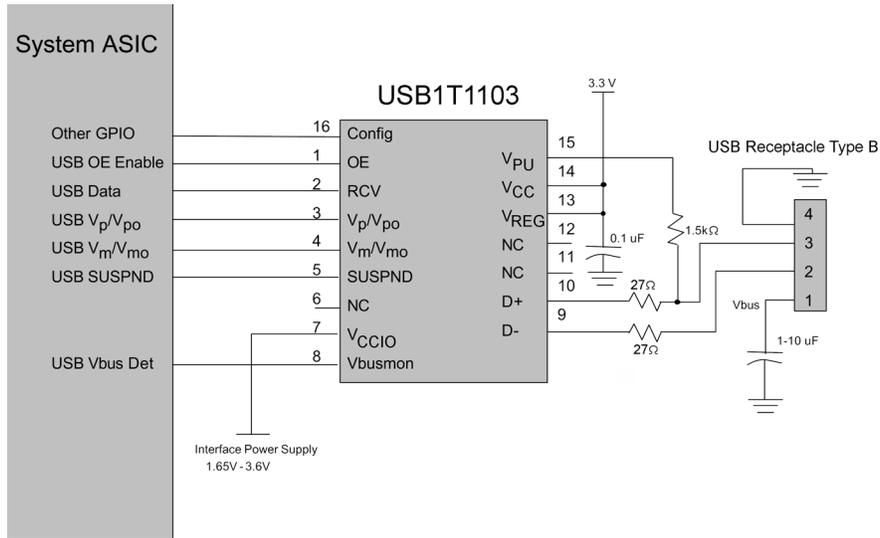
Over recommended range of supply voltage and operating free air temperature (unless otherwise noted).  
 V<sub>CC</sub> = 4.0V to 5.5V or V<sub>REG</sub> = 3.0V to 3.6V, V<sub>CCIO</sub> = 1.65V to 3.6V, C<sub>L</sub> = 50 pF; R<sub>L</sub> = 1.5K on D+ to V<sub>PJ</sub>.

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

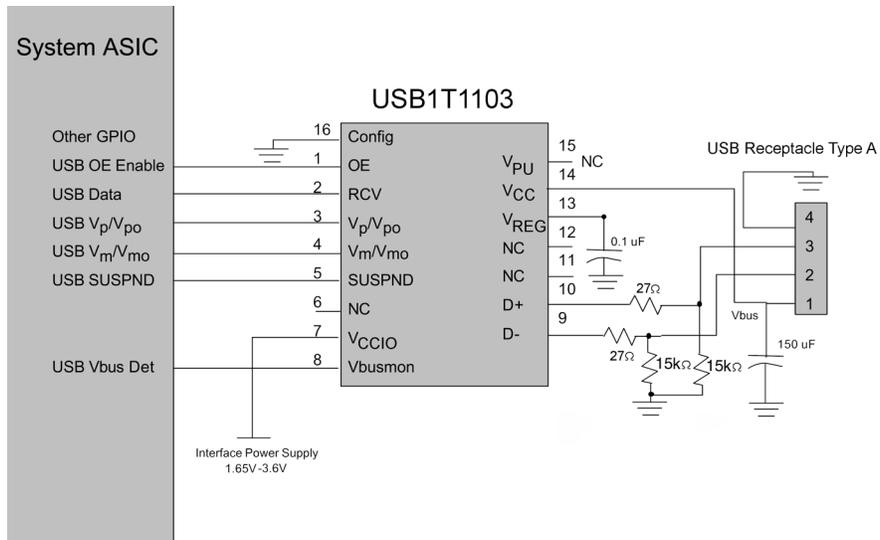
**NOTES:**

21. Not production tested; limits guaranteed by design.

## Typical Application Configurations

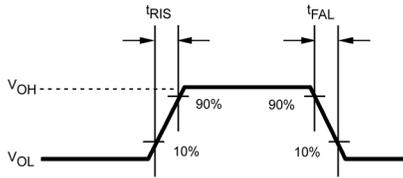


**Figure 6. Upstream Connection in Bypass Mode with Differential Outputs**

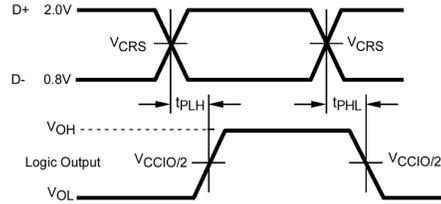


**Figure 7. Downstream Connection in Normal Mode with Differential Outputs**

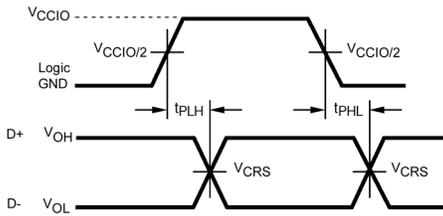
## AC Waveforms



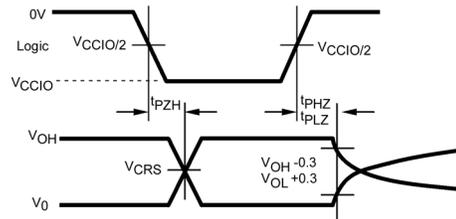
**Figure 8. Rise and Fall Times**



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

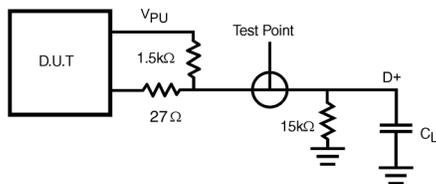


**Figure 9.  $V_{po}$ ,  $V_{mo}$  to D+/D-**



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

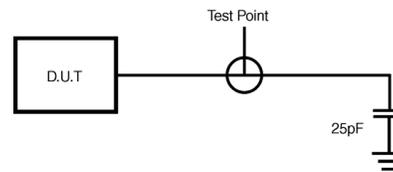
## Test Circuits and Waveforms



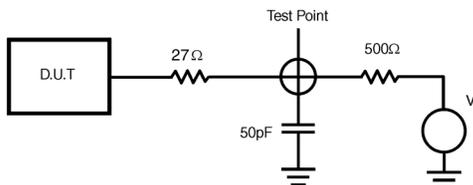
$C_L = 50$  pF Full Speed Propagation Delays

$C_L = -125$  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**

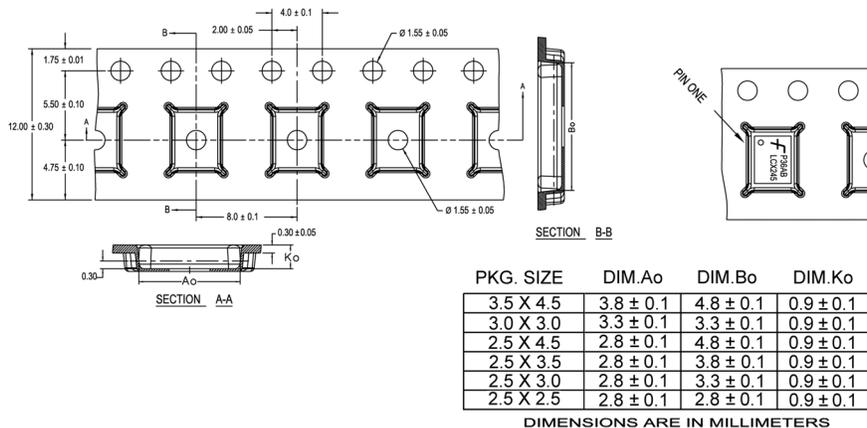
## Tape and Reel Specification

### 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.

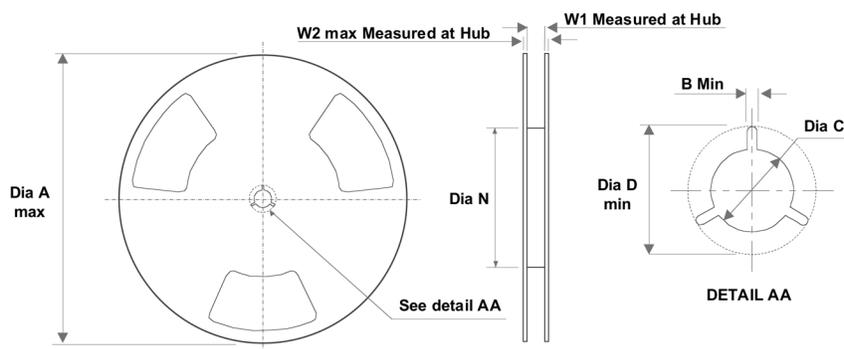


NOTES: unless otherwise specified

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

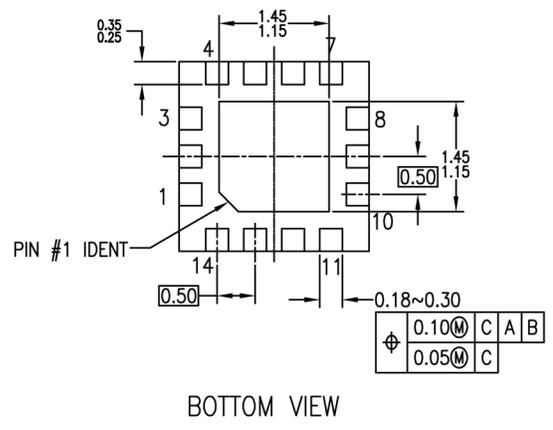
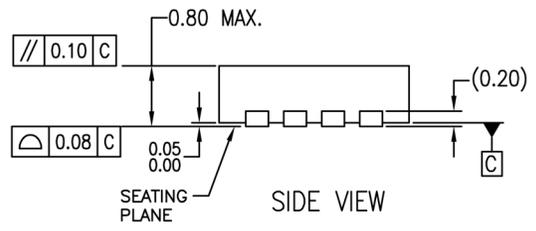
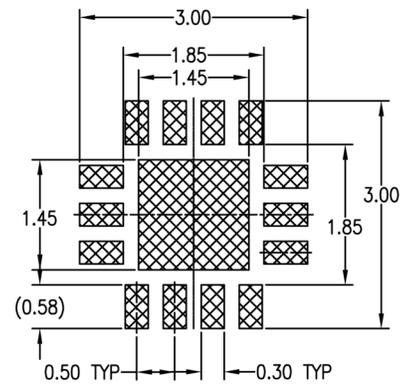
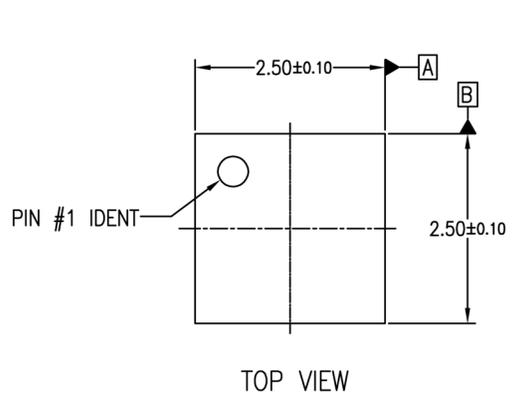
Dimensions are in inches (millimeters) unless otherwise specified.



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)

## Physical Dimensions

Dimensions are in inches (millimeters) unless otherwise noted.



### NOTES:

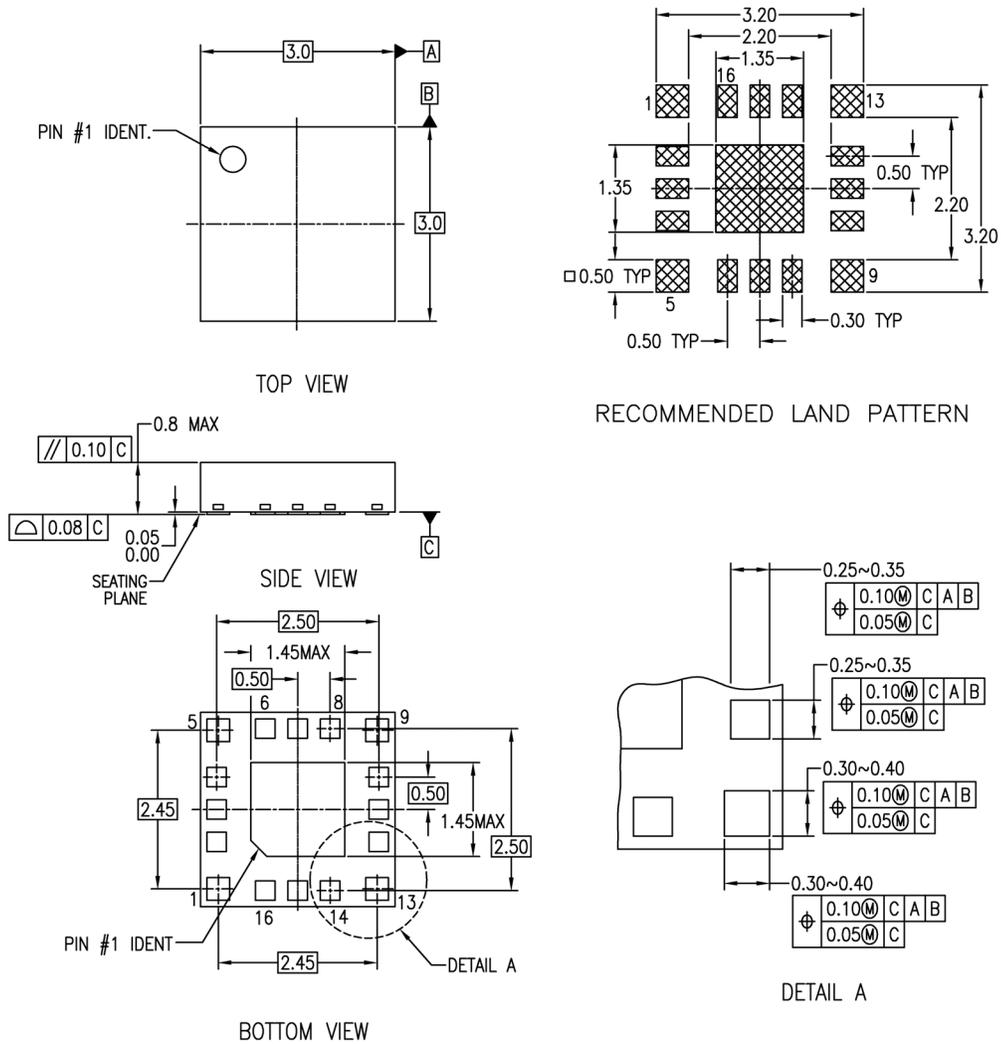
- A. NO JEDEC REGISTRATION
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

MLP14DrevA

**Figure 15. Pb-Free 14-Terminal Molded Leadless Package (MLP), 2.5mm Square**

## Physical Dimensions

Dimensions are in 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

**Figure 16. Pb-Free 16-Terminal Molded Leadless Package (MHBC), JEDEC MO-217, 3mm Square**

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ActiveArray <sup>™</sup>	GlobalOptoisolator <sup>™</sup>	OCXPro <sup>™</sup>	SMART START <sup>™</sup>	UltraFET <sup>®</sup>
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CoolFET <sup>™</sup>	I <sup>2</sup> C <sup>™</sup>	PACMAN <sup>™</sup>	SuperFET <sup>™</sup>	
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DOME <sup>™</sup>	ImpliedDisconnect <sup>™</sup>	Power247 <sup>™</sup>	SuperSOT <sup>™</sup> -6	
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E <sup>2</sup> CMOS <sup>™</sup>	ISOPLANAR <sup>™</sup>	PowerSaver <sup>™</sup>	SyncFET <sup>™</sup>	
EnSigna <sup>™</sup>	LittleFET <sup>™</sup>	PowerTrench <sup>®</sup>	TCM <sup>™</sup>	
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FAST <sup>®</sup>	MicroFET <sup>™</sup>	QS <sup>™</sup>	TinyBuck <sup>™</sup>	
FAST <sub>r</sub> <sup>™</sup>	MicroPak <sup>™</sup>	QT Optoelectronics <sup>™</sup>	TinyPWM <sup>™</sup>	
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FRFET <sup>™</sup>	MSX <sup>™</sup>	RapidConfigure <sup>™</sup>	TinyLogic <sup>®</sup>	
	MSXPro <sup>™</sup>	RapidConnect <sup>™</sup>	TINYOPTO <sup>™</sup>	
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The Power Franchise <sup>®</sup>		ScalarPump <sup>™</sup>	UHC <sup>™</sup>	
Programmable Active Droop <sup>™</sup>				

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