

FAIRCHILD
SEMICONDUCTOR®November 1999
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USB1T11A

Universal Serial Bus Transceiver

General Description

The USB1T11A is a one chip generic USB transceiver. It is designed to allow 5.0V or 3.3V programmable and standard logic to interface with the physical layer of the Universal Serial Bus. It is capable of transmitting and receiving serial data at both full speed (12Mbit/s) and low speed (1.5Mbit/s) data rates.

The input and output signals of the USB1T11A conform with the "Serial Interface Engine". Implementation of the Serial Interface Engine along with the USB1T11A allows the designer to make USB compatible devices with off-the-shelf logic and easily modify and update the application.

Features

- Complies with Universal Serial Bus specification 1.1
- Utilizes digital inputs and outputs to transmit and receive USB cable data
- Supports 12Mbit/s "Full Speed" and 1.5Mbit/s "Low Speed" serial data transmission
- Compatible with the VHDL "Serial Interface Engine" from USB Implementers' Forum
- Supports single-ended data interface
- Single 3.3V supply
- ESD Performance: Human Body Model
 - > 9.5 kV on D-, D+ pins only
 - > 4 kV on all other pins
- 16-lead Pb-Free MLP package saves space



Ordering Code:

Order Number	Package Number	Package Description
USB1T11AM (Note 1)	M14A	14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
USB1T11AM_NL (Note 2)	M14A	Pb-Free 14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
USB1T11ABQX	MLP16C	Pb-Free 16-Terminal Molded Leadless Package (MLP), JEDEC MO-220, 3mm square
USB1T11AMTC (Note 1)	MTC14	14-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide
USB1T11AMTC_NL (Note 2)	MTC14	Pb-Free 14-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide
USB1T11AMTCX_NL (Note 2)	MTC14	Pb-Free 14-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide

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

Note 1: Device also available in Tape and Reel. Specify by appending suffix letter "X" to the ordering code.

Note 2: "_NL" indicates Pb-Free package (per JEDEC J-STD-020B). Please use order number as indicated.

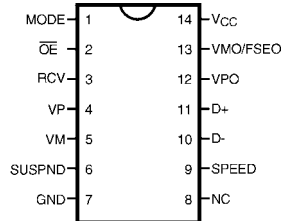
The USB-IF Logos are trademarks of Universal Serial Bus Implementers Forum, Inc.

USB1T11A Universal Serial Bus Transceiver

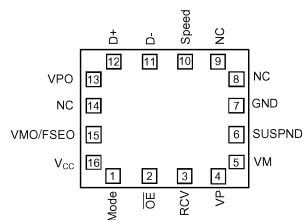


Connection Diagrams

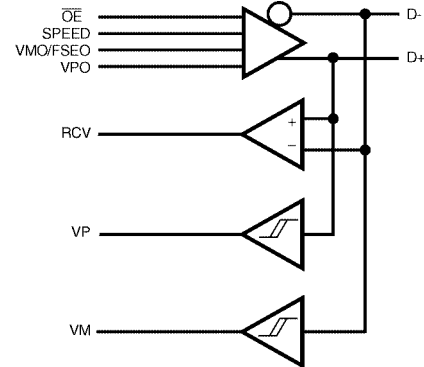
Pin Assignments for SOIC and TSSOP



Pin Assignments for MLP



Logic Diagram



Pin Descriptions

Pin Name	I/O	Description																																				
RCV	O	Receive data. CMOS level output for USB differential input																																				
\overline{OE}	I	Output Enable. Active LOW, enables the transceiver to transmit data on the bus. When not active the transceiver is in receive mode.																																				
MODE	I	Mode. When left unconnected, a weak pull-up transistor pulls it to V_{CC} and in this GND, the VMO/FSEO pin takes the function of FSEO (Force SEO).																																				
V_{PO} , V_{MO}/F_{SEO}	I	Inputs to differential driver. (Outputs from SIE).																																				
		<table><tr><th>MODE</th><th>VPO</th><th>VMO/FSEO</th><th>RESULT</th></tr><tr><td>0</td><td>0</td><td>0</td><td>Logic "0"</td></tr><tr><td></td><td>0</td><td>1</td><td>$\overline{SE0}$</td></tr><tr><td></td><td>1</td><td>0</td><td>Logic "1"</td></tr><tr><td></td><td>1</td><td>1</td><td>\overline{SEO}</td></tr><tr><td>1</td><td>0</td><td>0</td><td>$\overline{SE0}$</td></tr><tr><td></td><td>0</td><td>1</td><td>Logic "0"</td></tr><tr><td></td><td>1</td><td>0</td><td>Logic "1"</td></tr><tr><td></td><td>1</td><td>1</td><td>Illegal code</td></tr></table>	MODE	VPO	VMO/FSEO	RESULT	0	0	0	Logic "0"		0	1	$\overline{SE0}$		1	0	Logic "1"		1	1	\overline{SEO}	1	0	0	$\overline{SE0}$		0	1	Logic "0"		1	0	Logic "1"		1	1	Illegal code
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	0	1	Logic "0"																																			
	1	0	Logic "1"																																			
	1	1	Illegal code																																			
V_P , V_M	O	Gated version of D- and D+. Outputs are logic "0" and logic "1". Used to detect single ended zero (SE0), error conditions, and interconnect speed. (Input to SIE).																																				
		<table><tr><th>VP</th><th>VM</th><th>RESULT</th></tr><tr><td>0</td><td>0</td><td>$\overline{SE0}$</td></tr><tr><td>0</td><td>1</td><td>Low Speed</td></tr><tr><td>1</td><td>0</td><td>Full Speed</td></tr><tr><td>1</td><td>1</td><td>Error</td></tr></table>	VP	VM	RESULT	0	0	$\overline{SE0}$	0	1	Low Speed	1	0	Full Speed	1	1	Error																					
VP	VM	RESULT																																				
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0	1	Low Speed																																				
1	0	Full Speed																																				
1	1	Error																																				
D+, D-	A/I/O	Data+, Data-. Differential data bus conforming to the Universal Serial Bus standard.																																				
SUSPND	I	Suspend. Enables a low power state while the USB bus is inactive. While the suspend pin is active it will drive the RCV pin to a logic "0" state. Both D+ and D- are 3-STATE.																																				
SPEED	I	Edge rate control. Logic "1" operates at edge rates for "full speed". Logic "0" operates edge rates for "low speed".																																				
V_{CC}		3.0V to 3.6V power supply																																				
GND		Ground reference																																				

Functional Truth Table

Input					I/O		Outputs			Result
Mode	VPO	VMO/FSEO	\overline{OE}	SUSPND	D+	D-	RCV	V _P	V _M	
0	0	0	0	0	0	1	0	0	1	Logic 0
0	0	1	0	0	0	0	U	0	0	\overline{SEO}
0	1	0	0	0	1	0	1	1	0	Logic 1
0	1	1	0	0	0	0	U	0	0	\overline{SEO}
1	0	0	0	0	0	0	U	0	0	\overline{SEO}
1	0	1	0	0	0	1	0	0	1	Logic 0
1	1	0	0	0	1	0	1	1	0	Logic 1
1	1	1	0	0	1	1	U	U	U	Illegal Code
X	X	X	1	0	Z	Z	U	U	U	D+/D- Hi-Z
X	X	X	1	1	Z	Z	U	U	U	D+/D- Hi-Z

X = Don't Care
Z = 3-STATE
U = Undefined State

Absolute Maximum Ratings(Note 3)

DC Supply Voltage (V_{CC})	-0.5V to +7.0V
DC Input Diode Current (I_{IK})	
$V_I < 0$	-50 mA
Input Voltage (V_I)	
(Note 4)	-0.5V to +5.5V
Input Voltage ($V_{I/O}$)	-0.5V to $V_{CC} + 0.5V$
Output Diode Current (I_{OK})	
$V_O > V_{CC}$ or $V_O < 0$	±50 mA
Output Voltage (V_O)	
(Note 4)	-0.5V to $V_{CC} + 0.5V$
Output Source or Sink Current (I_O)	
VP, VM, RCV pins	
$V_O = 0$ to V_{CC}	±15 mA
Output Source or Sink Current (I_O)	
D+/D- pins	
$V_O = 0$ to V_{CC}	±50 mA
V_{CC} or GND Current (I_{CC} , I_{GND})	±100 mA
Storage Temperature (T_{STO})	-60°C to +150°C

Recommended Operating Conditions

Supply Voltage V_{CC}	3.0V to 3.6V
Input Voltage (V_I)	0V to 5.5V
Input Range for AI/O ($V_{AI/O}$)	0V to V_{CC}
Output Voltage (V_O)	0V to V_{CC}
Operating Ambient Temperature	
in free air (T_{amb})	-40°C to +85°C

Note 3: 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 4: The input and output voltage ratings may be exceeded if the input and output clamp current ratings are observed.

DC Electrical Characteristics (Digital Pins)

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted). $V_{CC} = 3.0V$ to $3.6V$

Symbol	Parameter	Test Conditions	Limits			Unit
			Temp = -40°C to +85°C			
			Min	Typ	Max	
INPUT LEVELS:						
V _{IL}	LOW Level Input Voltage				0.8	V
V _{IH}	HIGH Level Input Voltage		2.0			V
OUTPUT LEVELS:						
V _{OL}	LOW Level Output Voltage	I _{OL} = 4 mA			0.4	V
		I _{OL} = 20 μA			0.1	
V _{OH}	HIGH Level Output Voltage	I _{OH} = 4 mA	2.4			V
		I _{OH} = 20 μA	V _{CC} - 0.1			
LEAKAGE CURRENT:						
I _L	Input Leakage Current	V _{CC} = 3.0 to 3.6			±5	μA
I _{CCFS}	Supply Current (Full Speed)	V _{CC} = 3.0 to 3.6			5	mA
I _{CCLS}	Supply Current (Low Speed)	V _{CC} = 3.0 to 3.6			5	mA
I _{CCQ}	Quiescent Current	V _{CC} = 3.0 to 3.6 V _{IN} = V _{CC} or GND			5	mA
I _{CCS}	Supply Current in Suspend	V _{CC} = 3.0 to 3.6; Mode = V _{CC}			10	μA

DC Electrical Characteristics (D+/D- Pins)Over recommended range of supply voltage and operating free air temperature (unless otherwise noted). $V_{CC} = 3.0V$ to $3.6V$

Symbol	Parameter	Test Conditions	Limits			Units
			Temp = -40°C to +85°C			
			Min	Typ	Max	
INPUT LEVELS:						
V _{DI}	Differential Input Sensitivity	(D+) – (D–)	0.2			V
V _{CM}	Differential Common Mode Range	Includes V _{DI} Range			2.5	V
V _{SE}	Single Ended Receiver Threshold		0.8		2.0	V
OUTPUT LEVELS:						
V _{OL}	Static Output LOW Voltage	R _L of 1.5 kΩ to 3.6V			0.3	V
V _{OH}	Static Output HIGH Voltage	R _L of 15 kΩ to GND	2.8		3.6	V
V _{CR}	Differential Crossover		1.3		2.0	V
LEAKAGE CURRENT:						
I _{OZ}	High Z State Data Line Leakage Current	0V < V _{IN} < 3.3V			±5	μA
CAPACITANCE:						
C _{IN} (Note 6)	Transceiver Capacitance	Pin to GND			10	pF
	Capacitance Match				10	%
OUTPUT RESISTANCE:						
Z _{DRV} (Note 5)	Driver Output Resistance	Steady State Drive	4		20	Ω
	Resistance Match				10	%

Note 5: Excludes external resistor. In order to comply with USB Specification 1.1, external series resistors of $24\Omega \pm 1\%$ each on D+ and D- are recommended. This specification is guaranteed by design and statistical process distribution.**Note 6:** This specification is guaranteed by design and statistical process distribution.**AC Electrical Characteristics** (D+/D- Pins, Full Speed)Over recommended range of supply voltage and operating free air temperature (unless otherwise noted). $V_{CC} = 3.0V$ to $3.6V$ $C_L = 50$ pF; $R_L = 1.5$ k Ω on D+ to V_{CC}

Symbol	Parameter	Test Condition	Limits			Units
			Temp = -40°C to +85°C			
			Min	Typ	Max	
DRIVER CHARACTERISTICS:						
t _R	Rise Time	10% and 90% Figure 1	4		20	ns
t _F	Fall Time	Figure 1	4		20	
t _{RFM}	Rise/Fall Time Matching	(t _r /t _f)	90		110	%
V _{CRS}	Output Signal Crossover Voltage		1.3		2.0	V
DRIVER TIMINGS:						
t _{PLH}	Driver Propagation Delay	Figure 2			18	ns
t _{PLH}	(V _{PO} , V _{MO} /F _{SEO} to D+/D-)	Figure 2			18	ns
t _{PHZ}	Driver Disable Delay	Figure 4			13	ns
t _{PLZ}	(\overline{OE} to D+/D-)	Figure 4			13	ns
t _{PZH}	Driver Enable Delay	Figure 4			17	ns
t _{PZL}	(\overline{OE} to D+/D-)	Figure 4			17	ns
RECEIVER TIMINGS:						
t _{PLH}	Receiver Propagation Delay	Figure 3			16	ns
t _{PHL}	(D+, D- to RCV)	Figure 3			19	ns
t _{PLH}	Single-ended Receiver Delay	Figure 3			8	ns
t _{PHL}	(D+, D- to VP, VM)	Figure 3			8	ns

AC Electrical Characteristics (D+/D- Pins, Low Speed)

Over recommended range of supply voltage and operating free air temperature (unless otherwise noted). $V_{CC} = 3.0V$ to $3.6V$
 $C_L = 200$ pF to 600 pF; $R_L = 1.5k\Omega$ on D- to V_{CC}

Symbol	Parameter	Test Conditions	Limits			Unit
			T _{amb} = -40°C to +85°C			
			Min	Typ	Max	
DRIVER CHARACTERISTICS:						
t _{LR}	Rise Time	10% and 90% Figure 1	75		300	ns
t _{LF}	Fall Time	Figure 1	75		300	
t _{RFM}	Rise/Fall Time Matching	(t _r /t _f)	80		120	%
V _{CRS}	Output Signal Crossover Voltage		1.3		2.0	V
DRIVER TIMINGS:						
t _{PLH}	Driver Propagation Delay	Figure 2			300	ns
t _{PHL}	(V _{PO} , V _{MO} /F _{SEO} to D+/D-)	Figure 2			300	ns
t _{PHZ}	Driver Disable Delay	Figure 4			13	ns
t _{PLZ}	(\overline{OE} to D+/D-)	Figure 4			13	ns
t _{PZH}	Driver Enable Delay	Figure 4			205	ns
t _{PZL}	(\overline{OE} to D+/D-)	Figure 4			205	ns
RECEIVER TIMINGS:						
t _{PLH}	Receiver Propagation Delay	Figure 3			18	ns
t _{PHL}	(D+, D- to RCV)	Figure 3			18	ns
t _{PLH}	Single-ended Receiver Delay	Figure 3			28	ns
t _{PHL}	(D+, D- to VP, VM)	Figure 3			28	ns

AC Waveforms

V_{OL} and V_{OH} are the typical output voltage drops that occur with the output load. (V_{CC} never goes below 3.0V)

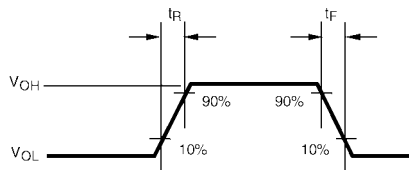


FIGURE 1. Rise and Fall Times

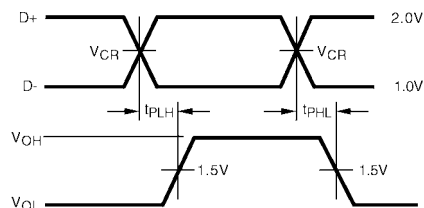


FIGURE 2. VPI, VMO/FSEO to D+/D-

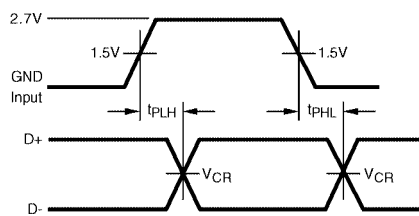


FIGURE 3. D+/D- to RCV, VP/VM

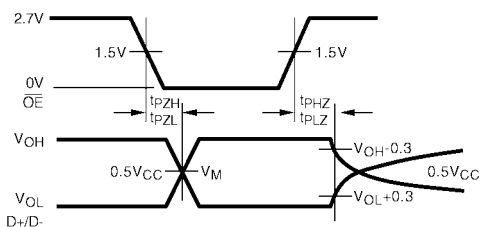
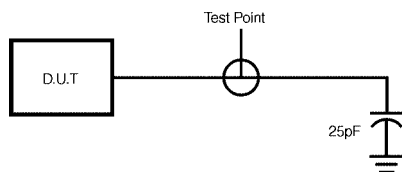
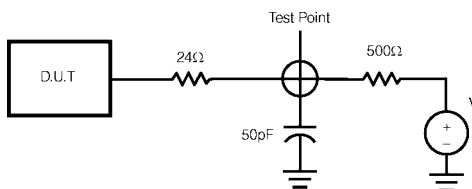


FIGURE 4. OE to D+/D-

Test Circuits and Waveforms



Load for VM/VP and RCV

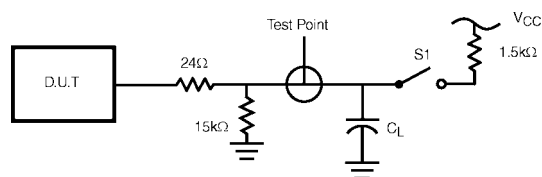


Load for Enable and Disable Times

Note:

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

$V = V_{CC}$ for t_{PZL} , t_{PLZ}



Load for D+/D-

$C_L = 50$ pF, Full Speed

$C_L = 200$ pF, Low Speed (Min Timing)

$C_L = 600$ pF, Low Speed (Max Timing)

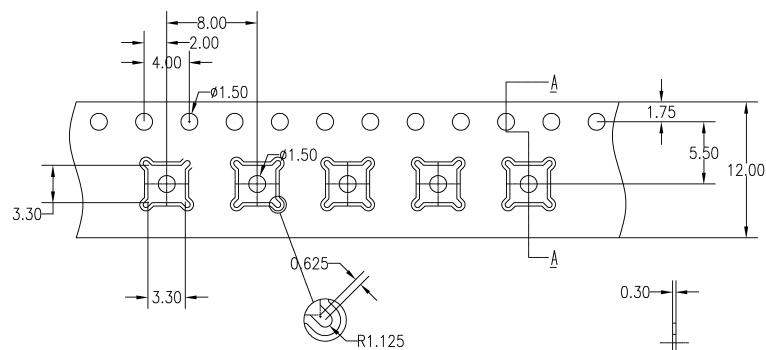
1.5 kΩ on D- (Low Speed) or D+ (Full Speed) only

Test	S1
D-/LS	Close
D+/LS	Open
D-/FS	Open
D+/FS	Close

Tape Format for MLP

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

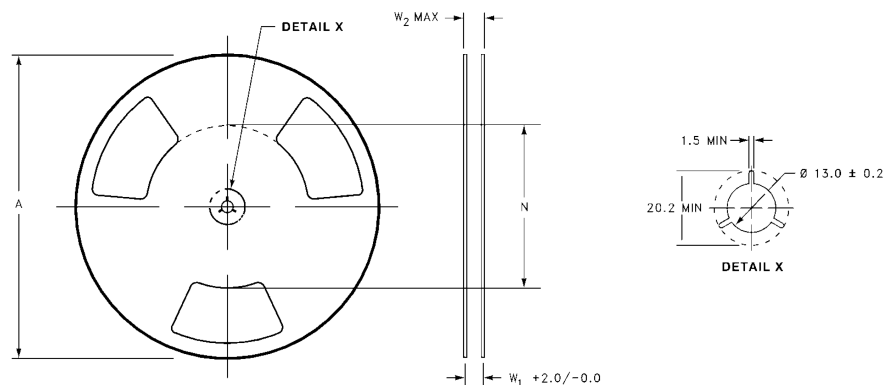
TAPE DIMENSIONS inches (millimeters)



NOTES : UNLESS OTHERWISE SPECIFIED

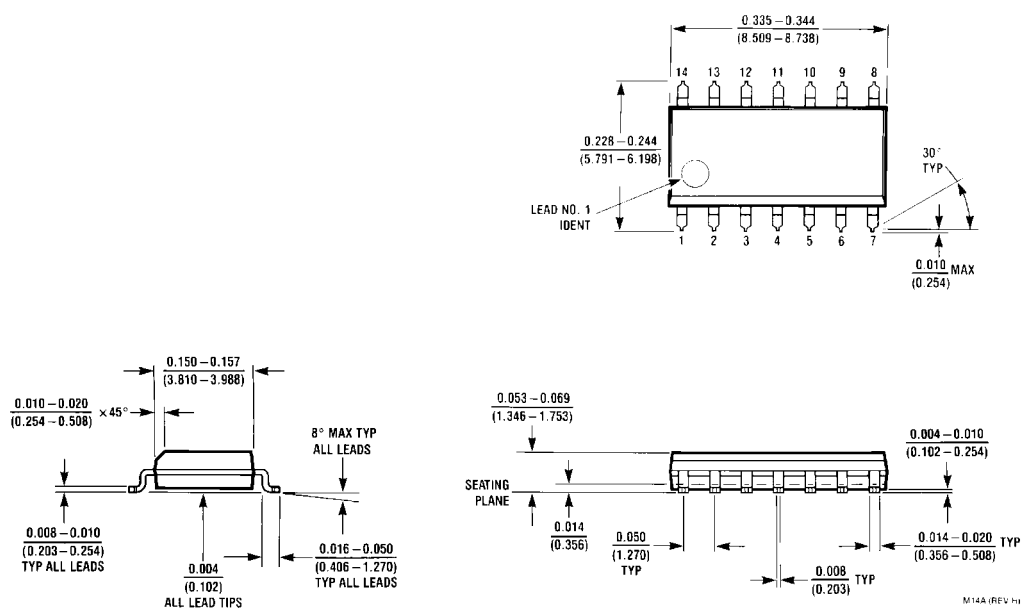
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ± 0.2
2. ALL DIMENSIONS ARE IN MILLIMETERS
3. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE
4. CAMBER IN COMPLIANCE WITH EIA 481
5. ADVANTEK PART DRAWING NUMBER ML0303-A

SECTION A - A

REEL DIMENSIONS inches (millimeters)

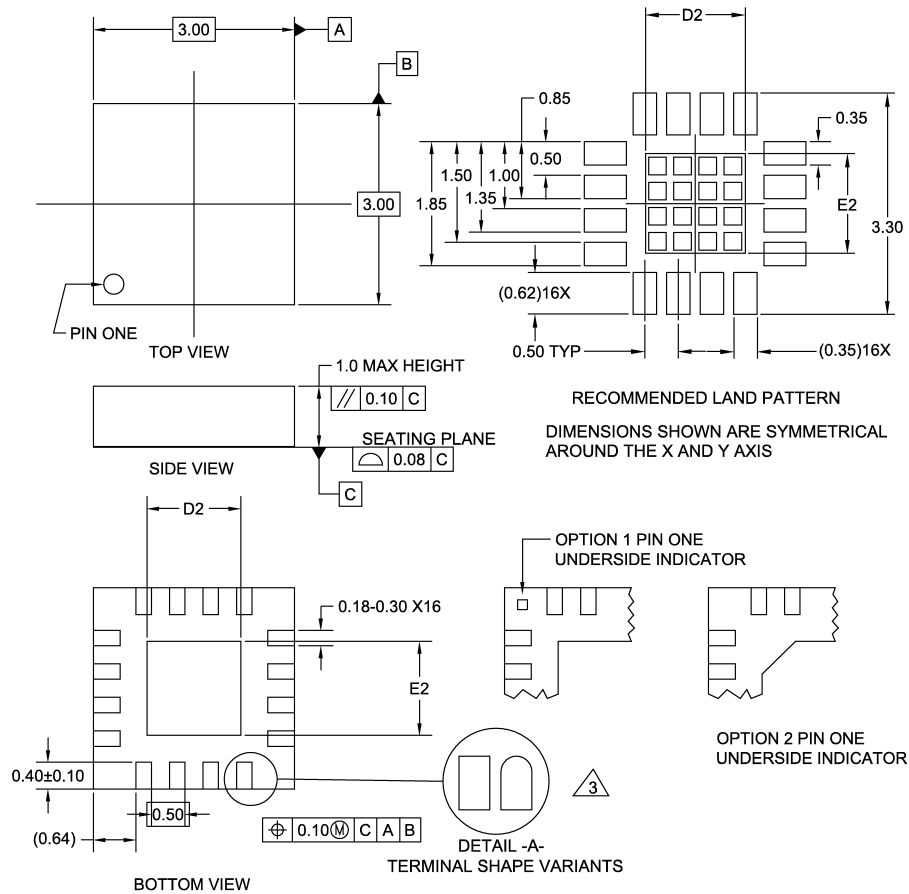
Tape Size	A (mm)	N (Typical) (mm)	W1 (mm)	W2 (Max) (mm)
12 mm	330	178	12.4	18.4

Physical Dimensions inches (millimeters) unless otherwise noted



**14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
Package Number M14A**

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



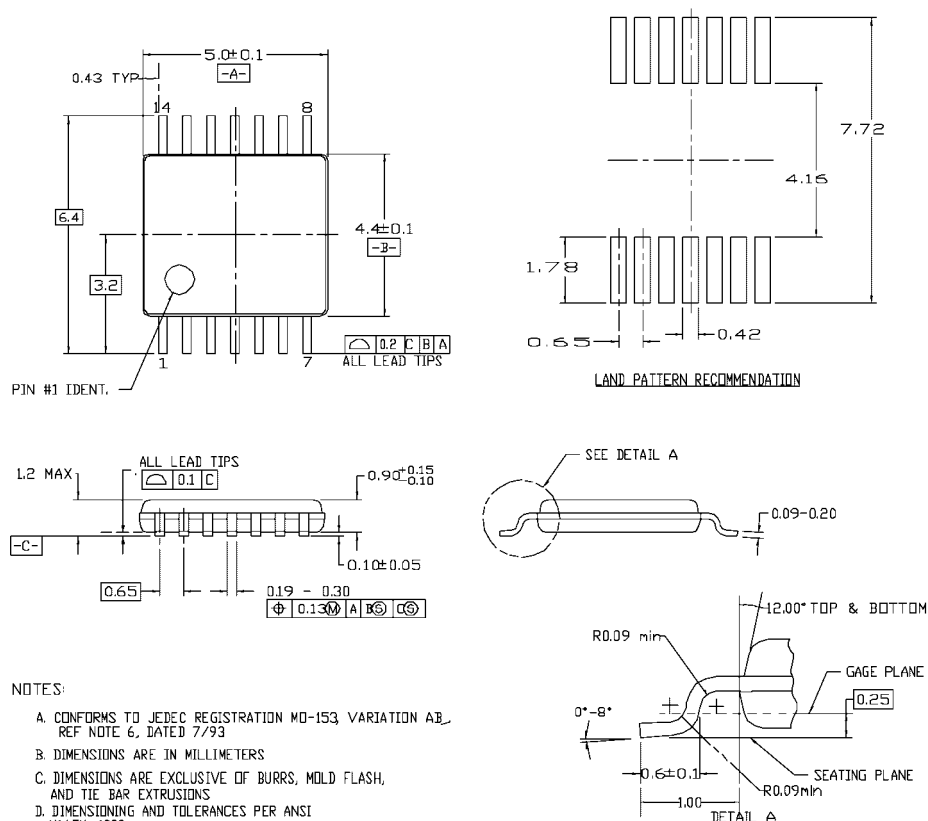
1. Package conforms to JEDEC MO-220
2. DIMENSIONS ARE IN MILLIMETERS
3. TERMINAL SHAPE MAY VARY ACCORDING TO PACKAGE SUPPLIER, SEE DETAIL A

DWG OPTION	DIM D2	DIM E2	TOLERANCE
01	1.40MM	1.40MM	+/- 0.10MM
02	1.50MM	1.50MM	+/- 0.10MM

MLP016CrevB

**Pb-Free 16-Terminal Molded Leadless Package (MLP), JEDEC MO-220, 3mm square
Package Number MLP16C**

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



14-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide
Package Number MTC14

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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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