

## 2x2 LVPECL CROSSPOINT SWITCH

### FEATURES

- High Speed 2x2 LVPECL Crosspoint Switch
- LVDS Crosspoint Switch Available in SN65LVCP22
- 50 ps (Typ), of Peak-to-Peak Jitter With PRBS =  $2^{23}-1$  Pattern
- Output (Channel-to-Channel) Skew Is 10 ps (Typ), 50 ps (Max)
- Configurable as 2:1 Mux, 1:2 Demux, Repeater or 1:2 Signal Splitter
- Inputs Accept LVDS, LVPECL, and CML Signals
- Fast Switch Time of 1.7 ns (Typ)
- Fast Propagation Delay of 0.75 ns (Typ)
- 16 Lead SOIC and TSSOP Packages
- Operating Temperature:  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

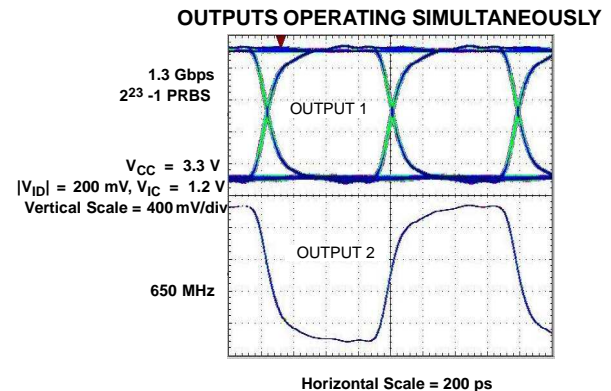
### APPLICATIONS

- Gigabit Ethernet Redundant Transmission Paths
- Gigabit Interface Converters (GBICs)
- Fibre Channel Redundant Transmission Paths
- HDTV Video Routing
- Base Stations
- Protection Switching for Serial Backplanes
- Network Switches/Routers
- Optical Networking Line Cards/Switches
- Clock Distribution

### DESCRIPTION

The SN65LVCP23 is a 2x2 LVPECL crosspoint switch. The dual channels incorporate wide common-mode (0 V to 4 V) receivers, allowing for the receipt of LVDS, LVPECL, and CML signals. The dual outputs are LVPECL drivers to provide high-speed operation. The SN65LVCP23 provides a single device supporting 2:2 buffering (repeating), 1:2 splitting, 2:1 multiplexing, 2x2 switching, and LVDS/CML to LVPECL level translation on each channel. The flexible operation of the SN65LVCP23 provides a single device to support the redundant serial bus transmission needs (working and protection switching cards) of fault-tolerant switch systems found in optical networking, wireless infrastructure, and data communications systems. TI offers an additional gigabit repeater/translator in the SN65LVDS101.

The SN65LVCP23 uses a fully differential data path to ensure low-noise generation, fast switching times, low pulse width distortion, and low jitter. Output channel-to-channel skew is less than 10 ps (typ) and 50 ps (max) to ensure accurate alignment of outputs in all applications. Both SOIC and TSSOP package options are available.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**ORDERING INFORMATION**

PACKAGE DESIGNATOR	PART NUMBER <sup>(1)</sup>	SYMBOLIZATION
SOIC	SN65LVCP23D	LVCP23
TSSOP	SN65LVCP23PW	LVCP23

(1) Add the suffix R for taped and reeled carrier

**PACKAGE DISSIPATION RATINGS**

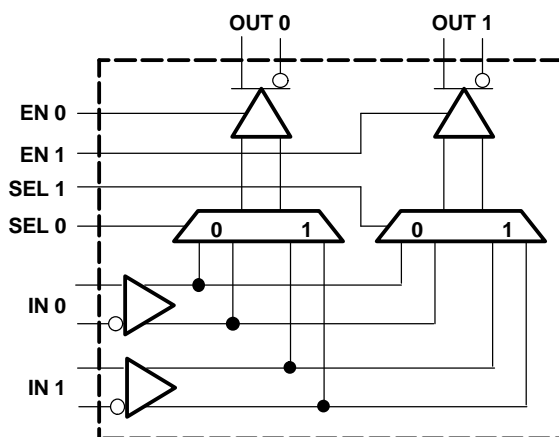
PACKAGE	CIRCUIT BOARD MODEL	T <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR <sup>(1)</sup> ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 85°C POWER RATING
SOIC (D)	High-K <sup>(2)</sup>	1361 mW	13.9 mW/°C	544 mW
TSSOP (PW)	High-K <sup>(2)</sup>	1074 mW	10.7 mW/°C	430 mW

(1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.  
 (2) In accordance with the High-K thermal metric definitions of EIA/JESD51-7.

**THERMAL CHARACTERISTICS**

PARAMETER		TEST CONDITIONS		VALUE	UNITS
θ <sub>JB</sub>	Junction-to-board thermal resistance	D		15.7	°C/W
		PW		22.1	°C/W
θ <sub>JC</sub>	Junction-to-case thermal resistance	D		26.1	°C/W
		PW		17.3	°C/W
P <sub>D</sub>	Device power dissipation	Typical	V <sub>CC</sub> = 3.3 V, T <sub>A</sub> = 25°C, 2 Gbps	165	mW
		Maximum	V <sub>CC</sub> = 3.6 V, T <sub>A</sub> = 85°C, 2 Gbps	234	mW

**FUNCTIONAL BLOCK DIAGRAM**

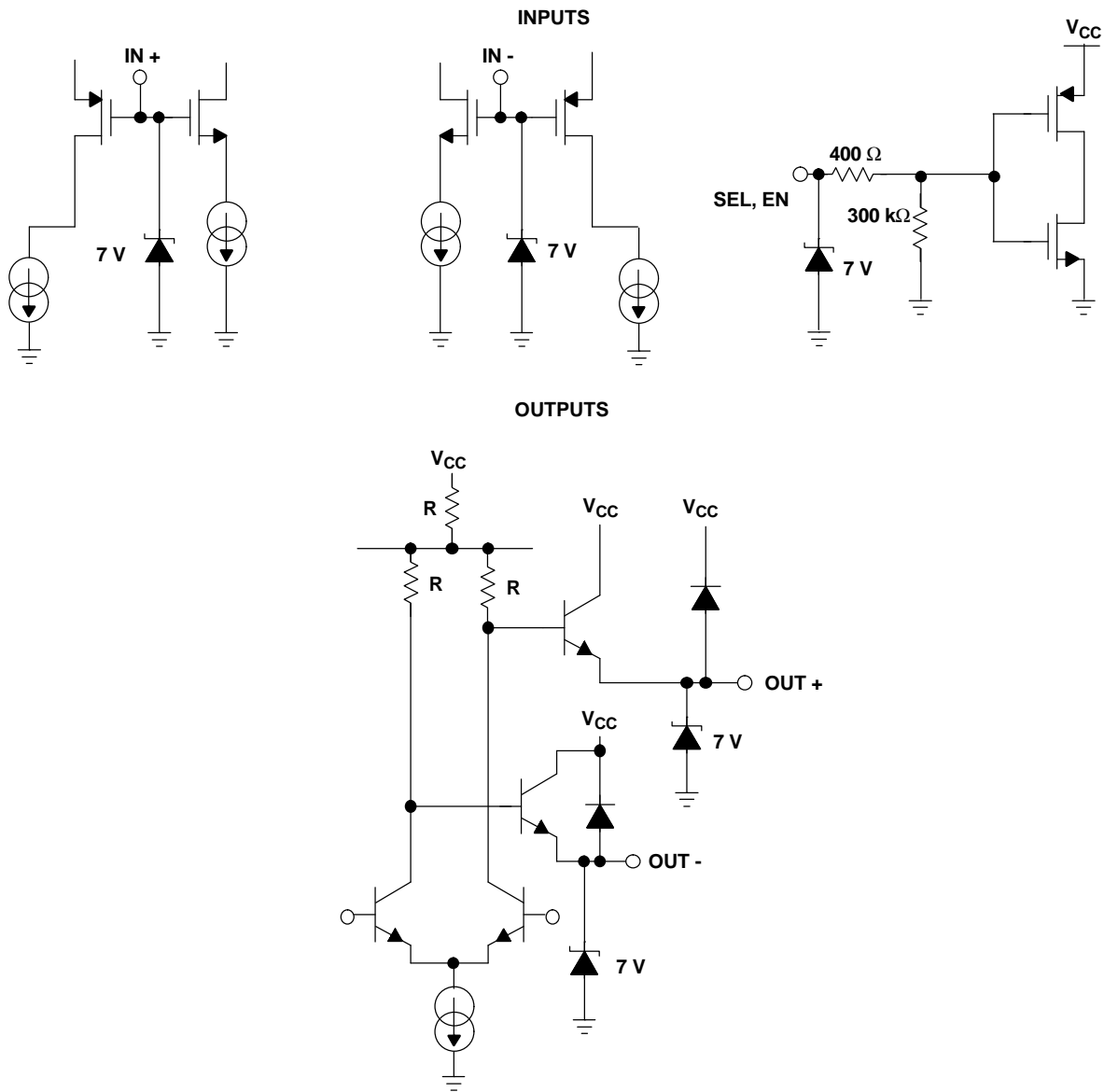


**CIRCUIT FUNCTION TABLE**

INPUTS <sup>(1)</sup>						OUTPUTS <sup>(1)</sup>		LOGIC DIAGRAM
IN 0	IN 1	SEL 0	SEL 1	EN 0	EN 1	OUT 0	OUT 1	
X	X	X	X	L	L	L	L	
>100 mV	X	L	L	H	L	H	L	
<-100 mV	X	L	L	H	L	L	L	
<-100 mV	X	L	L	H	H	L	L	
>100 mV	X	L	L	H	H	H	H	
>100 mV	X	L	L	L	H	L	H	
<-100 mV	X	L	L	L	H	L	L	
>100 mV	X	L	H	H	L	H	L	
<-100 mV	X	L	H	H	L	L	L	
<-100 mV	<-100 mV	L	H	H	H	L	L	
<-100 mV	>100 mV	L	H	H	H	L	H	
>100 mV	<-100 mV	L	H	H	H	H	L	
>100 mV	>100 mV	L	H	H	H	H	H	
X	>100 mV	L	H	L	H	L	H	
X	<-100 mV	L	H	L	H	L	L	
X	>100 mV	H	H	H	L	H	L	
X	<-100 mV	H	H	H	L	L	L	
X	<-100 mV	H	H	H	H	L	L	
X	>100 mV	H	H	H	H	H	H	
X	>100 mV	H	H	L	H	L	H	
X	<-100 mV	H	H	L	H	L	L	
X	>100 mV	H	L	H	L	H	L	
X	<-100 mV	H	L	H	L	L	L	
<-100 mV	<-100 mV	H	L	H	H	L	L	
<-100 mV	>100 mV	H	L	H	H	H	L	
>100 mV	<-100 mV	H	L	H	H	L	H	
>100 mV	>100 mV	H	L	H	H	H	H	
>100 mV	X	H	L	L	H	L	H	
<-100 mV	X	H	L	L	H	L	L	

(1) H = High level, L = Low level, Z = High impedance, X = Don't care

**EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS**



## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted<sup>(1)</sup>

		UNITS
Supply voltage range, <sup>(2)</sup> $V_{CC}$		–0.5 V to 4 V
CMOS/TTL input voltage (ENO, EN1, SEL0, SEL1)		–0.5 V to 4 V
Receiver input voltage (IN+, IN–)		–0.7 V to 4.3 V
LVPECL driver output voltage (OUT+, OUT–)		–0.5 V to 4 V
Output current	Continuous	50 mA
	Surge	100 mA
Storage temperature range		–65°C to 125°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds		235°C
Continuous power dissipation		See Dissipation Rating Table
Electrostatic discharge	Human body model <sup>(3)</sup>	All pins ±5 kV
	Charged-device mode <sup>(4)</sup>	All pins ±500 V

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminals.
- (3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101.

## RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
$V_{CC}$	Supply voltage	3	3.3	3.6	V
	Receiver input voltage	0		4	V
	Junction temperature			125	°C
$T_A$	Operating free-air temperature <sup>(1)</sup>	–40		85	°C
$ V_{ID} $	Magnitude of differential input voltage	0.1		3	V

- (1) Maximum free-air temperature operation is allowed as long as the device maximum junction temperature is not exceeded.

## INPUT ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
<b>CMOS/TTL DC SPECIFICATIONS (EN0, EN1, SEL0, SEL1)</b>						
V <sub>IH</sub>	High-level input voltage		2		V <sub>CC</sub>	V
V <sub>IL</sub>	Low-level input voltage		GND		0.8	V
I <sub>IH</sub>	High-level input current	V <sub>IN</sub> = 3.6 V or 2.0 V, V <sub>CC</sub> = 3.6 V		±3	±20	μA
I <sub>IL</sub>	Low-level input current	V <sub>IN</sub> = 0.0 V or 0.8 V, V <sub>CC</sub> = 3.6 V		±1	±10	μA
V <sub>CL</sub>	Input clamp voltage	I <sub>CL</sub> = -18 mA		-0.8	-1.5	V
<b>LVPECL OUTPUT SPECIFICATIONS (OUT0, OUT1)</b>						
V <sub>OH</sub>	Output high voltage	R <sub>L</sub> = 50 Ω to V <sub>TT</sub> , V <sub>TT</sub> = V <sub>CC</sub> - 2.0 V, See <a href="#">Figure 2</a>	V <sub>CC</sub> - 1.3		V <sub>CC</sub> - 0.85	V
V <sub>OL</sub>	Output low voltage		V <sub>CC</sub> - 2.2		V <sub>CC</sub> - 1.65	
V <sub>OD</sub>	Differential output voltage		600	800	1000	mV
C <sub>O</sub>	Differential output capacitance	V <sub>I</sub> = 0.4 sin(4E6πt) + 0.5 V		3		pF
<b>RECEIVER DC SPECIFICATIONS (IN0, IN1)</b>						
V <sub>TH</sub>	Positive-going differential input voltage threshold	See <a href="#">Figure 1</a> and <a href="#">Table 1</a>			100	mV
V <sub>TL</sub>	Negative-going differential input voltage threshold	See <a href="#">Figure 1</a> and <a href="#">Table 1</a>	-100			mV
V <sub>ID(HYS)</sub>	Differential input voltage hysteresis			25		mV
V <sub>CMR</sub>	Common-mode voltage range	V <sub>ID</sub> = 100 mV, V <sub>CC</sub> = 3.0 V to 3.6 V	0.05		3.95	V
I <sub>IN</sub>	Input current	V <sub>IN</sub> = 4 V, V <sub>CC</sub> = 3.6 V or 0.0 V		±1	±10	μA
		V <sub>IN</sub> = 0 V, V <sub>CC</sub> = 3.6 V or 0.0 V		±1	±10	
C <sub>IN</sub>	Differential input capacitance	V <sub>I</sub> = 0.4 sin(4E6πt) + 0.5 V		1		pF
<b>SUPPLY CURRENT</b>						
I <sub>CCD</sub>	DC supply current	No load		50	65	mA

(1) All typical values are at 25°C and with a 3.3-V supply.

## SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{SET}$	Input to SEL setup time	Figure 5	1	0.5		ns
$t_{HOLD}$	Input to SEL hold time	Figure 5	1.1	0.5		ns
$t_{SWITCH}$	SEL to switched output	Figure 5		1.7	2.5	ns
$t_{PHKL}$	Disable time, high-level-to-known LOW	Figure 4		2	2.5	ns
$t_{PKLH}$	Enable time, known LOW-to-high-level output	Figure 4		2	2.5	ns
$t_{LHT}$	Differential output signal rise time (20% – 80%) <sup>(1)</sup>	Figure 3	80	110	220	ps
$t_{HLT}$	Differential output signal fall time (20% – 80%) <sup>(1)</sup>	Figure 3	80	110	220	ps
$t_{JIT}$	Added peak-to-peak jitter	$V_{ID} = 200$ mV, 50% duty cycle, $V_{CM} = 1.2$ V, 650 MHz		15	30	ps
		$V_{ID} = 200$ mV, PRBS = $2^{23}-1$ data pattern and K28.5 (0011111010), $V_{CM} = 1.2$ V at 1.3 Gbps		50	100	ps
$t_{Jrms}$	Added random jitter (rms)	$V_{ID} = 200$ mV, 50% duty cycle, $V_{CM} = 1.2$ V, 650 MHz		0.3	0.5	ps <sub>RMS</sub>
$t_{PLHD}$	Propagation delay time, low-to-high-level output <sup>(1)</sup>	$V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$ , See Figure 3	400	750	1100	ps
$t_{PHLD}$	Propagation delay time, high-to-low-level output <sup>(1)</sup>	$V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$ , See Figure 3	400	750	1100	ps
$t_{skew}$	Pulse skew ( $ t_{PLHD} - t_{PHLD} $ ) <sup>(2)</sup>	Figure 3		20	100	ps
$t_{CCS}$	Output channel-to-channel skew, splitter mode	Figure 3		10	50	ps
$f_{MAX}$	Maximum operating frequency <sup>(3)</sup>		1			GHz

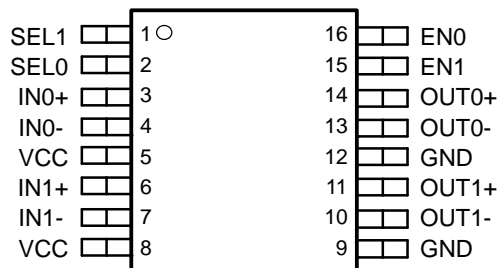
(1) Input:  $V_{IC} = 1.2$  V,  $V_{ID} = 200$  mV, 50% duty cycle, 1 MHz,  $t_r/t_f = 500$  ps

(2)  $t_{skew}$  is the magnitude of the time difference between the  $t_{PLHD}$  and  $t_{PHLD}$  of any output of a single device.

(3) Signal generator conditions: 50% duty cycle,  $t_r$  or  $t_f \leq 100$  ps (10% to 90%), transmitter output criteria: duty cycle = 45% to 55%  $V_{OD} \geq 300$  mV.

## PIN ASSIGNMENTS

D or PW PACKAGE  
(TOP VIEW)



PARAMETER MEASUREMENT INFORMATION

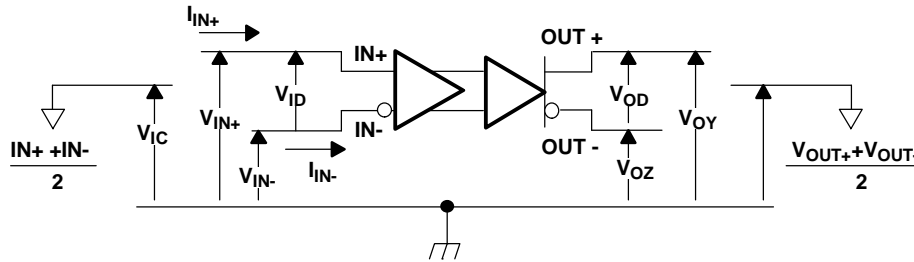


Figure 1. Voltage and Current Definitions

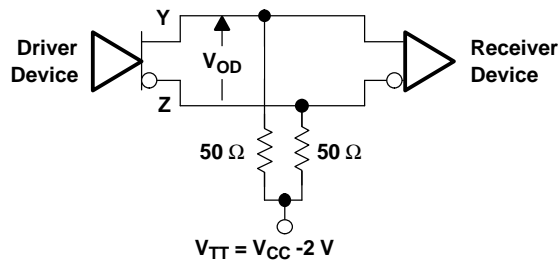
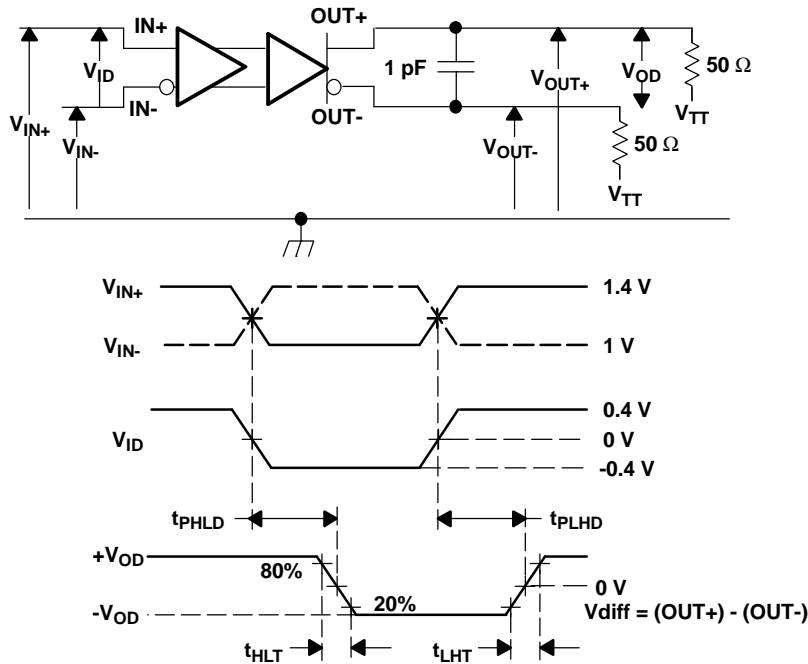


Figure 2. Typical Termination for LVPECL Output Driver

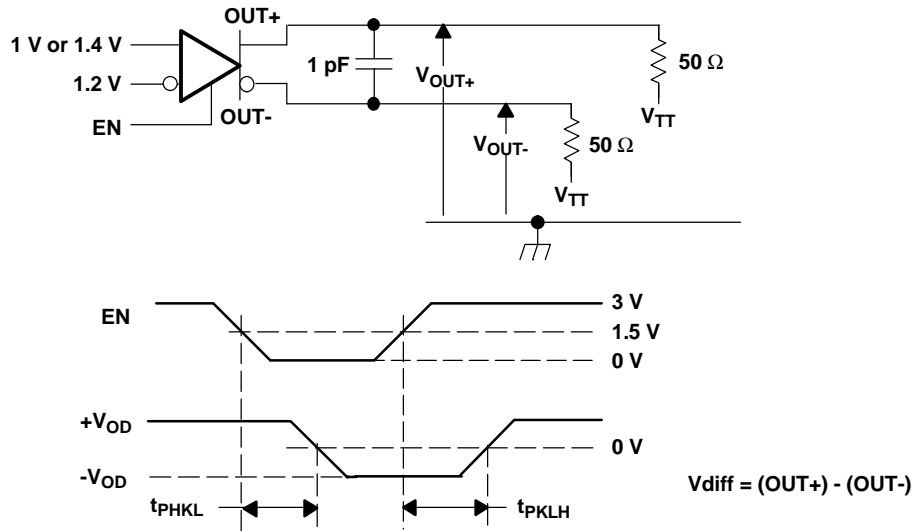


NOTE: All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 0.25$  ns, pulse-repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns;  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 3. Timing Test Circuit and Waveforms



PARAMETER MEASUREMENT INFORMATION (continued)



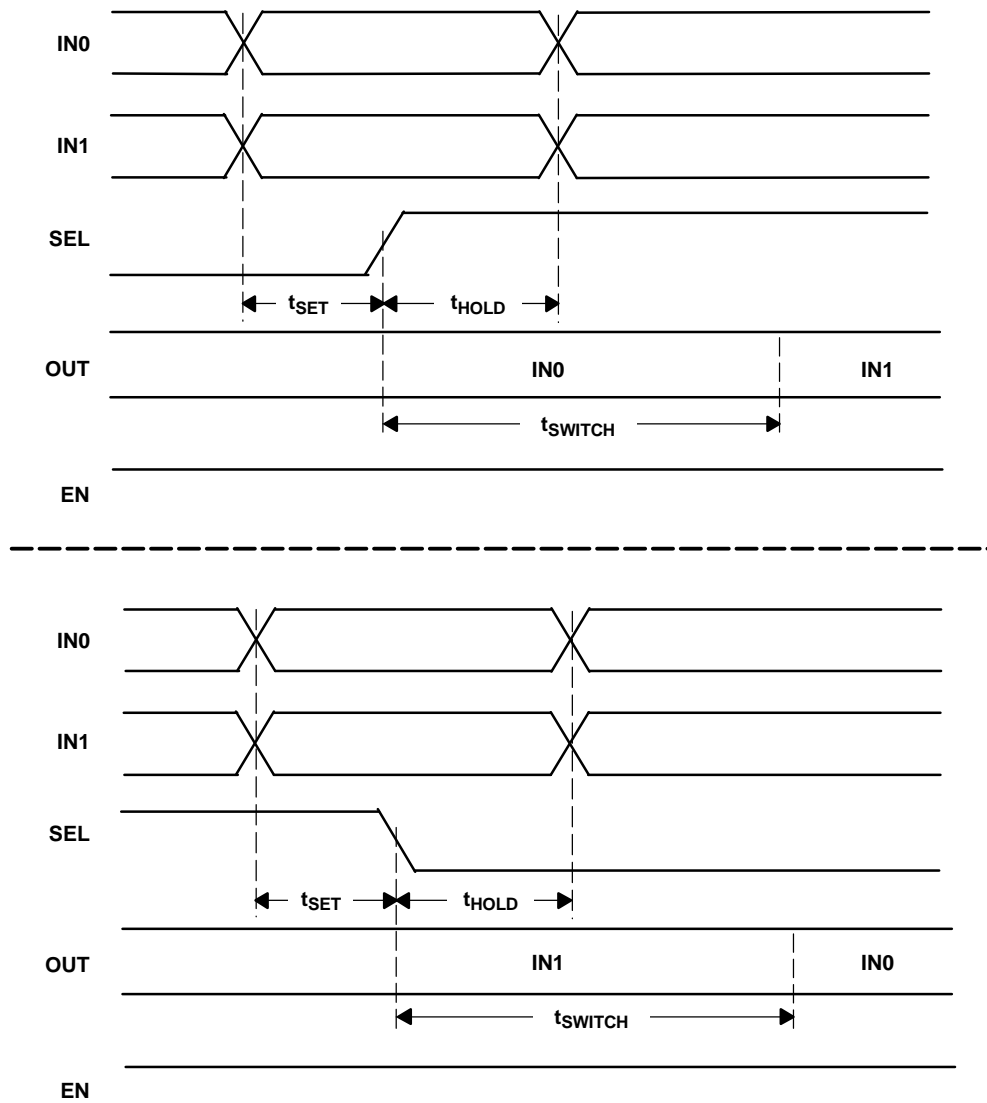
NOTE: All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse-repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns,  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 4. Enable and Disable Time Circuit and Definitions

Table 1. Receiver Input Voltage Threshold Test

APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	OUTPUT <sup>(1)</sup>
$V_{IA}$	$V_{IB}$	$V_{ID}$	$V_{IC}$	
1.25 V	1.15 V	100 mV	1.2 V	H
1.15 V	1.25 V	-100 mV	1.2 V	L
4.0 V	3.9 V	100 mV	3.95 V	H
3.9 V	4.0 V	-100 mV	3.95 V	L
0.1 V	0.0 V	100 mV	0.05 V	H
0.0 V	0.1 V	-100 mV	0.05 V	L
1.7 V	0.7 V	1000 mV	1.2 V	H
0.7 V	1.7 V	-1000 mV	1.2 V	L
4.0 V	3.0 V	1000 mV	3.5 V	H
3.0 V	4.0 V	-1000 mV	3.5 V	L
1.0 V	0.0 V	1000 mV	0.5 V	H
0.0 V	1.0 V	-1000 mV	0.5 V	L

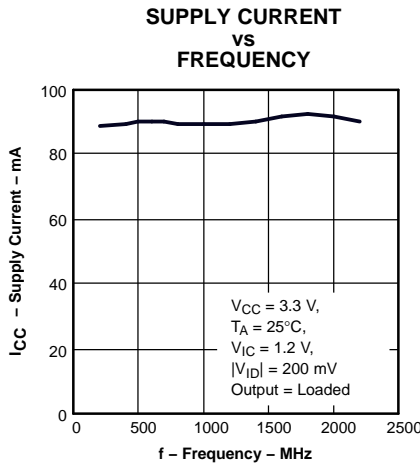
(1) H = high level, L = low level



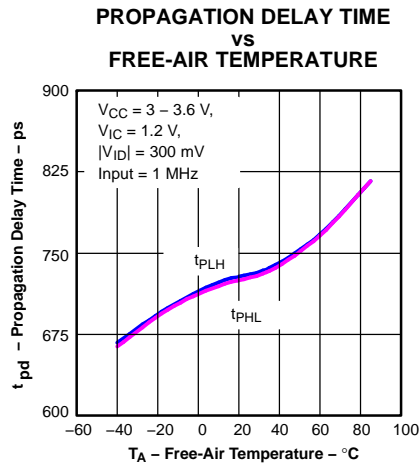
NOTE:  $t_{SET}$  and  $t_{HOLD}$  times specify that data must be in a stable state before and after mux control switches.

**Figure 5. Input to Select for Both Rising and Falling Edge Setup and Hold Times**

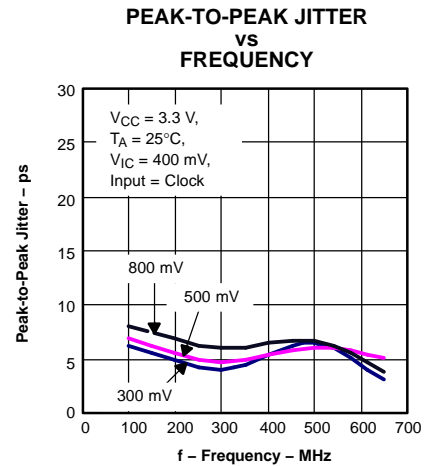
**TYPICAL CHARACTERISTICS**



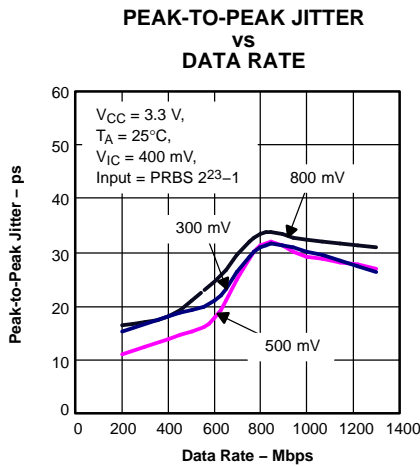
**Figure 6.**



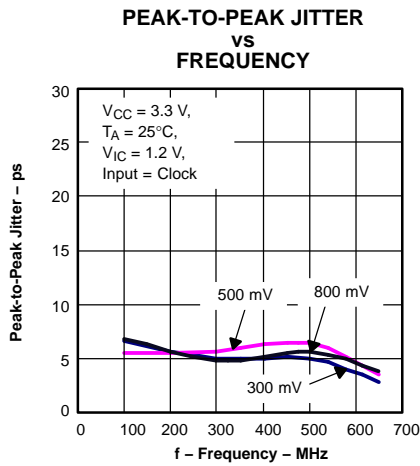
**Figure 7.**



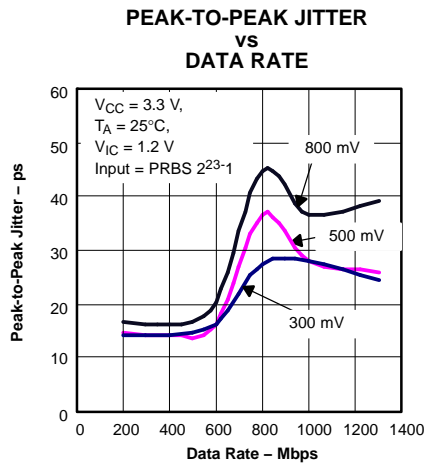
**Figure 8.**



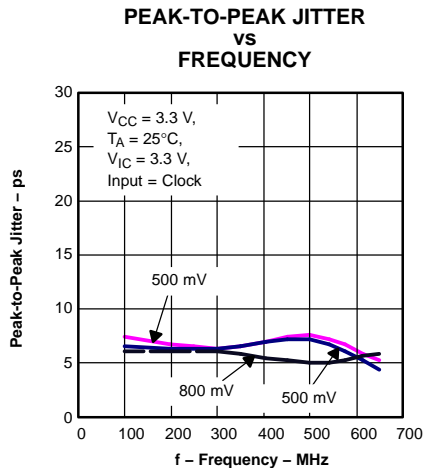
**Figure 9.**



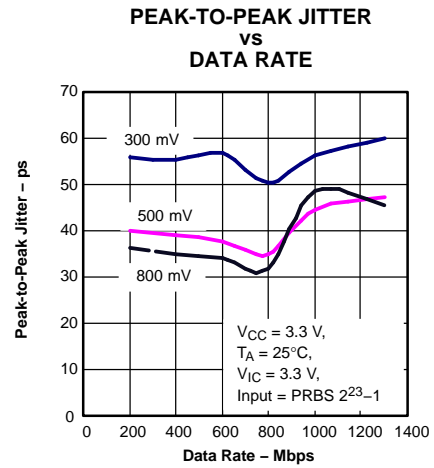
**Figure 10.**



**Figure 11.**

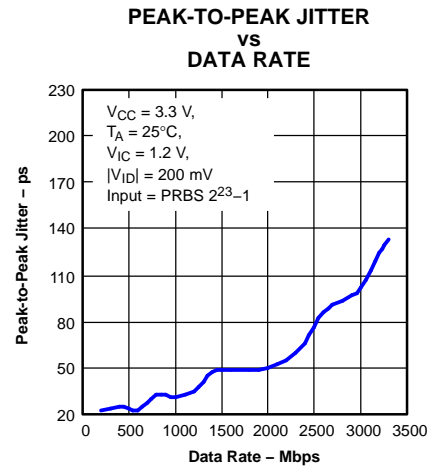
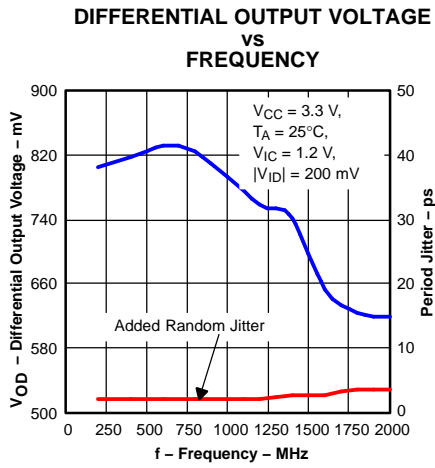


**Figure 12.**



**Figure 13.**

TYPICAL CHARACTERISTICS (continued)



APPLICATION INFORMATION

TYPICAL APPLICATION CIRCUITS (ECL, PECL, LVDS, etc.)

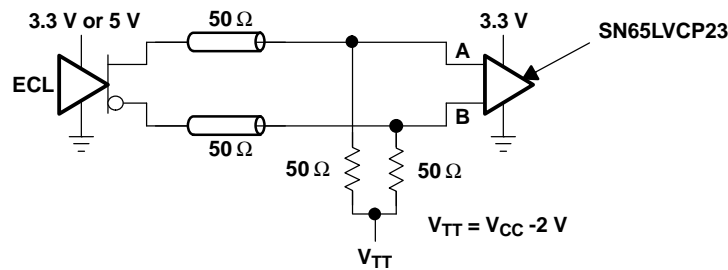


Figure 16. Low-Voltage Positive Emitter-Coupled Logic (LVPECL)

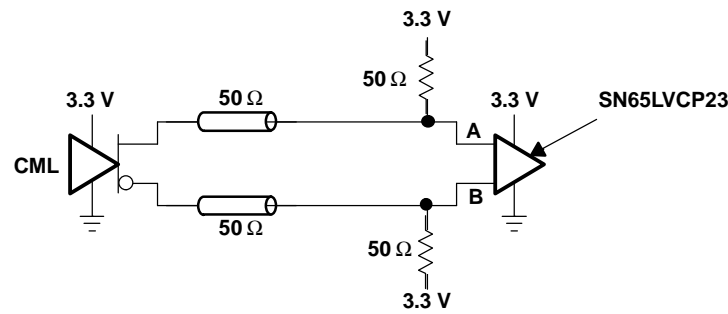


Figure 17. Current-Mode Logic (CML)

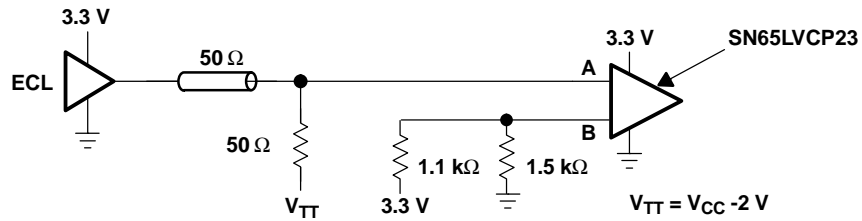


Figure 18. Single-Ended (LVPECL)

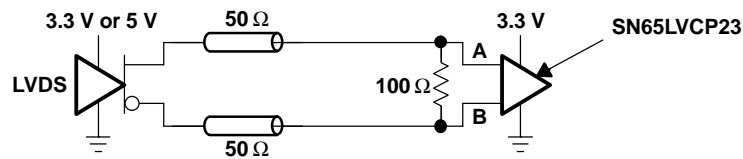


Figure 19. Low-Voltage Differential Signaling (LVDS)

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
SN65LVCP23D	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23DG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23DR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23DRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23PWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVCP23PWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

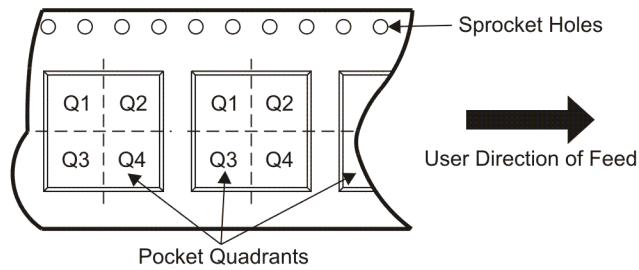
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**TAPE AND REEL INFORMATION**



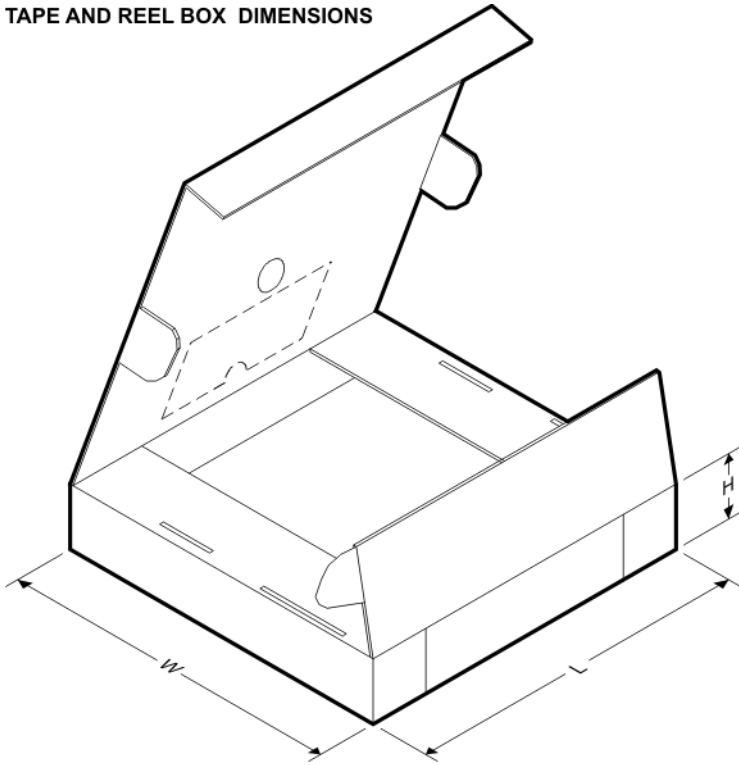
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN65LVCP23DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN65LVCP23PWR	TSSOP	PW	16	2000	330.0	12.4	6.67	5.4	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVCP23DR	SOIC	D	16	2500	346.0	346.0	33.0
SN65LVCP23PWR	TSSOP	PW	16	2000	346.0	346.0	29.0



PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN

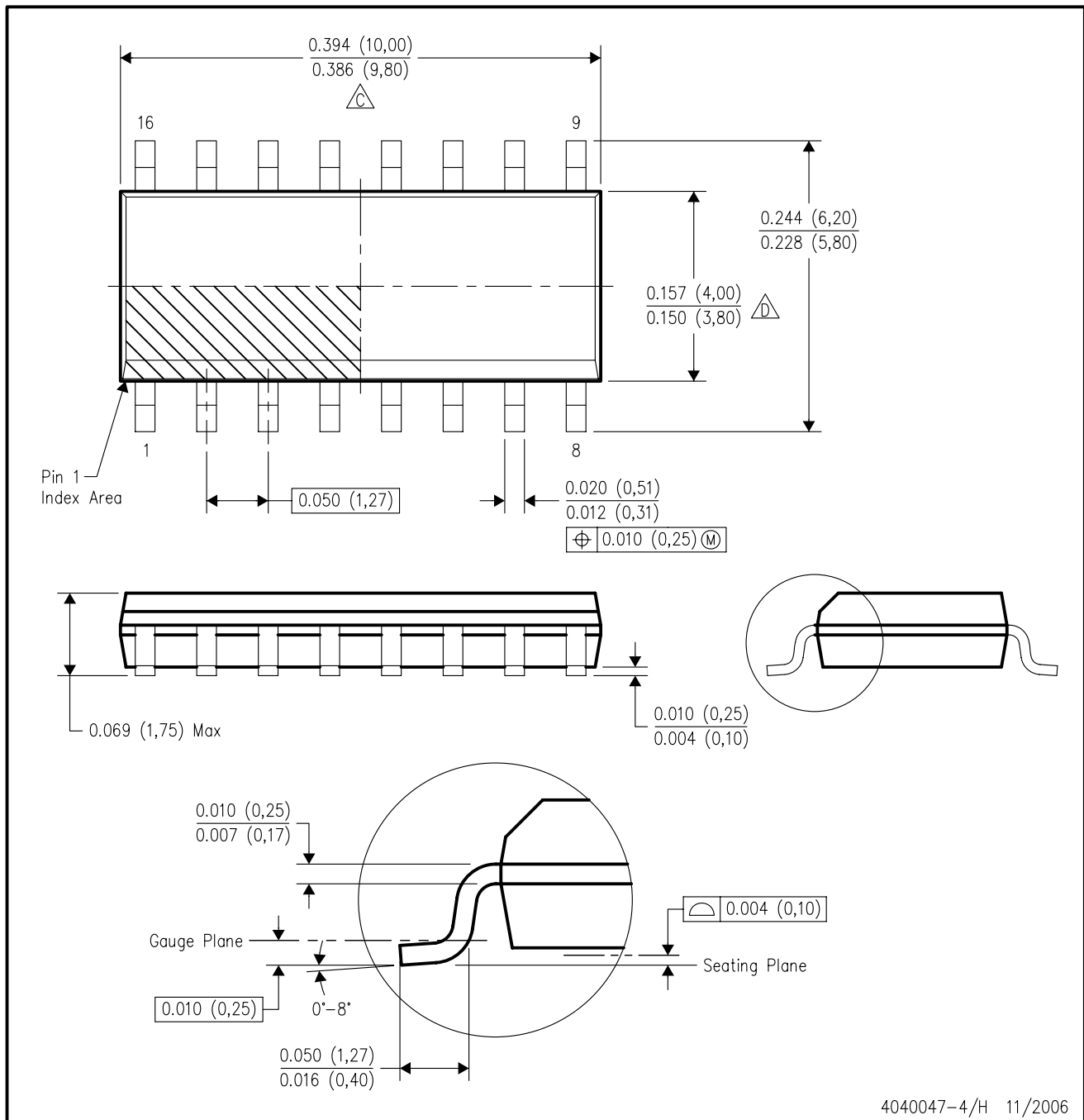


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- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AC.

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