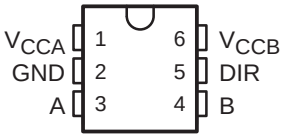
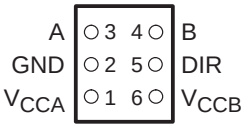
- **Available in the Texas Instruments NanoStar™ and NanoFree™ Packages**
- **Fully Configurable Dual-Rail Design Allows Each Port to Operate Over the Full 1.65-V to 5.5-V Power-Supply Range**
- **V_{CC} Isolation Feature − If Either V_{CC} Input Is at GND, Both Ports Are in the High-Impedance State**
- **DIR Referenced to V_{CCA}**
- **Low Power Consumption, 10-μA Max I_{CC}**
- **±24-mA Output Drive at 3.3 V**
- **I_{off} Supports Partial-Power-Down Mode Operation**

DBV OR DCK PACKAGE
(TOP VIEW)



YEP OR YZP PACKAGE
(BOTTOM VIEW)



description/ordering information

This single-bit noninverting bus transceiver uses two separate configurable power-supply rails. The A-port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.65 V to 5.5 V. The B-port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 1.65 V to 5.5 V. This allows universal low-voltage bidirectional translation between any of the 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes.

The SN74LVC1T45 is designed for asynchronous communication between data buses. The device transmits data from the A bus to the B bus or from the B bus to the A bus, depending on the logic level at the direction-control (DIR) input.

The SN74LVC1T245 is designed so that DIR is supplied by V_{CCA}.

This device is fully specified for partial-power-down applications using I_{off}. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

The V_{CC} isolation feature ensures that if either V_{CC} input is at GND, both ports are in the high-impedance state.

NanoStar™ and NanoFree™ package technology is a major breakthrough in IC packaging concepts, using the die as the package.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING‡
−40°C to 85°C	NanoStar™ − WCSP (DSBGA) 0.23-mm Large Bump − YEP	Tape and reel	SN74LVC1T45YEPR	TBD
	NanoFree™ − WCSP (DSBGA) 0.23-mm Large Bump − YZP (Pb-free)	Tape and reel	SN74LVC1T45YZPR	TBD
	SOT (SOT-23) − DBV	Tape and reel	SN74LVC1T45DBVR	TBD
	SOT (SC-70) − DCK	Tape and reel	SN74LVC1T45DCKR	TBD

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

‡ DBV/DCK: The actual top-side marking has one additional character that designates the assembly/test site.
YEP/YZP: The actual top-side marking has three preceding characters to denote year, month, and sequence code, and one following character to designate the assembly/test site. Pin 1 identifier indicates solder-bump composition (1 = SnPb, • = Pb-free).

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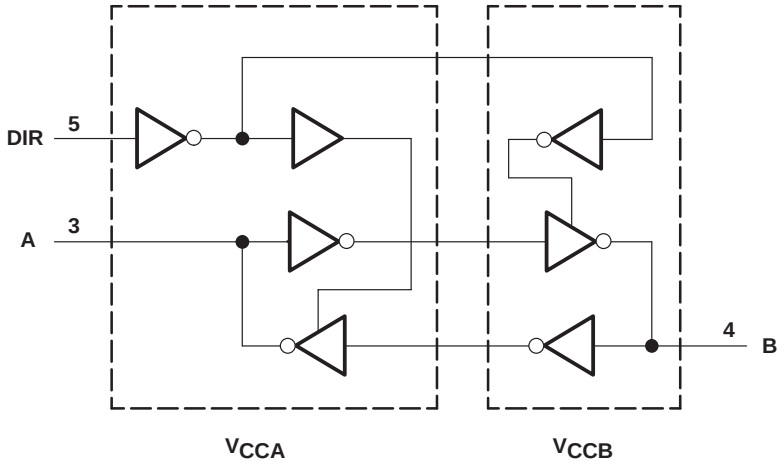
FUNCTION TABLE

INPUT DIR	OPERATION
L	B data to A bus
H	A data to B bus

logic diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CCA} and V_{CCB} . . . . . −0.5 V to 6.5 V
Input voltage range, V_I (see Note 1) . . . . . −0.5 V to 6.5 V
Voltage range applied to any output in the high-impedance or power-off state, V_O
(see Note 1) . . . . . −0.5 V to 6.5 V
Voltage range applied to any output in the high or low state, V_O (see Notes 1 and 2)
A port . . . . . −0.5 V to V_{CCA} + 0.5V
B port . . . . . −0.5 V to V_{CCB} + 0.5V
Input clamp current, I_{IK} (V_I < 0) . . . . . −50 mA
Output clamp current, I_{OK} (V_O < 0) . . . . . −50 mA
Continuous output current, I_O . . . . . ±50 mA
Continuous current through V_{CC} or GND . . . . . ±100 mA
Package thermal impedance, θ_{JA} (see Note 3): DBV package . . . . . 165°C/W
DCK package . . . . . 259°C/W
YEP/YZP package . . . . . 123°C/W
Storage temperature range, T_{stg} . . . . . −65°C to 150°C

† 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.

NOTES: 1. The input negative-voltage and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
2. The value of V_{CC} is provided in the recommended operating conditions table.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

PRODUCT PREVIEW

recommended operating conditions (see Notes 4 through 8)

			V_{CCI}	V_{CCO}	MIN	MAX	UNIT
V_{CCA}	Supply voltage				1.65	5.5	V
V_{CCB}					1.65	5.5	
V_{IH}	High-level input voltage	Data inputs (see Note 7)	1.65 V to 1.95 V		$V_{CCI} \times 0.65$		V
			2.3 V to 2.7 V		1.7		
			3 V to 3.6 V		2		
			4.5 V to 5.5 V		$V_{CCI} \times 0.7$		
V_{IL}	Low-level input voltage	Data inputs (see Note 7)	1.65 V to 1.95 V			$V_{CCI} \times 0.35$	V
			2.3 V to 2.7 V			0.7	
			3 V to 3.6 V			0.8	
			4.5 V to 5.5 V			$V_{CCI} \times 0.3$	
V_{IH}	High-level input voltage	DIR (Referenced to V_{CCA}) (see Note 8)	1.65 V to 1.95 V		$V_{CCA} \times 0.65$		V
			2.3 V to 2.7 V		1.7		
			3 V to 3.6 V		2		
			4.5 V to 5.5 V		$V_{CCA} \times 0.7$		
V_{IL}	Low-level input voltage	DIR (Referenced to V_{CCA}) (see Note 8)	1.65 V to 1.95 V			$V_{CCA} \times 0.35$	V
			2.3 V to 2.7 V			0.7	
			3 V to 3.6 V			0.8	
			4.5 V to 5.5 V			$V_{CCA} \times 0.3$	
V_I	Input voltage				0	5.5	V
V_O	Output voltage				0	V_{CCO}	V
I_{OH}	High-level output current			1.65 V to 1.95 V		−4	mA
				2.3 V to 2.7 V		−8	
				3 V to 3.6 V		−24	
				4.5 V to 5.5 V		−32	
I_{OL}	Low-level output current			1.65 V to 1.95 V		4	mA
				2.3 V to 2.7 V		8	
				3 V to 3.6 V		24	
				4.5 V to 5.5 V		32	
$\Delta t/\Delta v$	Input transition rise or fall rate	Data input	1.65 V to 1.95 V			20	ns/V
			2.3 V to 2.7 V			20	
			3 V to 3.6 V			10	
			4.5 V to 5.5 V			5	
		Control input	1.65 V to 5.5 V			5	
T_A	Operating free-air temperature				−40	85	°C

NOTES: 4. V_{CCI} is the V_{CC} associated with the data input port.
5. V_{CCO} is the V_{CC} associated with the output port.
6. All unused data inputs of the device must be held at V_{CCI} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.
7. For V_{CCI} values not specified in the data sheet, $V_{IH(min)} = V_{CCI} \times 0.7$ V, $V_{IL(max)} = V_{CCI} \times 0.3$ V.
8. For V_{CCI} values not specified in the data sheet, $V_{IH(min)} = V_{CCA} \times 0.7$ V, $V_{IL(max)} = V_{CCA} \times 0.3$ V.

PRODUCT PREVIEW

PRODUCT PREVIEW

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Notes 9 and 10)

PARAMETER		TEST CONDITIONS		V_{CCA}	V_{CCB}	T_A = 25°C			−40°C to 85°C		UNIT
						MIN	TYP	MAX	MIN	MAX	
V_{OH}		I_{OH} = −100 μA, V_I = V_{IH}		1.65 V to 4.5 V	1.65 V to 4.5 V				V_{CCO}−0.1		V
		I_{OH} = −4 mA, V_I = V_{IH}		1.65V	1.65 V				1.2		
		I_{OH} = −8 mA, V_I = V_{IH}		2.3 V	2.3 V				1.9		
		I_{OH} = −24 mA, V_I = V_{IH}		3 V	3 V				2.4		
		I_{OH} = −32 mA, V_I = V_{IH}		4.5 V	4.5 V				3.8		
V_{OL}		I_{OL} = 100 μA, V_I = V_{IL}		1.65 V to 4.5 V	1.65 V to 4.5 V					0.1	V
		I_{OL} = 4 mA, V_I = V_{IL}		1.65 V	1.65 V					0.45	
		I_{OL} = 8 mA, V_I = V_{IL}		2.3 V	2.3 V					0.3	
		I_{OL} = 24 mA, V_I = V_{IL}		3 V	3 V					0.55	
		I_{OL} = 32 mA, V_I = V_{IL}		4.5 V	4.5 V					0.55	
I_I	DIR input	V_I = V_{CCA} or GND		1.65 V to 5.5 V	1.65 V to 5.5 V			TBD		±5	μA
I_{off}	A port	V_I or V_O = 0 to 5.5 V		0 V	0 to 5.5 V			TBD		±10	μA
	B port			0 to 5.5 V	0 V			TBD		±10	
I_{OZ}	A or B ports	V_O = V_{CCO} or GND		1.65 V to 5.5 V	1.65 V to 5.5 V			TBD		±10	μA
I_{CCA}		V_I = V_{CCI} or GND	I_O = 0	1.95 V	1.95 V					1	μA
				2.7 V	2.7 V					1	
				3.6 V	3.6 V					1	
				5.5 V	0 V					2	
				0 V	5.5 V					0	
				5.5 V	5.5 V					1	
I_{CCB}		V_I = V_{CCI} or GND	I_O = 0	1.95 V	1.95 V					1	μA
				2.7 V	2.7 V					1	
				3.6 V	3.6 V					1	
				5.5 V	0 V					0	
				0 V	5.5 V					2	
				5.5 V	5.5 V					1	
I_{CCA} + I_{CCB} (see Table 1)		V_I = V_{CCI} or GND	I_O = 0	1.65 V to 5.5 V	1.65 V to 5.5 V					4	μA
ΔI_{CCA}	A port	A port at V_{CCA} − 0.6 V, DIR at V_{CCA}, B port = OPEN		3 V to 5.5 V	3 V to 5.5 V					50	μA
	DIR	DIR at V_{CCA} − 0.6 V, B port = OPEN, A port at V_{CCA} or GND								50	
ΔI_{CCB}	B port	B port at V_{CCB} − 0.6 V, DIR at GND, A port = OPEN		3 V to 5.5 V	3 V to 5.5 V					50	μA
C_i	DIR input	V_I = V_{CCA} or GND		3.3 V	3.3 V		TBD				pF
C_{io}	A or B ports	V_O = $V_{CCA/B}$ or GND		3.3 V	3.3 V		TBD				pF

NOTES: 9. V_{CCO} is the V_{CC} associated with the output port.
10. V_{CCI} is the V_{CC} associated with the input port.

switching characteristics over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V(unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	A	B									ns
t_{PHL}											
t_{PLH}	B	A									ns
t_{PHL}											
t_{PZH}	DIR	A									ns
t_{PZL}											
t_{PZH}	DIR	B									ns
t_{PZL}											
t_{PHZ}	DIR	A									ns
t_{PLZ}											
t_{PHZ}	DIR	B									ns
t_{PLZ}											

switching characteristics over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V(unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	A	B									ns
t_{PHL}											
t_{PLH}	B	A									ns
t_{PHL}											
t_{PZH}	DIR	A									ns
t_{PZL}											
t_{PZH}	DIR	B									ns
t_{PZL}											
t_{PHZ}	DIR	A									ns
t_{PLZ}											
t_{PHZ}	DIR	B									ns
t_{PLZ}											

PRODUCT PREVIEW

PRODUCT PREVIEW

switching characteristics over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V(unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	A	B									ns
t_{PHL}											
t_{PLH}	B	A									ns
t_{PHL}											
t_{PZH}	DIR	A									ns
t_{PZL}											
t_{PZH}	DIR	B									ns
t_{PZL}											
t_{PHZ}	DIR	A									ns
t_{PLZ}											
t_{PHZ}	DIR	B									ns
t_{PLZ}											

switching characteristics over recommended operating free-air temperature range, V_{CCA} = 5 V ± 0.5 V(unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CCB} = 1.8 V ± 0.15 V		V_{CCB} = 2.5 V ± 0.2 V		V_{CCB} = 3.3 V ± 0.3 V		V_{CCB} = 5 V ± 0.5 V		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	A	B									ns
t_{PHL}											
t_{PLH}	B	A									ns
t_{PHL}											
t_{PZH}	DIR	A									ns
t_{PZL}											
t_{PZH}	DIR	B									ns
t_{PZL}											
t_{PHZ}	DIR	A									ns
t_{PLZ}											
t_{PHZ}	DIR	B									ns
t_{PLZ}											

operating characteristics, T_A = 25°C

PARAMETER		TEST CONDITIONS	V_{CCA} = V_{CCB} = 1.8 V	V_{CCA} = V_{CCB} = 2.5 V	V_{CCA} = V_{CCB} = 3.3 V	V_{CCA} = V_{CCB} = 5 V	UNIT
			TYP	TYP	TYP	TYP	
C_{pdA}†	A port input, B port output	C_L = 0, f = 10 MHz, $t_r = t_f$ =1 ns					pF
	B port input, A port output						
C_{pdB}†	A port input, B port output						
	B port input, A port output						

† Power dissipation capacitance

power-up considerations

A proper power-up sequence always should be followed to avoid excessive supply current, bus contention, oscillations, or other anomalies. Take the following precautions, in the order given, to guard against such power-up problems:

1. Connect ground before any supply voltage is applied.
2. Power up V_{CCA}.
3. Ramp up V_{CCB} along with or after V_{CCA}.

typical total static power consumption (I_{CCA} and I_{CCB})

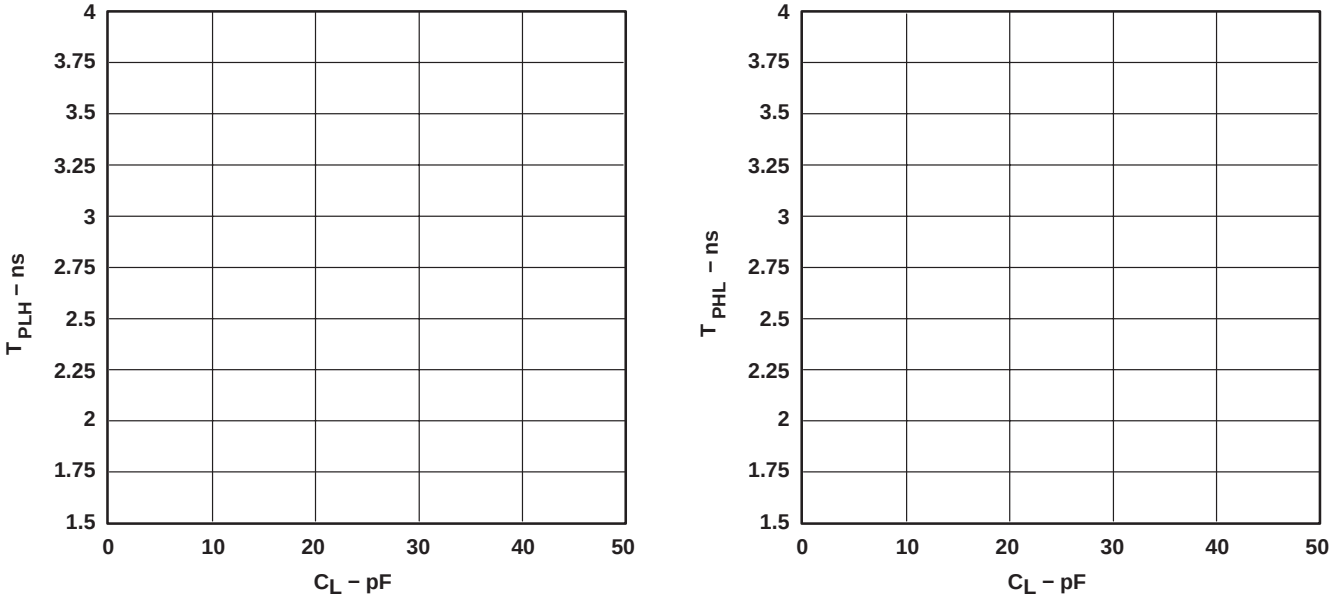
V_{CCB}	V_{CCA}				UNIT
	1.8 V	2.5 V	3.3 V	5 V	
1.8 V	<1	<1	<1	1.5	μA
2.5 V	<1	<1	<1	1	
3.3 V	<1	<1	<1	<1	
5 V	1.5	1	<1	<1	

TABLE 1

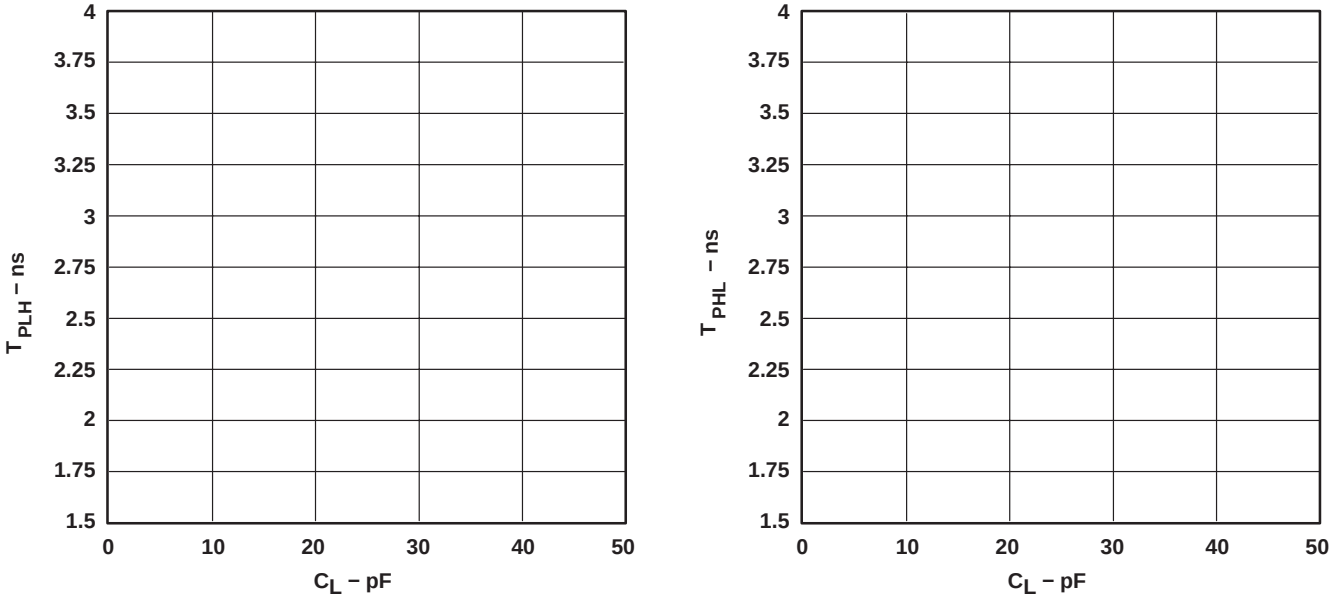
PRODUCT PREVIEW

PRODUCT PREVIEW

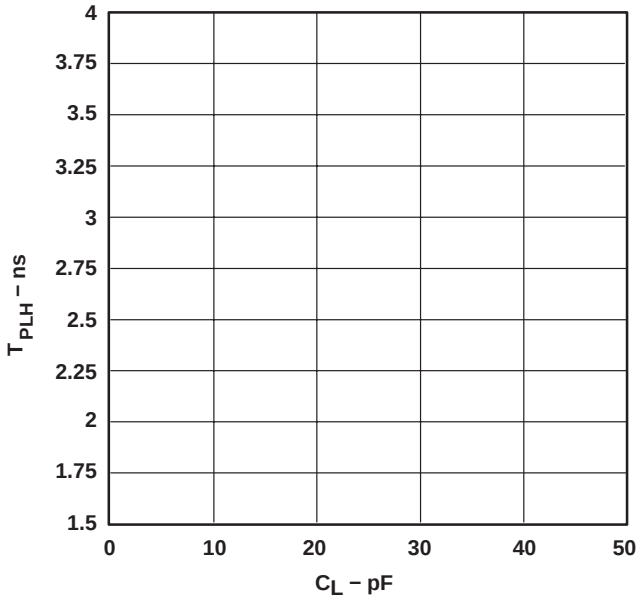
TYPICAL PROPAGATION DELAY vs LOAD CAPACITANCE,
T_A = 25°C, V_{CCA} = 1.8 V

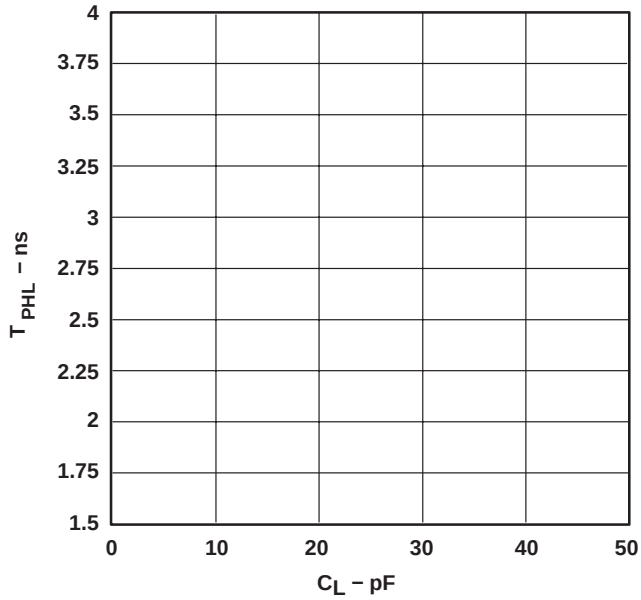


TYPICAL PROPAGATION DELAY vs LOAD CAPACITANCE,
T_A = 25°C, V_{CCA} = 2.5 V

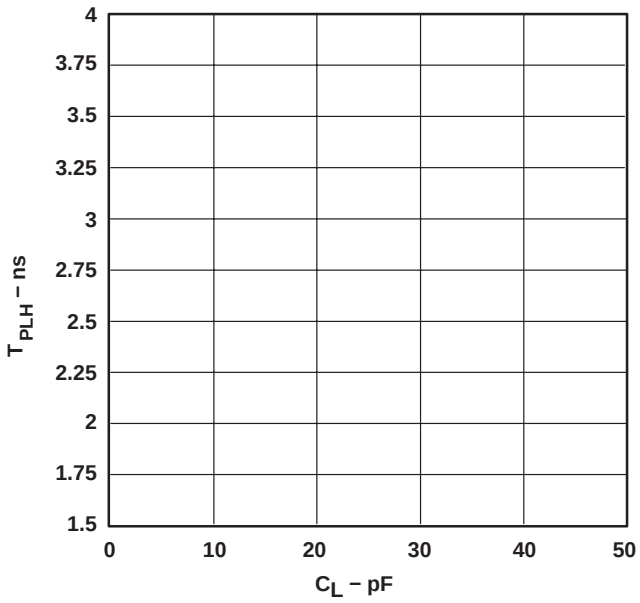


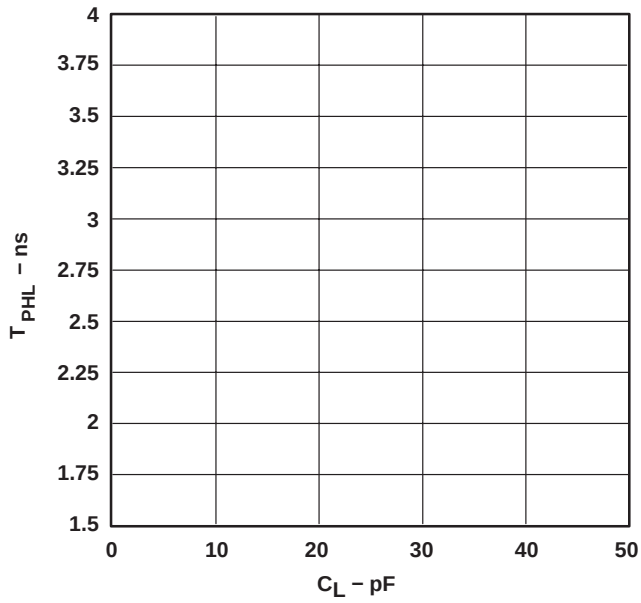
TYPICAL PROPAGATION DELAY vs LOAD CAPACITANCE,
T_A = 25°C,V_{CCA} = 3.3 V





TYPICAL PROPAGATION DELAY vs LOAD CAPACITANCE,
T_A = 25°C,V_{CCA} = 5 V

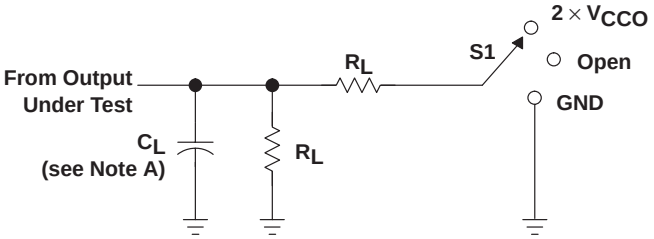




PRODUCT PREVIEW

PRODUCT PREVIEW

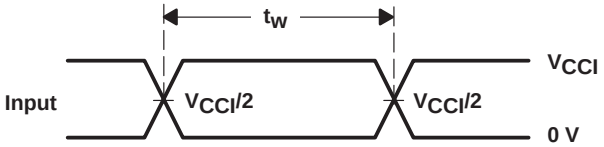
PARAMETER MEASUREMENT INFORMATION



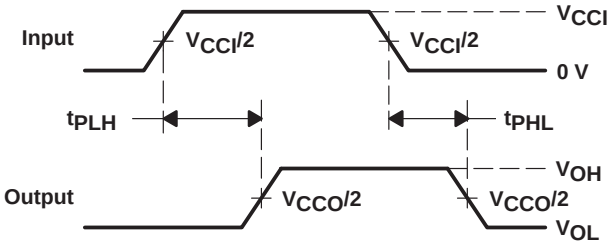
LOAD CIRCUIT

TEST	S1
t_{pd}	Open
t_{PLZ}/t_{PZL}	$2 \times V_{CCO}$
t_{PHZ}/t_{PZH}	GND

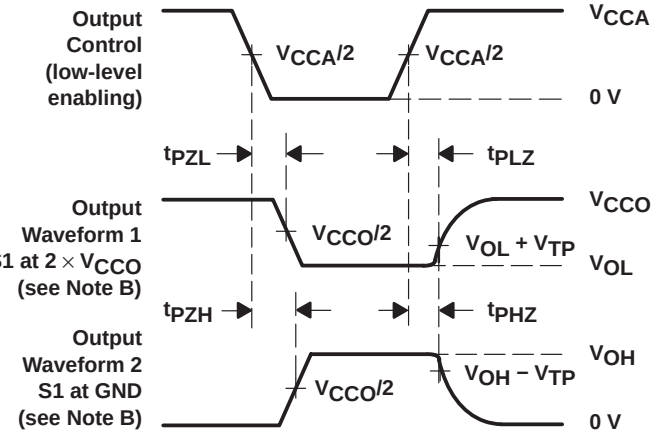
V_{CCO}	C_L	R_L	V_{TP}	t_r or t_f
1.8 V ± 0.15 V	15 pF	2 kΩ	0.15 V	≤2 ns
2.5 V ± 0.2 V	15 pF	2 kΩ	0.15 V	≤2ns
3.3 V ± 0.3 V	15 pF	2 kΩ	0.3 V	≤2.5 ns
5 V ± 0.5 V	15 pF	2 kΩ	0.3 V	≤2.5 ns



VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES



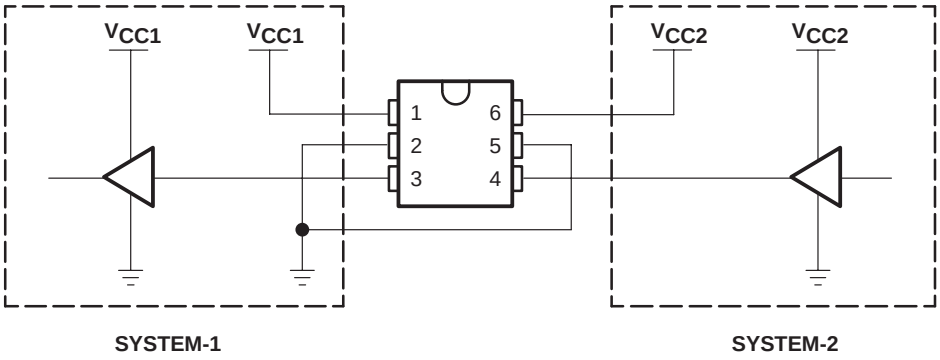
VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

NOTES: A. C_L includes probe and jig capacitance.
B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω.
D. The outputs are measured one at a time with one transition per measurement.
E. V_{CCI} is the power supply voltage associated with the input port.
F. V_{CCO} is the power supply voltage associated with the output port.

Figure 1. Load Circuit and Voltage Waveforms

APPLICATION INFORMATION

The following circuit is an example of the SN74LVC1T45 used in a unidirectional logic level-shifting application.



PIN	NAME	FUNCTION	DESCRIPTION
1	V_{CCA}	V_{CC1}	SYSTEM-1 supply voltage (1.65 V to 5.5 V)
2	GND	GND	Device GND
3	A	OUT	Output level depends on V_{CC1} voltage
4	B	IN	Input threshold-value depends on V_{CC2} voltage
5	DIR	DIR	The GND (low-level) determines B-port to A-port direction
6	V_{CCB}	V_{CC2}	SYSTEM-2 supply voltage (1.65 V to 5.5 V)

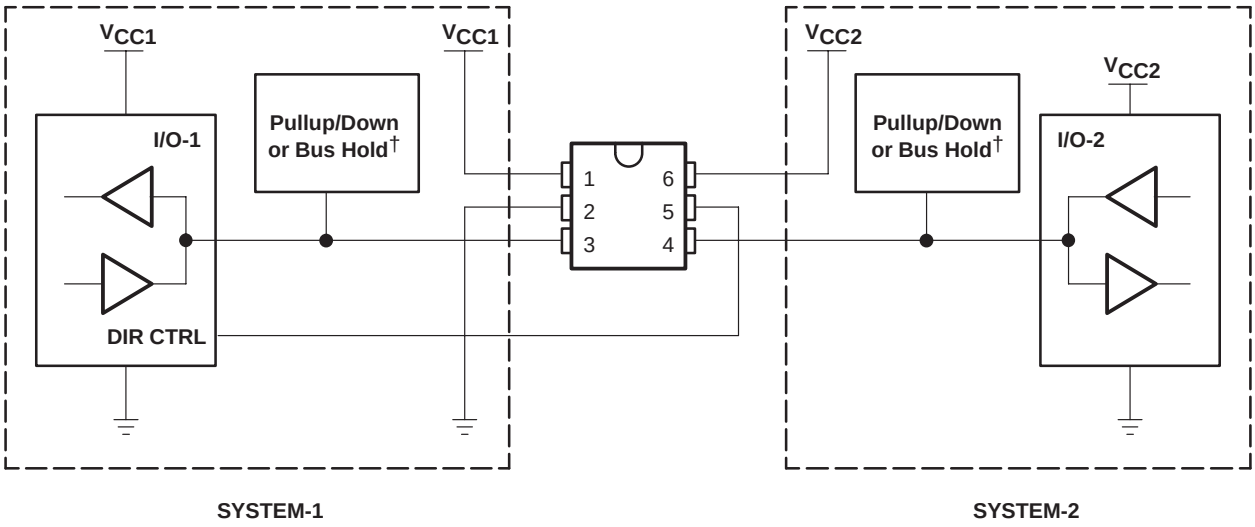
Figure 2. Unidirectional Logic Level-Shifting Application

PRODUCT PREVIEW

PRODUCT PREVIEW

APPLICATION INFORMATION

Figure 3 shows the SN74LVC1T45 being used in a bidirectional logic level-shifting application. Because the SN74LVC1T45 does not have an output enable (OE) pin, the system designer should take precautions to avoid bus contention between SYSTEM-1 and SYSTEM-2 when changing directions.



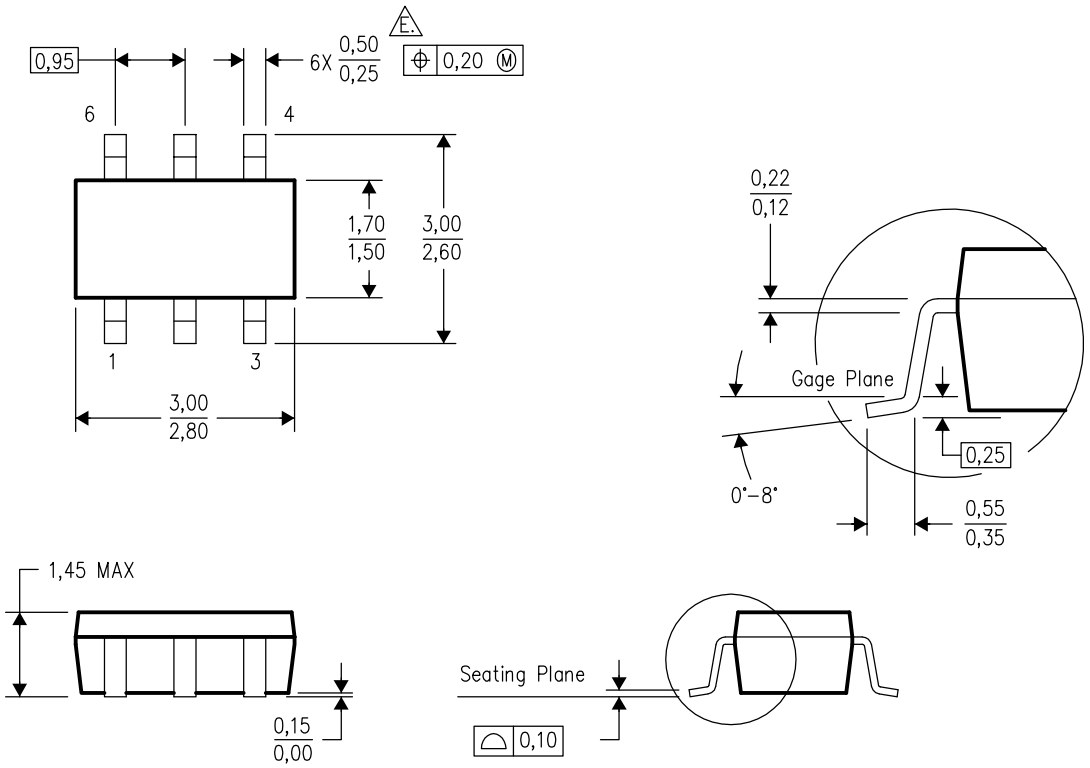
The sequence in Figure 3 illustrates data transmission from SYSTEM-1 to SYSTEM-2 and then from SYSTEM-2 to SYSTEM-1.

STATE	DIR CTRL	I/O 1	I/O 2	DESCRIPTION
1	H	OUT	IN	SYSTEM-1 data to SYSTEM-2
2	H	HI-Z	HI-Z	SYSTEM-2 is getting ready to send data to SYSTEM-1. I/O-1 and I/O-2 are disabled. The bus-line state depends on pullup or pulldown.†
3	L	HI-Z	HI-Z	DIR bit is flipped. I/O-1 and I/O-2 are still disabled. The bus-line state depends on pullup or pulldown.†
4	L	OUT	IN	SYSTEM-2 data to SYSTEM-1

† SYSTEM-1 and SYSTEM-2 must use the same conditions, i.e., both pullup or both pulldown.

Figure 3. Bidirectional Logic Level-Shifting Application

DBV (R–PDSO–G6) PLASTIC SMALL–OUTLINE PACKAGE



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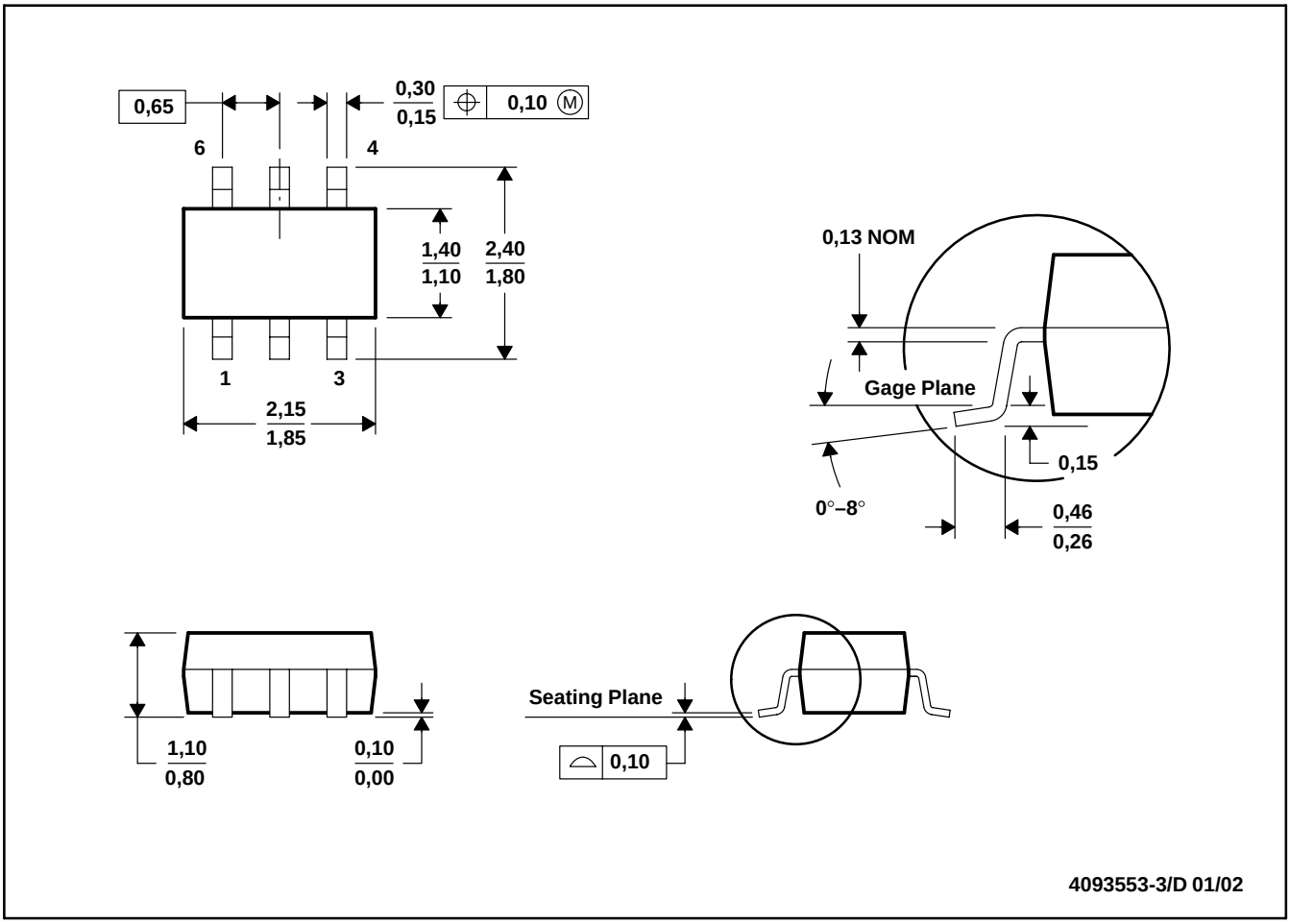
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
E. Falls within JEDEC MO–178 Variation AB, except minimum lead width.

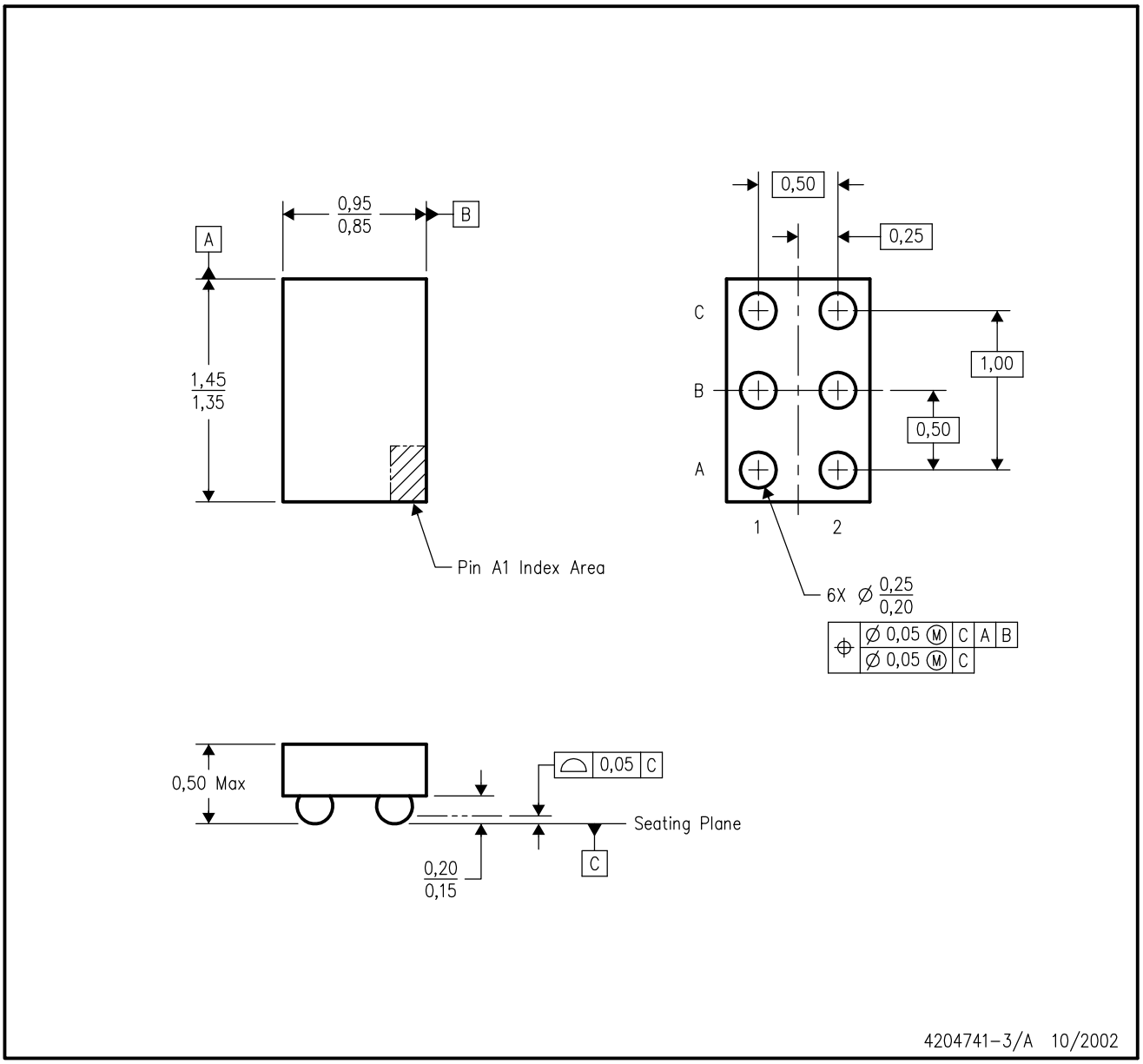
MPDS114 – FEBRUARY 2002

DCK (R-PDSO-G6) **PLASTIC SMALL-OUTLINE PACKAGE**



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.
D. Falls within JEDEC MO-203

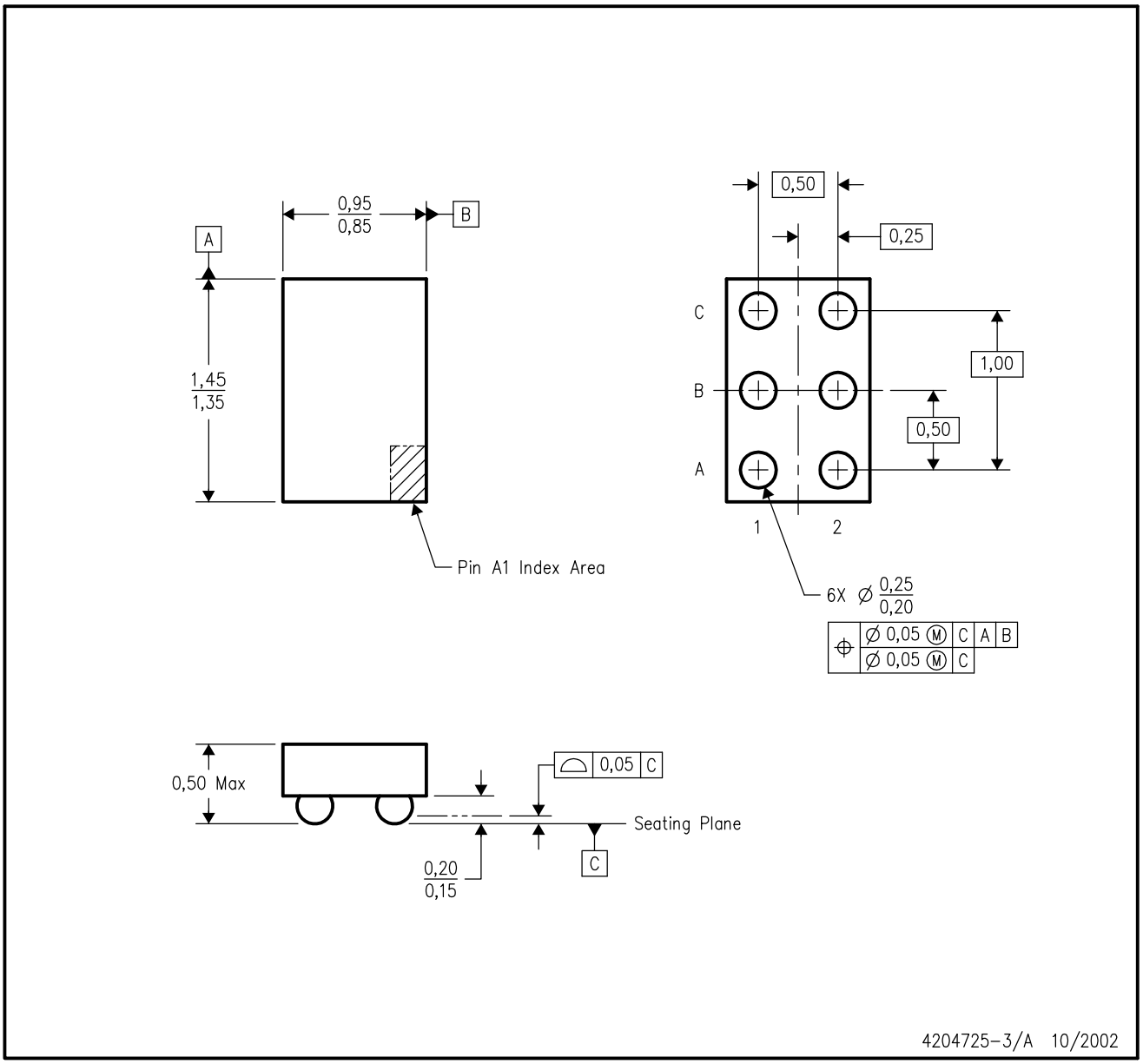
YZP (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. NanoFree™ package configuration.
D. This package is lead–free. Refer to the 6 YEP package (drawing 4204725) for tin–lead (SnPb).

NanoFree is a trademark of Texas Instruments.

YEP (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. NanoStar™ package configuration.
D. This package is tin–lead (SnPb). Refer to the 6 YZP package (drawing 4204741) for lead–free.

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