

# SN74CB3T3383

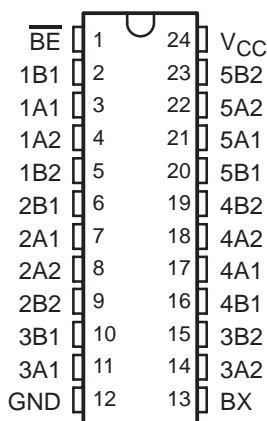
## 10-BIT FET BUS-EXCHANGE SWITCH

### 2.5-V/3.3-V LOW-VOLTAGE BUS SWITCH WITH 5-V-TOLERANT LEVEL SHIFTER

SCDS158A – OCTOBER 2003 – REVISED DECEMBER 2004

- Output Voltage Translation Tracks  $V_{CC}$
- Supports Mixed-Mode Signal Operation On All Data I/O Ports
  - 5-V Input Down To 3.3-V Output Level Shift With 3.3-V  $V_{CC}$
  - 5-V/3.3-V Input Down To 2.5-V Output Level Shift With 2.5-V  $V_{CC}$
- 5-V-Tolerant I/Os With Device Powered Up or Powered Down
- Bidirectional Data Flow, With Near-Zero Propagation Delay
- Low ON-State Resistance ( $r_{ON}$ ) Characteristics ( $r_{ON} = 5 \Omega$  Typical)
- Low Input/Output Capacitance Minimizes Loading ( $C_{iO(OFF)} = 8 \text{ pF}$  Typical)
- Data and Control Inputs Provide Undershoot Clamp Diodes
- Low Power Consumption ( $I_{CC} = 20 \mu\text{A}$  Max)
- $V_{CC}$  Operating Range From 2.3 V to 3.6 V
- Data I/Os Support 0- to 5-V Signaling Levels (0.8 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, 5 V)
- Control Inputs Can Be Driven by TTL or 5-V/3.3-V CMOS Outputs
- $I_{off}$  Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 250 mA Per JESD 17
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Supports Digital Applications: Level Translation, Memory Interleaving, Bus Isolation
- Ideal for Low-Power Portable Equipment

DBQ, DGV, DW, OR PW PACKAGE  
(TOP VIEW)



#### description/ordering information

#### ORDERING INFORMATION

$T_A$	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	SOIC – DW	Tube	SN74CB3T3383DW	CB3T3383
		Tape and reel	SN74CB3T3383DWR	
	SSOP (QSOP) – DBQ	Tape and reel	SN74CB3T3383DBQR	CB3T3383
		TSSOP – PW	Tube	SN74CB3T3383PW
	Tape and reel		SN74CB3T3383PWR	
TVSOP – DGV	Tape and reel	SN74CB3T3383DGV	KS383	

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



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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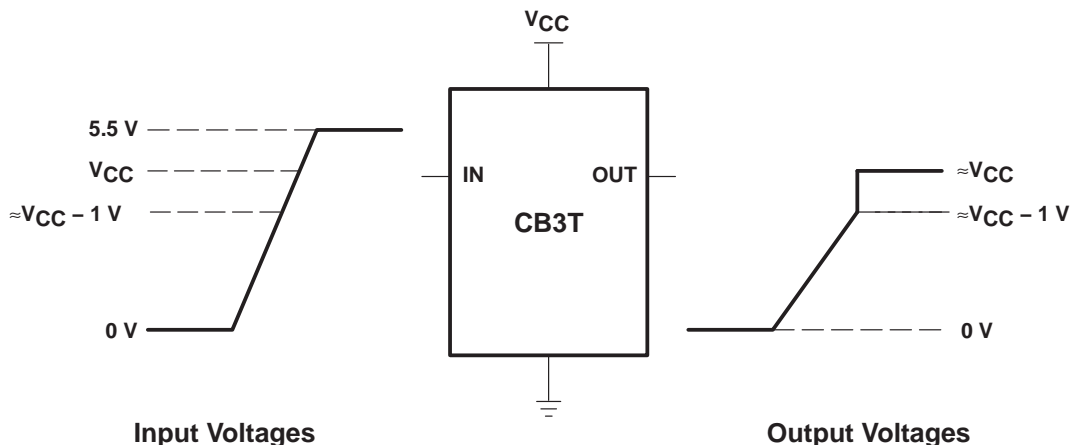
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**2.5-V/3.3-V LOW-VOLTAGE BUS SWITCH WITH 5-V-TOLERANT LEVEL SHIFTER**

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**description/ordering information (continued)**

The SN74CB3T3383 is a high-speed TTL-compatible FET bus-exchange switch with low ON-state resistance ( $r_{ON}$ ), allowing for minimal propagation delay. The device fully supports mixed-mode signal operation on all data I/O ports by providing voltage translation that tracks  $V_{CC}$ . The SN74CB3T3383 supports systems using 5-V TTL, 3.3-V LVTTTL, and 2.5-V CMOS switching standards, as well as user-defined switching levels (see Figure 1).



NOTE A: If the input high voltage ( $V_{IH}$ ) level is greater than or equal to  $V_{CC} - 1V$ , and less than or equal to 5.5 V, then the output high voltage ( $V_{OH}$ ) level will be equal to approximately the  $V_{CC}$  voltage level.

**Figure 1. Typical DC Voltage Translation Characteristics**

The SN74CB3T3383 is organized as a 10-bit bus switch or as a 5-bit bus-exchange with enable ( $\overline{BE}$ ) input. When used as a 5-bit bus-exchange, the device provides data exchanging between four signal ports. When  $\overline{BE}$  is low, the bus-exchange switch is ON, and the select input (BX) controls the data path. When  $\overline{BE}$  is high, the bus-exchange switch is OFF, and a high-impedance state exists between the A and B ports.

This device is fully specified for partial-power-down applications using  $I_{off}$ . The  $I_{off}$  feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down,  $\overline{BE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

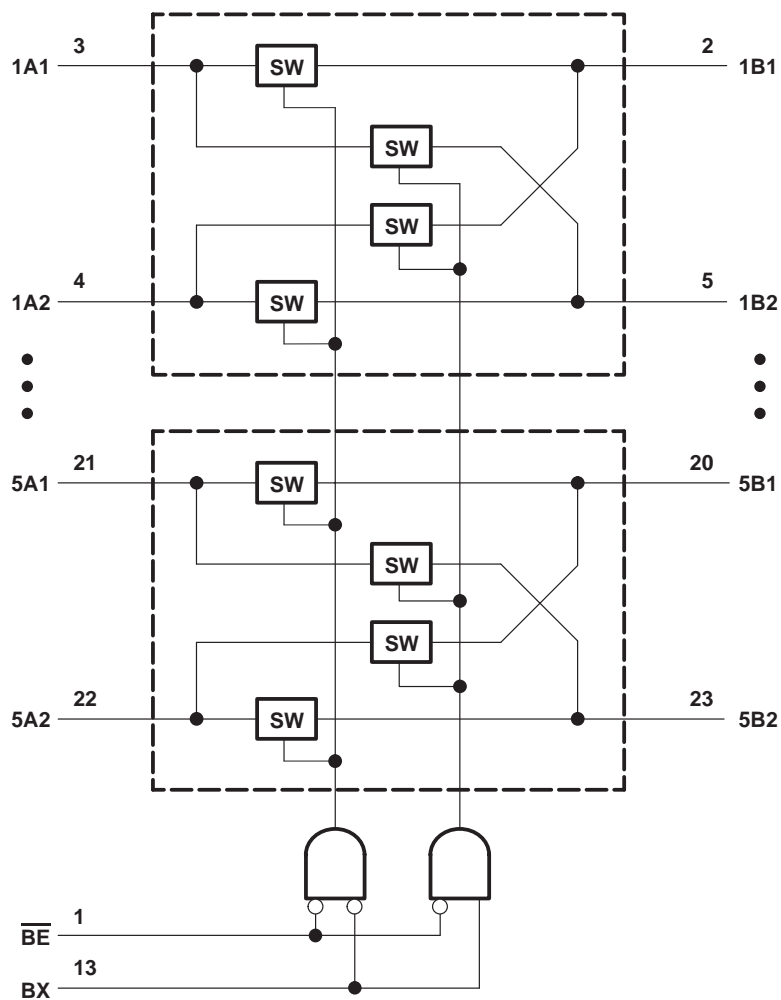
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FUNCTION TABLE  
 (each 5-bit switch)

INPUTS		INPUTS/OUTPUTS		FUNCTION
$\overline{BE}$	BX	A1	A2	
L	L	B1	B2	A1 port = B1 port A2 port = B2 port
L	H	B2	B1	A1 port = B2 port A2 port = B1 port
H	X	Z	Z	Disconnect

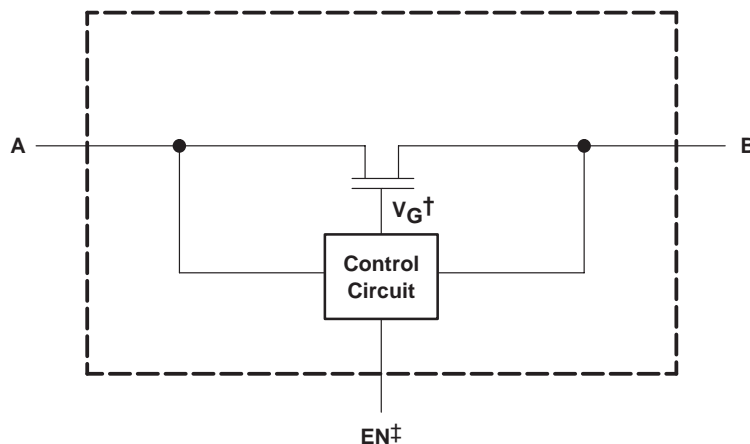
logic diagram (positive logic)



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**simplified schematic, each FET switch (SW)**



† Gate Voltage ( $V_G$ ) is approximately equal to  $V_{CC} + V_T$  when the switch is ON and  $V_I > V_{CC} + V_T$ .  
‡ EN is the internal enable signal applied to the switch.

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

Supply voltage range, $V_{CC}$ (see Note 1)	.....	-0.5 V to 7 V
Control input voltage range, $V_{IN}$ (see Notes 1 and 2)	.....	-0.5 V to 7 V
Switch I/O voltage range, $V_{I/O}$ (see Notes 1, 2, and 3)	.....	-0.5 V to 7 V
Control input clamp current, $I_{IK}$ ( $V_{IN} < 0$ )	.....	-50 mA
I/O port clamp current, $I_{I/OK}$ ( $V_{I/O} < 0$ )	.....	-50 mA
ON-state switch current, $I_{I/O}$ (see Note 4)	.....	$\pm 128$ mA
Continuous current through $V_{CC}$ or GND terminals	.....	$\pm 100$ mA
Package thermal impedance, $\theta_{JA}$ (see Note 5):		
DBQ package	.....	61°C/W
DGV package	.....	86°C/W
DW package	.....	46°C/W
PW package	.....	88°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. All voltages are with respect to ground unless otherwise specified.
  2. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
  3.  $V_I$  and  $V_O$  are used to denote specific conditions for  $V_{I/O}$ .
  4.  $I_I$  and  $I_O$  are used to denote specific conditions for  $I_{I/O}$ .
  5. The package thermal impedance is calculated in accordance with JESD 51-7.

**recommended operating conditions (see Note 6)**

		MIN	MAX	UNIT	
$V_{CC}$	Supply voltage	2.3	3.6	V	
$V_{IH}$	High-level control input voltage	$V_{CC} = 2.3$ V to 2.7 V	1.7	5.5	V
		$V_{CC} = 2.7$ V to 3.6 V	2	5.5	
$V_{IL}$	Low-level control input voltage	$V_{CC} = 2.3$ V to 2.7 V	0	0.7	V
		$V_{CC} = 2.7$ V to 3.6 V	0	0.8	
$V_{I/O}$	Data input/output voltage	0	5.5	V	
$T_A$	Operating free-air temperature	-40	85	°C	

NOTE 6: All unused control inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.



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**electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT	
$V_{IK}$		$V_{CC} = 3\text{ V}$ , $I_I = -18\text{ mA}$			-1.2	V	
$V_{OH}$		See Figures 3 and 4					
$I_{IN}‡$	Control inputs	$V_{CC} = 3.6\text{ V}$ , $V_{IN}‡ = 3.6\text{ V to } 5.5\text{ V or GND}$			±10	μA	
$I_I$	Switch ON, $V_{IN} = V_{CC}$ or GND	$V_I = V_{CC} - 0.7\text{ V to } 5.5\text{ V}$			±20	μA	
		$V_I = 0.7\text{ V to } V_{CC} - 0.7\text{ V}$			-40		
		$V_I = 0\text{ to } 0.7\text{ V}$			±5		
$I_{OZ}§$		$V_{CC} = 3.6\text{ V}$ , $V_O = 0\text{ to } 5.5\text{ V}$ , $V_I = 0$ , Switch OFF, $V_{IN} = V_{CC}$ or GND			±10	μA	
$I_{off}$		$V_{CC} = 0$ , $V_O = 0\text{ to } 5.5\text{ V}$ , $V_I = 0$ ,			10	μA	
$I_{CC}$	Switch ON or OFF, $V_{IN} = V_{CC}$ or GND	$V_I = V_{CC}$ or GND			20	μA	
		$V_I = 5.5\text{ V}$			20		
$\Delta I_{CC}¶$	Control inputs	$V_{CC} = 3\text{ V to } 3.6\text{ V}$ , One input at $V_{CC} - 0.6\text{ V}$ , Other inputs at $V_{CC}$ or GND			300	μA	
$C_{in}$	Control inputs	$V_{CC} = 3.3\text{ V}$ , $V_{IN} = V_{CC}$ or GND			4	pF	
$C_{io(OFF)}$		$V_{CC} = 3.3\text{ V}$ , $V_{I/O} = 5.5\text{ V, } 3.3\text{ V, or GND}$ , Switch OFF, $V_{IN} = V_{CC}$ or GND			8	pF	
$C_{io(ON)}$	Switch ON, $V_{IN} = V_{CC}$ or GND	$V_{I/O} = 5.5\text{ V or } 3.3\text{ V}$			7	pF	
		$V_{I/O} = \text{GND}$			21		
$r_{on}\#$	TYP at $V_{CC} = 2.5\text{ V}$ , $V_I = 0$	$V_{CC} = 2.3\text{ V}$ , $V_I = 0$	$I_O = 24\text{ mA}$		5	9	Ω
		$V_{CC} = 3\text{ V}$ , $V_I = 0$	$I_O = 16\text{ mA}$		5	9	
		$V_{CC} = 3\text{ V}$ , $V_I = 0$	$I_O = 64\text{ mA}$		5	8	
		$V_{CC} = 3\text{ V}$ , $V_I = 0$	$I_O = 32\text{ mA}$		5	8	

† All typical values are at  $V_{CC} = 3.3\text{ V}$  (unless otherwise noted),  $T_A = 25^\circ\text{C}$ .

‡  $V_{IN}$  and  $I_{IN}$  refer to control inputs.  $V_I$ ,  $V_O$ ,  $I_I$ , and  $I_O$  refer to data pins.

§ For I/O ports, the parameter  $I_{OZ}$  includes the input leakage current.

¶ This is the increase in supply current for each input that is at the specified TTL voltage level, rather than  $V_{CC}$  or GND.

# Measured by the voltage drop between A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.



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switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = 2.5 V ± 0.2 V		V <sub>CC</sub> = 3.3 V ± 0.3 V		UNIT
			MIN	MAX	MIN	MAX	
t <sub>pd</sub> <sup>†</sup>	A or B	B or A	0.15		0.25		ns
t <sub>pd(s)</sub>	BX	A or B	1	15	1	10	
t <sub>en</sub>	$\overline{BE}$	A or B	1	13.5	1	9	ns
t <sub>dis</sub>	$\overline{BE}$	A or B	1	7	1	8.5	ns

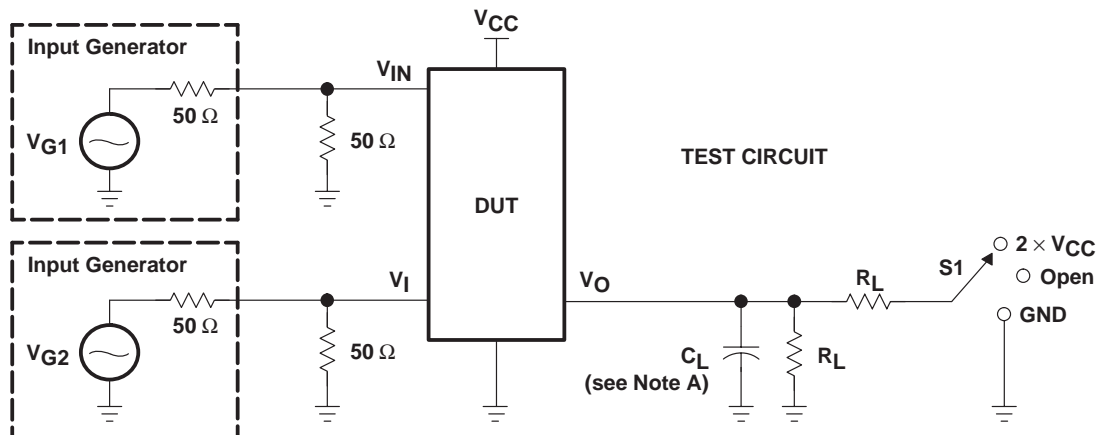
<sup>†</sup> The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).



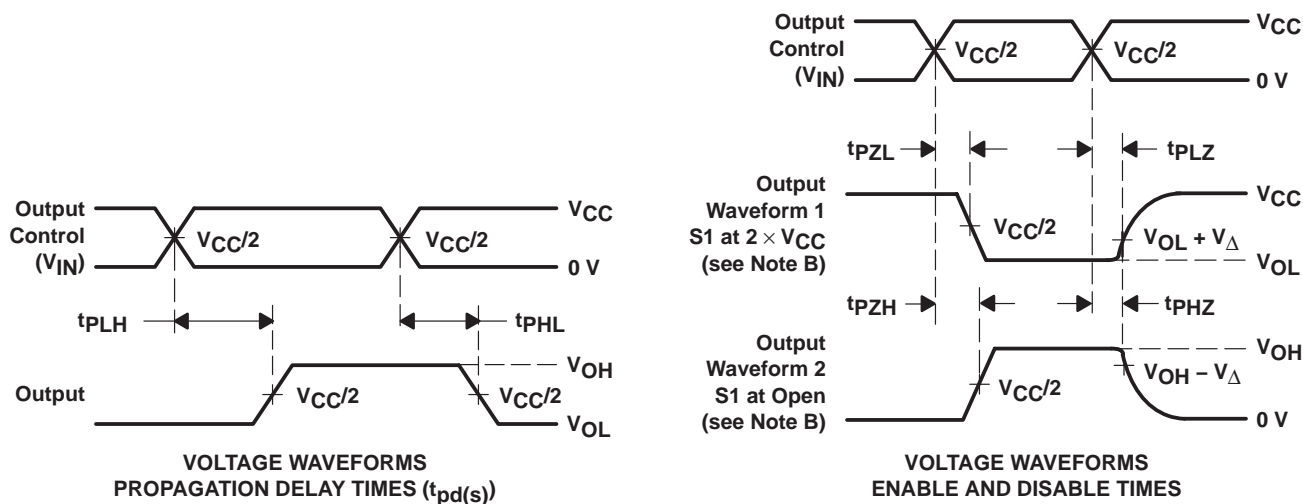
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**PARAMETER MEASUREMENT INFORMATION**



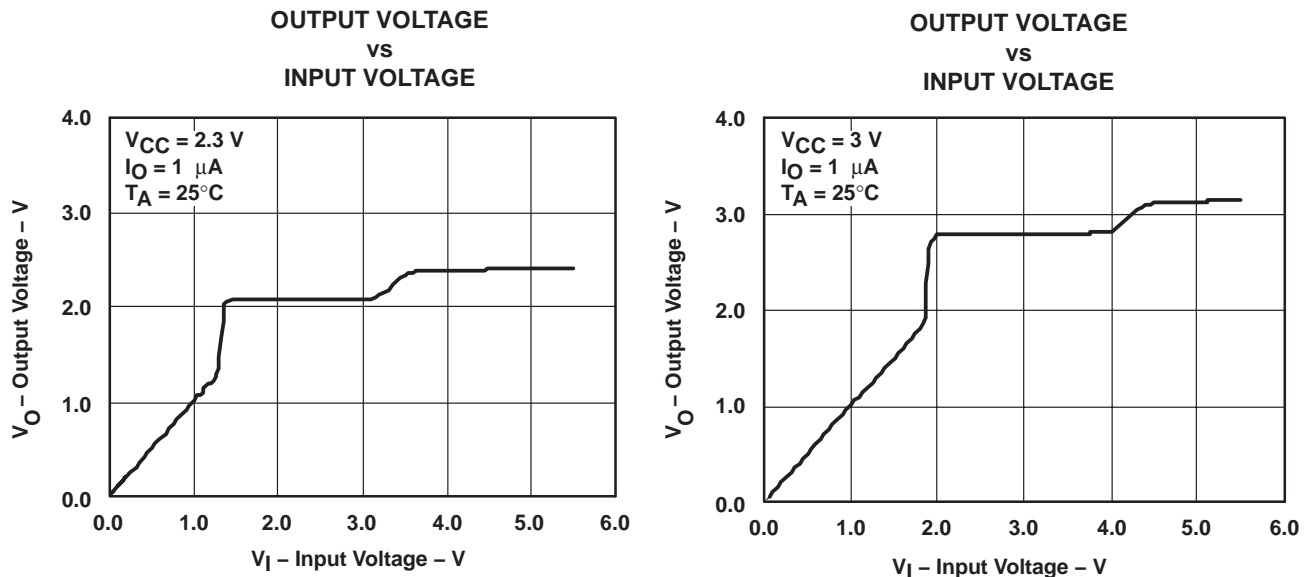
TEST	V <sub>CC</sub>	S1	R <sub>L</sub>	V <sub>I</sub>	C <sub>L</sub>	V <sub>Δ</sub>
t <sub>pd</sub> (s)	2.5 V ± 0.2 V	Open	500 Ω	3.6 V or GND	30 pF	
	3.3 V ± 0.3 V	Open	500 Ω	5.5 V or GND	50 pF	
t <sub>PLZ</sub> /t <sub>PZL</sub>	2.5 V ± 0.2 V	2 × V <sub>CC</sub>	500 Ω	GND	30 pF	0.15 V
	3.3 V ± 0.3 V	2 × V <sub>CC</sub>	500 Ω	GND	50 pF	0.3 V
t <sub>PHZ</sub> /t <sub>PZH</sub>	2.5 V ± 0.2 V	Open	500 Ω	3.6 V	30 pF	0.15 V
	3.3 V ± 0.3 V	Open	500 Ω	5.5 V	50 pF	0.3 V



- NOTES: A. C<sub>L</sub> 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<sub>O</sub> = 50 Ω, t<sub>r</sub> ≤ 2.5 ns, t<sub>f</sub> ≤ 2.5 ns.  
 D. The outputs are measured one at a time, with one transition per measurement.  
 E. t<sub>PLZ</sub> and t<sub>PZH</sub> are the same as t<sub>dis</sub>.  
 F. t<sub>PZL</sub> and t<sub>PZH</sub> are the same as t<sub>en</sub>.  
 G. t<sub>PLH</sub> and t<sub>PHL</sub> are the same as t<sub>pd</sub>(s). The t<sub>pd</sub> propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).  
 H. All parameters and waveforms are not applicable to all devices.

**Figure 2. Test Circuit and Voltage Waveforms**

**TYPICAL CHARACTERISTICS**



**Figure 3. Data Output Voltage vs Data Input Voltage**



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**TYPICAL CHARACTERISTICS (continued)**

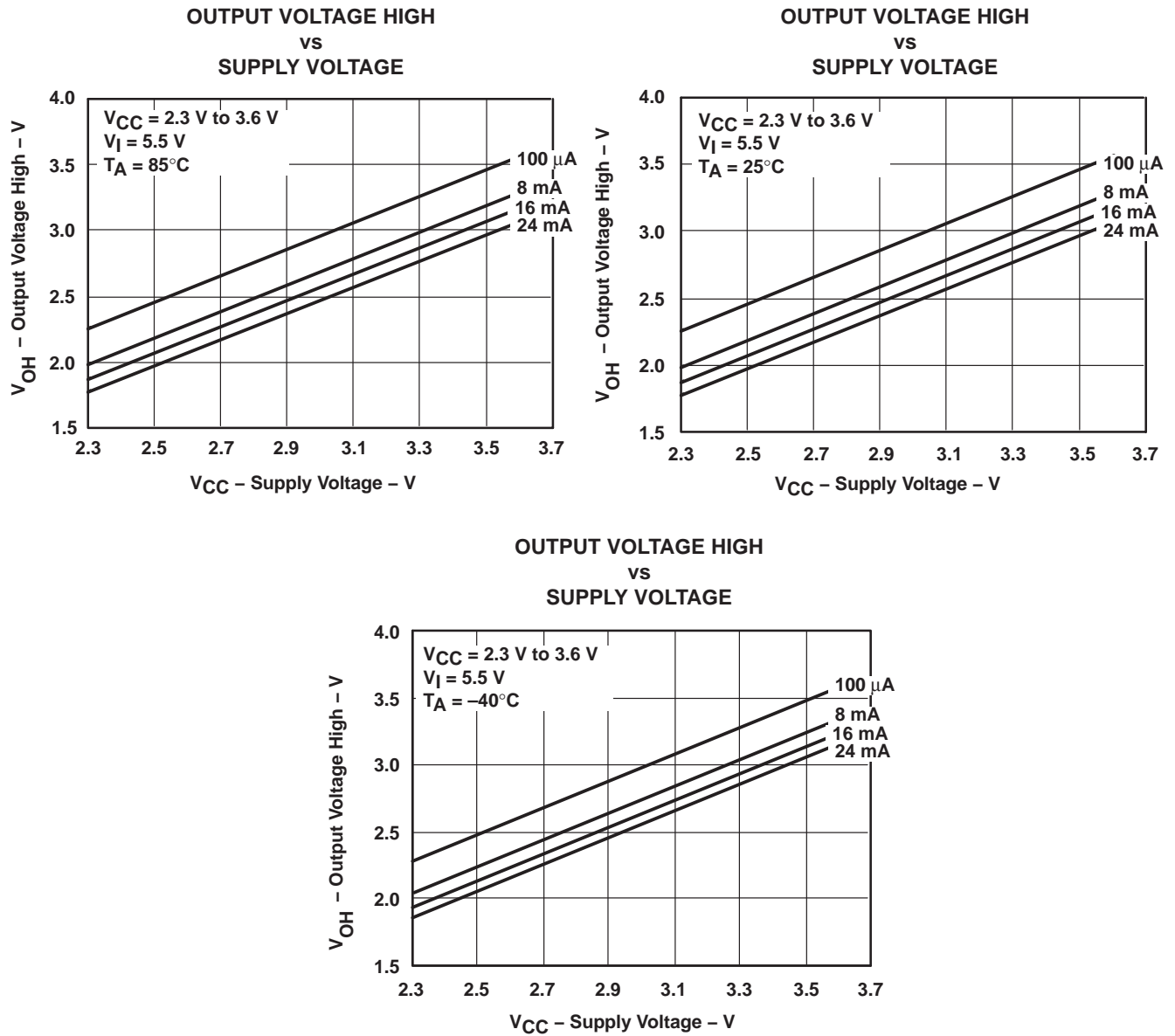


Figure 4.  $V_{OH}$  Values

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
74CB3T3383DBQRE4	ACTIVE	SSOP	DBQ	24		TBD	Call TI	Call TI	-40 to 85		<a href="#">Samples</a>
74CB3T3383DBQRG4	OBSOLETE	SSOP	DBQ	24		TBD	Call TI	Call TI	-40 to 85		
74CB3T3383DGVRE4	ACTIVE	TVSOP	DGV	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
74CB3T3383DGVRG4	ACTIVE	TVSOP	DGV	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383DGVRR	ACTIVE	TVSOP	DGV	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383DW	ACTIVE	SOIC	DW	24	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383DWE4	ACTIVE	SOIC	DW	24	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383DWG4	ACTIVE	SOIC	DW	24	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383DWR	ACTIVE	SOIC	DW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383DWRE4	ACTIVE	SOIC	DW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383DWRG4	ACTIVE	SOIC	DW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	CB3T3383	<a href="#">Samples</a>
SN74CB3T3383PW	ACTIVE	TSSOP	PW	24	60	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383PWE4	ACTIVE	TSSOP	PW	24	60	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383PWG4	ACTIVE	TSSOP	PW	24	60	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383PWR	ACTIVE	TSSOP	PW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383PWRE4	ACTIVE	TSSOP	PW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>
SN74CB3T3383PWRG4	ACTIVE	TSSOP	PW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	KS383	<a href="#">Samples</a>

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

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**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.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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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
SN74CB3T3383DGVR	TVSOP	DGV	24	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74CB3T3383DWR	SOIC	DW	24	2000	330.0	24.4	10.75	15.7	2.7	12.0	24.0	Q1
SN74CB3T3383PWR	TSSOP	PW	24	2000	330.0	16.4	6.95	8.3	1.6	8.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74CB3T3383DGVR	TVSOP	DGV	24	2000	367.0	367.0	35.0
SN74CB3T3383DWR	SOIC	DW	24	2000	367.0	367.0	45.0
SN74CB3T3383PWR	TSSOP	PW	24	2000	367.0	367.0	38.0

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

PLASTIC SMALL-OUTLINE

24 PINS SHOWN



4073251/E 08/00

- 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 per side.  
 D. Falls within JEDEC: 24/48 Pins – MO-153  
 14/16/20/56 Pins – MO-194

DW (R-PDSO-G24)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AD.





PW (R-PDSO-G24)

PLASTIC SMALL OUTLINE

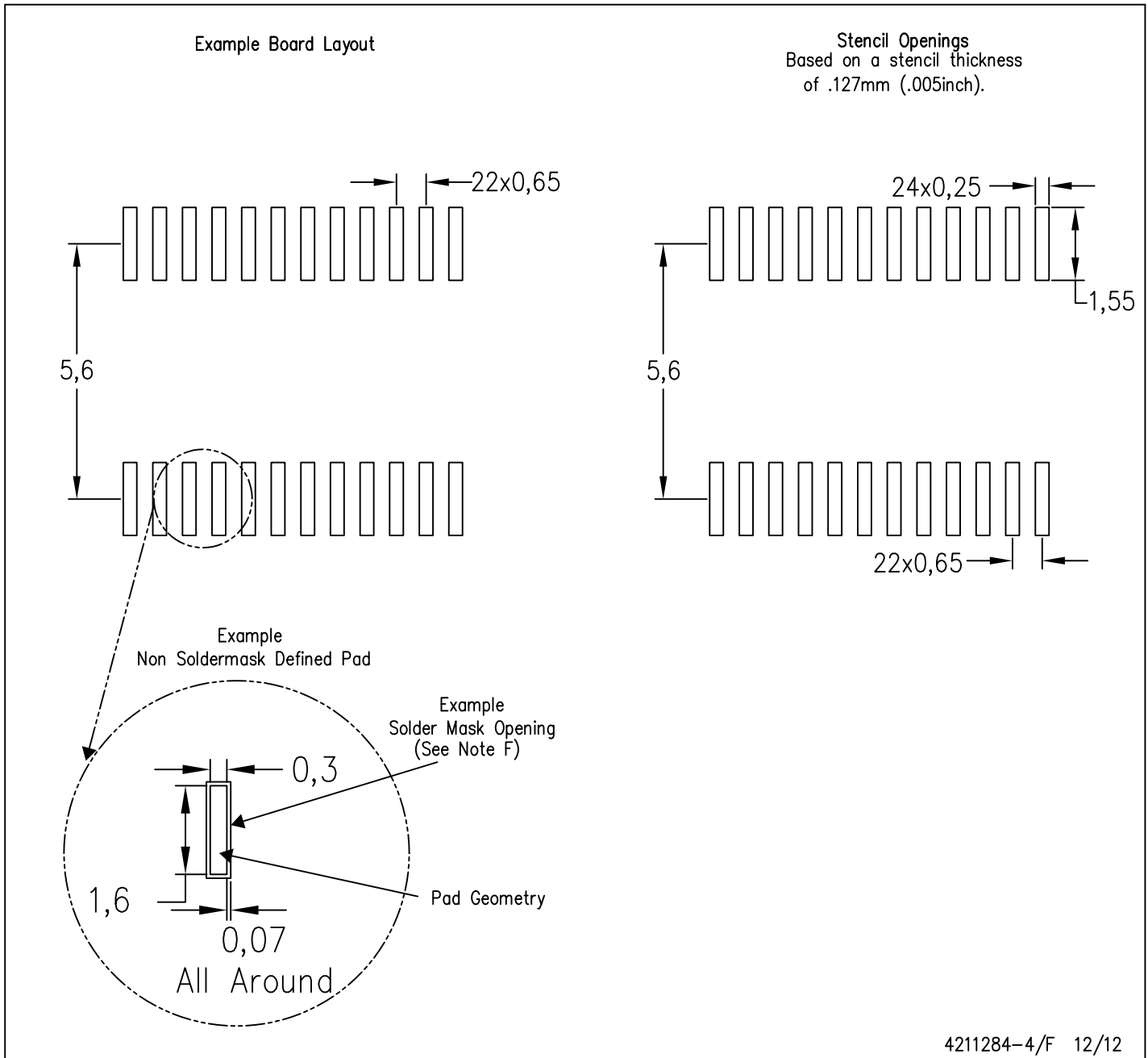


4040064-6/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G24)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate design.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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