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**TPS3700**

SBVS187D – FEBRUARY 2012 – REVISED JANUARY 2015

## TPS3700 Window Comparator With Internal Reference for Overvoltage and Undervoltage Detection

### 1 Features

- Wide Supply Voltage Range: 1.8 V to 18 V
- Adjustable Threshold: Down to 400 mV
- High Threshold Accuracy:
  - 1.0% Over Temperature
  - 0.25% (Typical)
- Low Quiescent Current: 5.5  $\mu$ A (Typical)
- Open-Drain Outputs for Overvoltage and Undervoltage Detection
- Internal Hysteresis: 5.5 mV (Typ)
- Temperature Range:  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$
- Packages:
  - SOT-6
  - 1.5-mm  $\times$  1.5-mm WSON-6

### 2 Applications

- Industrial Control Systems
- Automotive Systems
- Embedded Computing Modules
- DSP, Microcontroller, or Microprocessor Applications
- Notebook and Desktop Computers
- Portable- and Battery-Powered Products
- FPGA and ASIC Applications

### 3 Description

The TPS3700 wide-supply voltage window comparator operates over a 1.8-V to 18-V range. The device has two high-accuracy comparators with an internal 400-mV reference and two open-drain outputs rated to 18 V for over- and undervoltage detection. The TPS3700 can be used as a window comparator or as two independent voltage monitors; the monitored voltage can be set with the use of external resistors.

OUTA is driven low when the voltage at INA+ drops below  $(V_{ITP} - V_{HYS})$ , and goes high when the voltage returns above the respective threshold  $(V_{ITP})$ . OUTB is driven low when the voltage at INB– rises above  $V_{ITP}$ , and goes high when the voltage drops below the respective threshold  $(V_{ITP} - V_{HYS})$ . Both comparators in the TPS3700 include built-in hysteresis for filtering to reject brief glitches, thereby ensuring stable output operation without false triggering.

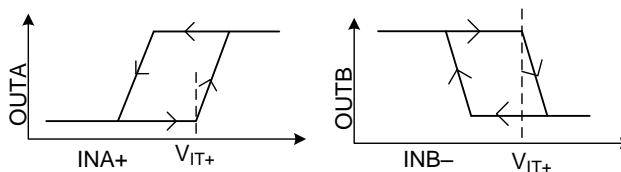
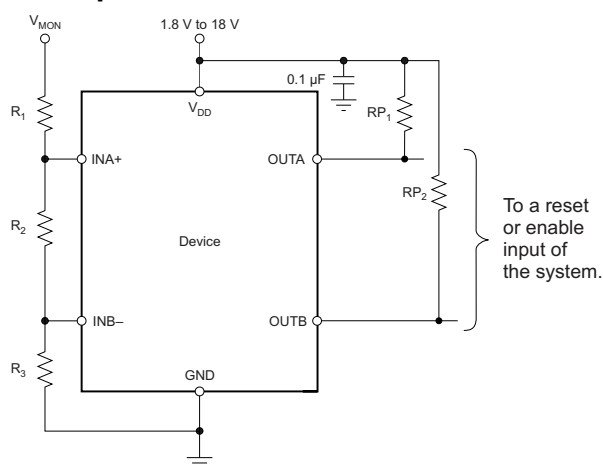
The TPS3700 is available in a SOT-6 and a 1.5-mm  $\times$  1.5-mm WSON-6 package and is specified over the junction temperature range of  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

#### Device Information<sup>(1)</sup>

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS3700	SOT (6)	2.90 mm $\times$ 1.60 mm
	WSON (6)	1.50 mm $\times$ 1.50 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

### 4 Simplified Schematic



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## 5 Revision History

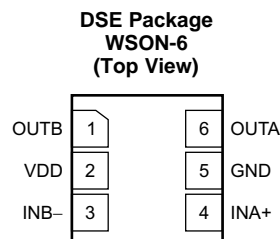
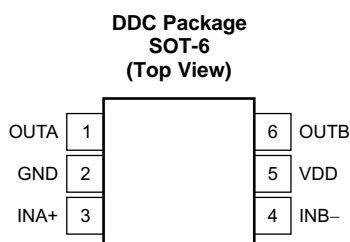
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (May 2013) to Revision D	Page
• Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section.....	<b>4</b>
• Changed HBM maximum specification from 2 kV to 2.5 kV in <i>ESD Ratings</i> .....	<b>4</b>
• Changed <i>Functional Block Diagram</i> ; added hysteresis symbol.....	<b>9</b>

Changes from Revision B (April 2012) to Revision C	Page
• Changed <i>Packages</i> Features bullet.....	<b>1</b>
• Added SON-6 package option to Description section.....	<b>1</b>
• Added DSE pin out graphic to front page.....	<b>1</b>
• Added DSE pin out graphic.....	<b>3</b>
• Added DSE package to Thermal Information table.....	<b>4</b>

Changes from Revision A (February 2012) to Revision B	Page
• Moved to Production Data.....	<b>1</b>

## 6 Pin Configuration and Functions



### Pin Functions

PIN			I/O	DESCRIPTION
NAME	DDC	DSE		
GND	2	5	—	Ground
INA+	3	4	I	This pin is connected to the voltage to be monitored with the use of an external resistor divider. When the voltage at this terminal drops below the threshold voltage ( $V_{ITP} - V_{HYS}$ ), OUTA is driven low.
INB-	4	3	I	This pin is connected to the voltage to be monitored with the use of an external resistor divider. When the voltage at this terminal exceeds the threshold voltage ( $V_{ITP}$ ), OUTB is driven low.
OUTA	1	6	O	INA+ comparator open-drain output. OUTA is driven low when the voltage at this comparator is below ( $V_{ITP} - V_{HYS}$ ). The output goes high when the sense voltage returns above the respective threshold ( $V_{ITP}$ ).
OUTB	6	1	O	INB- comparator open-drain output. OUTB is driven low when the voltage at this comparator exceeds $V_{ITP}$ . The output goes high when the sense voltage returns below the respective threshold ( $V_{ITP} - V_{HYS}$ ).
VDD	5	2	I	Supply voltage input. Connect a 1.8-V to 18-V supply to VDD to power the device. Good analog design practice is to place a 0.1- $\mu$ F ceramic capacitor close to this pin.

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## 7 Specifications

### 7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage <sup>(2)</sup>	V <sub>DD</sub>	−0.3	20	V
	OUTA, OUTB	−0.3	20	V
	INA+, INB−	−0.3	7	V
Current	Output terminal current		40	mA
Operating junction temperature, T <sub>J</sub>		−40	125	°C
Storage temperature, T <sub>stg</sub>		−65	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to network ground terminal.

### 7.2 ESD Ratings

		VALUE	UNIT
V <sub>(ESD)</sub> Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	±2500	V
	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	±1000	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

over operating temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>DD</sub>	Supply voltage	1.8		18	V
V <sub>I</sub>	Input voltage	0		6.5	V
V <sub>O</sub>	Output voltage	0		18	V

### 7.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TPS3700		UNIT
		DDC (SOT)	DSE (WSON)	
		6 PINS	6 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	204.6	194.9	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	50.5	128.9	
R <sub>θJB</sub>	Junction-to-board thermal resistance	54.3	153.8	
ψ <sub>JT</sub>	Junction-to-top characterization parameter	0.8	11.9	
ψ <sub>JB</sub>	Junction-to-board characterization parameter	52.8	157.4	
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	N/A	

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](http://www.ti.com/lit/zip/spra953).

## 7.5 Electrical Characteristics

Over the operating temperature range of  $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ , and  $1.8\text{ V} < V_{DD} < 18\text{ V}$ , unless otherwise noted.

Typical values are at  $T_J = 25^{\circ}\text{C}$  and  $V_{DD} = 5\text{ V}$ .

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{DD}$ Supply voltage range		1.8		18	V
$V_{(POR)}$ Power-on reset voltage <sup>(1)</sup>	$V_{OLmax} = 0.2\text{ V}$ , $I_{(OUTA/B)} = 15\text{ }\mu\text{A}$			0.8	V
$V_{IT+}$ Positive-going input threshold voltage	$V_{DD} = 1.8\text{ V}$	396	400	404	mV
	$V_{DD} = 18\text{ V}$	396	400	404	
$V_{IT-}$ Negative-going input threshold voltage	$V_{DD} = 1.8\text{ V}$	387	394.5	400	mV
	$V_{DD} = 18\text{ V}$	387	394.5	400	
$V_{hys}$ Hysteresis voltage ( $hys = V_{IT+} - V_{IT-}$ )			5.5	12	
$I_{(INA+)}$ Input current (at the INA+ terminal)	$V_{DD} = 1.8\text{ V}$ and $18\text{ V}$ , $V_I = 6.5\text{ V}$	-25	1	25	nA
$I_{(INB-)}$ Input current (at the INB- terminal)	$V_{DD} = 1.8\text{ V}$ and $18\text{ V}$ , $V_I = 0.1\text{ V}$	-15	1	15	nA
$V_{OL}$ Low-level output voltage	$V_{DD} = 1.3\text{ V}$ , $I_O = 0.4\text{ mA}$			250	mV
	$V_{DD} = 1.8\text{ V}$ , $I_O = 3\text{ mA}$			250	
	$V_{DD} = 5\text{ V}$ , $I_O = 5\text{ mA}$			250	
$I_{(kg(OD))}$ Open-drain output leakage-current	$V_{DD} = 1.8\text{ V}$ and $18\text{ V}$ , $V_O = V_{DD}$			300	nA
	$V_{DD} = 1.8\text{ V}$ , $V_O = 18\text{ V}$			300	
$I_{DD}$ Supply current	$V_{DD} = 1.8\text{ V}$ , no load		5.5	11	$\mu\text{A}$
	$V_{DD} = 5\text{ V}$		6	13	
	$V_{DD} = 12\text{ V}$		6	13	
	$V_{DD} = 18\text{ V}$		7	13	
Start-up delay <sup>(2)</sup>			150		$\mu\text{s}$
UVLO Undervoltage lockout <sup>(3)</sup>	$V_{DD}$ falling	1.3		1.7	V

(1) The lowest supply voltage ( $V_{DD}$ ) at which output is active;  $t_{r(VDD)} > 15\text{ }\mu\text{s/V}$ . Below  $V_{(POR)}$ , the output cannot be determined.

(2) During power on,  $V_{DD}$  must exceed  $1.8\text{ V}$  for at least  $150\text{ }\mu\text{s}$  before the output is in a correct state.

(3) When  $V_{DD}$  falls below UVLO, OUTA is driven low and OUTB goes to high impedance. The outputs cannot be determined below  $V_{(POR)}$ .

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### 7.6 Timing Requirements

Over operating temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
$t_{PHL}$	High-to-low propagation delay <sup>(1)</sup>		18		$\mu s$
$t_{PLH}$	Low-to-high propagation delay <sup>(1)</sup>		29		$\mu s$

(1) High-to-low and low-to-high refers to the transition at the input terminals (INA+ and INB–).

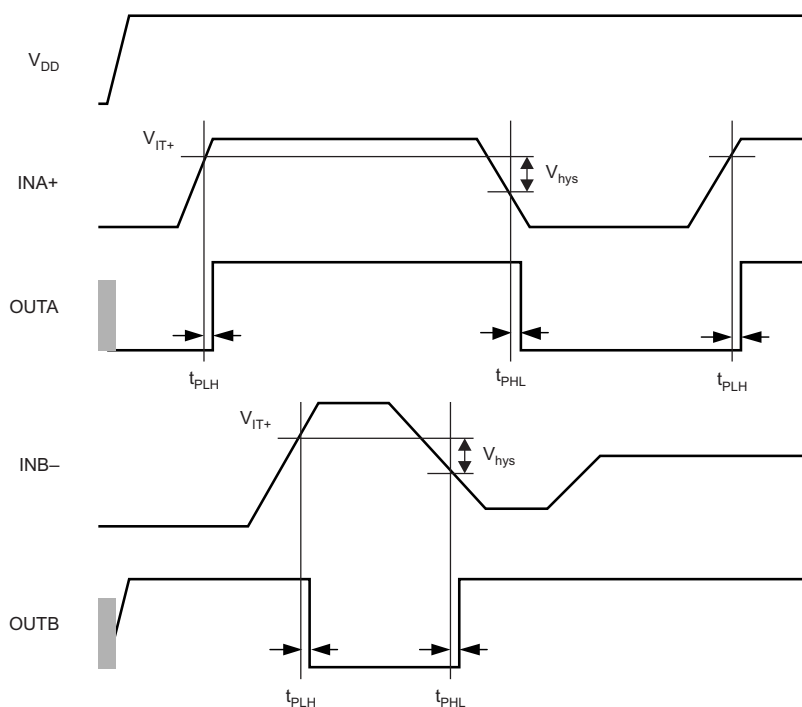


Figure 1. Timing Diagram

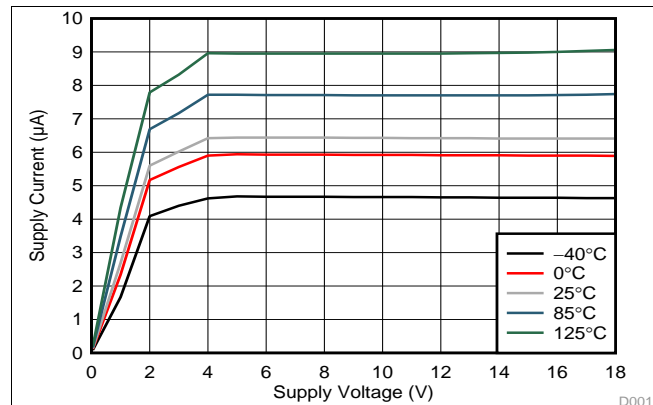
### 7.7 Switching Characteristics

Over operating temperature range (unless otherwise noted)

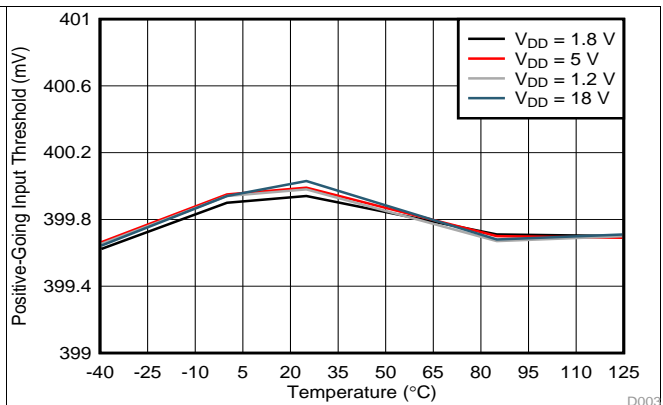
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_r$	Output rise time $V_{DD} = 5 V$ , 10-mV input overdrive, $R_P = 10 k\Omega$ , $V_O = (0.1 \text{ to } 0.9) \times V_{DD}$		2.2		$\mu s$
$t_f$	Output fall time $V_{DD} = 5 V$ , 10-mV input overdrive, $R_P = 10 k\Omega$ , $V_O = (0.1 \text{ to } 0.9) \times V_{DD}$		0.22		$\mu s$

## 7.8 Typical Characteristics

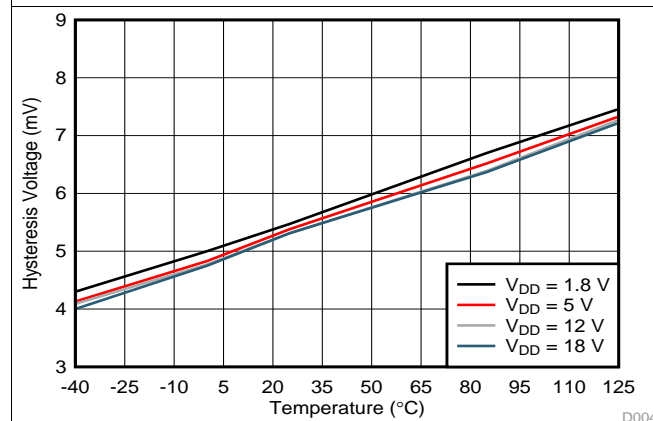
At  $T_J = 25^\circ\text{C}$  and  $V_{DD} = 5\text{ V}$ , unless otherwise noted.



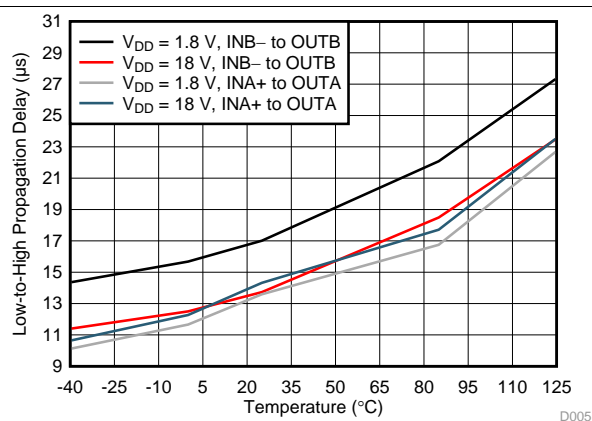
**Figure 2. Supply Current ( $I_{DD}$ ) vs Supply Voltage ( $V_{DD}$ )**



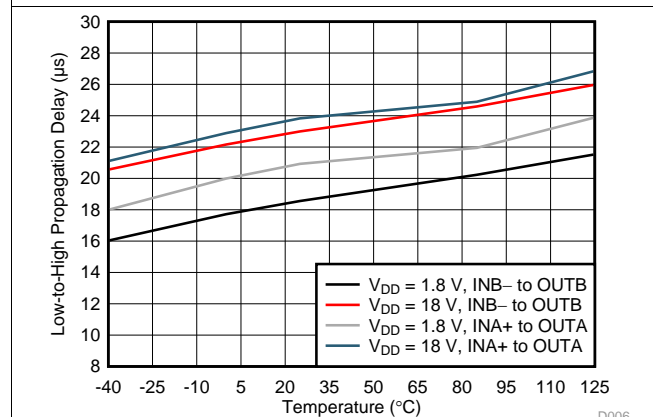
**Figure 3. Rising Input Threshold Voltage ( $V_{IT+}$ ) vs Temperature**



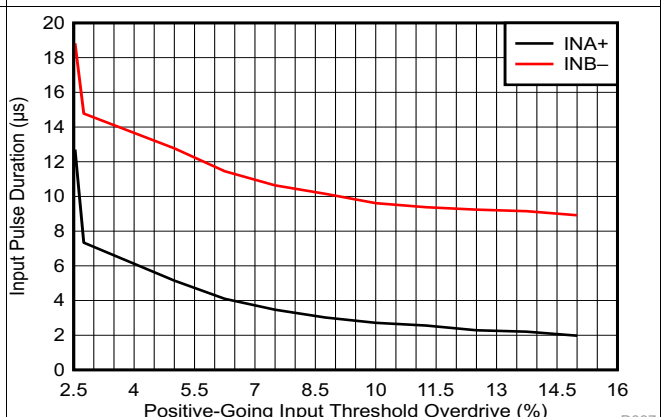
**Figure 4. Hysteresis ( $V_{hys}$ ) vs Temperature**



**Figure 5. Propagation Delay vs Temperature (High-to-Low Transition at the Inputs)**



**Figure 6. Propagation Delay vs Temperature (Low-to-High Transition at the Inputs)**



INA+ = negative spike below  $V_{IT-}$   
INB- = positive spike above  $V_{IT+}$

**Figure 7. Minimum Pulse Width vs Threshold Overdrive Voltage**



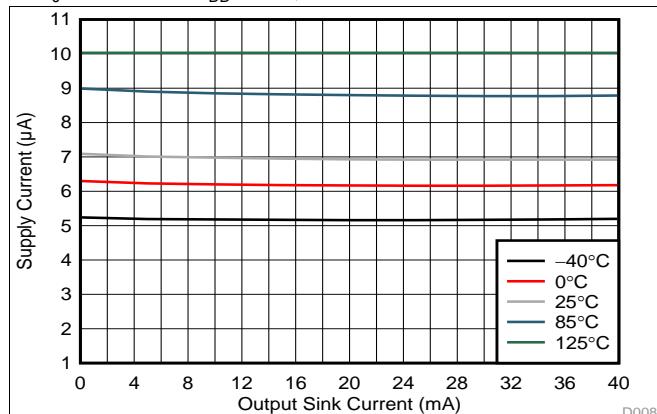
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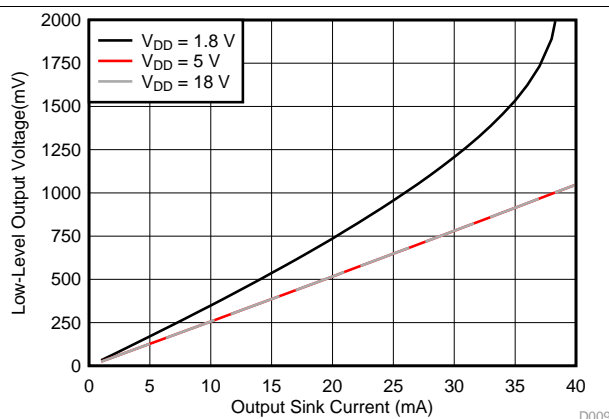
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### Typical Characteristics (continued)

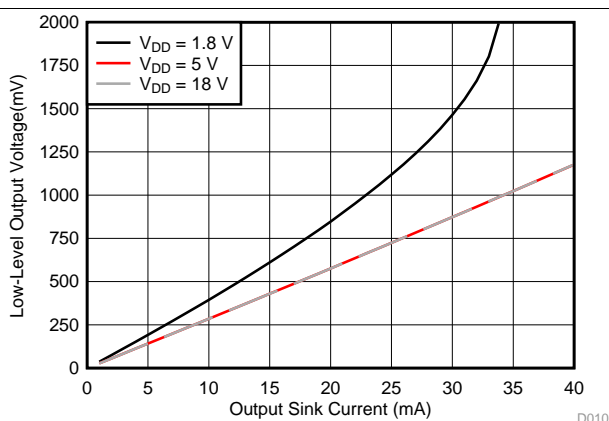
At  $T_J = 25^\circ\text{C}$  and  $V_{DD} = 5\text{ V}$ , unless otherwise noted.



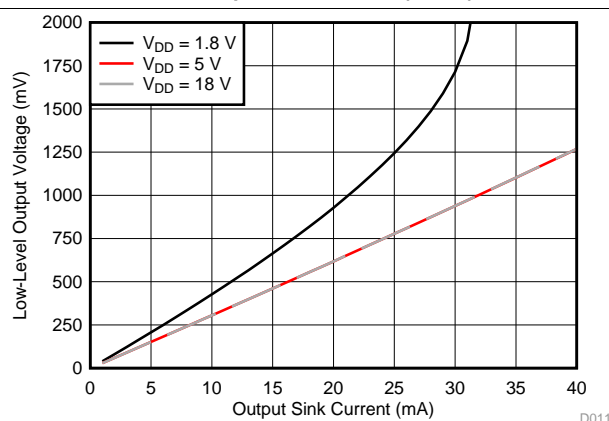
**Figure 8. Supply Current ( $I_{DD}$ ) vs Output Sink Current**



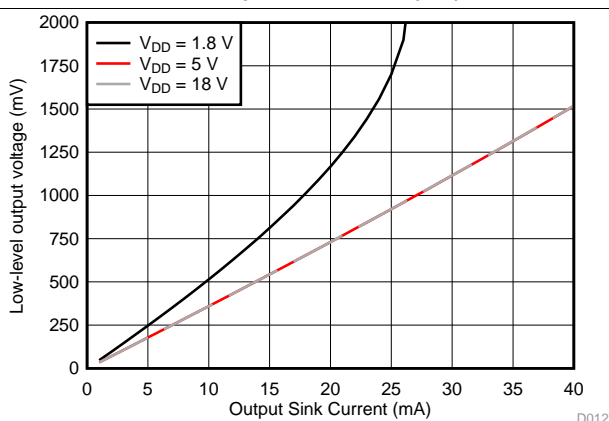
**Figure 9. Output Voltage Low ( $V_{OL}$ ) vs Output Sink Current ( $-40^\circ\text{C}$ )**



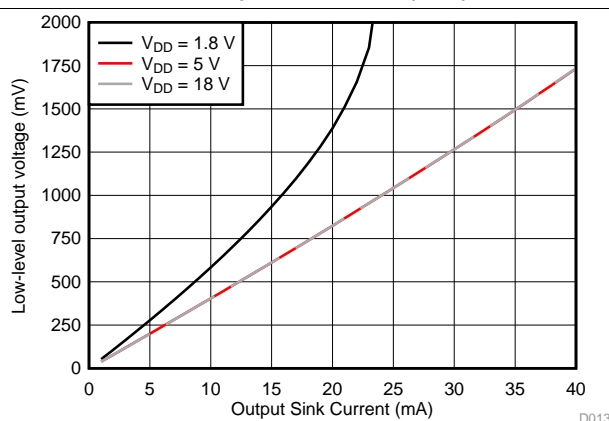
**Figure 10. Output Voltage Low ( $V_{OL}$ ) vs Output Sink Current ( $0^\circ\text{C}$ )**



**Figure 11. Output Voltage Low ( $V_{OL}$ ) vs Output Sink Current ( $25^\circ\text{C}$ )**



**Figure 12. Output Voltage Low ( $V_{OL}$ ) vs Output Sink Current ( $85^\circ\text{C}$ )**



**Figure 13. Output Voltage Low ( $V_{OL}$ ) vs Output Sink Current ( $125^\circ\text{C}$ )**

## 8 Detailed Description

### 8.1 Overview

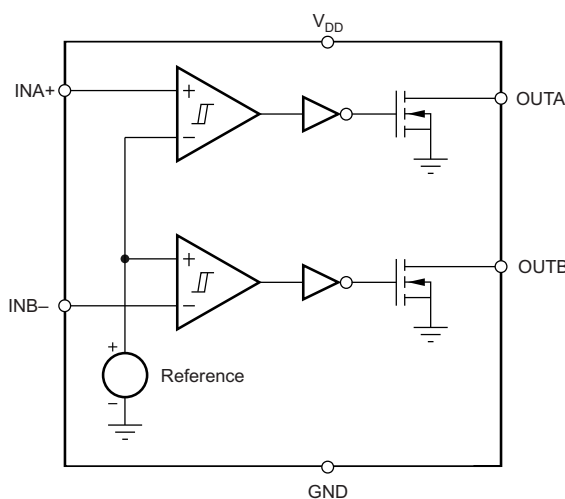
The TPS3700 device combines two comparators for overvoltage and undervoltage detection. The TPS3700 device is a wide-supply voltage range (1.8 V to 18 V) device with a high-accuracy rising input threshold of 400 mV (1% over temperature) and built-in hysteresis. The outputs are also rated to 18 V and can sink up to 40 mA.

The TPS3700 device is designed to assert the output signals, as shown in Table 1. Each input terminal can be set to monitor any voltage above 0.4 V using an external resistor divider network. With the use of two input terminals of different polarities, the TPS3700 device forms a window comparator. Broad voltage thresholds can be supported that allow the device to be used in a wide array of applications.

**Table 1. TPS3700 Truth Table**

CONDITION	OUTPUT	STATUS
$INA+ > V_{IT+}$	OUTA high	Output A not asserted
$INA+ < V_{IT-}$	OUTA low	Output A asserted
$INB- > V_{IT+}$	OUTB low	Output B asserted
$INB- < V_{IT-}$	OUTB high	Output B not asserted

### 8.2 Functional Block Diagram



### 8.3 Feature Description

#### 8.3.1 Inputs (INA+, INB-)

The TPS3700 device combines two comparators. Each comparator has one external input (inverting and noninverting); the other input is connected to the internal reference. The comparator rising threshold is designed and trimmed to be equal to the reference voltage (400 mV). Both comparators also have a built-in falling hysteresis that makes the device less sensitive to supply rail noise and ensures stable operation.

The comparator inputs can swing from ground to 6.5 V, regardless of the device supply voltage used. Although not required in most cases, good analog design practice is to place a 1-nF to 10-nF bypass capacitor at the comparator input for extremely noisy applications to reduce sensitivity to transients and layout parasitics.

For comparator A, the corresponding output (OUTA) is driven to logic low when the input INA+ voltage drops below  $(V_{IT+} - V_{hys})$ . When the voltage exceeds  $V_{IT+}$ , the output (OUTA) goes to a high-impedance state; see Figure 1.

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### Feature Description (continued)

For comparator B, the corresponding output (OUTB) is driven to logic low when the voltage at input INB– exceeds  $V_{IT+}$ . When the voltage drops below  $V_{IT+} - V_{hys}$  the output (OUTB) goes to a high-impedance state; see [Figure 1](#). Together, these comparators form a window-detection function as discussed in [Window Comparator](#).

#### 8.3.2 Outputs (OUTA, OUTB)

In a typical TPS3700 application, the outputs are connected to a reset or enable input of the processor (such as a digital signal processor [DSP], central processing unit [CPU], field-programmable gate array [FPGA], or application-specific integrated circuit [ASIC]) or the outputs are connected to the enable input of a voltage regulator (such as a DC-DC or low-dropout regulator [LDO]).

The TPS3700 device provides two open-drain outputs (OUTA and OUTB). Pullup resistors must be used to hold these lines high when the output goes to high impedance (not asserted). By connecting pullup resistors to the proper voltage rails, the outputs can be connected to other devices at the correct interface-voltage levels. The TPS3700 outputs can be pulled up to 18 V, independent of the device supply voltage. By using wired-OR logic, OUTA and OUTB can merge into one logic signal that goes low if either outputs are asserted because of a fault condition.

[Table 1](#) and [Inputs \(INA+, INB–\)](#) describe how the outputs are asserted or deasserted. See [Figure 1](#) for a timing diagram that describes the relationship between threshold voltages and the respective output.

#### 8.3.3 Window Comparator

The inverting and noninverting configuration of the comparators forms a window-comparator detection circuit using a resistor divider network, as shown in [Figure 14](#) and [Figure 15](#). The input terminals can monitor any system voltage above 400 mV with the use of a resistor divider network. The INA+ and INB– terminals monitor for undervoltage and overvoltage conditions, respectively.

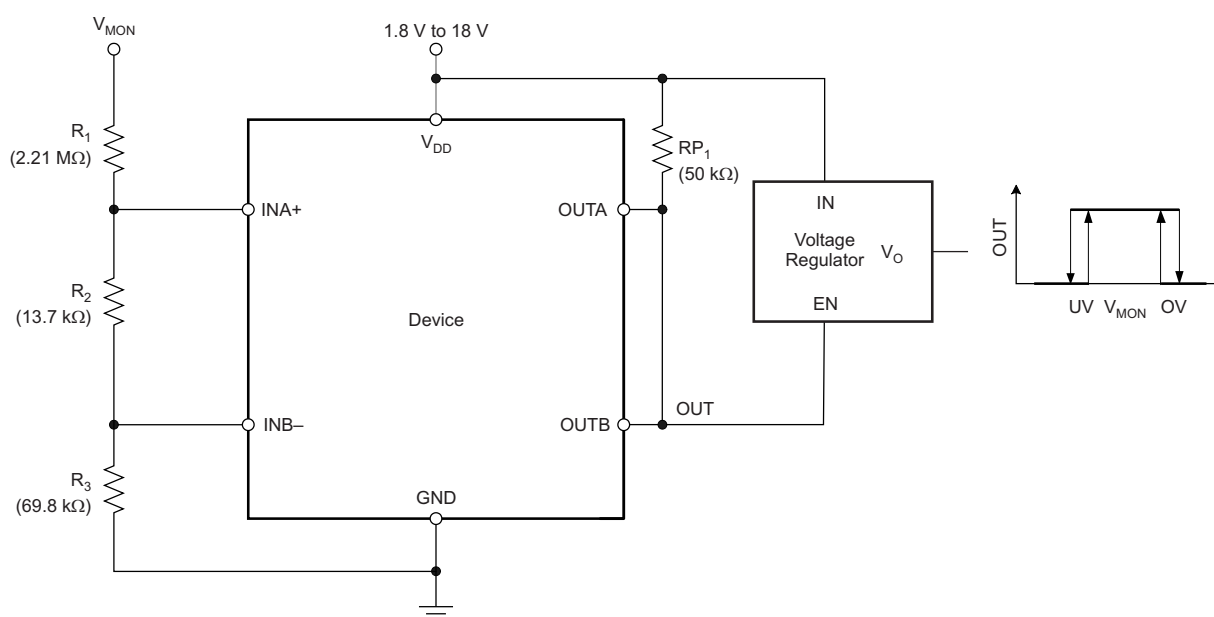
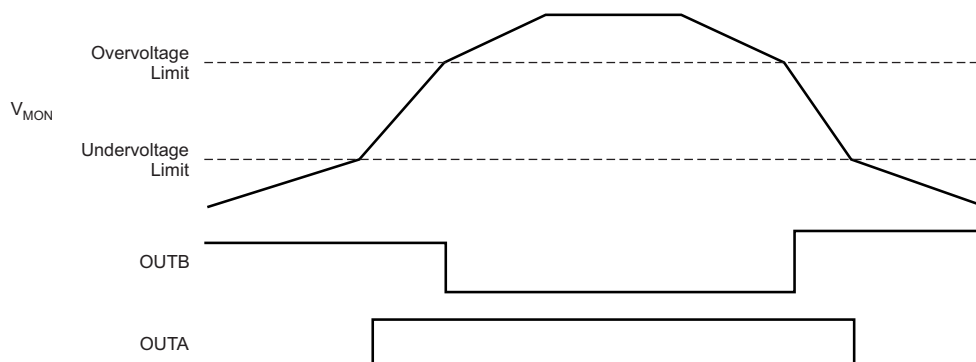


Figure 14. Window Comparator Block Diagram

## Feature Description (continued)



**Figure 15. Window Comparator Timing Diagram**

### 8.3.4 Immunity to Input Terminal Voltage Transients

The TPS3700 device is relatively immune to short voltage transient spikes on the input terminals. Sensitivity to transients depends on both transient duration and amplitude; see the *Minimum Pulse Width vs Threshold Overdrive Voltage* curve (Figure 7) in *Typical Characteristics*.

## 8.4 Device Functional Modes

### 8.4.1 Normal Operation ( $V_{DD} > UVLO$ )

When the voltage on  $V_{DD}$  is greater than 1.8 V for at least 150  $\mu$ s, the OUTA and OUTB signals correspond to the voltage on INA+ and INB– as listed in Table 1.

### 8.4.2 Undervoltage Lockout ( $V_{(POR)} < V_{DD} < UVLO$ )

When the voltage on  $V_{DD}$  is less than the device UVLO voltage, and greater than the power-on reset voltage,  $V_{(POR)}$ , the OUTA and OUTB signals are asserted and high impedance, respectively, regardless of the voltage on INA+ and INB–.

### 8.4.3 Power-On Reset ( $V_{DD} < V_{(POR)}$ )

When the voltage on  $V_{DD}$  is lower than the required voltage to internally pull the asserted output to GND ( $V_{(POR)}$ ), both outputs are in a high-impedance state.

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## 9 Application and Implementation

### NOTE

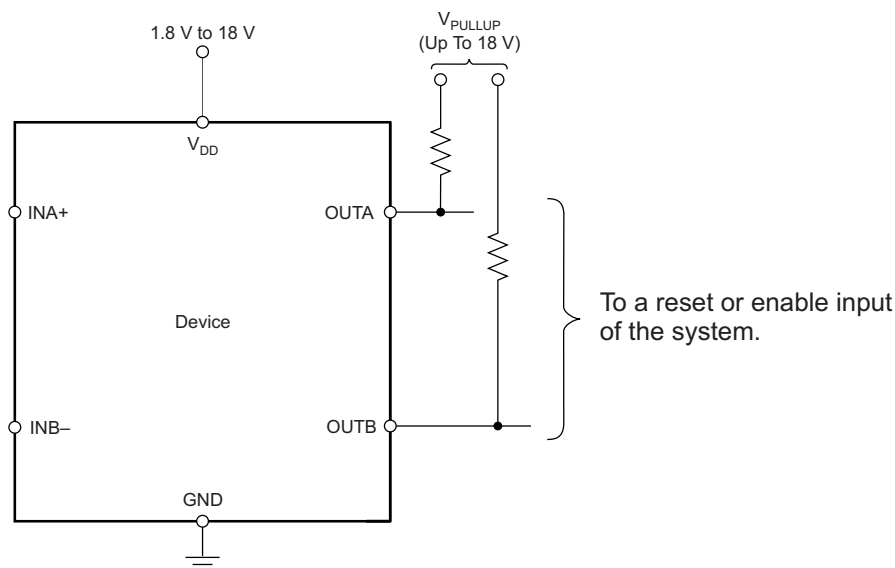
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The TPS3700 device is a wide-supply voltage window comparator that operates over a  $V_{DD}$  range of 1.8 V to 18 V. The device has two high-accuracy comparators with an internal 400-mV reference and two open-drain outputs rated to 18 V for overvoltage and undervoltage detection. The device can be used either as a window comparator or as two independent voltage monitors. The monitored voltages are set with the use of external resistors.

#### 9.1.1 $V_{PULLUP}$ to a Voltage Other Than $V_{DD}$

The outputs are often tied to  $V_{DD}$  through a resistor. However, some applications may require the outputs to be pulled up to a higher or lower voltage than  $V_{DD}$  to correctly interface with the reset and enable terminals of other devices.

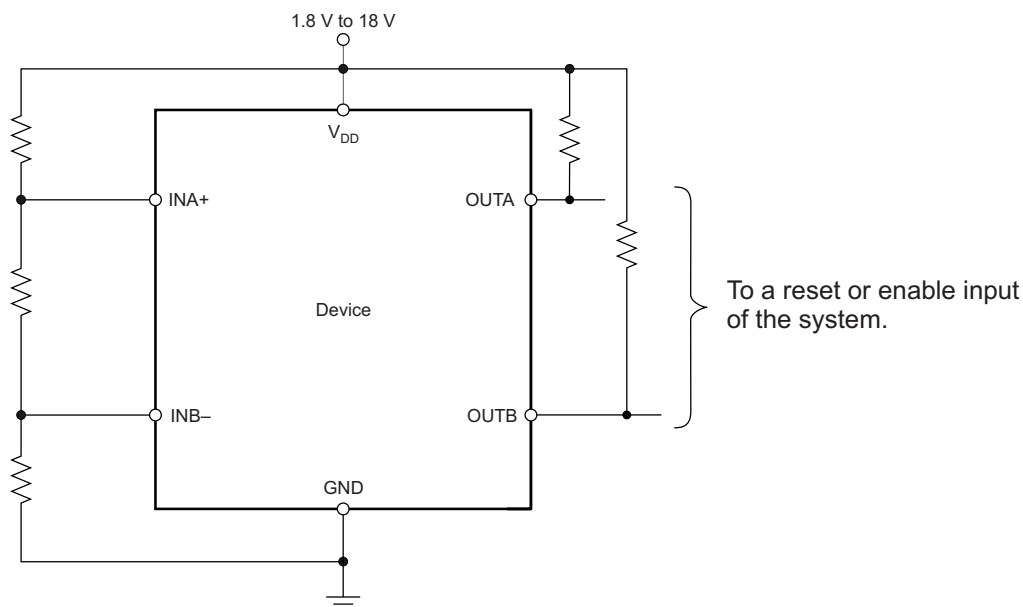


**Figure 16. Interfacing to Voltages Other Than  $V_{DD}$**

## Application Information (continued)

### 9.1.2 Monitoring $V_{DD}$

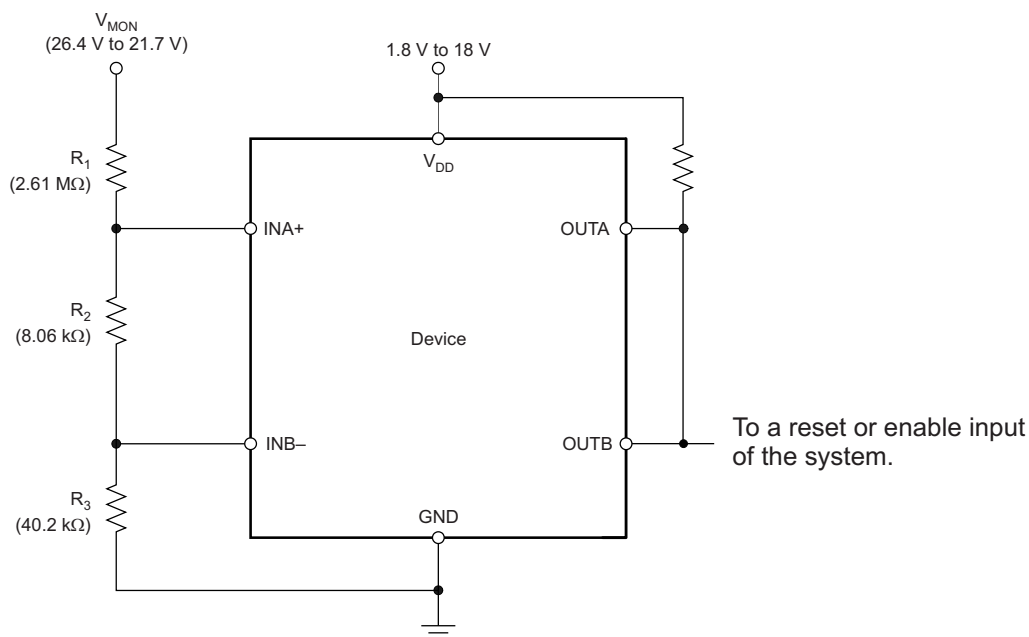
Many applications monitor the same rail that is powering  $V_{DD}$ . In these applications the resistor divider is simply connected to the  $V_{DD}$  rail.



**Figure 17. Monitoring the Same Voltage as  $V_{DD}$**

### 9.1.3 Monitoring a Voltage Other Than $V_{DD}$

Some applications monitor rails other than the one that is powering  $V_{DD}$ . In these types of applications the resistor divider used to set the desired thresholds is connected to the rail that is being monitored.



**NOTE:** The inputs can monitor a voltage higher than  $V_{DDmax}$  with the use of an external resistor divider network.

**Figure 18. Monitoring a Voltage Other Than  $V_{DD}$**

## TPS3700

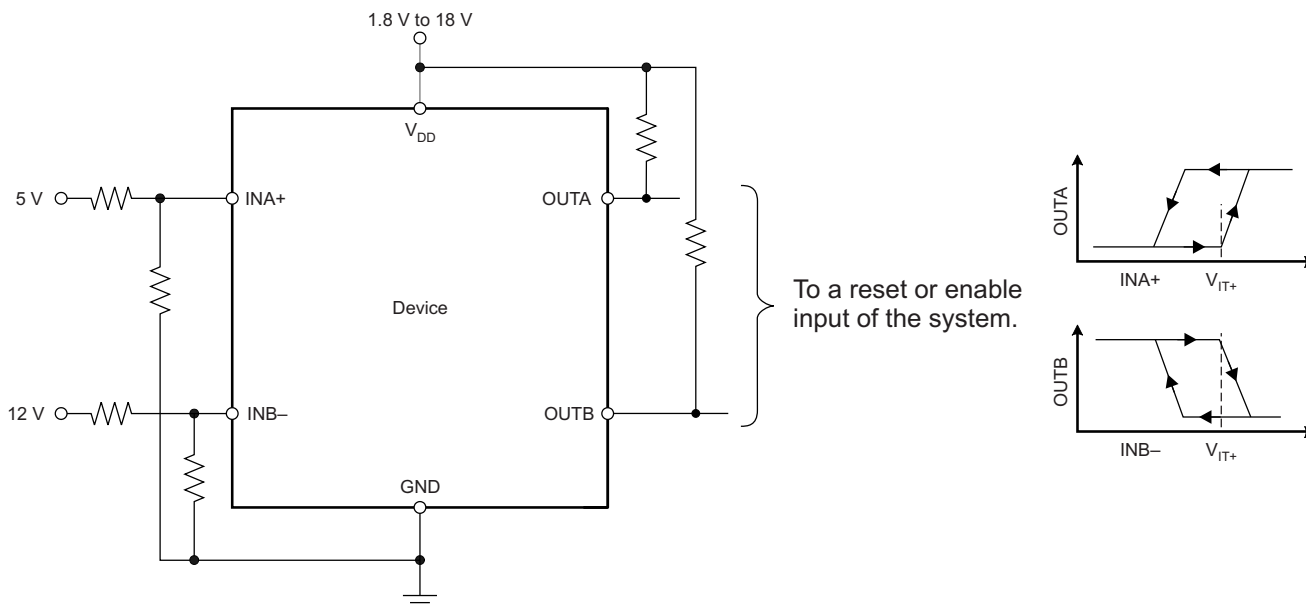
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### Application Information (continued)

#### 9.1.4 Monitoring Overvoltage and Undervoltage for Separate Rails

Some applications may want to monitor for overvoltage conditions on one rail while also monitoring for undervoltage conditions on a different rail. In these applications two independent resistor dividers must be used.



**NOTE:** In this case,  $OUTA$  is driven low when an undervoltage condition is detected at the 5-V rail and  $OUTB$  is driven low when an overvoltage condition is detected at the 12-V rail.

**Figure 19. Monitoring Overvoltage for One Rail and Undervoltage for a Different Rail**

## 9.2 Typical Application

The TPS3700 device is a wide-supply voltage window comparator that operates over a  $V_{DD}$  range of 1.8 to 18 V. The monitored voltages are set with the use of external resistors, so the device can be used either as a window comparator or as two independent overvoltage and undervoltage monitors.

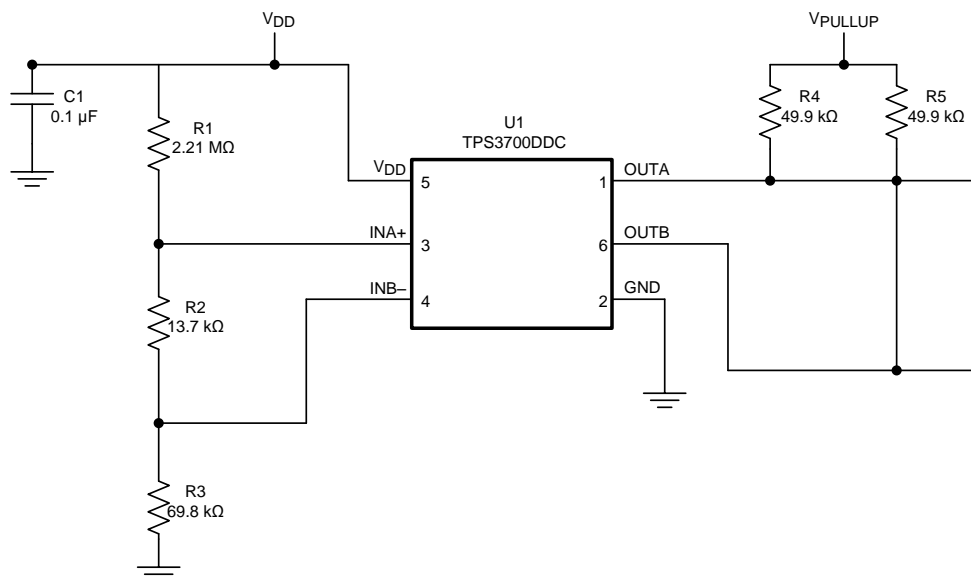


Figure 20. Typical Application Schematic

### 9.2.1 Design Requirements

For this design example, use the values summarized in Table 2 as the input parameters.

Table 2. Design Parameters

PARAMETER	DESIGN REQUIREMENT	DESIGN RESULT
Monitored voltage	12-V nominal rail with maximum rising and falling thresholds of $\pm 10\%$	$V_{MON(UV)} = 10.99 \text{ V (8.33\%)} \pm 2.94\%$ , $V_{MON(OV)} = 13.14 \text{ V (8.33\%)} \pm 2.94\%$

### 9.2.2 Detailed Design Procedure

#### 9.2.2.1 Resistor Divider Selection

Use Equation 1 through Equation 4 to calculate the resistor divider values and target threshold voltages.

$$R_T = R_1 + R_2 + R_3 \quad (1)$$

Select a value for  $R_T$  such that the current through the divider is approximately 100 times higher than the input current at the INA+ and INB- terminals. The resistors can have high values to minimize current consumption as a result of low-input bias current without adding significant error to the resistive divider. See the application note *Optimizing Resistor Dividers at a Comparator Input* (SLVA450) for details on sizing input resistors.

Use Equation 2 to calculate the value of  $R_3$ .

$$R_3 = \frac{R_T}{V_{MON(OV)}} \times V_{IT+}$$

where:

$V_{MON(OV)}$  is the target voltage at which an overvoltage condition is detected (2)



## TPS3700

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Use Equation 3 or Equation 4 to calculate the value of  $R_2$ .

$$R_2 = \left[ \frac{R_T}{V_{MON}(no\ UV)} \times V_{IT+} \right] - R_3$$

where:

$V_{MON}(no\ UV)$  is the target voltage at which an undervoltage condition is removed as  $V_{MON}$  rises (3)

$$R_2 = \left[ \frac{R_T}{V_{MON}(UV)} \times (V_{IT+} - V_{hys}) \right] - R_3$$

where:

$V_{MON}(UV)$  is the target voltage at which an undervoltage condition is detected (4)

The worst-case tolerance can be calculated by referring to Equation 13 in application report [SLVA450, Optimizing Resistor Dividers at a Comparator Input](#) (available for download at [www.ti.com](#)). An example of the rising threshold error,  $V_{MON}(OV)$ , is given in Equation 5.

$$\% \text{ ACC} = \% \text{ TOL}(V_{IT+}(INB)) + 2 \times \left[ 1 - \frac{V_{IT+}(INB)}{V_{MON}(OV)} \right] \times \% \text{ TOL}_R = 1\% + 2 \times \left[ 1 - \frac{0.4}{13.2} \right] \times 1\% = 2.94\% \quad (5)$$

### 9.2.2.2 Pullup Resistor Selection

To ensure proper voltage levels, the pullup resistor value is selected by ensuring that the pullup voltage divided by the resistor does not exceed the sink-current capability of the device. This confirmation is calculated by verifying that the pullup voltage minus the output-leakage current ( $I_{lk}(OD)$ ) multiplied by the resistor is greater the desired logic-high voltage. These values are specified in the [Electrical Characteristics](#).

Use Equation 6 to calculate the value of the pullup resistor.

$$\frac{(V_{HI} - V_{PU})}{I_{lk}(OD)} \geq R_{PU} \geq \frac{V_{PU}}{I_O} \quad (6)$$

### 9.2.2.3 Input Supply Capacitor

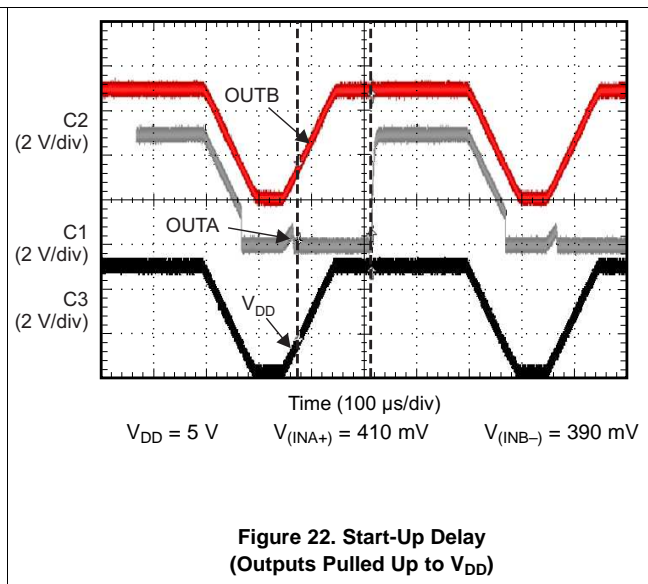
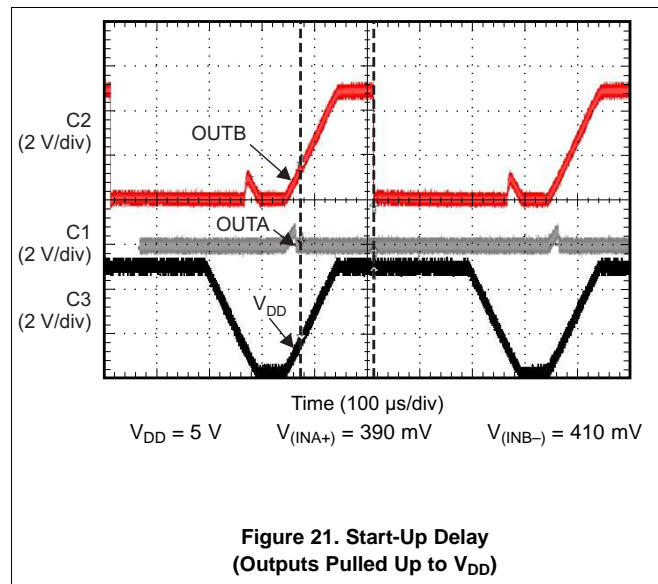
Although an input capacitor is not required for stability, connecting a 0.1-μF low equivalent series resistance (ESR) capacitor across the  $V_{DD}$  terminal and GND terminal is good analog design practice. A higher-value capacitor may be necessary if large, fast rise-time load transients are anticipated, or if the device is not located close to the power source.

### 9.2.2.4 Input Capacitors

Although not required in most cases, for extremely noisy applications, placing a 1-nF to 10-nF bypass capacitor from the comparator inputs (INA+, INB-) to the GND terminal is good analog design practice. This capacitor placement reduces device sensitivity to transients.

### 9.2.3 Application Curves

At  $T_J = 25^\circ\text{C}$



### 9.3 Do's and Don'ts

It is good analog design practice to have a 0.1- $\mu\text{F}$  decoupling capacitor from  $V_{DD}$  to GND.

If the monitored rail is noisy, connect decoupling capacitors from the comparator inputs to GND.

Do not use resistors for the voltage divider that cause the current through them to be less than 100 times the input current of the comparators without also accounting for the effect to the accuracy.

Do not use pullup resistors that are too small, because the larger current sunk by the output then exceeds the desired low-level output voltage ( $V_{OL}$ ).

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## 10 Power-Supply Recommendations

These devices are designed to operate from an input voltage supply range between 1.8 V and 18 V.

## 11 Layout

### 11.1 Layout Guidelines

Placing a 0.1- $\mu$ F capacitor close to the  $V_{DD}$  terminal to reduce the input impedance to the device is good analog design practice. The pullup resistors can be separated if separate logic functions are needed (see Figure 23) or both resistors can be tied to a single pullup resistor if a logical AND function is desired.

### 11.2 Layout Example

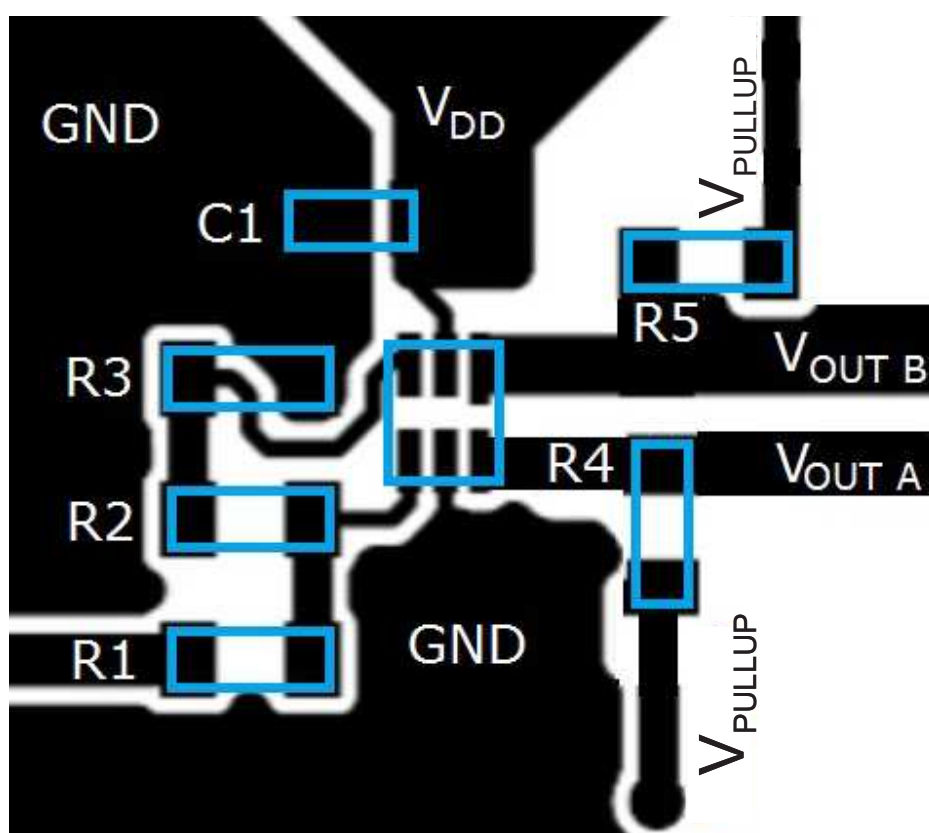


Figure 23. TPS3700 Layout Schematic

## 12 Device and Documentation Support

### 12.1 Device Support

#### 12.1.1 Development Support

##### 12.1.1.1 Evaluation Modules

Two evaluation modules (EVMs) are available to assist in the initial circuit performance evaluation using the TPS3700. The [TPS3700EVM-114 evaluation module](#) and the [TPS3700EVM-202 evaluation module](#) (and the related user's guides) can be requested at the Texas Instruments website through the [TPS3700 product folder](#) or purchased directly from [the TI eStore](#).

#### 12.1.2 Device Nomenclature

**Table 3. Device Nomenclature**

PRODUCT	DESCRIPTION
TPS3700yyyz	yyy is package designator z is package quantity

### 12.2 Documentation Support

#### 12.2.1 Related Documentation

For related documentation, see the following:

- Application report, *Using the TPS3700 as a Negative Rail Over- and Undervoltage Detector*, [SLVA600](#)
- Application report, *Optimizing Resistor Dividers at a Comparator Input*, [SLVA450](#)
- *TPS3700EVM-114 Evaluation Module User Guide*, [SLVU683](#)
- *TPS3700EVM-202 Evaluation Module User Guide*, [SLVU950](#)

### 12.3 Trademarks

All trademarks are the property of their respective owners.

### 12.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 12.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

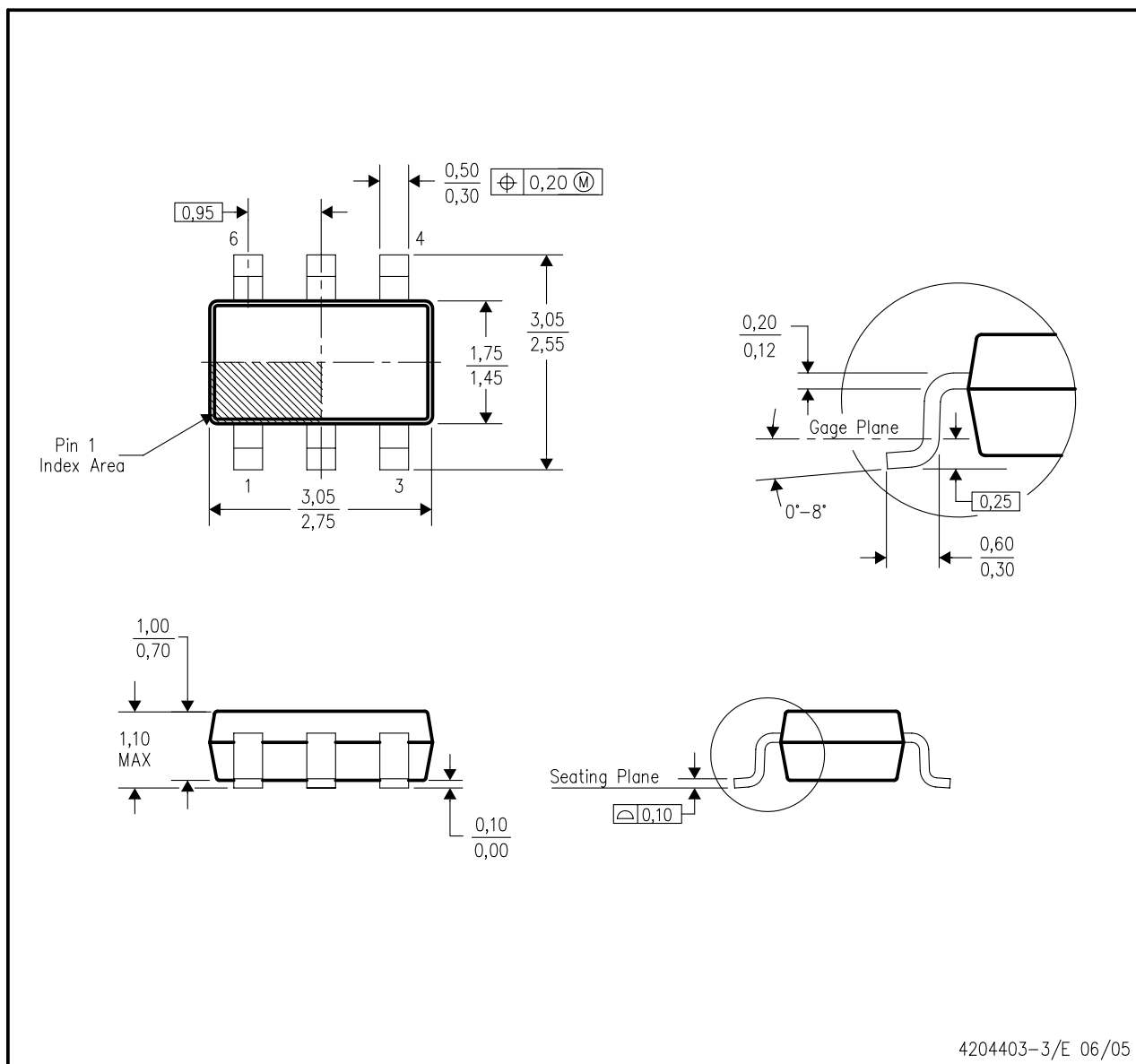
## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## MECHANICAL DATA

DDC (R-PDSO-G6)

PLASTIC SMALL-OUTLINE

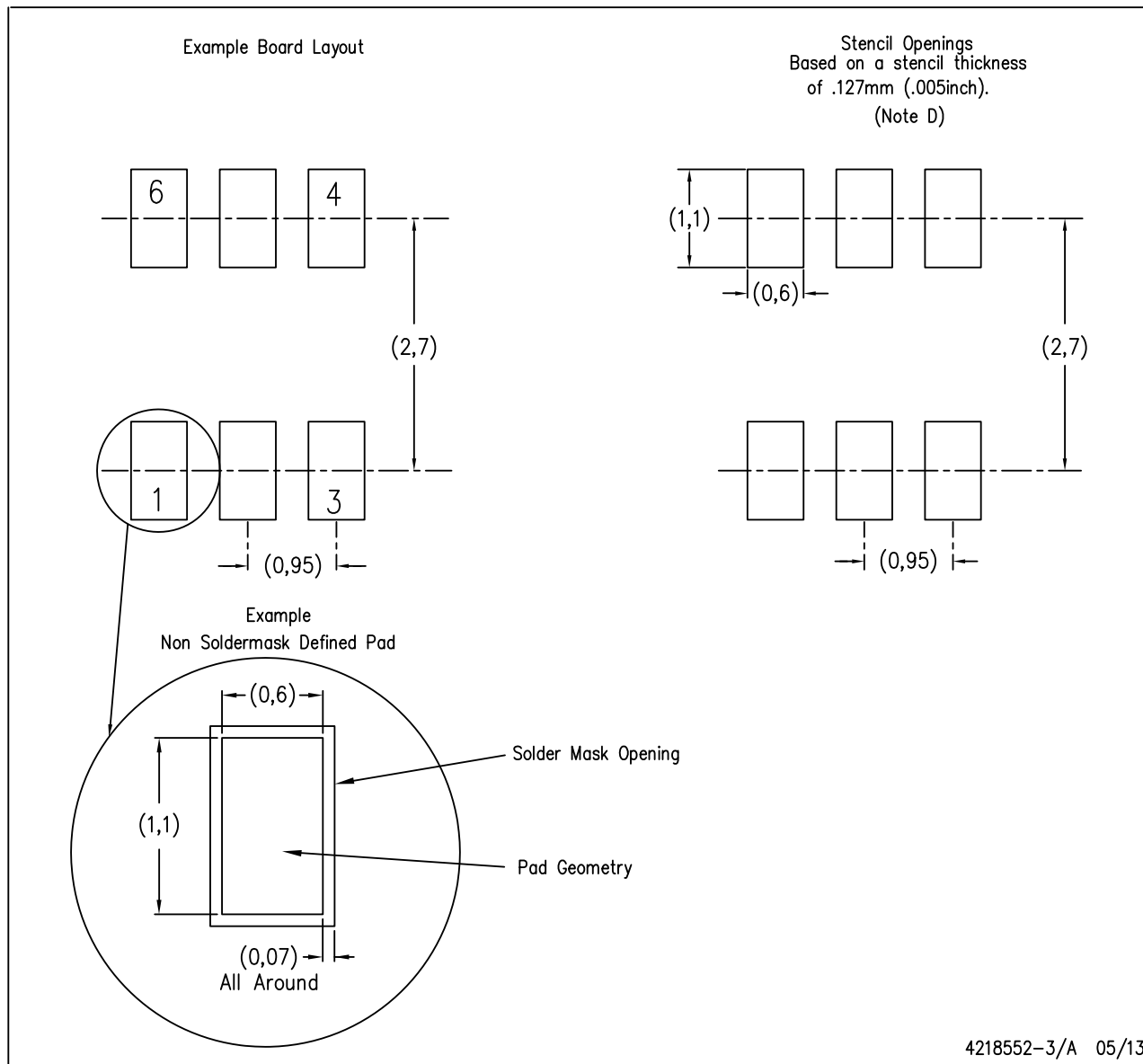


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion.
  - Falls within JEDEC MO-193 variation AA (6 pin).

## LAND PATTERN DATA

DDC (R-PDSO-G6)

PLASTIC SMALL OUTLINE

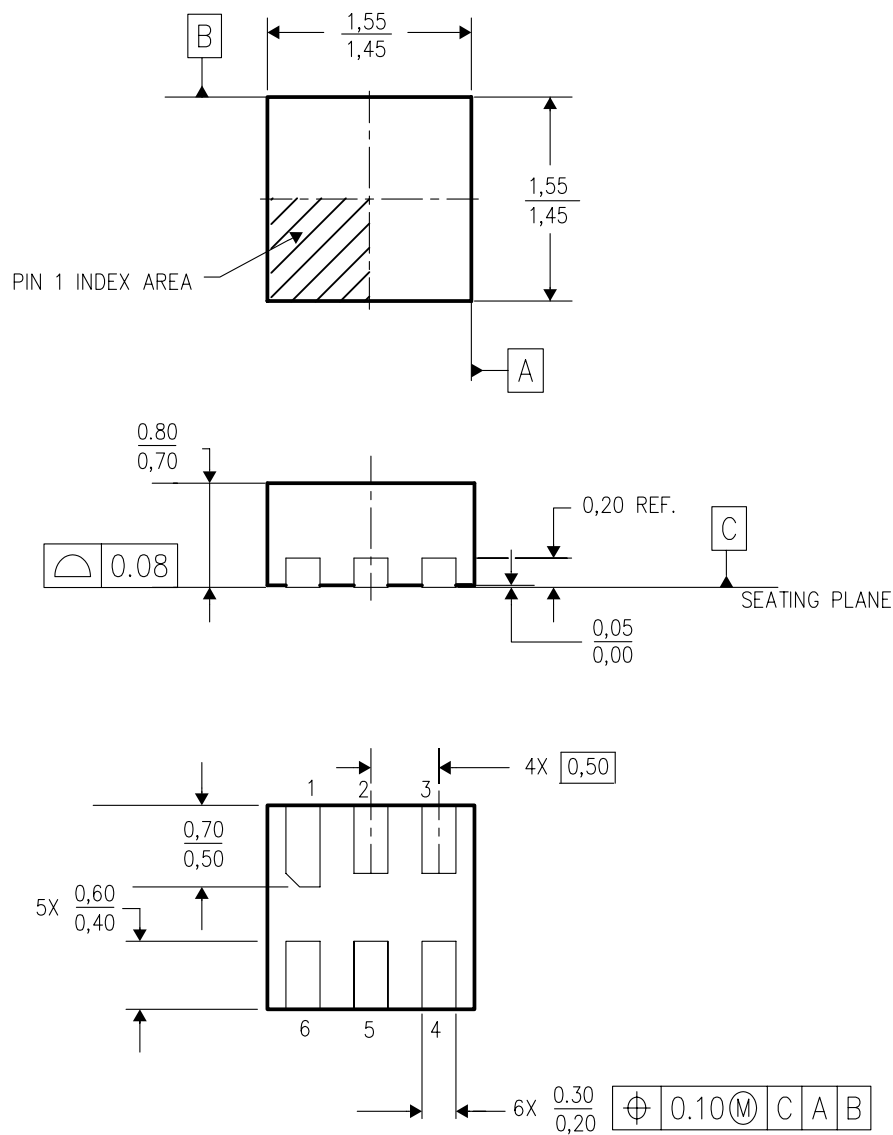


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

## MECHANICAL DATA

### DSE (S-PDSO-N6)

### PLASTIC SMALL OUTLINE



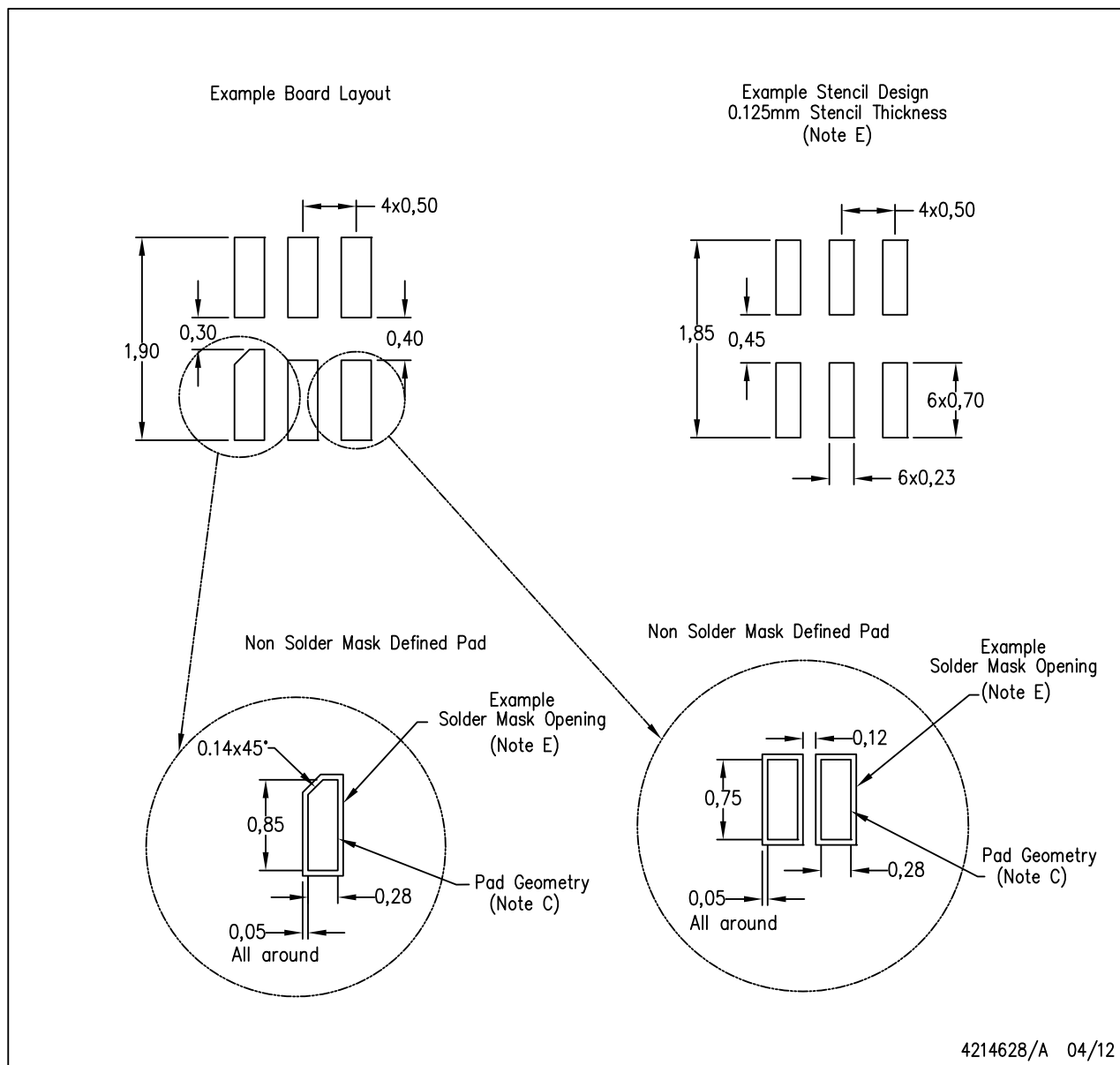
4207810/A 03/06

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Small Outline No-Lead (SON) package configuration.
  - This package is lead-free.

## LAND PATTERN DATA

DSE (S-PWSON-N6)

PLASTIC SMALL OUTLINE NO-LEAD



- 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 designs.
  - 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 stencil design considerations.
  - E. Customers should contact their board fabrication site for solder mask tolerances.



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS3700DDCR	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PXVQ	<a href="#">Samples</a>
TPS3700DDCR2	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PB4Q	<a href="#">Samples</a>
TPS3700DDCT	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PXVQ	<a href="#">Samples</a>
TPS3700DSE	ACTIVE	WSON	DSE	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BE	<a href="#">Samples</a>
TPS3700DSET	ACTIVE	WSON	DSE	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BE	<a href="#">Samples</a>

(1) 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.

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

(2) 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)

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

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

(5) 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.



<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF TPS3700 :**

- Automotive: [TPS3700-Q1](#)

**NOTE: Qualified Version Definitions:**

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**

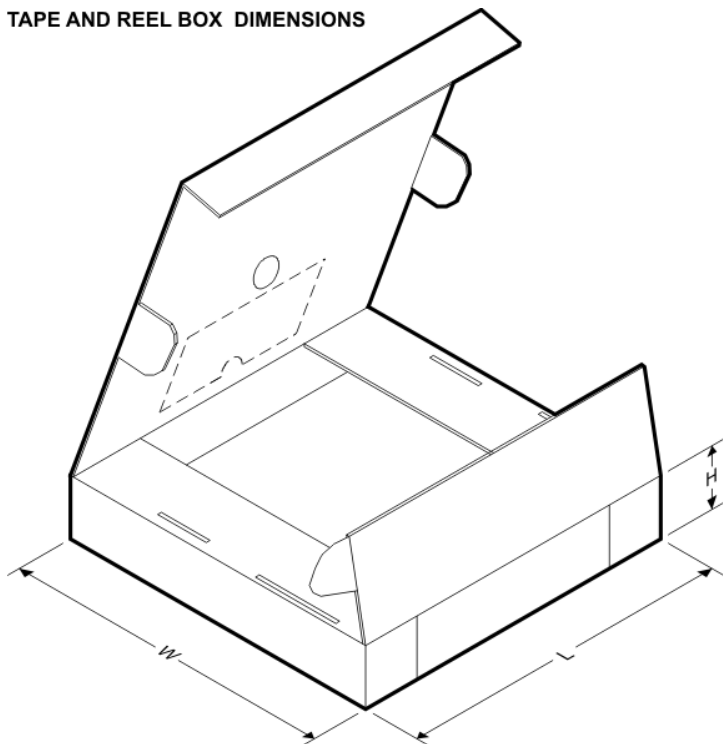


\*All dimensions are nominal

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
TPS3700DDCR	SOT	DDC	6	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS3700DDCR2	SOT	DDC	6	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q2
TPS3700DDCT	SOT	DDC	6	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS3700DSER	WSON	DSE	6	3000	179.0	8.4	1.8	1.8	1.0	4.0	8.0	Q2
TPS3700DSET	WSON	DSE	6	250	179.0	8.4	1.8	1.8	1.0	4.0	8.0	Q2

## PACKAGE MATERIALS INFORMATION

### TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS3700DDCR	SOT	DDC	6	3000	195.0	200.0	45.0
TPS3700DDCR2	SOT	DDC	6	3000	195.0	200.0	45.0
TPS3700DDCT	SOT	DDC	6	250	195.0	200.0	45.0
TPS3700DSER	WSON	DSE	6	3000	203.0	203.0	35.0
TPS3700DSET	WSON	DSE	6	250	203.0	203.0	35.0

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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
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### Applications

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Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
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Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
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