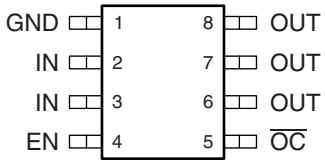
POWER-DISTRIBUTION SWITCHES

Check for Samples: TPS2032-Q1

FEATURES

- **Qualified for Automotive Applications**
- **33-mΩ (5-V Input) High-Side MOSFET Switch**
- **Short-Circuit and Thermal Protection**
- **Overcurrent Logic Output**
- **Operating Range: 2.7 V to 5.5 V**
- **Logic-Level Enable Input**
- **Typical Rise Time: 6.1 ms**
- **Undervoltage Lockout**
- **Maximum Standby Supply Current: 10 μA**
- **No Drain-Source Back-Gate Diode**
- **Available in 8-pin SOIC Package**
- **Ambient Temperature Range, –40°C to 125°C**
- **2-kV Human-Body-Model, 200-V Machine-Model ESD Protection**
- **UL Listed – File No. E169910**

D PACKAGE
(TOP VIEW)



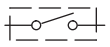
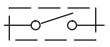
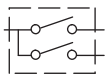
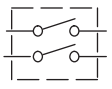
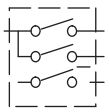
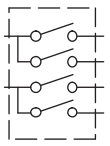
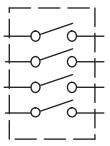
DESCRIPTION

The TPS2032 power distribution switch is intended for applications where heavy capacitive loads and short circuits are likely to be encountered. These devices are 50-mΩ N-channel MOSFET high-side power switches. The switch is controlled by a logic enable compatible with 5-V logic and 3-V logic. Gate drive is provided by an internal charge pump designed to control the power-switch rise times and fall times to minimize current surges during switching. The charge pump requires no external components and allows operation from supplies as low as 2.7 V.

When the output load exceeds the current-limit threshold or a short is present, the TPS2032 limits the output current to a safe level by switching into a constant-current mode, pulling the overcurrent ($\overline{OC}$) logic output low. When continuous heavy overloads and short circuits increase the power dissipation in the switch, causing the junction temperature to rise, a thermal protection circuit shuts off the switch to prevent damage. Recovery from a thermal shutdown is automatic once the device has cooled sufficiently. Internal circuitry ensures the switch remains off until valid input voltage is present.

The TPS2032 limits at 1.5-A load. The TPS2032 is available in an 8-pin small-outline integrated-circuit (SOIC) package and operates over a temperature range of –40°C to 125°C.

GENERAL SWITCH CATALOG

33 mΩ, Single	80 mΩ, Single	80 mΩ, Dual	80 mΩ, Dual	80 mΩ, Triple	80 mΩ, Quad	80 mΩ, Quad
						
TPS201xA 0.2 A to 2 A TPS202x 0.2 A to 2 A TPS203x 0.2 A to 2 A	TPS2014 600 mA TPS2015 1 A TPS2041B 500 mA TPS2051B 500 mA TPS2045A 250 mA TPS2049 100 mA TPS2055A 250 mA TPS2061 1 A TPS2065 1 A TPS2068 1.5 A TPS2069 1.5 A	TPS2042B 500 mA TPS2052B 500 mA TPS2046B 250 mA TPS2056 250 mA TPS2062 1 A TPS2066 1 A TPS2060 1.5 A TPS2064 1.5 A	TPS2080 500 mA TPS2081 500 mA TPS2082 500 mA TPS2090 250 mA TPS2091 250 mA TPS2092 250 mA	TPS2043B 500 mA TPS2053B 500 mA TPS2047B 250 mA TPS2057A 250 mA TPS2063 1 A TPS2067 1 A	TPS2044B 500 mA TPS2054B 500 mA TPS2048A 250 mA TPS2058 250 mA	TPS2085 500 mA TPS2086 500 mA TPS2087 500 mA TPS2095 250 mA TPS2096 250 mA TPS2097 250 mA

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.

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.

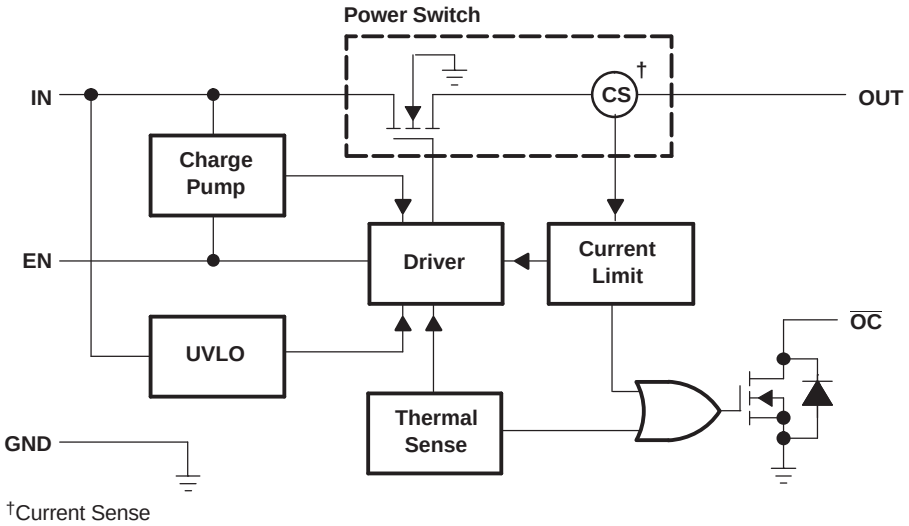
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Table 1. ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOIC – D	Reel of 2500	TPS2032QDRQ1	2032Q

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

FUNCTIONAL BLOCK DIAGRAM



TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
EN	4	I	Enable input. Logic high turns on power switch.
GND	1	I	Ground
IN	2, 3	I	Input voltage
$\overline{OC}$	5	O	Overcurrent. Logic output active low
OUT	6, 7, 8	O	Power-switch output

DETAILED DESCRIPTION

POWER SWITCH

The power switch is an N-channel MOSFET with a maximum on-state resistance of 50 mΩ ($V_{I(IN)}$ = 5 V). Configured as a high-side switch, the power switch prevents current flow from OUT to IN and IN to OUT when disabled.

CHARGE PUMP

An internal charge pump supplies power to the driver circuit and provides the necessary voltage to pull the gate of the MOSFET above the source. The charge pump operates from input voltages as low as 2.7 V and requires very little supply current.

DRIVER

The driver controls the gate voltage of the power switch. To limit large current surges and reduce the associated electromagnetic interference (EMI) produced, the driver incorporates circuitry that controls the rise times and fall times of the output voltage. The rise and fall times are typically in the 2-ms to 9-ms range.

ENABLE (EN)

The logic enable disables the power switch, the bias for the charge pump, driver, and other circuitry to reduce the supply current to less than 10 μA when a logic low is present on EN . A logic high input on EN restores bias to the drive and control circuits and turns the power on. The enable input is compatible with both TTL and CMOS logic levels.

OVERCURRENT ($\overline{OC}$)

The $\overline{OC}$ open drain output is asserted (active low) when an overcurrent or overtemperature condition is encountered. The output will remain asserted until the overcurrent or overtemperature condition is removed.

CURRENT SENSE

A sense FET monitors the current supplied to the load. The sense FET measures current more efficiently than conventional resistance methods. When an overload or short circuit is encountered, the current-sense circuitry sends a control signal to the driver. The driver, in turn, reduces the gate voltage and drives the power FET into its saturation region, which switches the output into a constant current mode and holds the current constant while varying the voltage on the load.

THERMAL SENSE

An internal thermal-sense circuit shuts off the power switch when the junction temperature rises to approximately 140°C. Hysteresis is built into the thermal sense circuit. After the device has cooled approximately 20°C, the switch turns back on. The switch continues to cycle off and on until the fault is removed.

UNDERVOLTAGE LOCKOUT

A voltage sense circuit monitors the input voltage. When the input voltage is below approximately 2 V, a control signal turns off the power switch.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)(1)

			VALUE	UNIT
$V_{I(IN)}$ (2)	Input voltage range		–0.3 to 6	V
$V_{O(OUT)}$ (2)	Output voltage range		–0.3 to $V_{I(IN)}$ + 0.3	V
$V_{I(EN)}$	Input voltage range		–0.3 to 6	V
$I_{O(OUT)}$	Continuous output current		Internally limited	
	Continuous total power dissipation		See Dissipation Rating Table	
T_A	Operating free-air temperature range		–40 to 125	°C
T_{stg}	Storage temperature range		–65 to 150	°C
ESD	Electrostatic discharge protection:	Human body model	2	kV
		Machine model	200	V
		Charged device model (CDM)	750	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 voltages are with respect to GND.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
D	725 mW	5.8 mW°C	464 mW	377 mW

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_I	Input voltage	IN	2.7	5.5	V
		EN	0	5.5	V
I_O	Continuous output current		0	1	A
T_A	Operating free-air temperature		–40	125	°C

ELECTRICAL CHARACTERISTICS

over recommended operating junction temperature range, $V_{I(IN)}$ = 5.5 V, I_O = rated current, EN = 5 V (unless otherwise noted)

POWER SWITCH							
PARAMETER		TEST CONDITIONS(1)			MIN	TYP	MAX	UNIT
$r_{DS(on)}$	Static drain-source on-state resistance	$V_{I(IN)}$ = 5 V,	T_A = 25°C,	I_O = 1 A		33	50	mΩ
		$V_{I(IN)}$ = 5 V,	T_A = 125°C,	I_O = 1 A		44	68	
		$V_{I(IN)}$ = 3.3 V,	T_A = 25°C,	I_O = 1 A		37	51	
		$V_{I(IN)}$ = 3.3 V,	T_A = 125°C,	I_O = 1 A		51	72	
		$V_{I(IN)}$ = 5 V,	T_A = 25°C,	I_O = 0.18 A		30	49	
		$V_{I(IN)}$ = 5 V,	T_A = 125°C,	I_O = 0.18 A		39	65	
		$V_{I(IN)}$ = 3.3 V,	T_A = 25°C,	I_O = 0.18 A		33	49	
		$V_{I(IN)}$ = 3.3 V,	T_A = 125°C,	I_O = 0.18 A		44	66	
t_r	Rise time, output	$V_{I(IN)}$ = 5.5 V, C_L = 1 µF,	T_A = 25°C, R_L = 10 Ω			6.1		ms
		$V_{I(IN)}$ = 2.7 V, C_L = 1 µF,	T_A = 25°C, R_L = 10 Ω			8.6		

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

ELECTRICAL CHARACTERISTICS (continued)

over recommended operating junction temperature range, $V_{I(IN)}$ = 5.5 V, I_O = rated current, EN = 5 V (unless otherwise noted)

POWER SWITCH					
PARAMETER	TEST CONDITIONS(1)		MIN	TYP	MAX	UNIT
t_f Fall time, output	$V_{I(IN)}$ = 5.5 V, C_L = 1 µF,	T_A = 25°C, R_L = 10 Ω		3.4		ms
	$V_{I(IN)}$ = 2.7 V, C_L = 1 µF,	T_A = 25°C, R_L = 10 Ω		3		

ENABLE INPUT (EN)						
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IH}	high-level input voltage	2.7 V ≤ $V_{I(IN)}$ ≤ 5.5 V	2			V
V_{IL}	Low-level input voltage	4.5 V ≤ $V_{I(IN)}$ ≤ 5.5 V			0.8	V
		2.7 V ≤ $V_{I(IN)}$ ≤ 4.5 V			0.5	
I_I	Input current	EN = 0 V or EN = $V_{I(IN)}$	–0.5		0.5	µA
t_{on}	Turnon time	I_O = 750 mA			20	ms
t_{off}	Turnoff time	I_O = 750 mA			40	

CURRENT LIMIT2						
PARAMETER		TEST CONDITIONS(1)	MIN	TYP	MAX	UNIT
I_{OS}	Short-circuit output current	T_A = 25°C, V_I = 5.5 V, OUT connected to GND, Device enable into short circuit	1.1	1.5	1.8	A

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

SUPPLY CURRENT						
PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
Supply current, low-level output	No Load on OUT	EN = 0	T_A = 25°C		0.3	1	µA
			40°C ≤ T_A ≤ 125°C			10	
Supply current, high-level output	No Load on OUT	EN = $V_{I(IN)}$	T_A = 25°C		58	75	µA
			40°C ≤ T_A ≤ 125°C		75	100	
Leakage current	OUT connected to ground	EN = 0	40°C ≤ T_A ≤ 125°C		10		µA

UNDERVOLTAGE LOCKOUT					
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Low-level input voltage		2		2.5	V
Hysteresis	T_A = 25°C		100		mV
OVERCURRENT ($\overline{OC}$)					
Output low voltage	I_O = 10 mA, $V_{OL(\overline{OC})}$			0.4	V
Off-state current(1)	V_O = 5 V, V_O = 3.3 V			1	µA

(1) Specified by design, not production tested.

PARAMETER MEASUREMENT INFORMATION

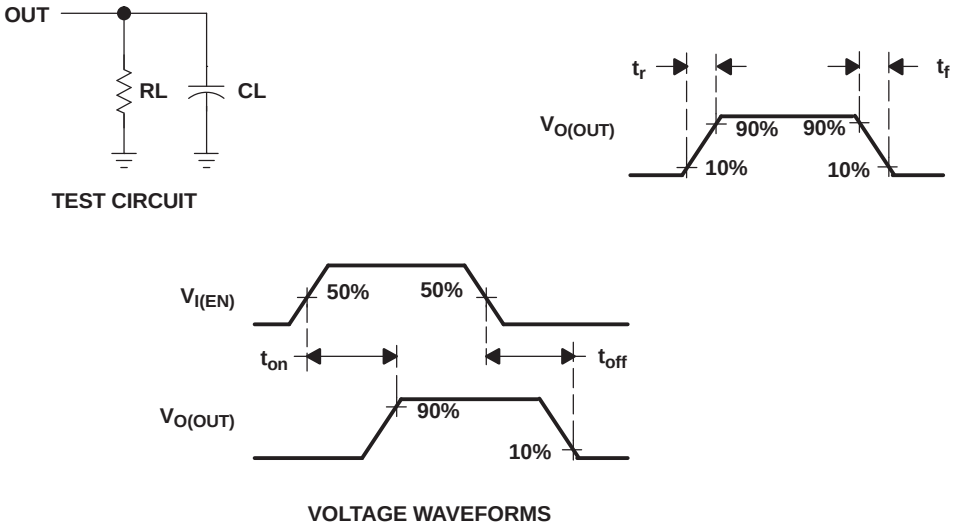


Figure 1. Test Circuit and Voltage Waveforms

Table 2. TABLE OF TIMING DIAGRAMS

	FIGURE
Turnon Delay and Rise Time	2
Turnoff Delay and Fall Time	3
Turnon Delay and Rise Time with 1-μF Load	4
Turnoff Delay and Rise TIME with 1-μF Load	5
Device Enabled Into Short	6
Ramped Load on Enabled Device	7
2.6-Ω Load Connected to an Enabled TPS2032 Device	8
1.2-Ω Load Connected to an Enabled TPS2032 Device	9

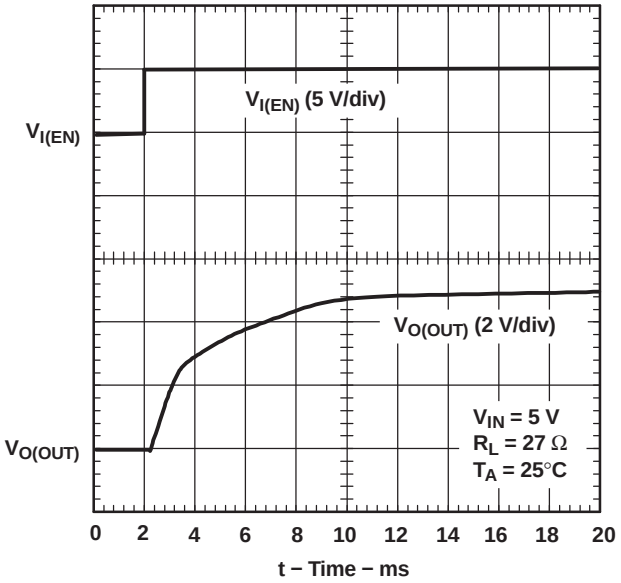


Figure 2. Turnon Delay and Rise Time

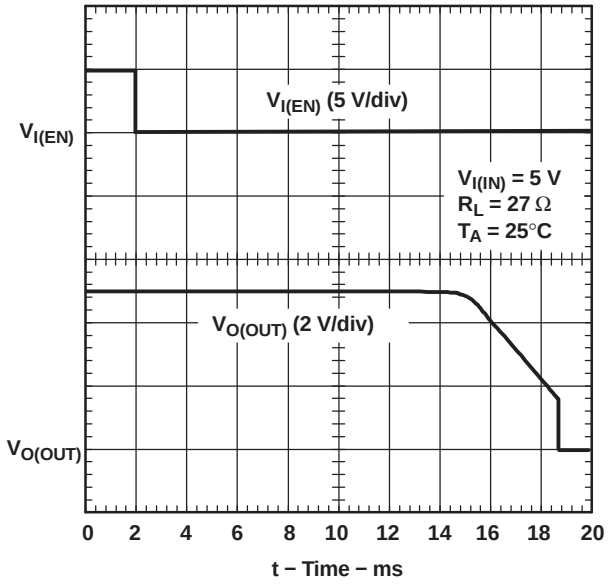


Figure 3. Turnoff Delay and Fall Time

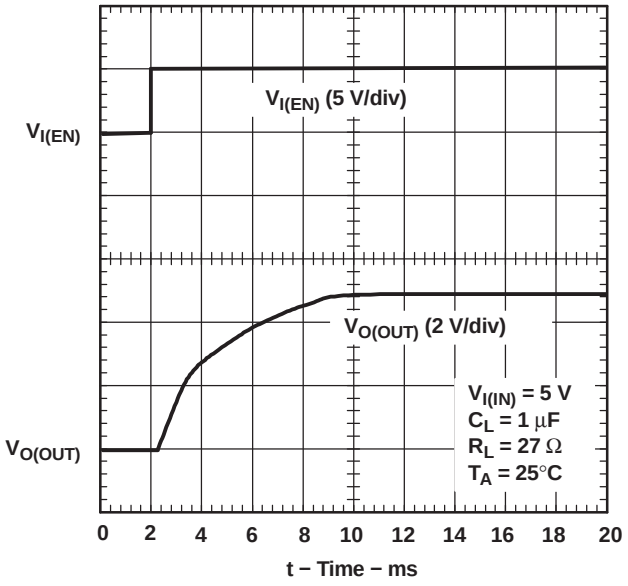


Figure 4. Turnon Delay and Rise Time With 1-μF Load

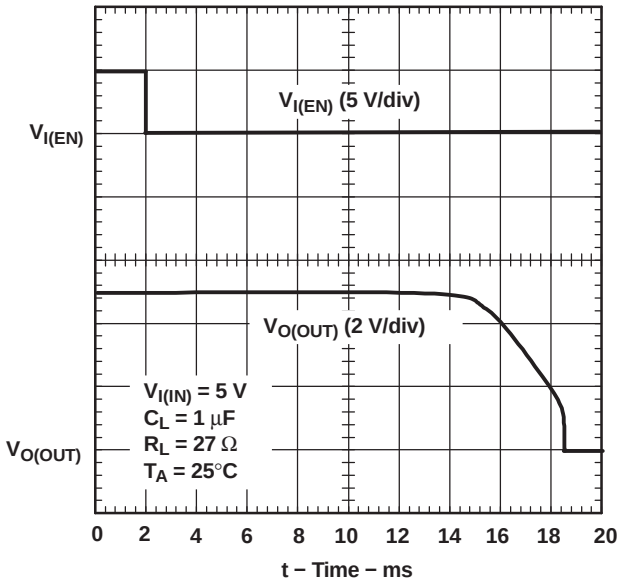


Figure 5. Turnoff Delay and Fall Time With 1-μF Load

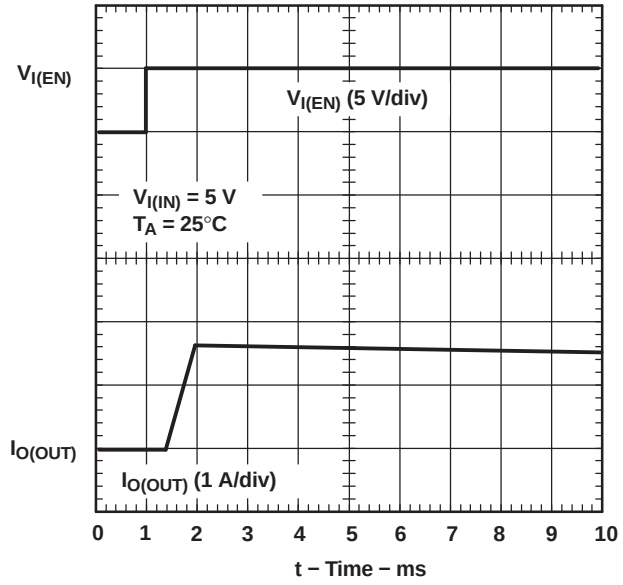


Figure 6. Device Enabled Into Short

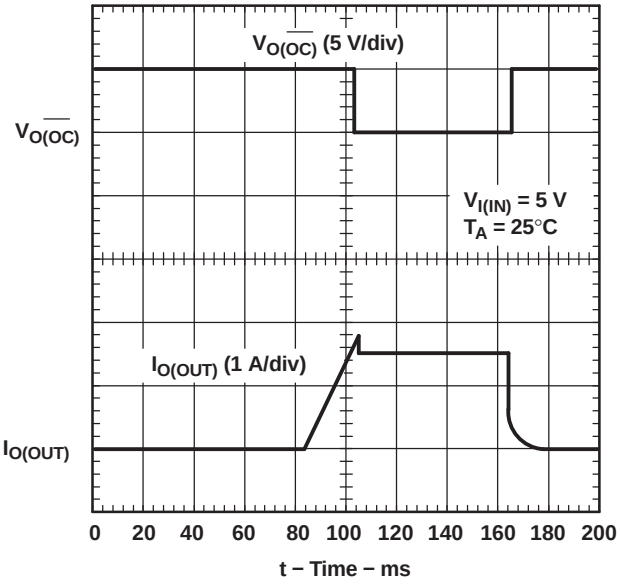


Figure 7. TPS2032, Ramped Load on Enabled Device

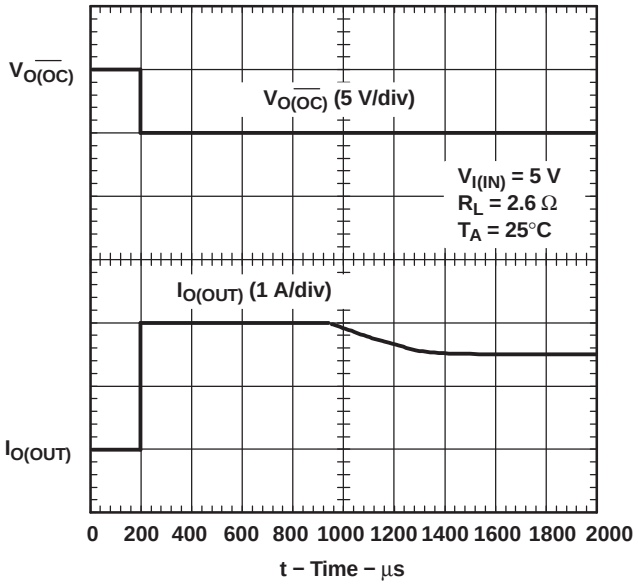


Figure 8. 2.6-Ω Load Connected to an Enabled TPS2032 Device

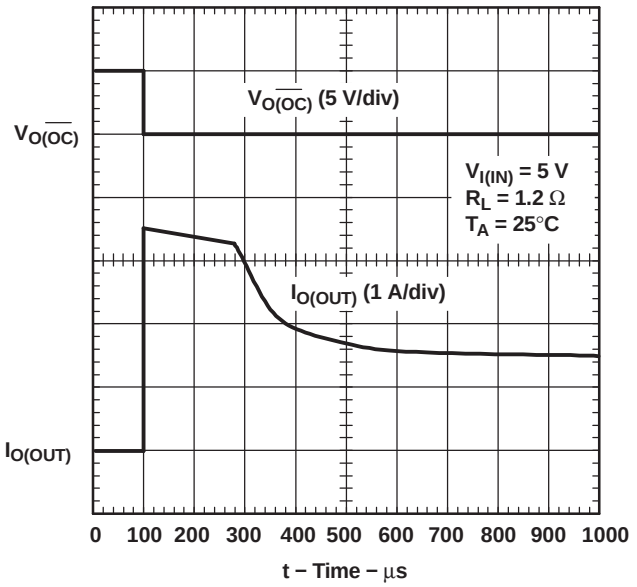


Figure 9. 1.2-Ω Load Connected to an Enabled TPS2032 Device

TYPICAL CHARACTERISTICS

Table 3. TABLE OF GRAPHS

			FIGURE
$t_{d(on)}$	Turnon delay time	vs Output voltage	13
$t_{d(off)}$	Turnoff delay time	vs Input voltage	14
t_r	Rise time	vs Load current	15
t_f	Fall time	vs Load current	16
	Supply current (enabled)	vs Junction temperature	17
	Supply current (disabled)	vs Junction temperature	18
	Supply current (enabled)	vs Input voltage	19
	Supply current (disabled)	vs Input voltage	20
I_{OS}	Short-circuit current limit	vs Input voltage	21
		vs Junction temperature	22
$r_{DS(on)}$	Static drain-source on-state resistance	vs Input voltage	23
		vs Junction temperature	24
		vs Input voltage	25
		vs Junction temperature	26
V_I	Input voltage	Undervoltage lockout	27

TURNON DELAY TIME vs OUTPUT VOLTAGE

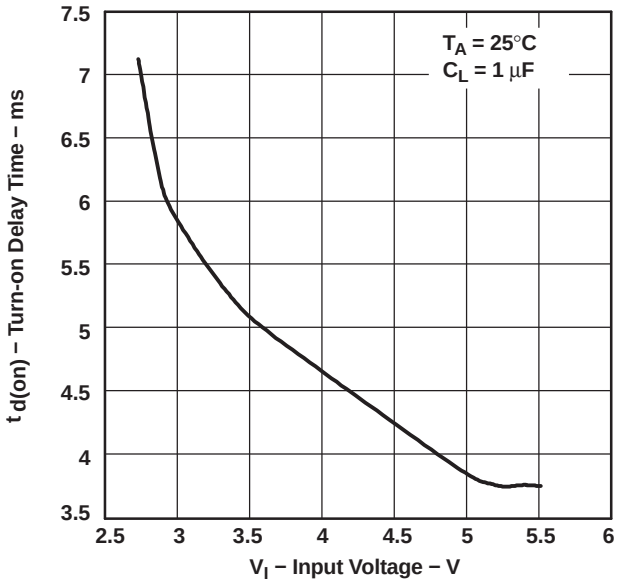


Figure 10.

TURNOFF DELAY TIME vs INPUT VOLTAGE

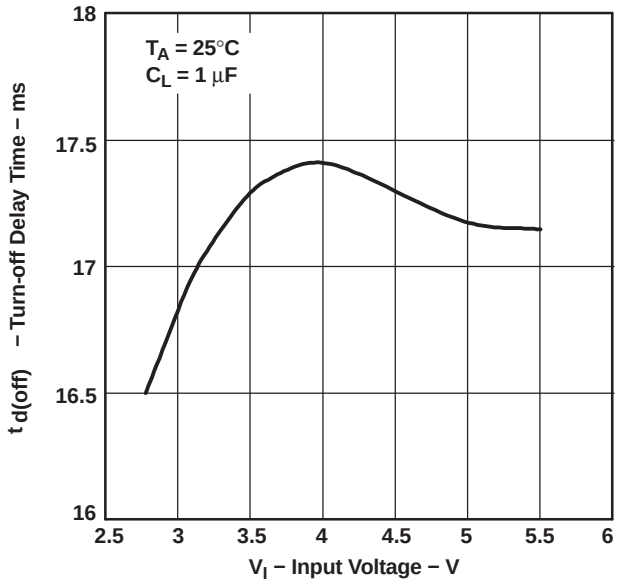


Figure 11.

RISE TIME vs LOAD CURRENT

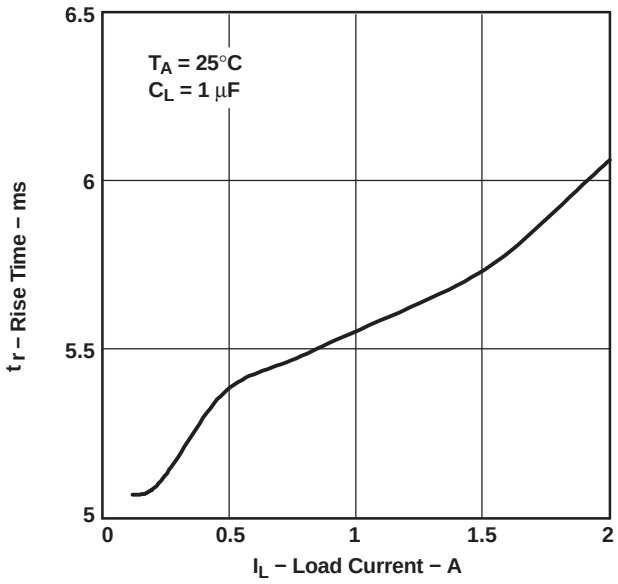


Figure 12.

FALL TIME vs LOAD CURRENT

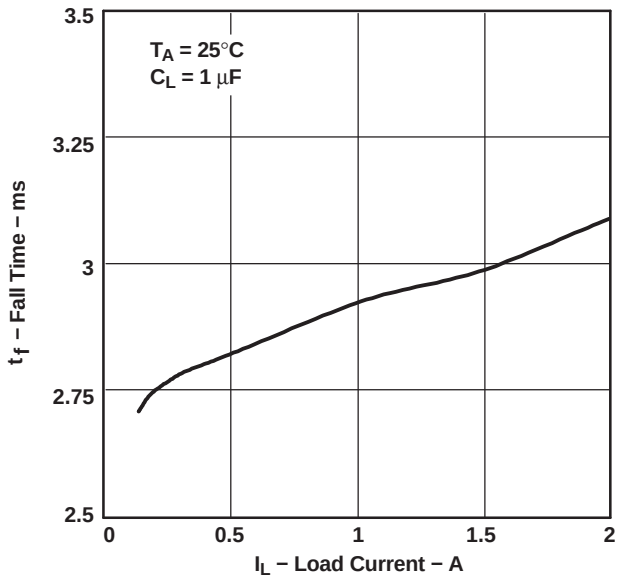


Figure 13.

SUPPLY CURRENT (ENABLED)
vs
JUNCTION TEMPERATURE

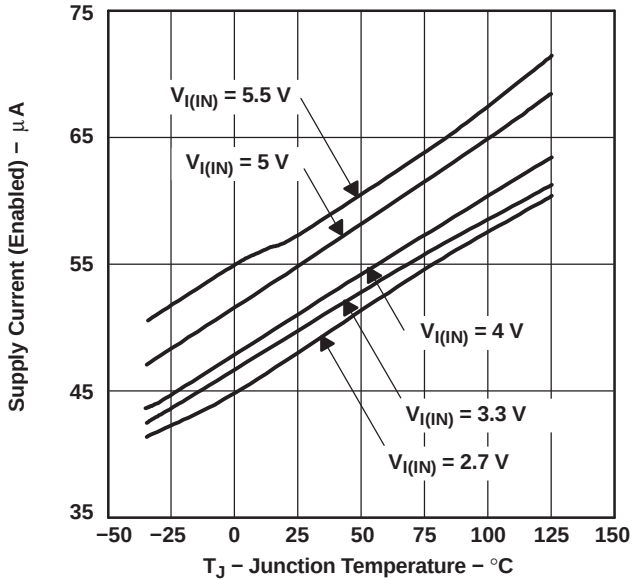


Figure 14.

SUPPLY CURRENT (DISABLED)
vs
JUNCTION TEMPERATURE

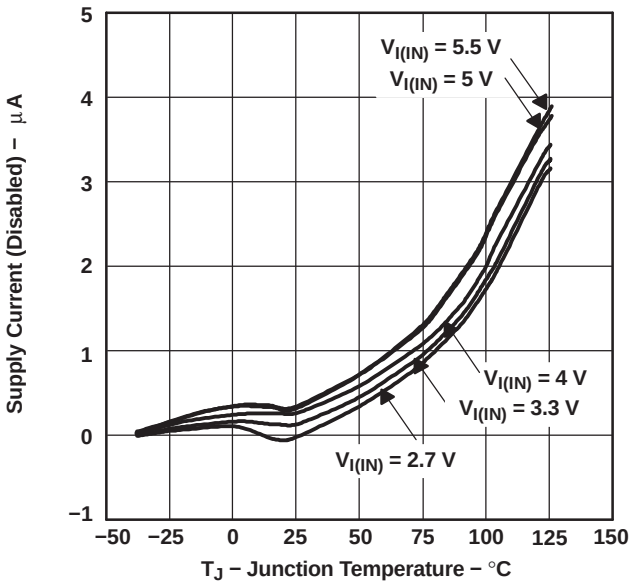


Figure 15.

SUPPLY CURRENT (ENABLED)
vs
INPUT VOLTAGE

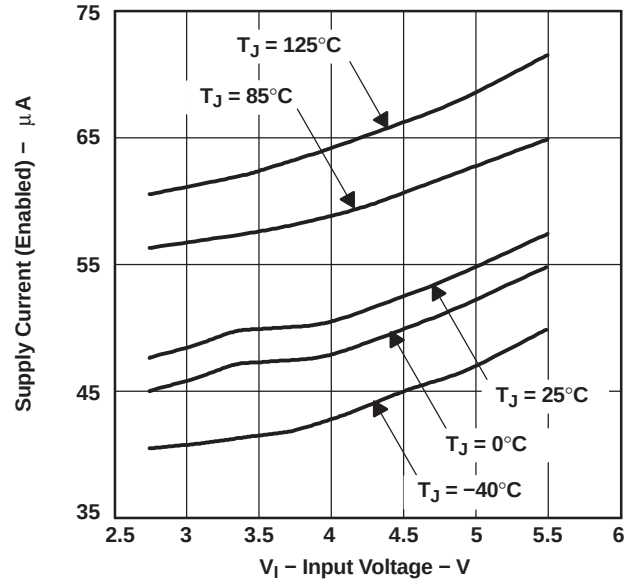


Figure 16.

SUPPLY CURRENT (DISABLED)
vs
INPUT VOLTAGE

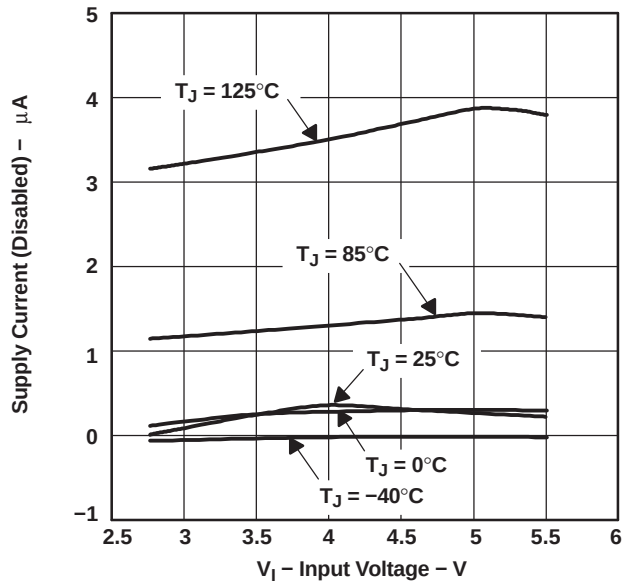


Figure 17.

SHORT-CIRCUIT CURRENT LIMIT
vs
INPUT VOLTAGE

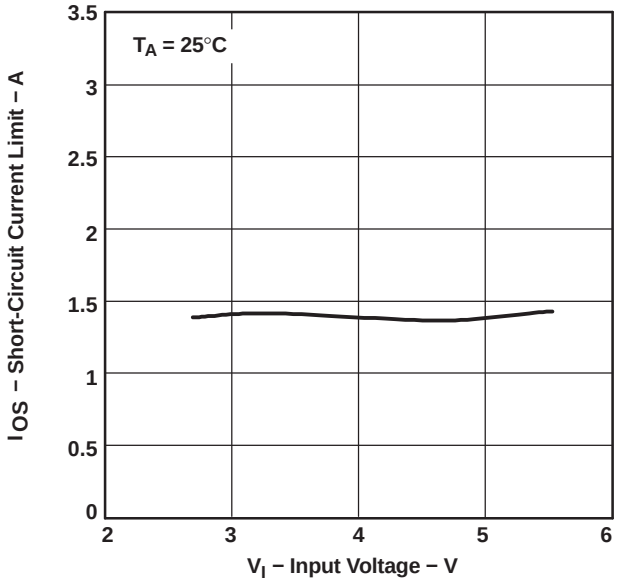


Figure 18.

SHORT-CIRCUIT CURRENT LIMIT
vs
JUNCTION TEMPERATURE

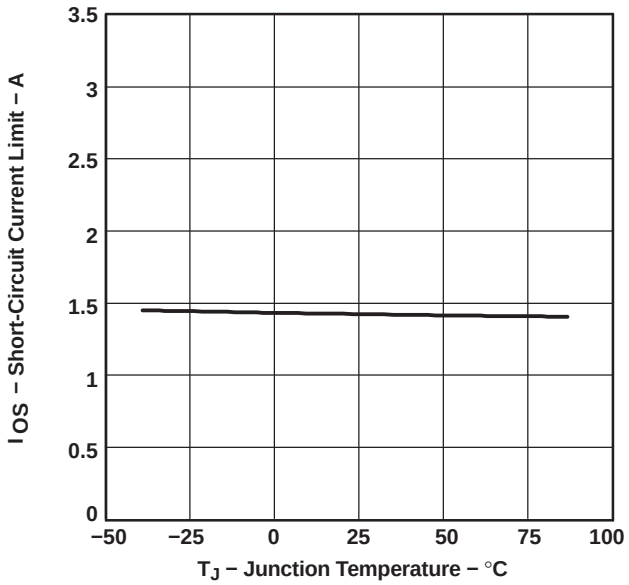


Figure 19.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
INPUT VOLTAGE

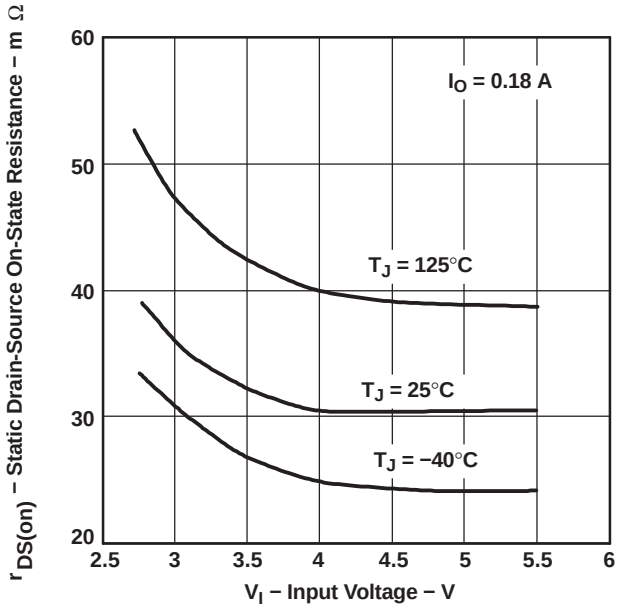


Figure 20.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
JUNCTION TEMPERATURE

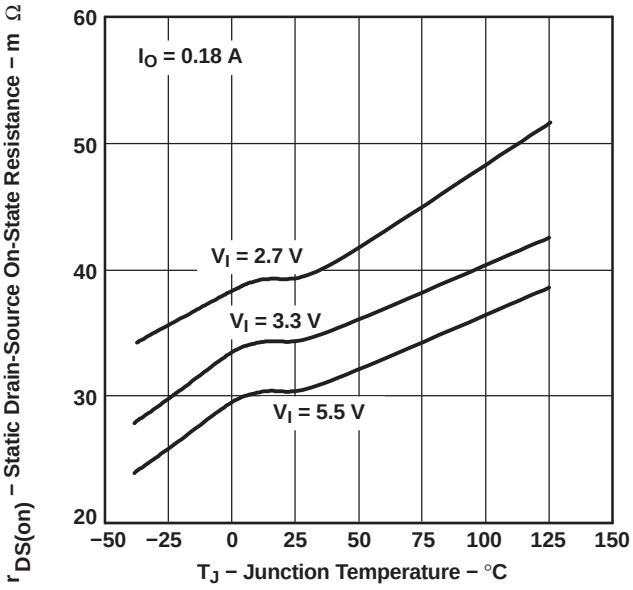


Figure 21.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
INPUT VOLTAGE

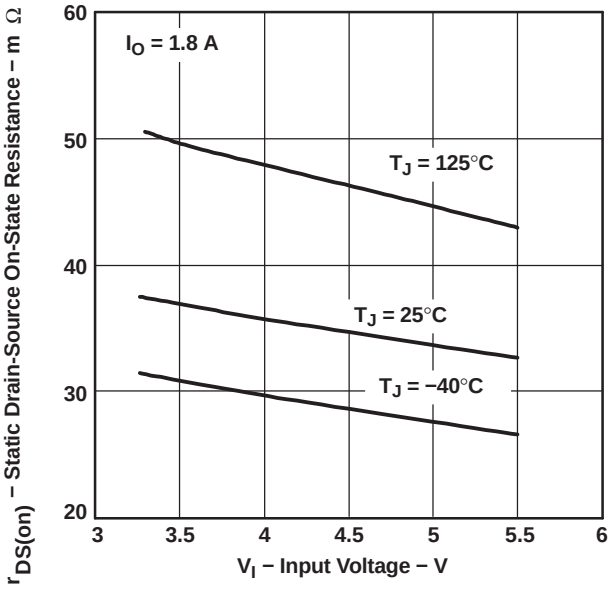


Figure 22.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
JUNCTION TEMPERATURE

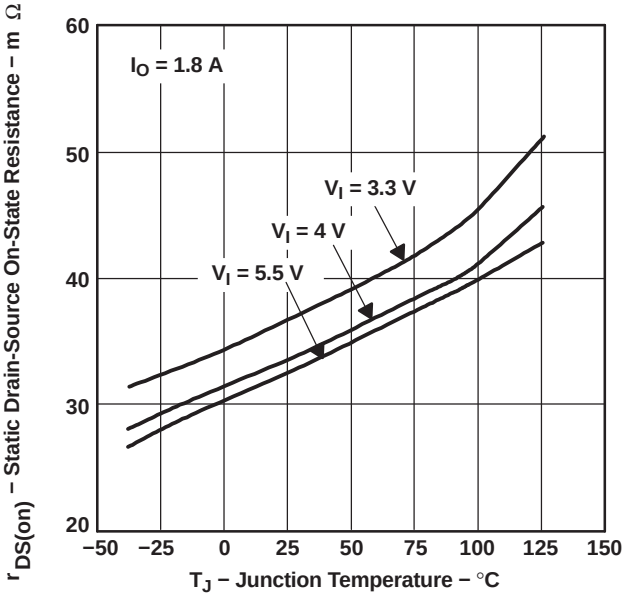


Figure 23.

UNDERVOLTAGE LOCKOUT

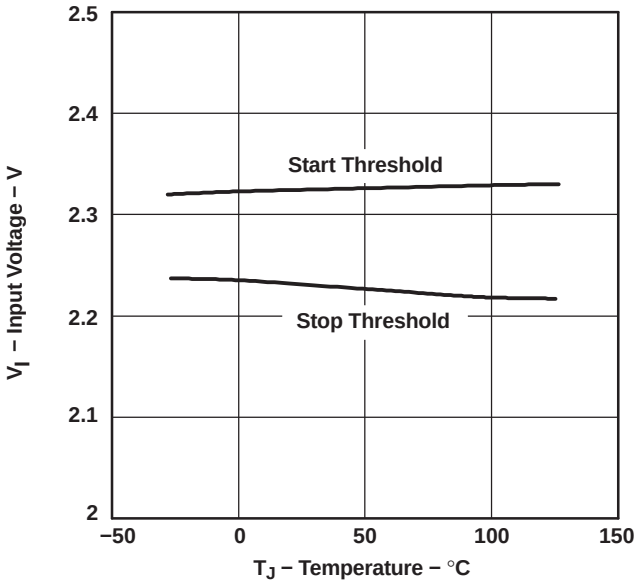


Figure 24.

APPLICATION INFORMATION

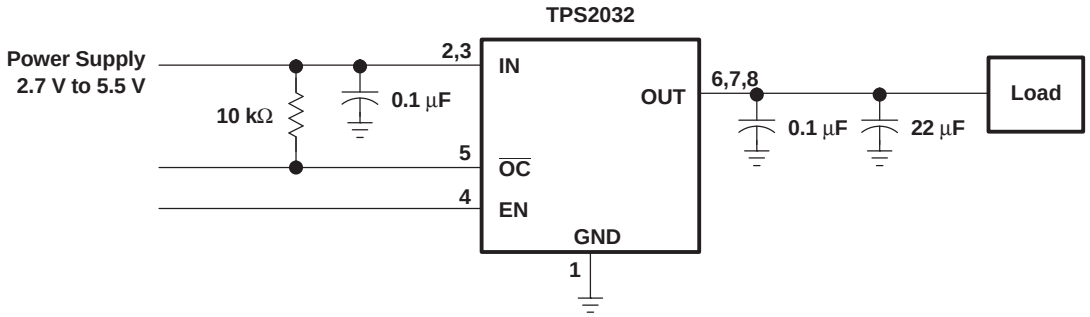


Figure 25. Typical Application

POWER SUPPLY CONSIDERATIONS

A 0.01-µF to 0.1-µF ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the output and input pins is recommended when the output load is heavy. This precaution reduces power supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

OVERCURRENT

A sense FET checks for overcurrent conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault is present long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before $V_{I(IN)}$ has been applied (see Figure 6). The TPS2032 senses the short and immediately switches into a constant-current output.

In the second condition, the excessive load occurs while the device is enabled. At the instant the excessive load occurs, very high currents may flow for a short time before the current-limit circuit can react (see Figure 9). After the current-limit circuit has tripped (reached the overcurrent trip threshold) the device switches into constant-current mode.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold is reached or until the thermal limit of the device is exceeded. The TPS2032 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its constant-current mode.

$\overline{\text{OC}}$ RESPONSE

The $\overline{\text{OC}}$ open-drain output is asserted (active low) when an overcurrent or overtemperature condition is encountered. The output will remain asserted until the overcurrent or overtemperature condition is removed. Connecting a heavy capacitive load to an enabled device can cause momentary false overcurrent reporting from the inrush current flowing through the device, charging the downstream capacitor. An RC filter can be connected to the $\overline{\text{OC}}$ pin to reduce false overcurrent reporting. Using low-ESR electrolytic capacitors on the output lowers the inrush current flow through the device during hot-plug events by providing a low impedance energy source, thereby reducing erroneous overcurrent reporting.

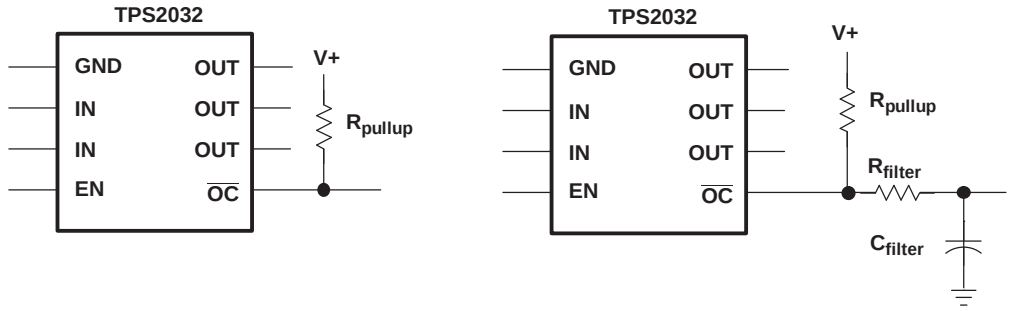


Figure 26. Typical Circuit for $\overline{OC}$ Pin and RC Filter for Damping Inrush $\overline{OC}$ Responses

POWER DISSIPATION AND JUNCTION TEMPERATURE

The low on-resistance on the n-channel MOSFET allows small surface-mount packages, such as SOIC, to pass large currents. The thermal resistances of these packages are high compared to those of power packages; it is good design practice to check power dissipation and junction temperature. The first step is to find $r_{DS(on)}$ at the input voltage and operating temperature. As an initial estimate, use the highest operating ambient temperature of interest and read $r_{DS(on)}$ from Figure 20 through Figure 23. Next, calculate the power dissipation using:

$$P_D = r_{DS(on)} \times I^2 \quad (1)$$

Finally, calculate the junction temperature:

$$T_J = P_D \times R_{\theta JA} + T_A \quad (2)$$

Where:

T_A = Ambient temperature, °C

$R_{\theta JA}$ = Thermal resistance SOIC = 172°C/W, PDIP = 106°C/W

Compare the calculated junction temperature with the initial estimate. If they do not agree within a few degrees, repeat the calculation, using the calculated value as the new estimate. Two or three iterations are generally sufficient to get an acceptable answer.

THERMAL PROTECTION

Thermal protection prevents damage to the IC when heavy-overload or short-circuit faults are present for extended periods of time. The faults force the TPS2032 into constant current mode, which causes the voltage across the high-side switch to increase; under short-circuit conditions, the voltage across the switch is equal to the input voltage. The increased dissipation causes the junction temperature to rise to high levels. The protection circuit senses the junction temperature of the switch and shuts it off. Hysteresis is built into the thermal sense circuit, and after the device has cooled approximately 20 degrees, the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed.

UNDERVOLTAGE LOCKOUT (UVLO)

An undervoltage lockout ensures that the power switch is in the off state at powerup. Whenever the input voltage falls below approximately 2 V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed. The UVLO also keeps the switch from being turned on until the power supply has reached at least 2 V, even if the switch is enabled. Upon reinsertion, the power switch will be turned on, with a controlled rise time to reduce EMI and voltage overshoots.

GENERIC HOT-PLUG APPLICATIONS (Figure 27)

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Because of the controlled rise times and fall times of the TPS2032, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the TPS2032 also ensures the switch will be off after the card has been removed, and the switch will be off during the next insertion. The UVLO feature ensures a soft start with a controlled rise time for every insertion of the card or module.

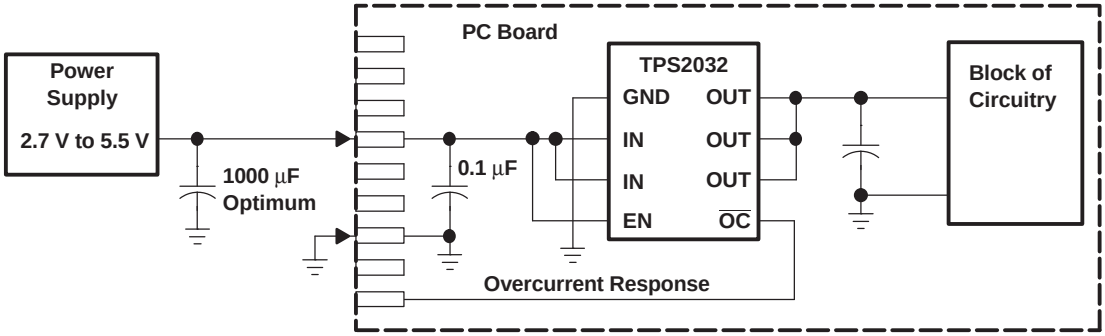


Figure 27. Typical Hot-Plug Implementation

By placing the TPS2032 between the V_{CC} input and the rest of the circuitry, the input power will reach this device first after insertion. The typical rise time of the switch is approximately 9 ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge currents and provides a hot-plugging mechanism for any device.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS2032QDRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2032Q	Samples

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

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

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

OTHER QUALIFIED VERSIONS OF TPS2032-Q1 :

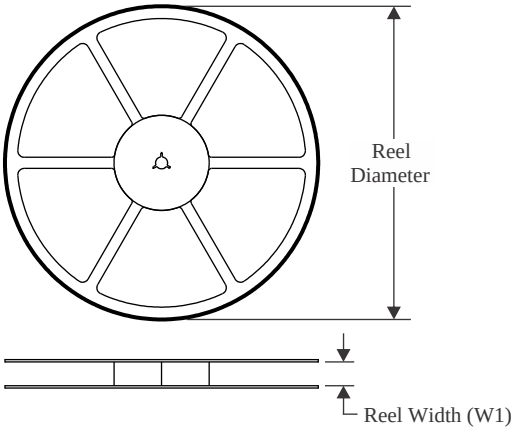
- Catalog: TPS2032

NOTE: Qualified Version Definitions:

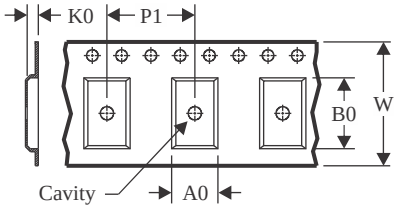
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

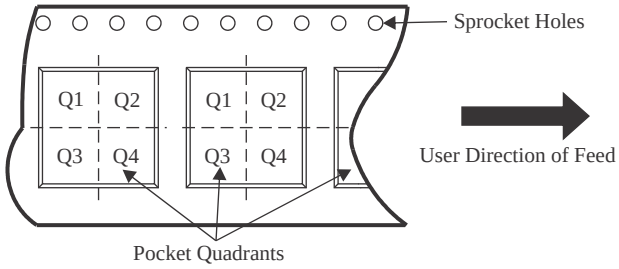


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

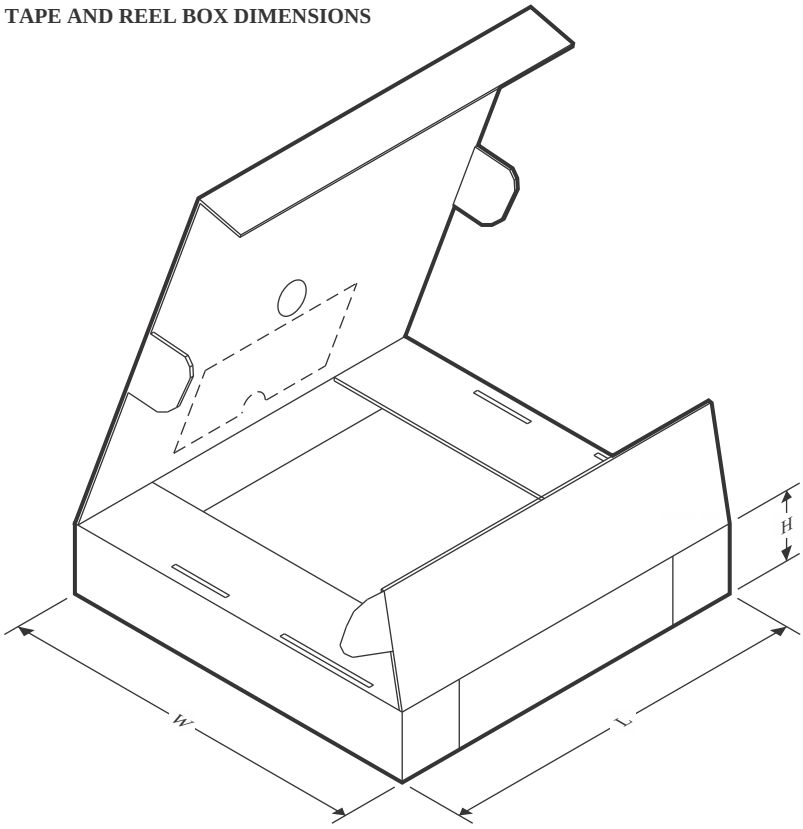
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

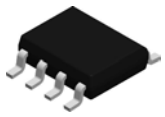
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS2032QDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS2032QDRQ1	SOIC	D	8	2500	353.0	353.0	32.0

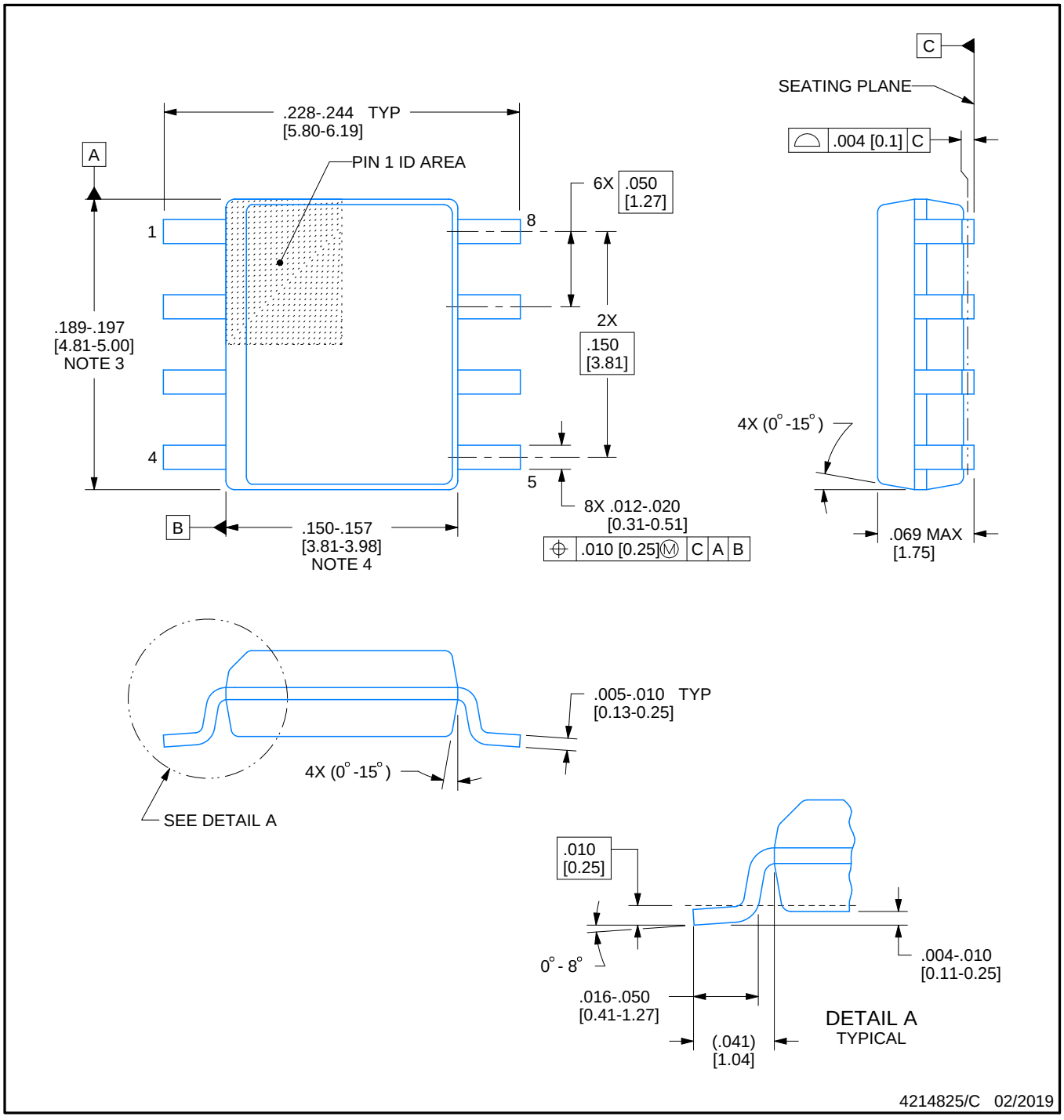


PACKAGE OUTLINE

D0008A

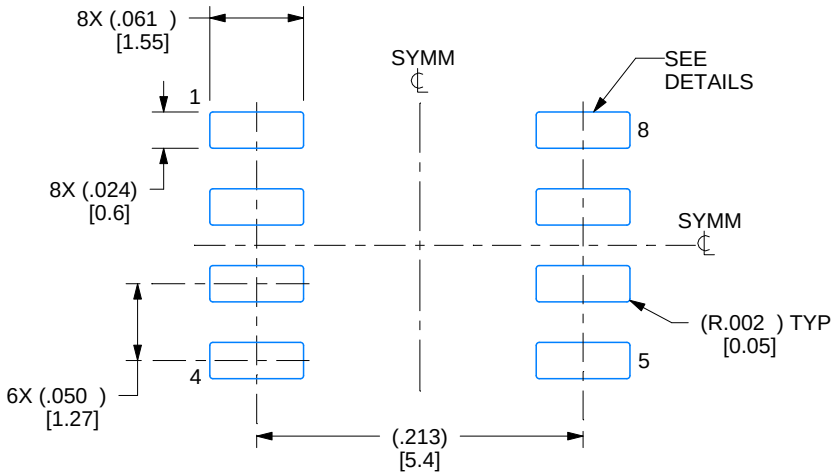
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

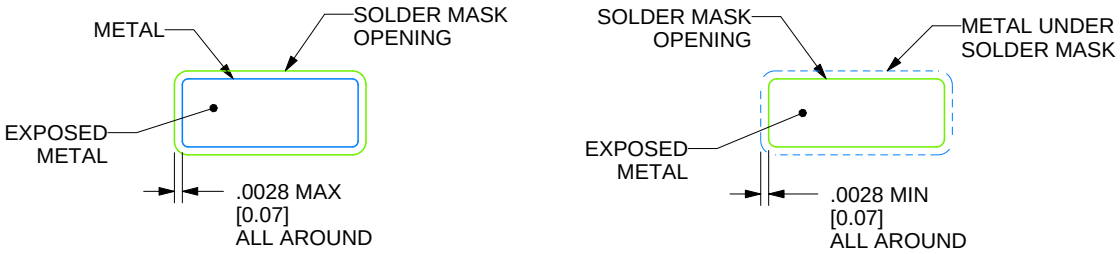


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

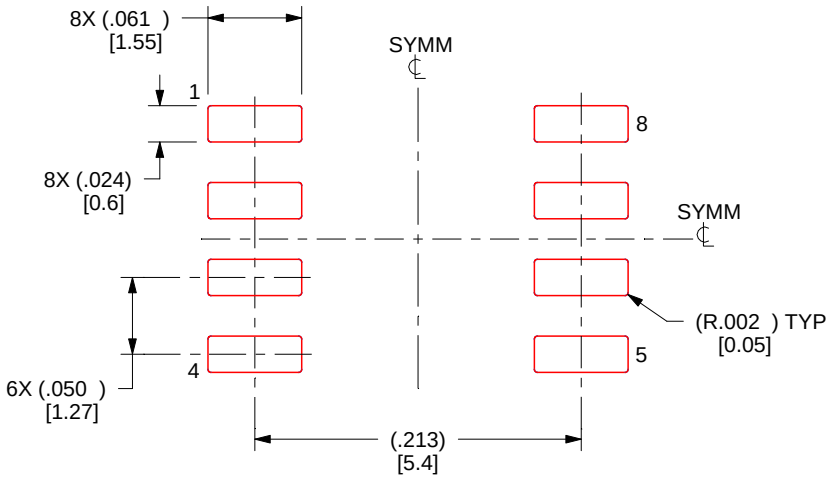
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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