Ultra-Small, Low on Resistance Load Switch with Controlled Turn-on

Check for Samples: TPS22929

FEATURES

- **Integrated Single Load Switch**
- **Small SOT23-6 package**
- **Input Voltage Range: 1.4-V to 5.5-V**
- **Low ON-Resistance**
  - r_{ON} **= 115-mΩ at VIN = 5-V**
  - r_{ON} **= 115-mΩ at VIN = 3.3-V**
  - r_{ON} **= 118-mΩ at VIN = 2.5-V**
  - r_{ON} **= 129-mΩ at VIN = 1.5-V**
- **1.8-A Continuous Switch Current (25C)**
- **Low Threshold Control Input**
- **Controlled Slew-rate Options**
- **Under-Voltage Lock Out**
- **Quick Output Discharge Transistor**
- **Reverse Current Protection**

APPLICATIONS

- **Portable Industrial Equipment**
- **Portable Medical Equipment**
- **Portable Media Players**
- **Point Of Sales Terminal**
- **GPS Devices**
- **Digital Cameras**
- **Portable Instrumentation**
- **Smartphones**

DESCRIPTION

The TPS22929 is a small, low r_{ON} load switch with controlled turn on. The device contains a P-channel MOSFET that can operate over an input voltage range of 1.4 V to 5.5 V. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage control signals. The TPS22929 is active high enable.

The TPS22929 contains a 150-Ω on-chip load resistor for quick output discharge when the switch is turned off. The rise time of the device is internally controlled in order to avoid inrush current. The TPS22929 family has various slew rate options (see).

The TPS22929 device provides circuit breaker functionality by latching off the power-switch during reverse voltage situations. An internal reverse voltage comparator disables the power-switch when the output voltage (V_{OUT}) is driven higher than the input (V_{IN}) to quickly (10µs typ) stop the flow of current towards the input side of the switch. Reverse current is always active, even when the power-switch is disabled. Additionally, under-voltage lockout (UVLO) protection turns the switch off if the input voltage is too low.

The TPS22929 is available in an small, space-saving 6-pin SOT23-6 package and is characterized for operation over the free-air temperature range of –40°C to 85°C.

TYPICAL APPLICATION

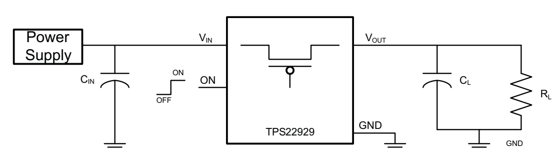


Table 1. Feature List

DEVICE	rON (typ) at 3.3 V	Rise Time at 3.3 V (typ)	QUICK OUTPUT DISCHARGE(1)	MAXIMUM OUTPUT CURRENT (3.3 V and 25°C)(2)	ENABLE
TPS22929A(3)	115-mΩ	0.5 µs	Yes	1.8-A	Active High
TPS22929B(3)	115-mΩ	100 µs	Yes	1.8-A	Active High
TPS22929C(3)	115-mΩ	1000 µs	Yes	1.8-A	Active High
TPS22929D	115-mΩ	4500 µs	Yes	1.8-A	Active High

(1) This feature discharges the output of the switch to ground through an 150-Ω resistor, preventing the output from floating.
(2) See “Thermal Considerations” section in Application Information to calculate maximum continuous current for a specific application.
(3) Contact local sales/distributor or factory for availability.

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

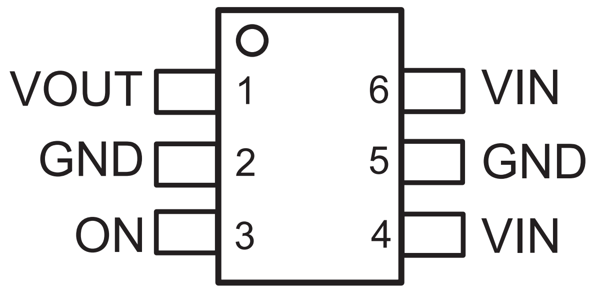
ORDERING INFORMATION

T_A	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	DBV	Contact factory for availability(2)	TPS22929ADBVT	Contact factory for availability(2)
			TPS22929ADBVR	
			TPS22929BDBVT	
			TPS22929BDBVR	
			TPS22929CDBVT	
			TPS22929CDBVR	
		Tape of 3000	TPS22929DDBVT	_F4_
		Reel of 250	TPS22929DDBVR	

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(2) Contact factory for details and availability for PREVIEW devices, minimum order quantities may apply.

DEVICE INFORMATION

DBV PACKAGE



PIN FUNCTIONS

TPS22929 DBV	PIN NAME	DESCRIPTION
2, 5	GND	Ground
3	ON	Switch control input, active high. Do not leave floating
1	VOUT	Switch output
4, 6	VIN	Switch input, bypass this input with a ceramic capacitor to ground

BLOCK DIAGRAM

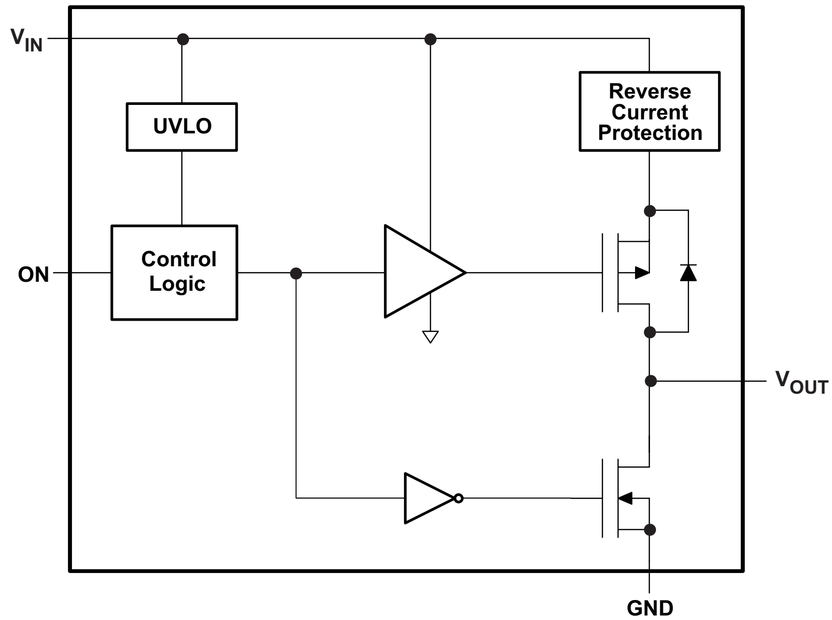


Table 2. FUNCTION TABLE

ON	VIN to VOUT	VOUT to GND[(1)]
L	OFF	ON
H	ON	OFF

(1) See Application section ‘Output Pull-Down’

ABSOLUTE MAXIMUM RATINGS

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

			VALUE	UNIT
V_{IN}	Input voltage range		–0.3 to 6	V
V_{OUT}	Output voltage range		VIN + 0.3	V
V_{ON}	Input voltage range		–0.3 to 6	V
P_{MAX}	Maximum continuous power dissipation @ 25°C		463	mW
	Maximum continuous power dissipation @ 70°C		254	
	Maximum continuous power dissipation @ 85°C		185	
I_{MAX}	Maximum continuous operating current		2	A
T_A	Operating free-air temperature range		–40 to 85	°C
T_J	Maximum junction temperature		125	°C
T_{STG}	Storage temperature range		–65 to 150	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM) (VIN, VOUT, GND pins)	2000	V
		Charged-Device Model (CDM) (VIN, VOUT, ON, GND pins)	1000	

THERMAL INFORMATION

THERMAL METRIC(1)		TPS22929 SOT23-6 (6) PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance	216	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	209	
θ_{JB}	Junction-to-board thermal resistance	131	
ψ_{JT}	Junction-to-top characterization parameter	52	
ψ_{JB}	Junction-to-board characterization parameter	110	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	N/A	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_{IN}	Input voltage range		1.4	5.5	V
V_{ON}	ON voltage range		0	5.5	V
V_{OUT}	Output voltage range			V_{IN}	
V_{IH}	High-level input voltage, ON	VIN = 3.61 V to 5.5 V	1.1	5.5	V
		VIN = 1.4 V to 3.6 V	1.1	5.5	V
V_{IL}	Low-level input voltage, ON	VIN = 3.61 V to 5.5 V		0.6	V
		VIN = 1.4 V to 3. 6V		0.4	V
C_{IN}	Input Capacitor		1 (1)		μF

(1) Refer to the application section.

ELECTRICAL CHARACTERISTICS

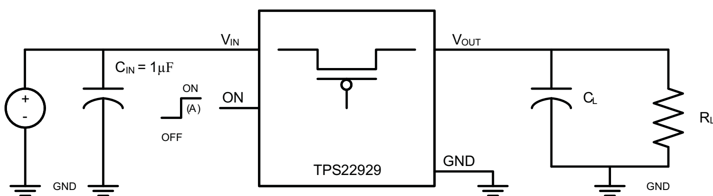
VIN = 1.4 V to 5.5 V, T_A = –40ºC to 85ºC (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
I_{IN}	Quiescent current	I_{OUT} = 0, V_{IN} = V_{ON} = 5.25 V	Full		2.2	10	µA
		I_{OUT} = 0, V_{IN} = V_{ON} = 4.2 V			2.1	7.0	
		I_{OUT} = 0, V_{IN} = V_{ON} = 3.6 V			2.0	7.0	
		I_{OUT} = 0, V_{IN} = V_{ON} = 2.5 V			1.0	5.0	
		I_{OUT} = 0, V_{IN} = V_{ON} = 1.5 V			0.8	5.0	
$I_{IN(off)}$	Off supply current	V_{ON} = GND, V_{OUT} = Open, V_{IN} = 5.25 V	Full		0.8	10	µA
		V_{ON} = GND, V_{OUT} = Open, V_{IN} = 4.2 V			0.3	7.0	
		V_{ON} = GND, V_{OUT} = Open, V_{IN} = 3.6 V			0.2	7.0	
		V_{ON} = GND, V_{OUT} = Open, V_{IN} = 2.5 V			0.2	5.0	
		V_{ON} = GND, V_{OUT} = Open, V_{IN} = 1.5 V			0.1	5.0	
$I_{IN(Leakage)}$	Leakage current	V_{ON} = GND, V_{OUT} = 0, V_{IN} = 5.25 V	Full		0.8	10	µA
		V_{ON} = GND, V_{OUT} = 0, V_{IN} = 4.2 V			0.3	7.0	
		V_{ON} = GND, V_{OUT} = 0, V_{IN} = 3.6 V			0.2	7.0	
		V_{ON} = GND, V_{OUT} = 0, V_{IN} = 2.5 V			0.2	5.0	
		V_{ON} = GND, V_{OUT} = 0, V_{IN} = 1.5 V			0.1	5.0	
r_{ON}	On-resistance	V_{IN} = 5.25 V, I_{OUT} = –200 mA	25°C		115	150	mΩ
			Full			175	
		V_{IN} = 5.0 V, I_{OUT} = –200 mA	25°C		115	150	
			Full			175	
		V_{IN} = 4.2 V, I_{OUT} = –200 mA	25°C		115	150	
			Full			175	
		V_{IN} = 3.3 V, I_{OUT} = –200 mA	25°C		115	150	
			Full			175	
		V_{IN} = 2.5 V, I_{OUT} = –200 mA	25°C		118	155	
			Full			180	
		V_{IN} = 1.5 V, I_{OUT} = –200 mA	25°C		129	170	
			Full			200	
RPD	Output pull down resistance	V_{IN} = 3.3 V, V_{ON} = 0, I_{OUT} = 30 mA	25°C		150	200	Ω
UVLO	Under voltage lockout	V_{IN} increasing, V_{ON} = 3.6 V, I_{OUT} = –100 mA	Full			1.4	V
		V_{IN} decreasing, V_{ON} 3.6 V, R_L = 10 Ω		0.50			
I_{ON}	ON input leakage current	V_{ON} = 1.4 V to 5.25 V or GND	Full			1	µA
V_{RVP}	Reverse Current Voltage Threshold				77		mV
t_{DELAY}	Reverse Current Response Delay	V_{IN} = 5V			10		µs

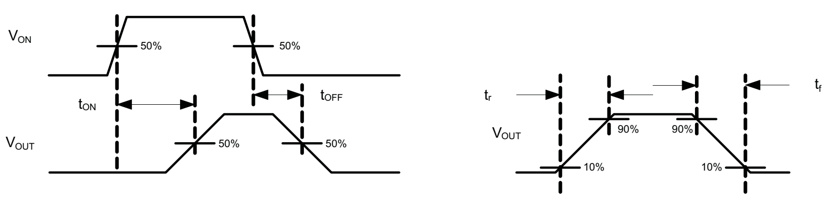
SWITCHING CHARACTERISTICS

PARAMETER		TEST CONDITION	TPS22929D TYP	UNIT
VIN = 5 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	3315	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	7.4	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	3660	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	6.1	
VIN = 3.3 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	4655	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	9.5	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	4150	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	3.0	
VIN = 1.5 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	10175	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	18.3	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	7812	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	3.0	

PARAMETRIC MEASUREMENT INFORMATION



TEST CIRCUIT



t_{ON}/t_{OFF} WAVEFORMS

A. Rise and fall times of the control signal is 100 ns.

Figure 1. Test Circuit and t_{ON}/t_{OFF} Waveforms

TYPICAL CHARACTERISTICS

ON-STATE RESISTANCE vs INPUT VOLTAGE

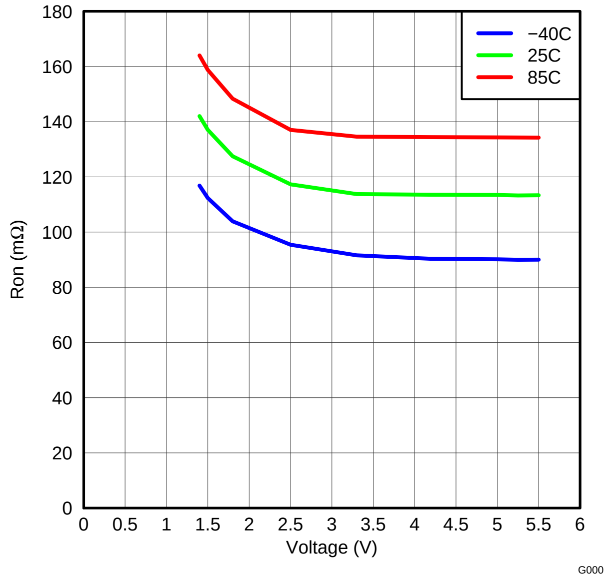


Figure 2.

ON INPUT THRESHOLD

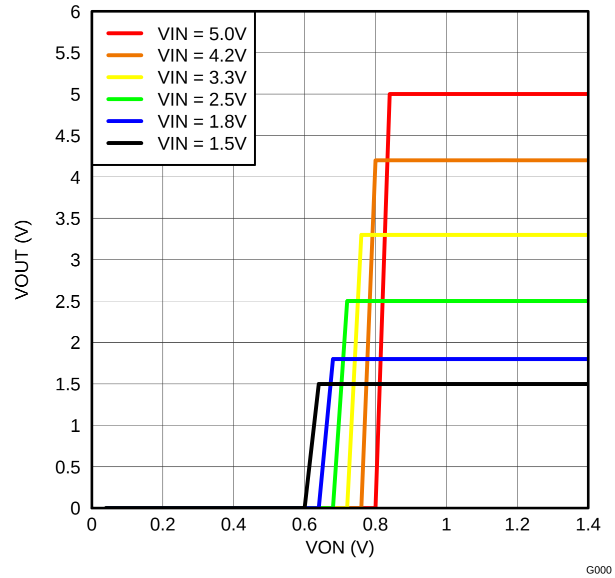


Figure 3.

INPUT CURRENT, QUIESCENT vs INPUT VOLTAGE

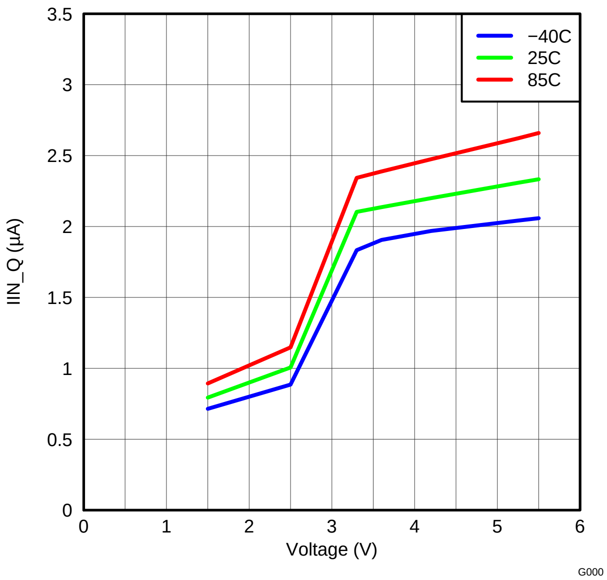


Figure 4.

INPUT CURRENT, LEAK vs INPUT VOLTAGE

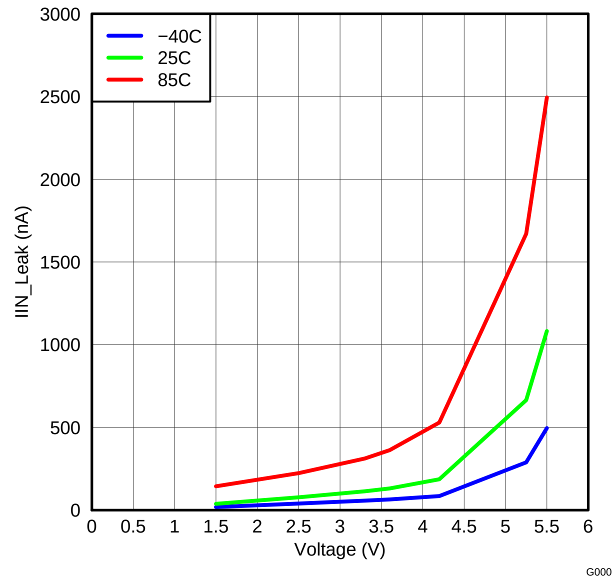


Figure 5.

TYPICAL CHARACTERISTICS (continued)

ON-STATE RESISTANCE vs TEMPERATURE

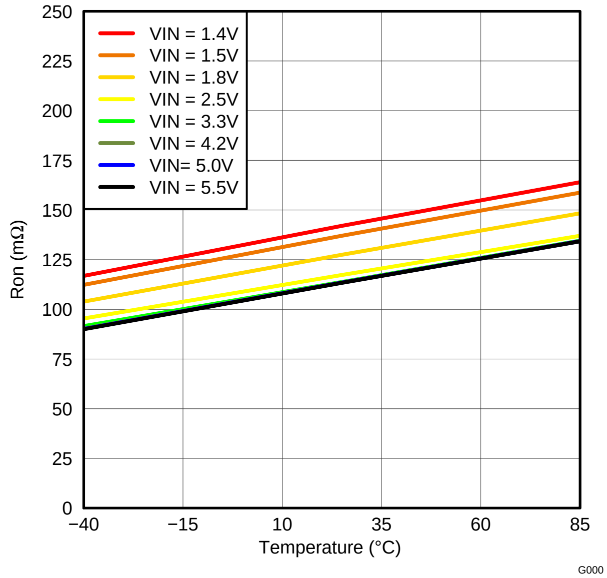


Figure 6.

INPUT CURRENT, OFF vs INPUT VOLTAGE

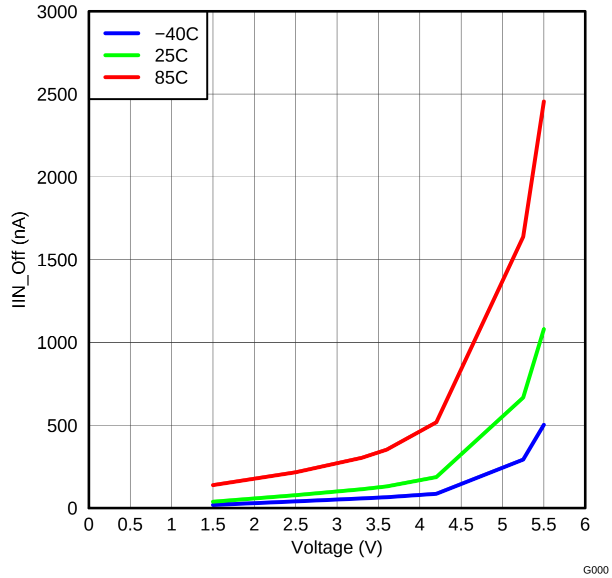


Figure 7.

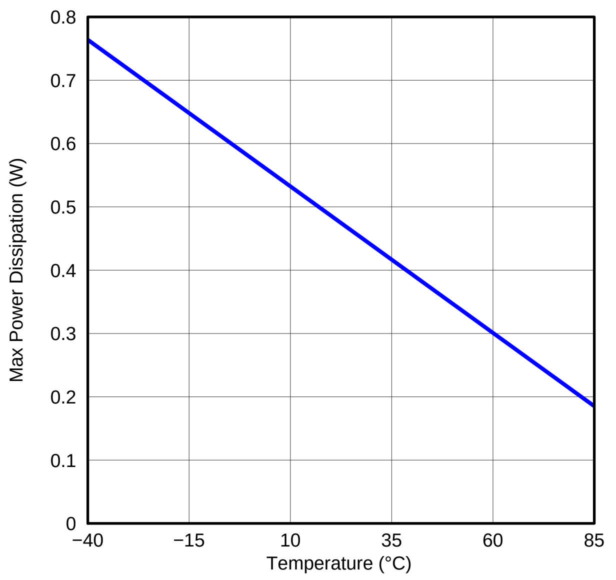


Figure 8. Allowable Power Dissipation

TYPICAL CHARACTERISTICS (continued)

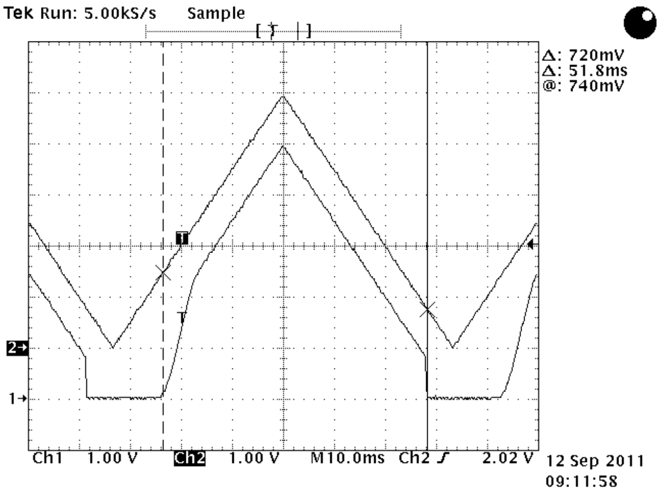


Figure 9. ULVO Response I_{OUT} = -100mA

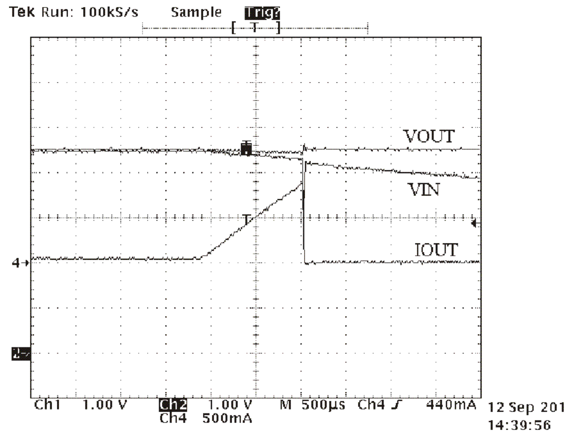


Figure 10. Reverse Current Protection V_{OUT} = 3.3V, V_{IN} = 3.3V Decreasing to 0V

TYPICAL AC CHARACTERISTICS FOR tps22929B

RISE TIME vs TEMPERATURE

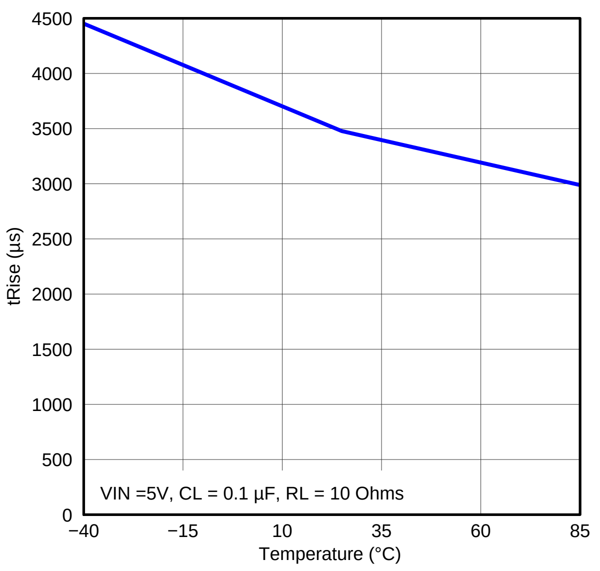


Figure 11.

FALL TIME vs TEMPERATURE

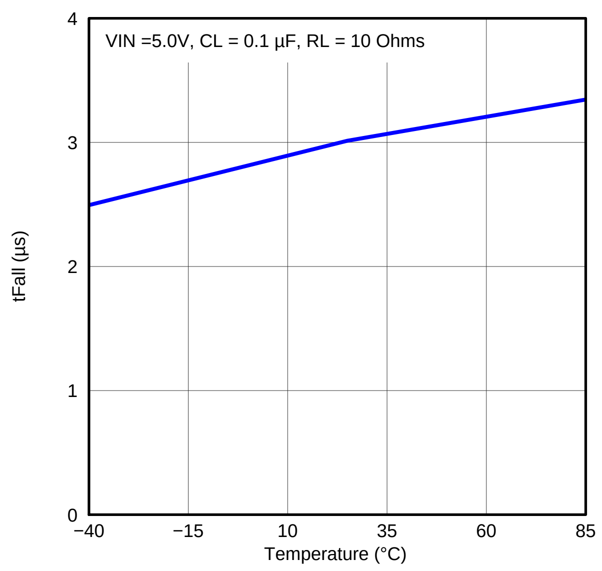


Figure 12.

TYPICAL CHARACTERISTICS (continued)

RISE TIME vs TEMPERATURE

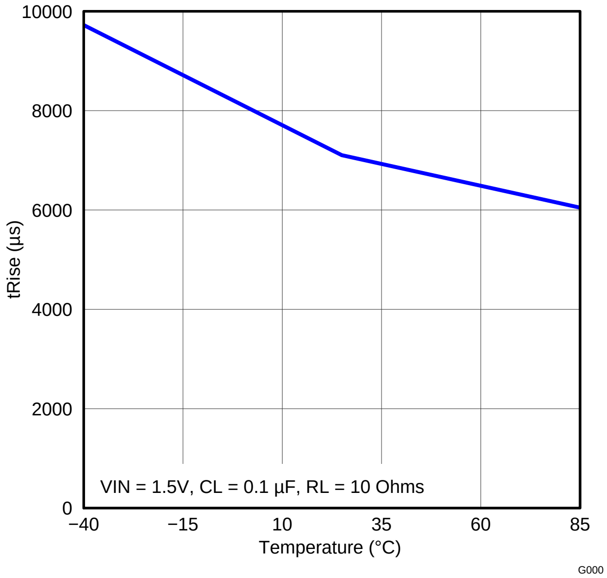


Figure 13.

FALL TIME vs TEMPERATURE

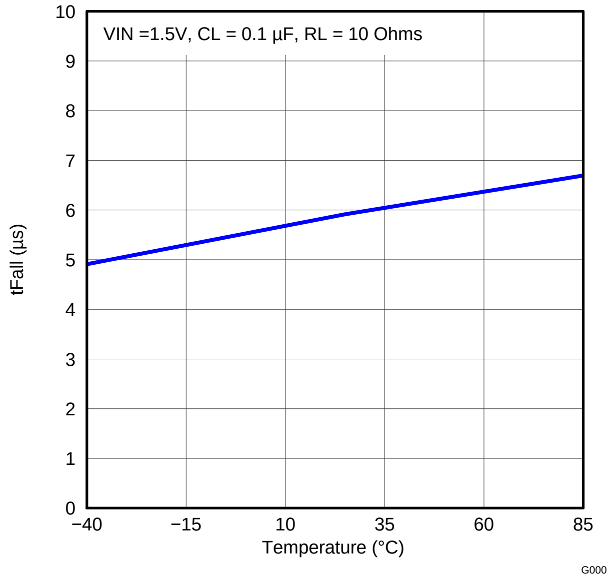


Figure 14.

TURN-ON TIME vs TEMPERATURE

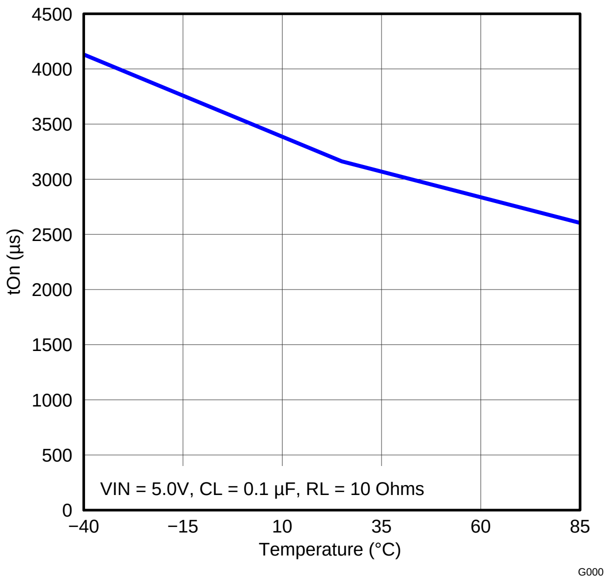


Figure 15.

TURN-OFF TIME vs TEMPERATURE

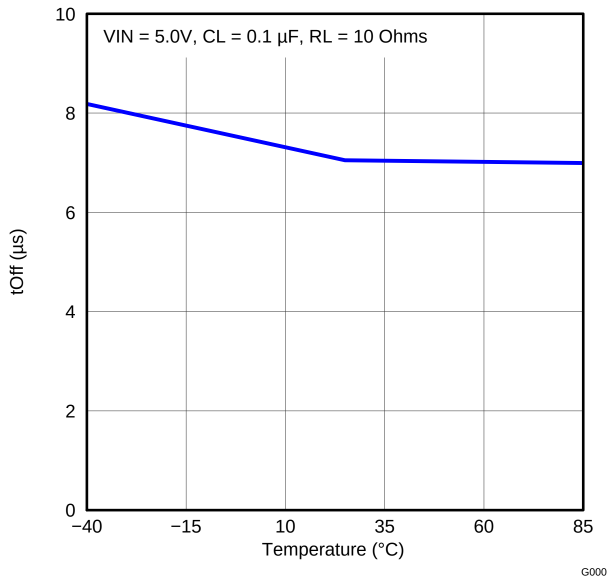


Figure 16.

TYPICAL CHARACTERISTICS (continued)

TURN-ON TIME vs TEMPERATURE

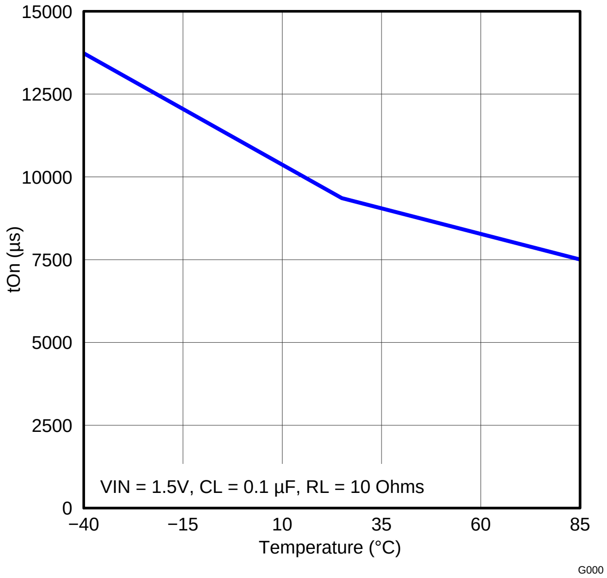


Figure 17.

TURN-OFF TIME vs TEMPERATURE

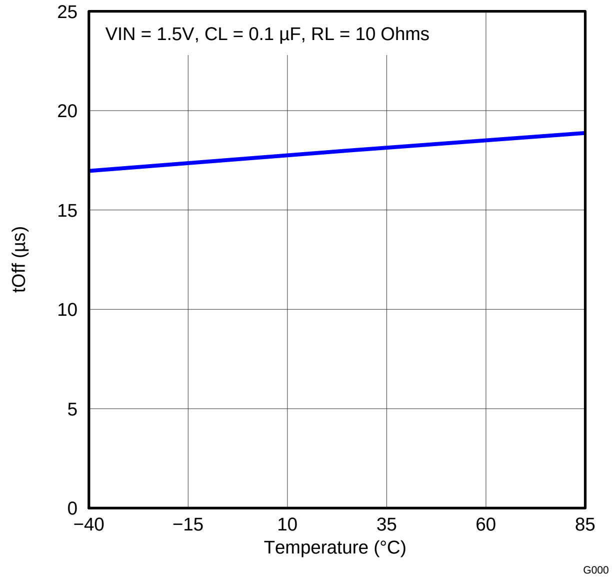


Figure 18.

RISE TIME vs INPUT VOLTAGE

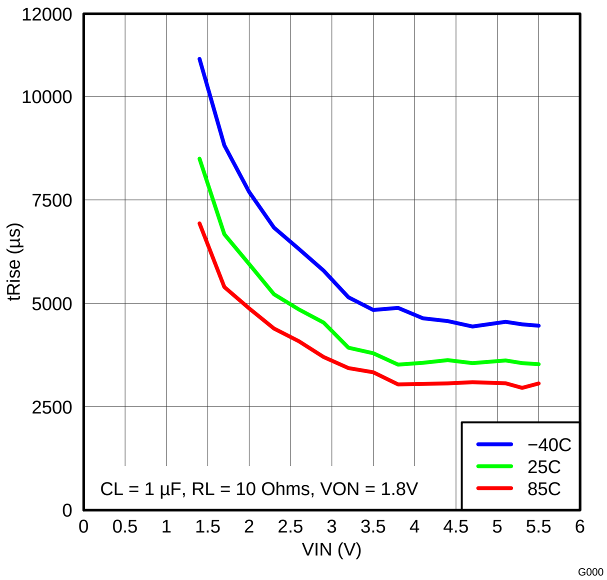


Figure 19.

RISE TIME vs INPUT VOLTAGE

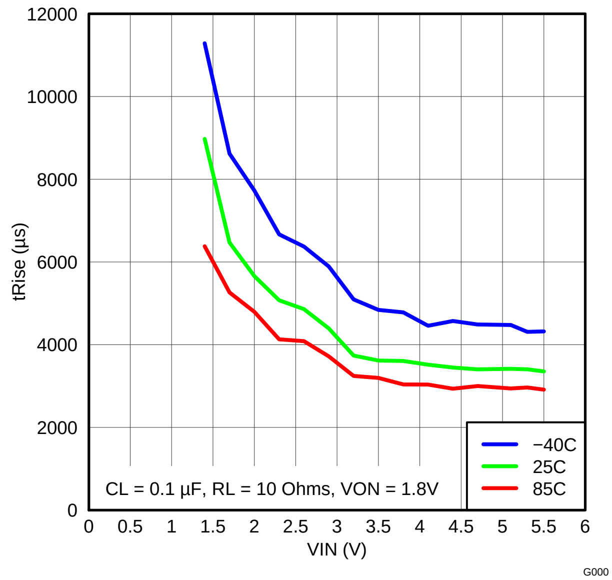


Figure 20.

TYPICAL CHARACTERISTICS (continued)

TURN-ON RESPONSE
V_{IN} = 5V, T_A = 25°C, C_{IN} = 10μF, C_L = 1μF, R_L = 10Ω

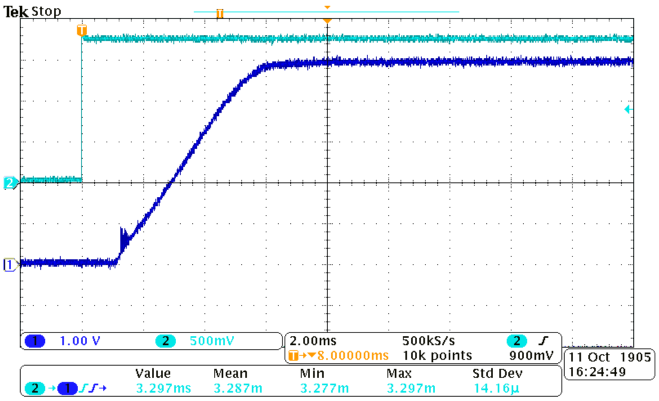


Figure 21.

TURN-OFF RESPONSE
V_{IN} = 5V, T_A = 25°C, C_{IN} = 10μF, C_L = 1μF, R_L = 10Ω

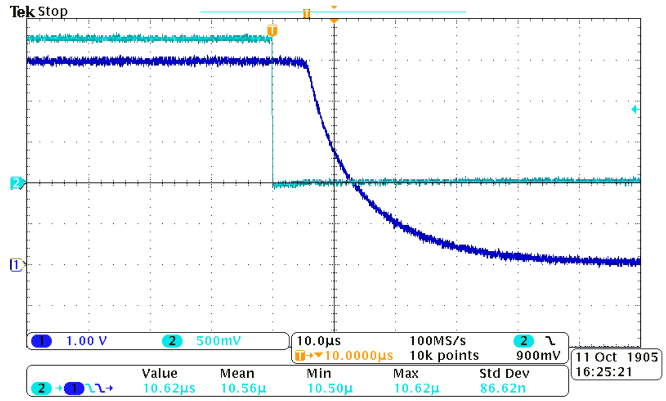


Figure 22.

TURN-ON RESPONSE TIME
V_{IN} = 5V, T_A = 25°C, C_{IN} =1μF, C_L = 0.1μF, R_L = 10Ω

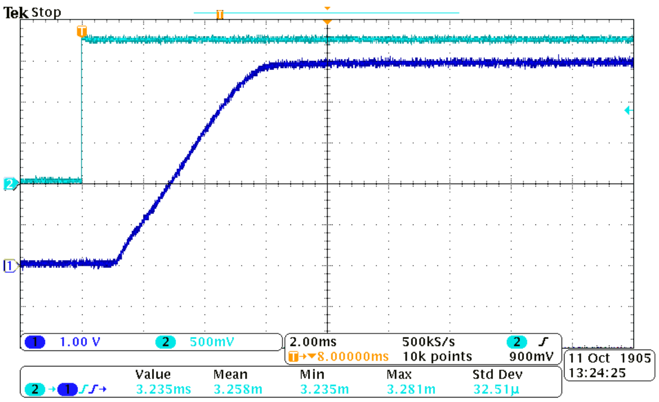


Figure 23.

TURN-OFF RESPONSE TIME
V_{IN} = 5V, T_A = 25°C, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω

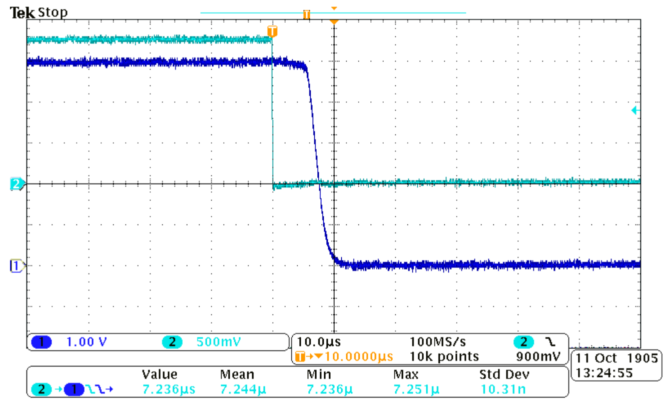


Figure 24.

TURN-ON RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 10μF, C_L = 1μF, R_L = 10Ω

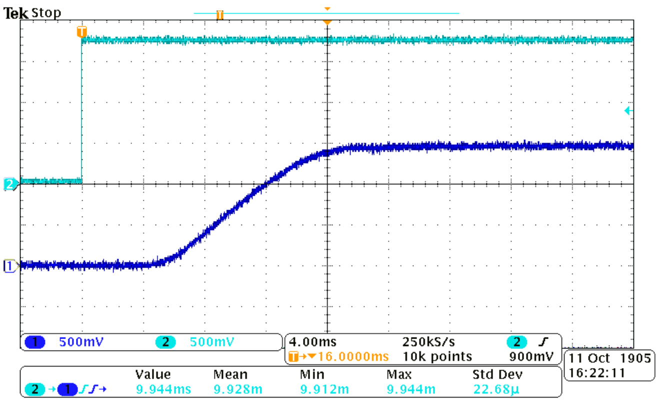


Figure 25.

TURN-OFF RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 10μF, C_L = 1μF, R_L = 10Ω

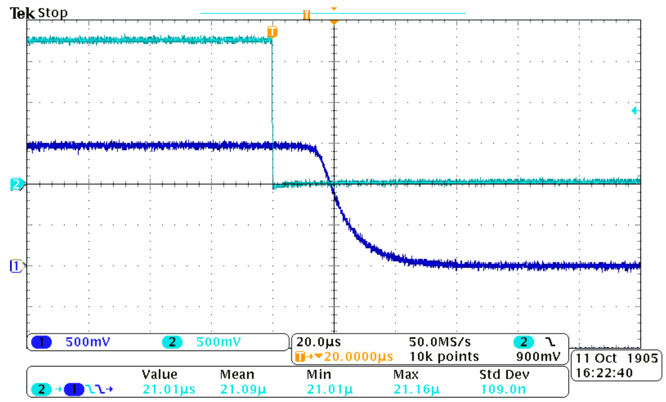


Figure 26.

TYPICAL CHARACTERISTICS (continued)

TURN-ON RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω

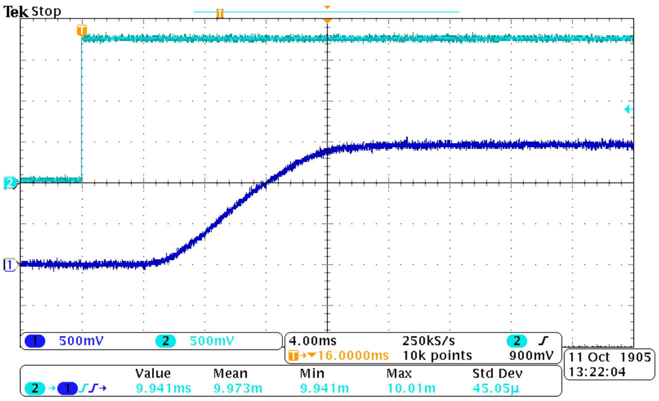


Figure 27.

TURN-OFF RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω

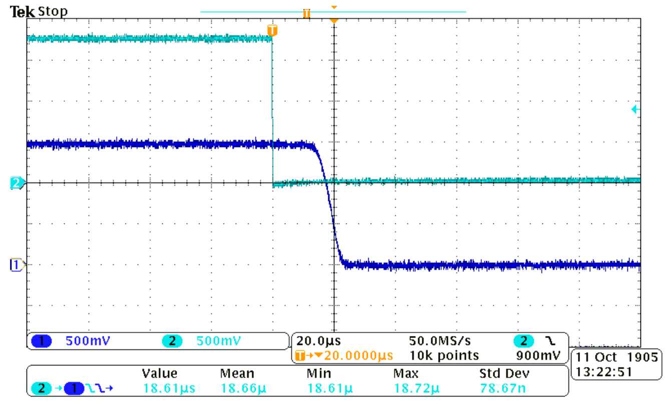


Figure 28.

APPLICATION INFORMATION

On/Off Control

The ON pin controls the state of the switch. Asserting ON high enables the switch. ON is active high and has a low threshold, making it capable of interfacing with low-voltage signals. The ON pin is compatible with standard GPIO logic threshold. It can be used with any microcontroller with 1.2-V, 1.8-V, 2.5-V or 3.3-V GPIOs.

Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush currents, when the switch turns on into a discharged load capacitor or short-circuit, a capacitor needs to be placed between VIN and GND. A 1-μF ceramic capacitor, CIN, placed close to the pins is usually sufficient. Higher values of CIN can be used to further reduce the voltage drop.

Output Capacitor

A C_{IN} to C_L ratio of 10 to 1 is recommended for minimizing V_{IN} dip caused by inrush currents during startup.

Output Pull-Down

The output pulldown is active when the user is turning off the main pass FET. The pulldown discharges the output rail to approximately 10% of the rail, and then the output pulldown is automatically disconnected to optimize the shutdown current.

Under-Voltage Lockout

The under-voltage lockout turns-off the switch if the input voltage drops below the under-voltage lockout threshold. During under-voltage lockout (UVLO), if the voltage level at V_{OUT} exceeds the voltage level at V_{IN} by the Reverse Current Voltage Threshold (V_{RVP}), the body diode will be disengaged to prevent any current flow to V_{IN}. With the ON pin active the input voltage rising above the under-voltage lockout threshold will cause a controlled turn-on of the switch which limits current over-shoots.

Reverse Current Protection

In a scenario where V_{OUT} is greater than V_{IN}, there is potential for reverse current through the pass FET or the body diode. The TPS22929 monitors V_{IN} and V_{OUT} voltage levels. When the reverse current voltage threshold (V_{RVP}) is exceeded, the switch is disabled (within 10μs typ). Additionally, the body diode is disengaged so as to prevent any reverse current flow to V_{IN}. The FET, and the output (V_{OUT}), will resume normal operation when the reverse current scenario is no longer present.

Use the following formula to calculate the amount of reverse current for a particular application:

$$I_{RC} = \frac{0.077V}{R_{ON(VIN)}}$$

Where,

I_{RC} is the amount of reverse current,

$R_{ON(VIN)}$ is the on-resistance at the VIN of the reverse current condition.

Board Layout

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for V_{IN}, V_{OUT}, and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

Thermal Considerations

For best device performance, be sure to follow the thermal guidelines in the Thermal Information table on page 4. To calculate max allowable continuous current for your application for a specific V_{IN} and ambient temperature, use the following formula:

$$I_{MAX} = \sqrt{\frac{\frac{T_J - T_A}{\theta_{JA}}}{R_{ON}}}$$

Where:

I_{MAX}= Max allowable continuous current
T_J= Max thermal junction temperature (125°C)
T_A= Ambient temperature of the application
θ_{JA}= Junction-to-air thermal impedance (216°C/W)
R_{ON}= R_{ON} at a specified input voltage VIN (see Electrical Characteristics table on page 5)

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
TPS22929DDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPS22929DDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

(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) 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.

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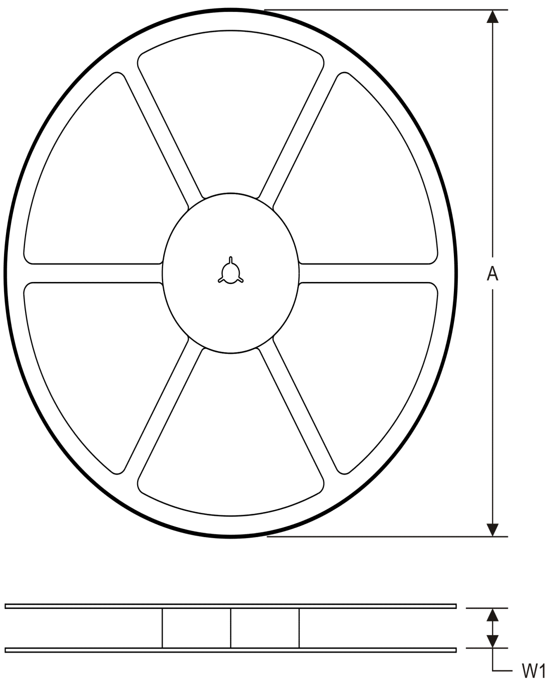
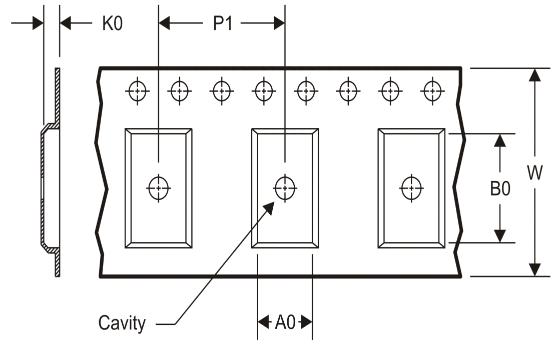
TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



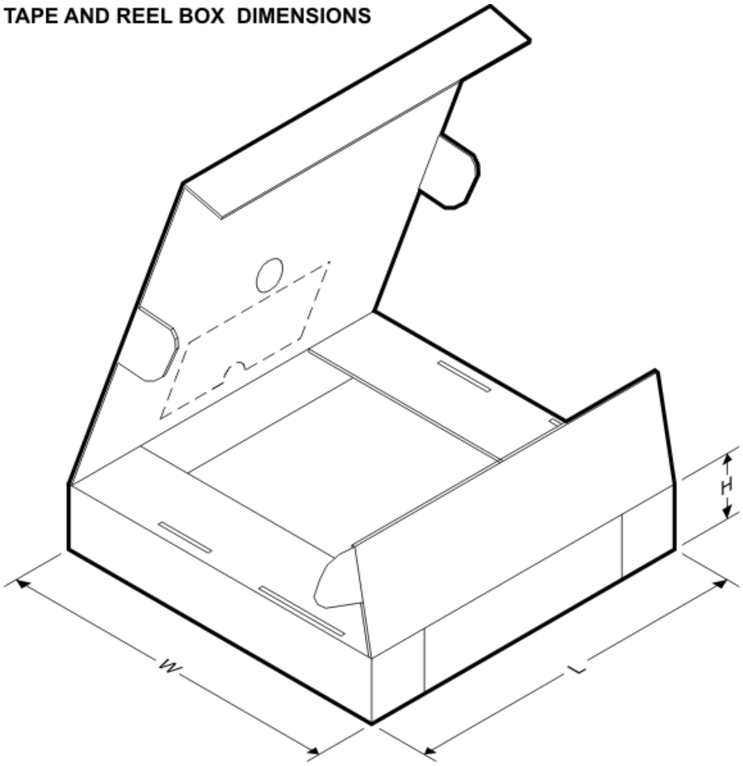
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
TPS22929DDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TPS22929DDBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3

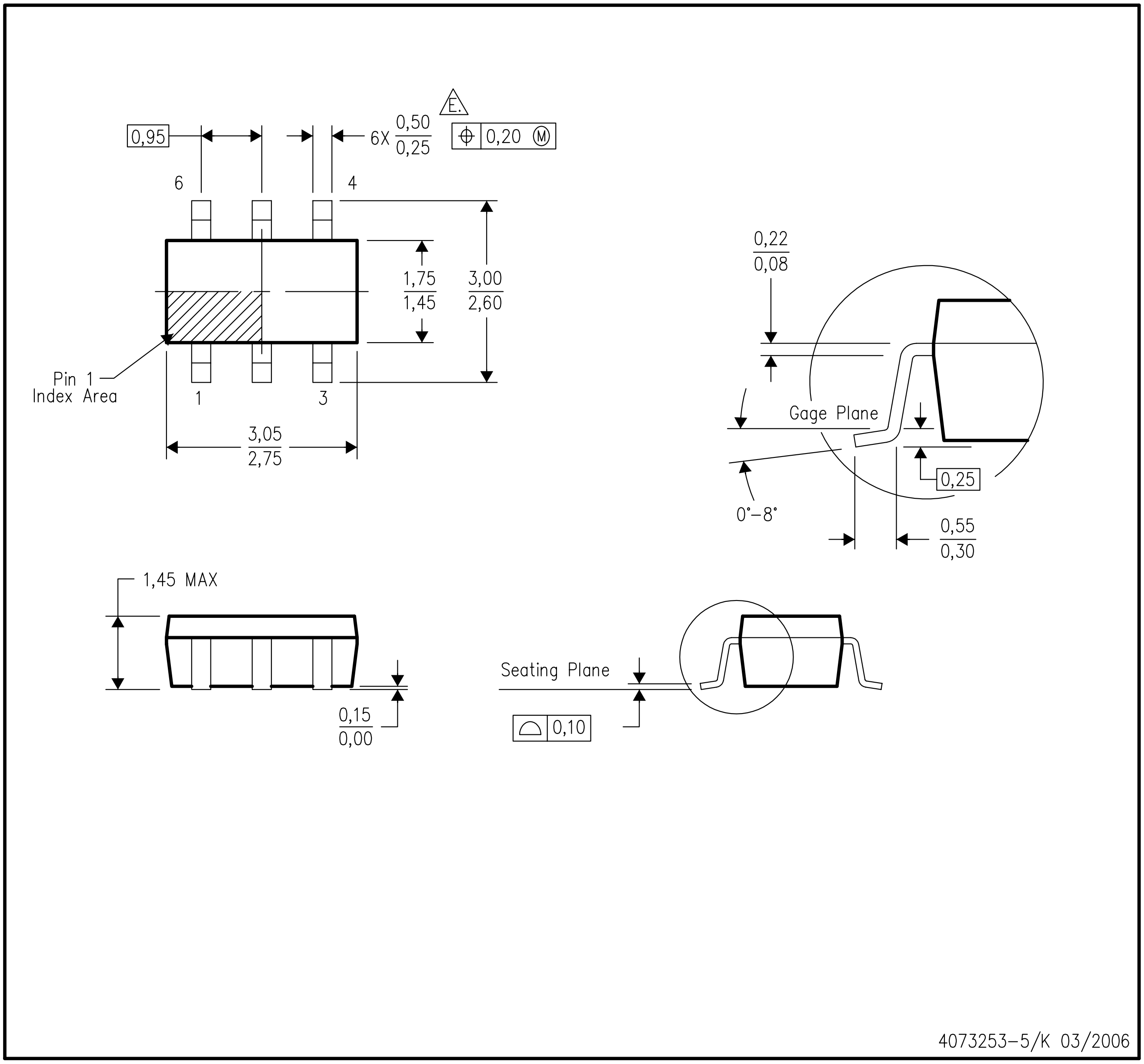
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

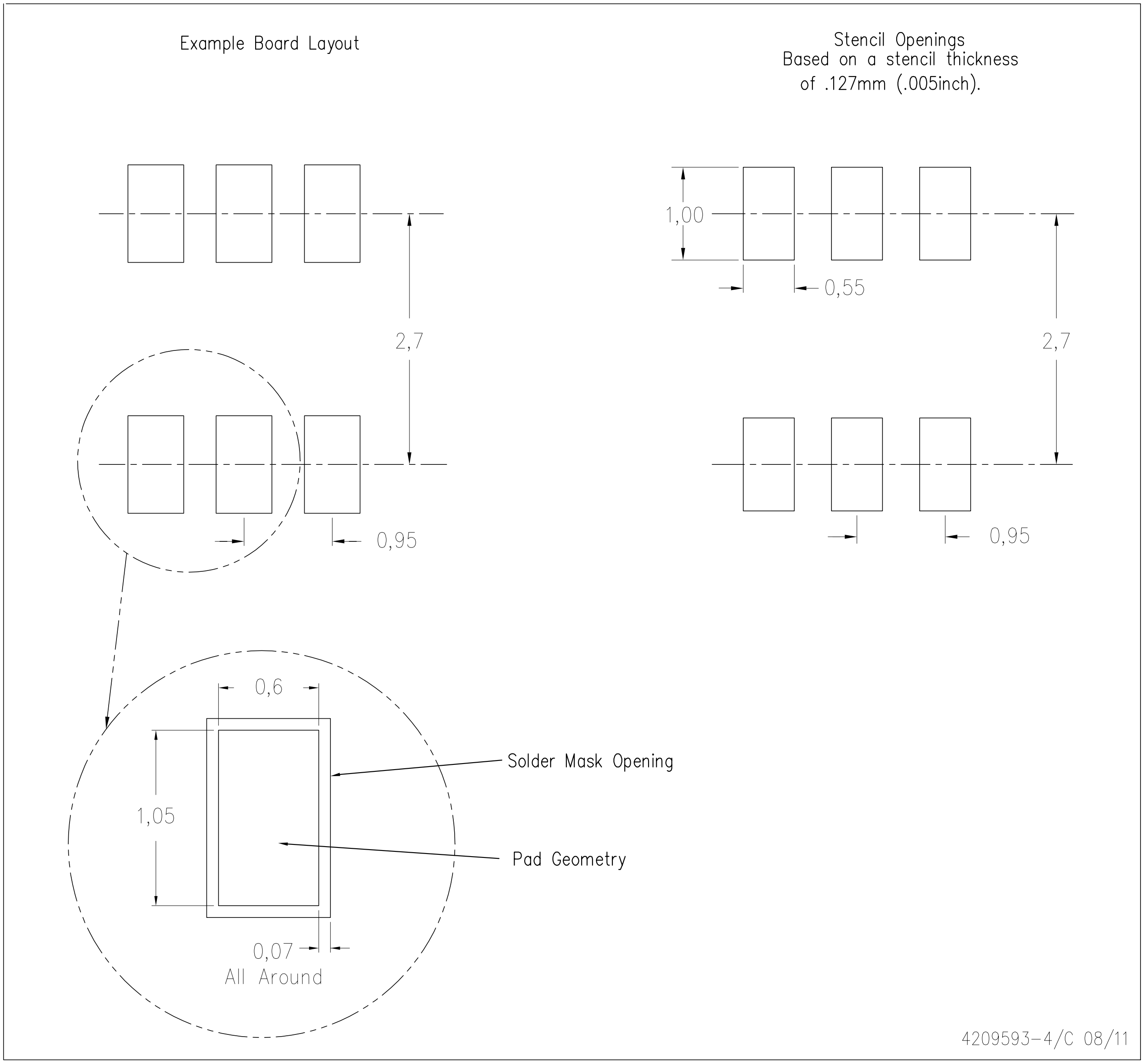
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22929DDBVR	SOT-23	DBV	6	3000	180.0	180.0	18.0
TPS22929DDBVT	SOT-23	DBV	6	250	180.0	180.0	18.0

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



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- E. Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
- D. Publication IPC-7351 is recommended for alternate designs.
- E. 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.

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