TPS22946 Ultralow Power, Low Input Voltage, Current-Limited Load Switch With Shutoff, Auto-Restart, and Overcurrent Condition Time-Out

1 Features

- Ultralow Quiescent Current 1 µA (Typical) at V_{IN} = 1.8 V
- Input Voltage Range: 1.62 V to 5.5 V
- Low ON-Resistance
  - r_{ON} = 300 mΩ at V_{IN} = 5.5 V
  - r_{ON} = 400 mΩ at V_{IN} = 3.3 V
  - r_{ON} = 500 mΩ at V_{IN} = 2.5 V
  - r_{ON} = 600 mΩ at V_{IN} = 1.8 V
- Selectable Minimum Current Limit: 155 mA, 70 mA, or 30 mA
- Integrated Inrush Current Time-out (8 ms)
- Shutdown Current: < 1 µA
- Thermal Shutdown
- Fault Blanking
- Auto Restart
- Overcurrent Condition Time-out (Automatic Disable for Permanent Overcurrent)
- 1.8-V Compatible Control Input
- ESD Performance Tested Per JESD 22
  - 6000-V Human-Body Model (A114-B, Class II)
- Tiny DSGBA Package 1.4 mm × 0.9 mm (YZP)

2 Applications

- Fingerprint Module Protection
- Portable Consumer Electronics
- Mobile Phones
- Smartphones
- Notebooks
- GPS Devices

3 Description

The TPS22946 is an ultralow power load switch that provides protection to systems and loads in high-current conditions. The device contains a 300-mΩ current-limited P-channel MOSFET that can operate over an input voltage range of 1.62 V to 5.5 V. The switch is controlled by an on/off input (ON), which can interface directly with low-voltage control signals. The TPS22946 includes thermal shutdown protection that prevents damage to the device when a continuous over-current condition causes excessive heating by turning off the switch.

When the switch current reaches the maximum limit, the TPS22946 operates in a constant-current mode to prohibit excessive currents from causing damage. The current limit can be selected using the CL input: a high CL input sets the current limit to 155 mA, a low CL input sets the current limit to 70 mA, and a floating CL input sets the current limit to 30 mA.

If the constant current condition persists after 10 ms, the switch is turned off and the fault signal pin (OC) is pulled low. The TPS22946 has an auto-restart feature which turns the switch on again after 70 ms if the ON pin is still active. If the TPS22946 remains in an over-current condition for 5 seconds, the device shuts off until it is turned on again by setting the ON control signal off and then on.

If the device is used to protect an LDO, the inrush current required by the LDO at startup can, in some cases, exceed the current limit and initiate a blanking (current limiting) condition. The TPS22946 provides allowance for this scenario during startup of the LDO by temporarily increasing the current limit to 435 mA for 8 ms after the load switch is enabled.

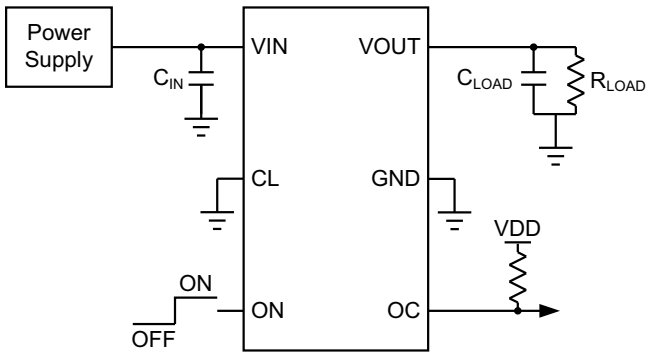
The TPS22946 is available in space-saving 6-pin DSBGA (YZP) package. The device is characterized for operation over the free-air temperature range of –40°C to 85°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS22946	DSBGA (6)	0.90 mm × 1.40 mm

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

Typical Application Schematic



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

Changes from Revision A (February 2010) to Revision B **Page**

- Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1

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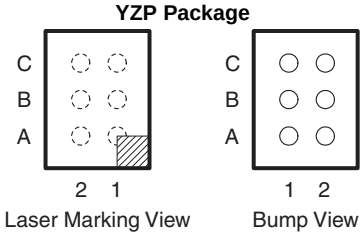
5 Pin Configuration and Functions

6-Pin DSBGA
YZP Package



Pin Assignments

C	ON	OC
B	CL	GND
A	V_{IN}	V_{OUT}
	2	**1**

Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
A1	V_{OUT}	O	Output of the power switch
A2	V_{IN}	I	Supply. Input to the power switch and the supply voltage for the device
B1	GND	–	Ground
B2	CL	I	Current limit selection. CL high is 155-mA current limit, CL low is 70-mA current limit, and CL floating is 30-mA current limit.
C1	OC	O	Overcurrent output flag. Active-low open-drain output that indicates an overcurrent, supply undervoltage, or overtemperature state.
C2	ON	I	On/off control input

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6 Specifications

6.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_I	Input voltage	V_{IN}, V_{OUT}, ON, CL	–0.3	6	V
T_J	Operating junction temperature		–40	125	°C
T_{stg}	Storage temperature		–65	150	°C

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per JEDEC specification JESD22 (A114-B, Class II)(1)	±6000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±2000	

(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.

6.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V_{IN}	Input voltage		1.62	5.5	V
V_{ON}	ON pin voltage		0	5.5	V
V_{CL}	CL pin voltage		0	V_{IN}	V
V_{OUT}	OUT pin voltage		0	V_{IN}	V
T_A	Ambient free-air temperature		–40	85	°C
t_{CLSET}	CL pin setting time		8		ms
C_{IN}	Input capacitor		1(1)		µF
V_{IH}	ON high-level input voltage	V_{IN} = 1.8 V	1.1	5.5	V
		V_{IN} = 2.5 V	1.2	5.5	
		V_{IN} = 3.3 V	1.3	5.5	
		V_{IN} = 5.5 V	1.4	5.5	
V_{IL}	ON low-level input voltage	V_{IN} = 1.8 V		0.4	V
		V_{IN} = 2.5 V		0.4	
		V_{IN} = 3.3 V		0.5	
		V_{IN} = 5.5 V		0.6	
V_{IH}	CL low-level input voltage	V_{IN} = 1.62 V to 5.5 V, I_{IH} = 55 µA	0.7 V_{IN}	V_{IN}	V
V_{IL}	CL high-level input voltage	V_{IN} = 1.62 V to 5.5 V, I_{IL} = 55 µA	GND	0.3 V_{IN}	V

(1) See *Application Information*.

6.4 Thermal Information

THERMAL METRIC(1)		TPS22946 YZP (DSBGA) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	131	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	1.3	
$R_{\theta JB}$	Junction-to-board thermal resistance	22.6	
ψ_{JT}	Junction-to-top characterization parameter	5.2	
ψ_{JB}	Junction-to-board characterization parameter	22.6	

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

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6.5 Electrical Characteristics

V_{IN} = 1.62 V to 5.5 V, TYP values at T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	MIN	TYP	MAX	UNIT
I_{IN}	Average quiescent current	I_{OUT} = 0 mA, V_{IN} = 4.5 V to 5.5 V		Full range		1.5	5	µA
		I_{OUT} = 0 mA, V_{IN} = 3.0 V to 3.6 V				1.3	4	
		I_{OUT} = 0 mA, V_{IN} = 1.62 V to 1.98 V				1	3	
$I_{IN(OFF)}$	OFF state supply current	V_{ON} = 0 V	V_{IN} = 3.6 V, V_{OUT} open	Full range		0.1	1	µA
$I_{OUT(LEAKAGE)}$	OFF state switch current	V_{ON} = 0 V	V_{IN} = 3.6 V, V_{OUT} short to GND	Full range		0.1	1.1	µA
r_{ON}	ON-state resistance	I_{OUT} = –100 mA	V_{IN} = 5.5 V	25°C		0.3	0.4	Ω
				Full range			0.45	
			V_{IN} = 3.3 V	25°C		0.4	0.5	
				Full range			0.55	
			V_{IN} = 2.5 V	25°C		0.5	0.6	
				Full range			0.65	
			V_{IN} = 1.8 V	25°C		0.6	0.8	
				Full range			0.85	
			V_{IN} = 1.62 V	25°C		0.7	0.9	
				Full range			1	
I_{ON}	ON input leakage current	V_{ON} = V_{IN} or GND		Full range			1	µA
I_{LIM}	Current limit	V_{IN} = 1.8 V, V_{OUT} = 1.5 V, CL = GND		Full range	70	85	120	mA
		V_{IN} = 3.3 V, V_{OUT} = 3.0 V, CL = GND		Full range	60	80	115	
		V_{IN} = 1.8 V, V_{OUT} = 1.5 V, CL = VIN		Full range	155	175	235	
		V_{IN} = 3.3 V, V_{OUT} = 3.0 V, CL = VIN		Full range	135	165	230	
		V_{IN} = 1.8 V, V_{OUT} = 1.5 V, CL floating		Full range	30	45	60	
		V_{IN} = 3.3 V, V_{OUT} = 3.0 V, CL floating		Full range	28	40	60	
I_{limit_inrush}	Inrush current limit	R_l = 1 Ω, V_{IN} = 3.3 V, V_{OUT} = 2.3 V		Full range	375	435	685	mA
	Thermal shutdown (2)	Shutdown threshold		Full range		135		°C
		Return from shutdown				125		
		Hysteresis				10		
V_{OL}	OC output logic low voltage	V_{IN} = 5 V, I_{SINK} = 10 mA		Full range		0.1	0.2	V
		V_{IN} = 1.8 V, I_{SINK} = 10 mA				0.1	0.3	
I_{OH}	OC output high leakage current	V_{IN} = 5 V, Switch ON		Full range			1	µA

(1) Full range T_A = –40°C to 85°C
(2) See *Overtemperature Protection*.

6.6 Switching Characteristics

V_{IN} = 1.8 V, R_L = 50 Ω, CL = 1 µF, T_A = –40°C to 85°C, TYP values at T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PWRON}	Power-on time	R_L = 50 Ω, C_L = 1 µF		192		µs
t_{PWROFF}	Power-off time	R_L = 50 Ω, C_L = 1 µF		0.55		µs
t_{ON}	Turnon time	R_L = 50 Ω, C_L = 1 µF		125		µs
t_{OFF}	Turnoff time	R_L = 50 Ω, C_L = 1 µF		115		µs
t_R	V_{OUT} rise time	R_L = 50 Ω, C_L = 1 µF		35		µs
t_F	V_{OUT} fall time	R_L = 50 Ω, C_L = 1 µF		120		µs
t_{BLANK}	Overcurrent blanking time		7	10	15	ms
t_{RSTART}	Auto-restart time		50	70	95	ms
$t_{TIMEOUT}$	Overcurrent detection time-out(1)	V_{IN} = V_{ON} = 3.3 V, hard short(2)		6000		ms
t_{OVRTMP}	Overtemperature detection maximum response time			7.7		ms
t_{MODOC}	Moderate overcurrent detection maximum response time	V_{IN} = V_{ON} = 1.8 V, Moderate over-current condition(3)		63.5		ms
		V_{IN} = V_{ON} = 3.3 V, Moderate overcurrent condition(3)		65.5		
$t_{HARDSHORT}$	Hard-short detection maximum response time	V_{IN} = V_{ON} = 1.8 V, hard short(2)		270		µs
		V_{IN} = V_{ON} = 3.3 V, hard short(2)		295		

(1) See *Automatic Disable in Case of Permanent Overcurrent*.
(2) Hard short check is performed at the output voltage of the switch. Hard short condition is active when V_{OUT} < 2/3 V_{IN}.
(3) If the current going through the switch is above I_{LIM}, then the moderate over-current condition is activated

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6.7 Typical Characteristics

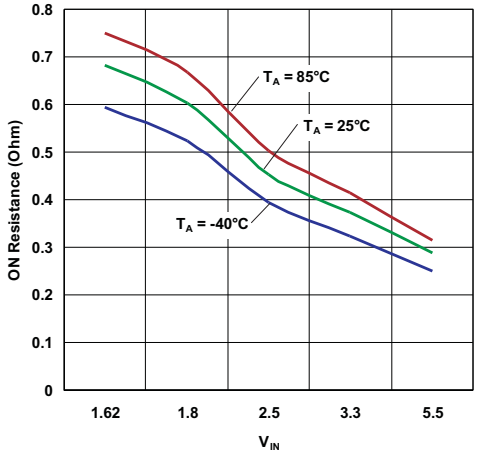

Figure 1. ON-Resistance vs Input Voltage

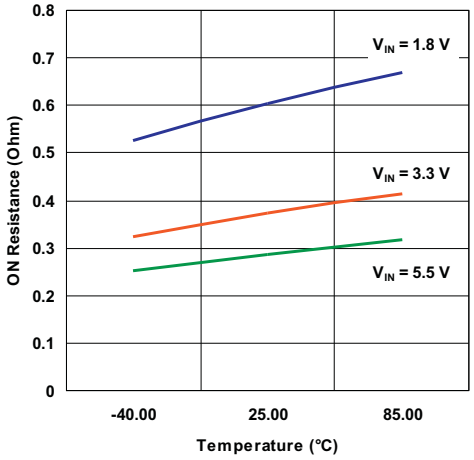

Figure 2. ON-Resistance Vs Temperature

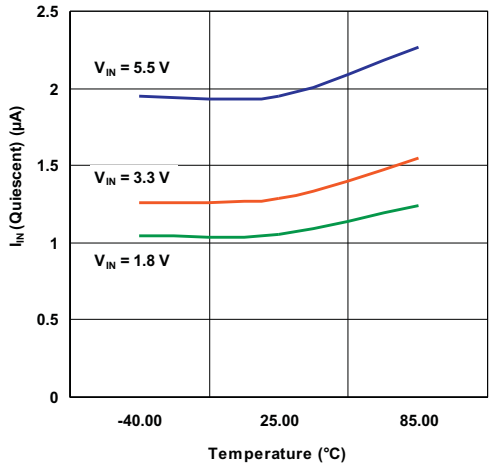

Figure 3. Input Current (Quiescent) vs Temperature

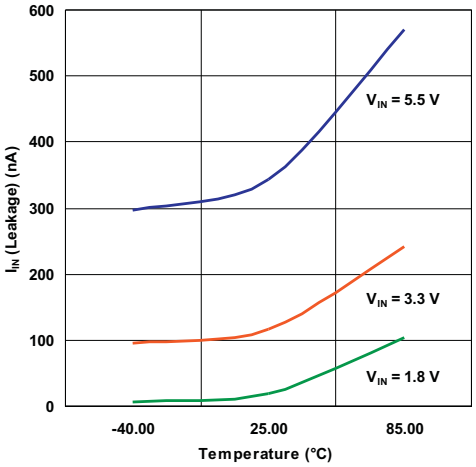

Figure 4. Input Current (Leakage) vs Temperature

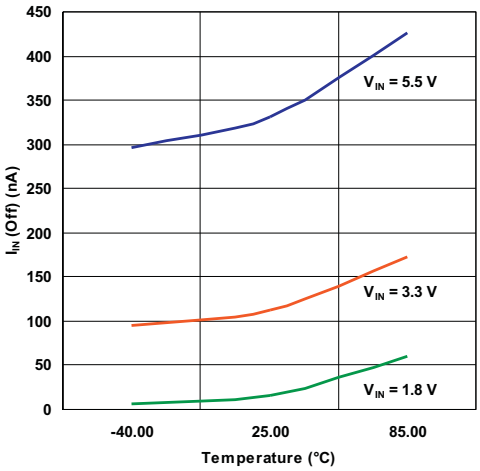

Figure 5. Input Current (Off) vs Temperature

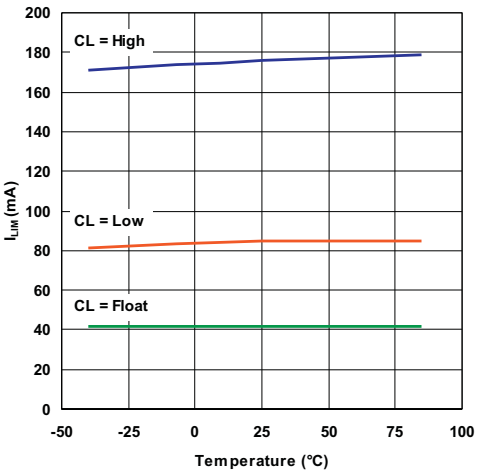

Figure 6. Current Limit vs Temperature

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Typical Characteristics (continued)

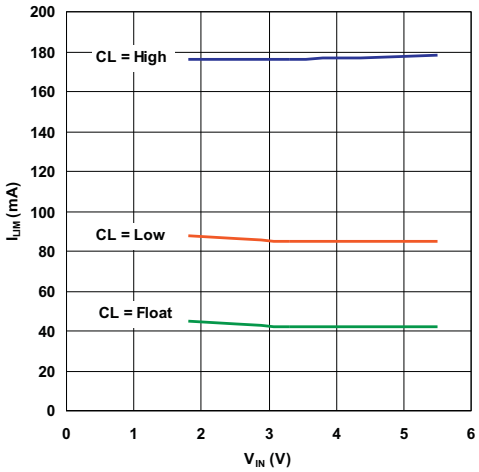

Figure 7. Current Limit vs Input Voltage

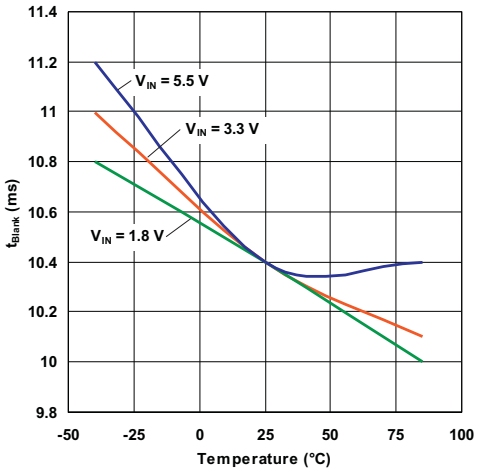

Figure 8. t_{Blank} vs Temperature

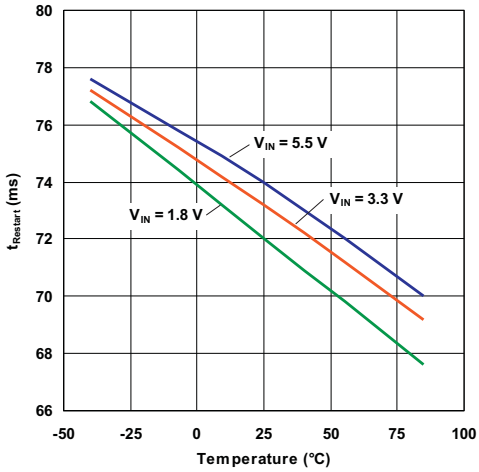

Figure 9. t_{Reset} vs Temperature

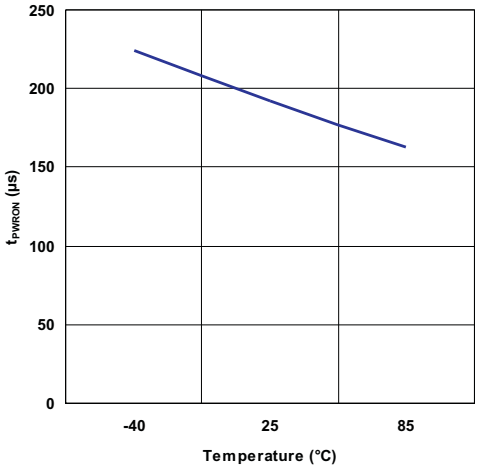

Figure 10. t_{PWRON} vs Temperature

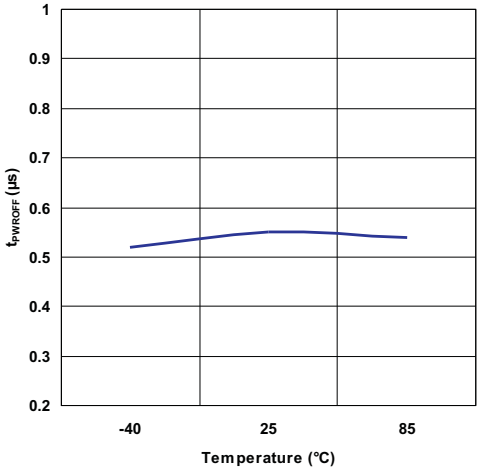

Figure 11. t_{PWROFF} vs Temperature

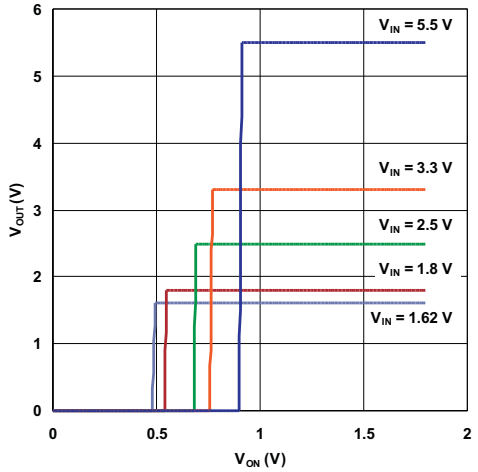

Figure 12. ON Threshold

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Typical Characteristics (continued)

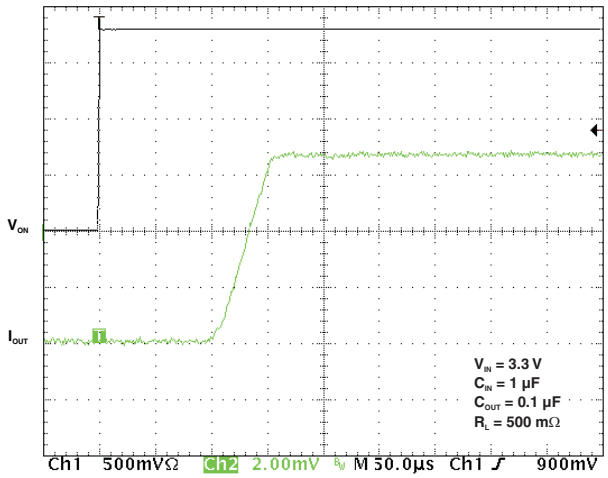


Figure 13. t_{ON} Response

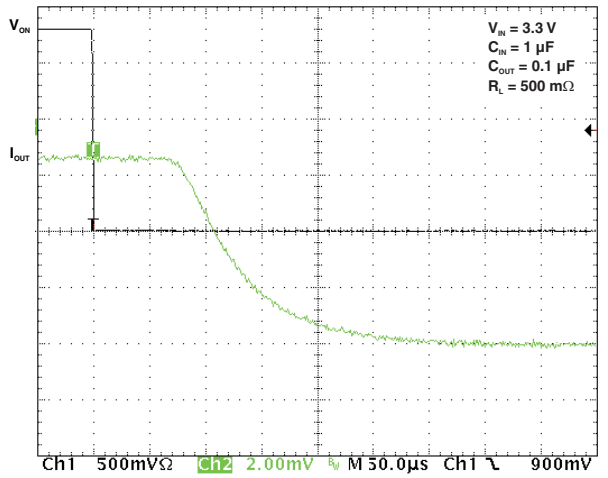
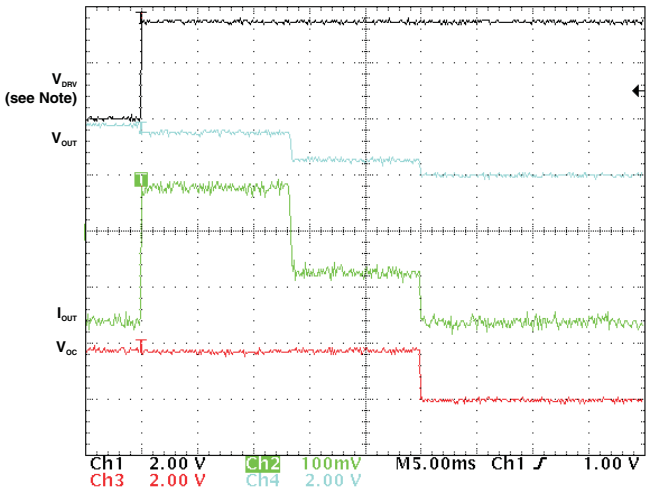
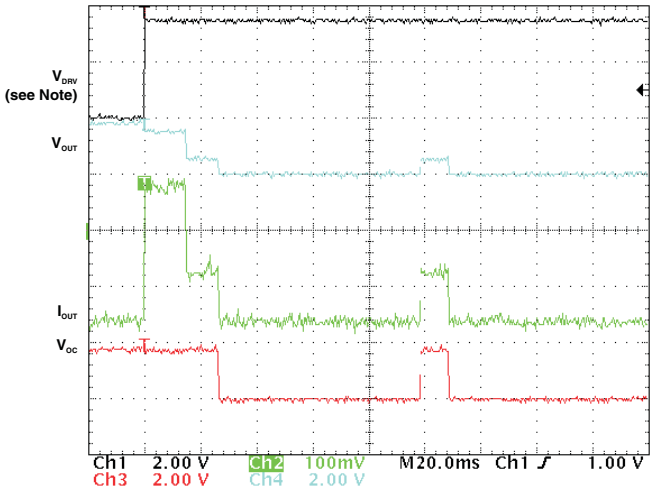


Figure 14. t_{OFF} Response



NOTE: V_{DRV} signal forces the device to go into over-current mode.

Figure 15. t_{Blank} Response



NOTE: V_{DRV} signal forces the device to go into over-current mode.

Figure 16. $t_{Restart}$ Response

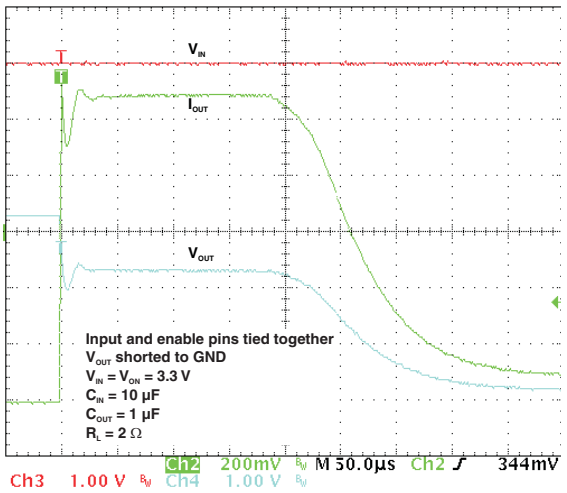


Figure 17. Hard Short-Circuit Response

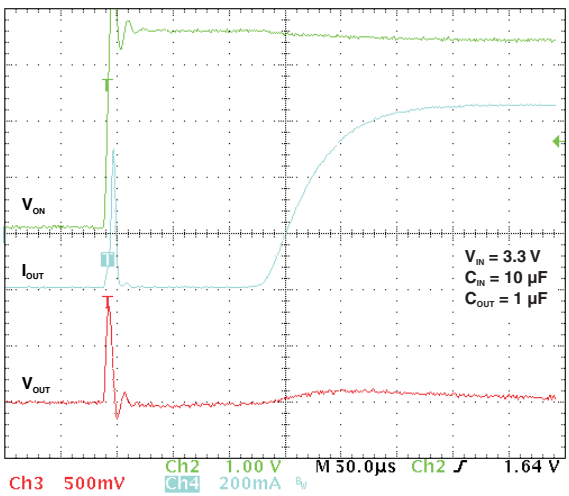


Figure 18. Short-Circuit Response

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Typical Characteristics (continued)

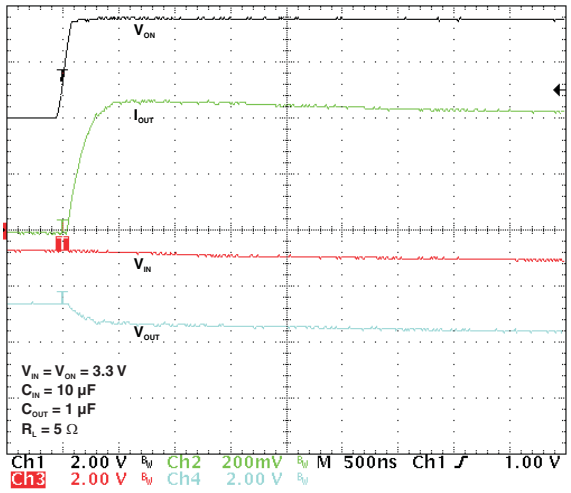

Figure 19. Moderate Overcurrent Response

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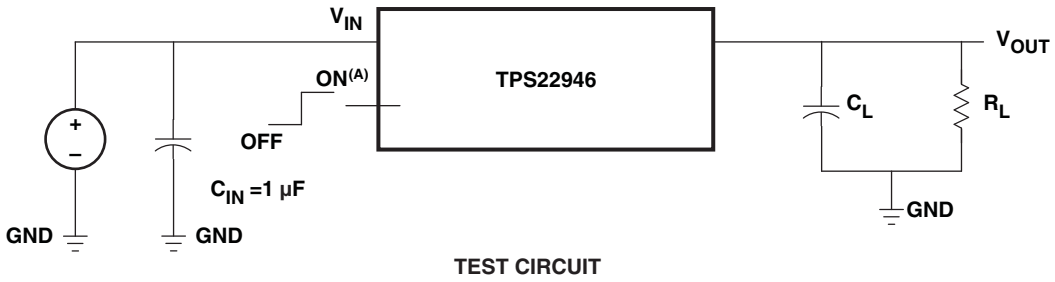
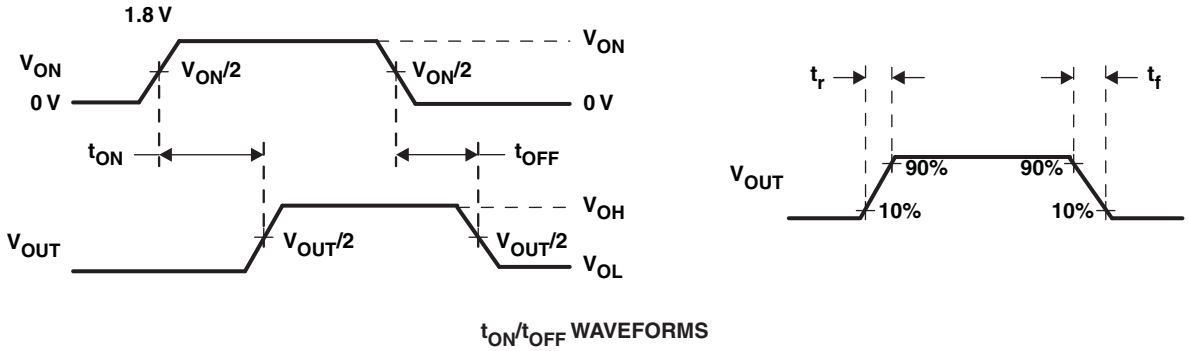
7 Parameter Measurement Information



TEST CIRCUIT



t_{ON}/t_{OFF} WAVEFORMS

Figure 20. Test Circuit and t_{ON}/t_{OFF} Waveforms

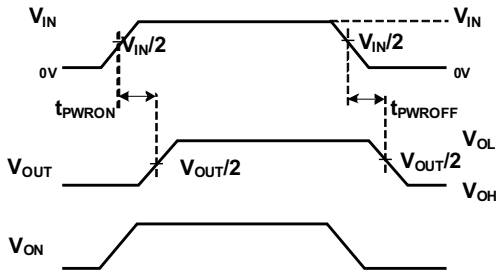


Figure 21. t_{PWRON}/t_{PWROFF} Waveforms

8 Detailed Description

8.1 Overview

The TPS22946 is an ultralow power load switch that provides protection to systems and loads in high-current conditions. The device contains a 300-mΩ current-limited P-channel MOSFET that can operate over an input voltage range of 1.62 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 TPS22946 includes thermal shutdown protection that prevents damage to the device when a continuous over-current condition causes excessive heating by turning off the switch.

When the switch current reaches the maximum limit, the TPS22946 operates in a constant-current mode to prohibit excessive currents from causing damage. The current limit can be selected using the CL input: a high CL input sets the current limit to 155 mA, a low CL input sets the current limit to 70 mA, and a floating CL input sets the current limit to 30 mA.

If the constant current condition still persists after 10 ms, the switch is turned off and the fault signal pin (OC) is pulled low. The TPS22946 has an auto-restart feature which turns the switch on again after 70 ms if the ON pin is still active. If the TPS22946 remains in an over-current condition for 5 seconds, the device shuts off until it is turned on again by setting the ON control signal off and then on.

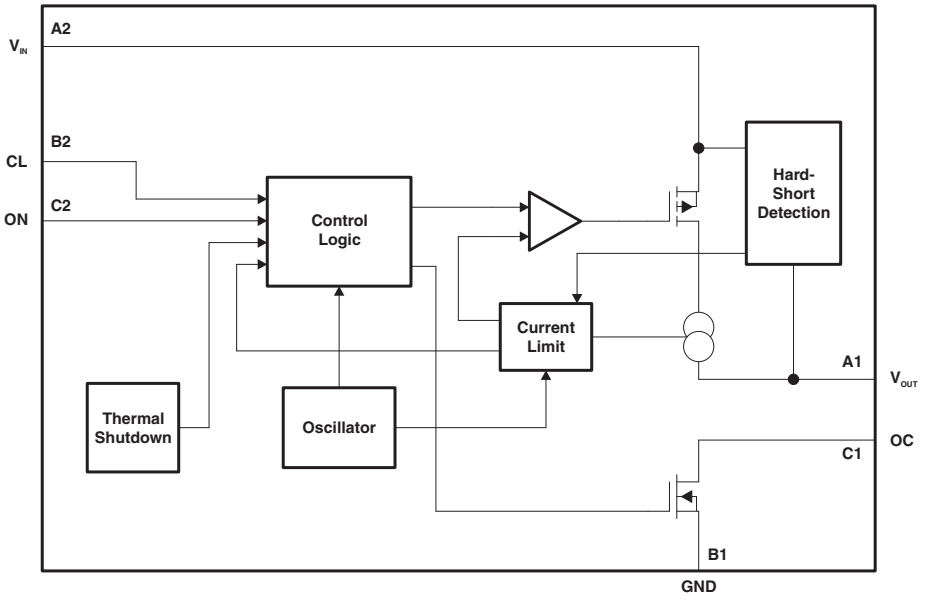
If the device is used to protect an LDO, the inrush current required by the LDO at startup can, in some cases, exceed the current limit and initiate a blanking (current limiting) condition. The TPS22946 device provides allowance for this scenario during startup of the LDO by temporarily increasing the current limit to 435 mA for 8 ms after the load switch is enabled.

The TPS22946 is available in a space-saving 6-pin DSBGA (YZP) package. The device is characterized for operation over the free-air temperature range of –40°C to 85°C.

Table 1. Feature List

	r_{ON} (TYP) AT 5.5 V	CURRENT LIMIT	INTEGRATED INRUSH CURRENT TIME-OUT	CURRENT LIMIT BLANKING TIME	AUTO-RESTART TIME	OVERCURRENT TIME-OUT	ENABLE
TPS22946	300 mΩ	30 mA, 70 mA, or 155 mA	Yes	10 ms	70 ms	6 s	Active high

8.2 Functional Block Diagram



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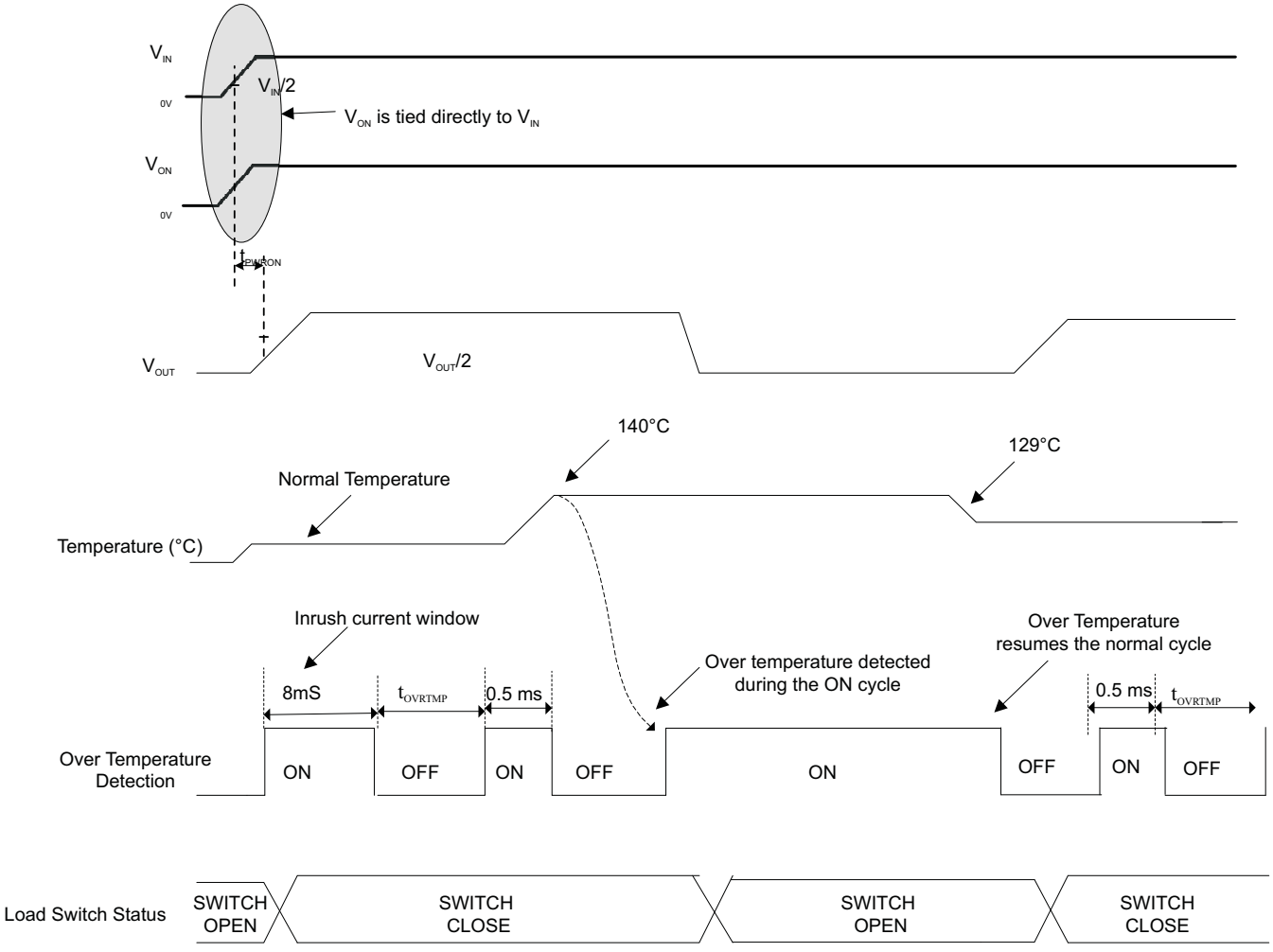
8.3 Feature Description

8.3.1 Detection Schemes

8.3.1.1 Overtemperature Detection

The thermal shutdown detection circuit is active every 8 ms for a period of 0.5 ms. The thermal shutdown protects the part from internally or externally generated excessive temperatures. During an over-temperature condition the switch is turned-off (Open). The switch automatically turns-on (closes) again if temperature of the die drops below the threshold temperature while the part is still enabled.

In addition, if an overcurrent fault condition is detected due to a moderate overcurrent or a hard-short, the thermal shutdown is activated immediately and stays on continuously for the duration of blanking (see Figure 32).



NOTE: Case where the temperature causes the overtemperature detection circuit to trip before the other detection schemes.

Figure 22. Overtemperature Detection

Feature Description (continued)

8.3.1.2 Hard-Short Detection

The hard-short detection circuit is active every 250 µs for a period of 125 µs. A comparator monitors the output voltage, V_{OUT}. A hard short is detected when V_{OUT} is lower than 2/3 V_{IN}. The switch then goes into current-limiting mode.

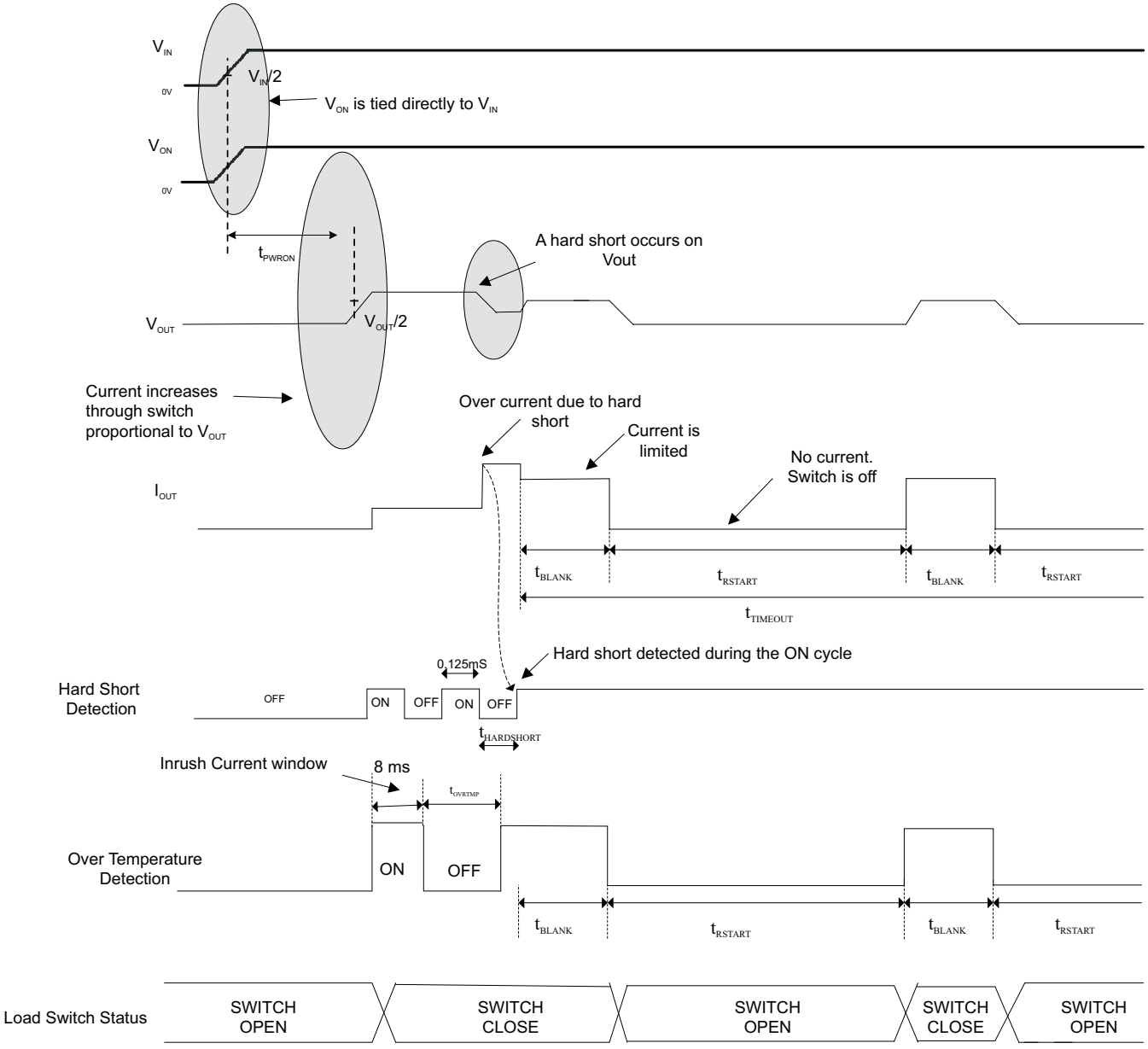


Figure 23. Hard-Short Detection

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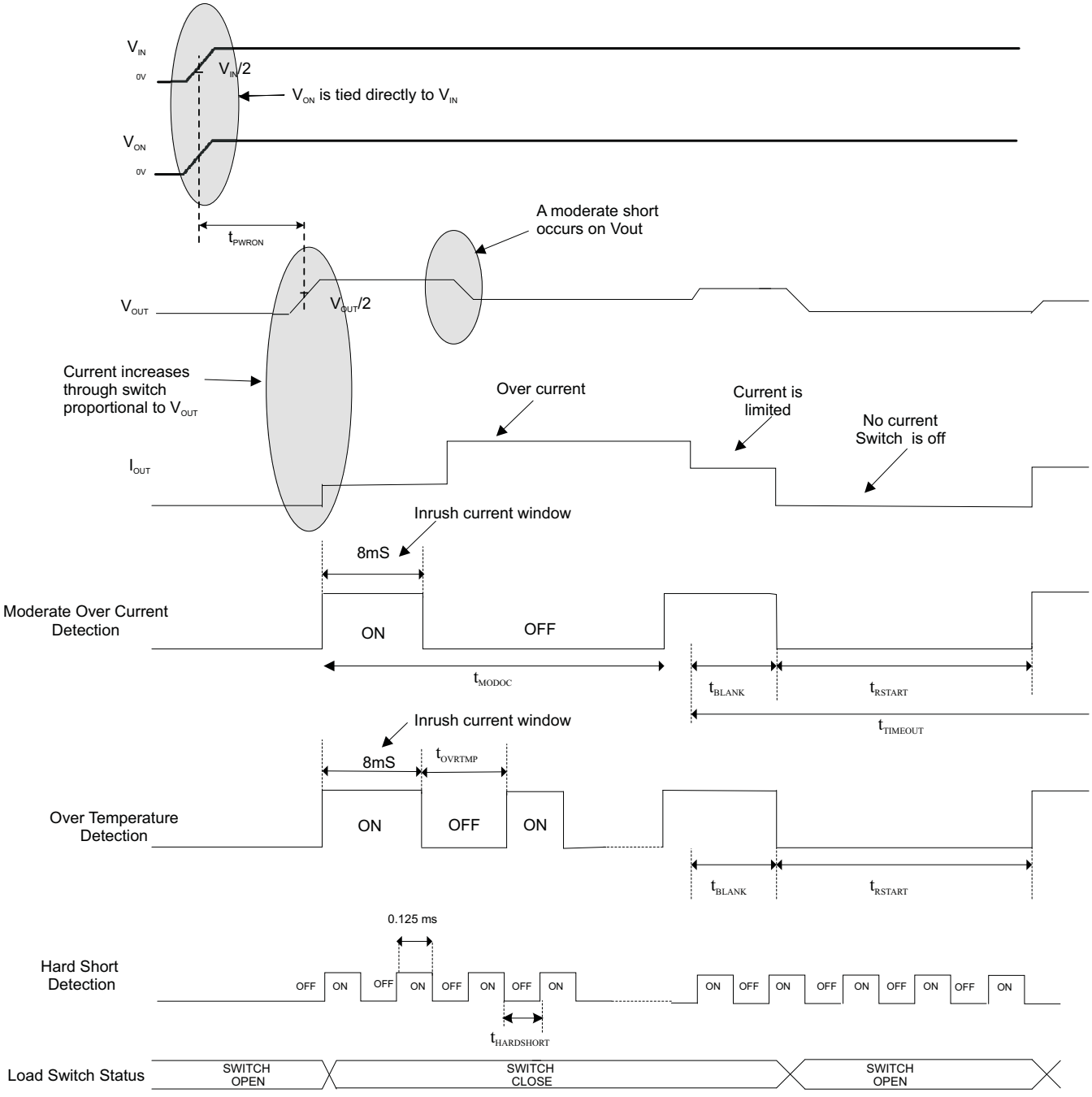
Feature Description (continued)

8.3.1.3 Moderate Overcurrent Detection

The moderate overcurrent detection circuit is active every 64 ms for a period of 0.5 ms. A moderate over-current condition is triggered when the output current of the switch exceeds the current limit value and is not yet into hard short condition. The switch then goes into current-limiting mode.



NOTE: The overcurrent does not cause the temperature to go above 140°C here.

Figure 24. Moderate Overcurrent Detection

Feature Description (continued)

8.3.1.4 Current Limiting Mode

When an overcurrent condition (moderate or a hard short) is detected, the TPS22946 operates in a constant-current mode to prohibit excessive currents from causing damage. TPS22946 has a current limit of 30 mA, 70 mA, or 155 mA.

If the constant current condition still persists after 10ms, the device shuts off the switch and pulls the fault signal pin (OC) low. The TPS22946 has an auto-restart feature which turns the switch on again after 70 ms if the ON pin is still active.

8.3.1.5 Fault Reporting

When a moderate overcurrent, hard short or overtemperature condition is detected, OC is set active low to signal a fault condition. OC is an open-drain MOSFET and requires a pullup resistor between V_{IN} and OC. During shutdown, the pulldown on OC is disabled, reducing current draw from the supply.

8.3.1.6 Power-On and Power-Off Sequence

The device is enabled internally only once the hard-short detection circuit is enabled.

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Feature Description (continued)

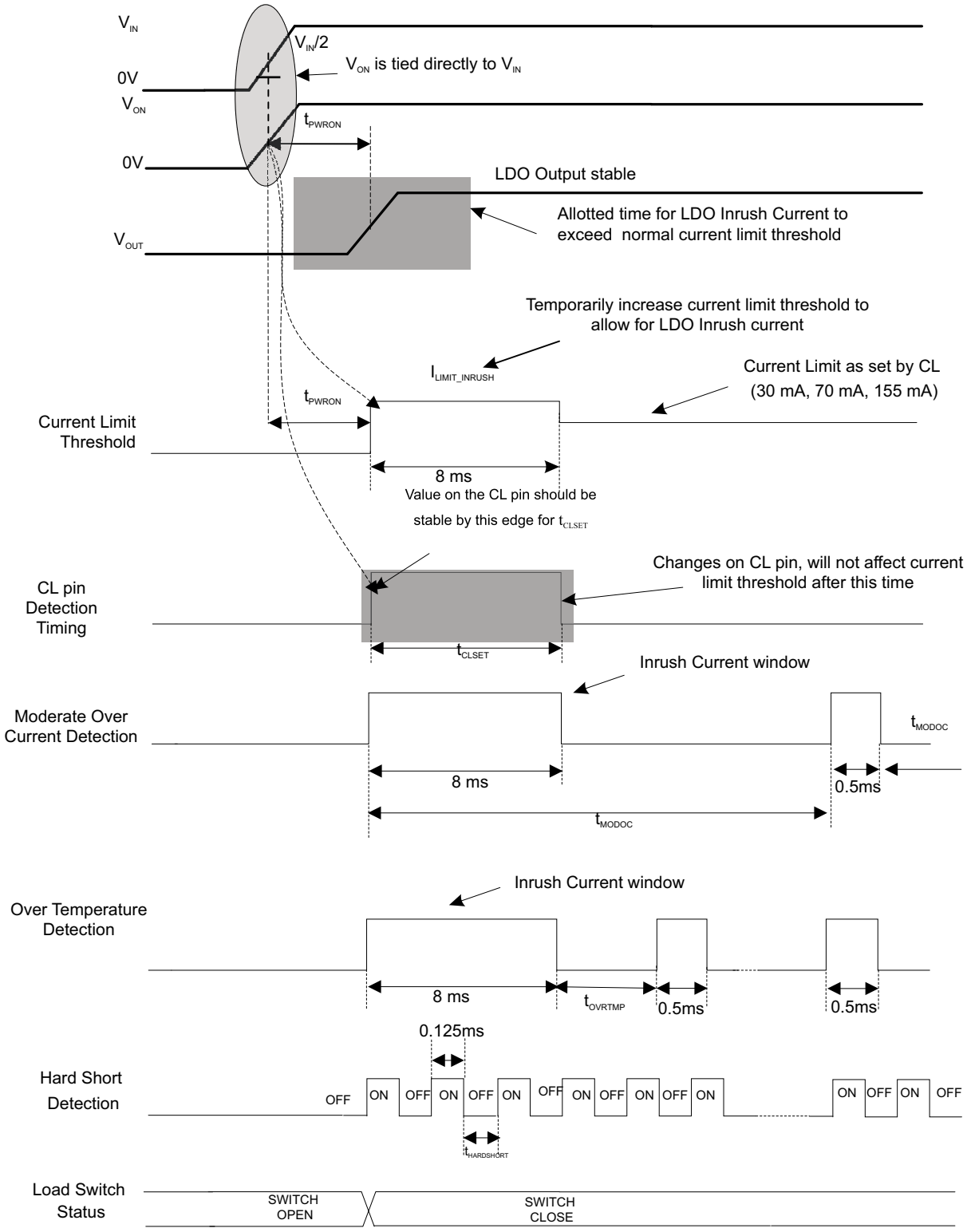

Figure 25. Power-On/Power-Off Sequence Timing

Feature Description (continued)

8.3.1.7 Automatic Disable in Case of Permanent Overcurrent

When the switch enters the current-limiting mode due to a hard short condition or a moderate over-current condition, TPS22946 goes through the 10-ms blanking state and the 70-ms auto restart state. If the hard-short condition or the moderate over-current condition persists after 5 s, the part shuts off regardless of the ON signal. The switch is turned on again after a power reset if the ON pin is HIGH.

8.3.2 Inrush Current Time-out Feature

The inrush current required by the LDO at startup can in some cases exceed the current limit and initiate a blanking (current limiting) condition. TPS22946 provides allowance for this scenario by temporarily increasing the current limit to 435 mA for 8 ms after the load switch is enabled. This time-out is initiated by the positive edge transition on the ON signal.

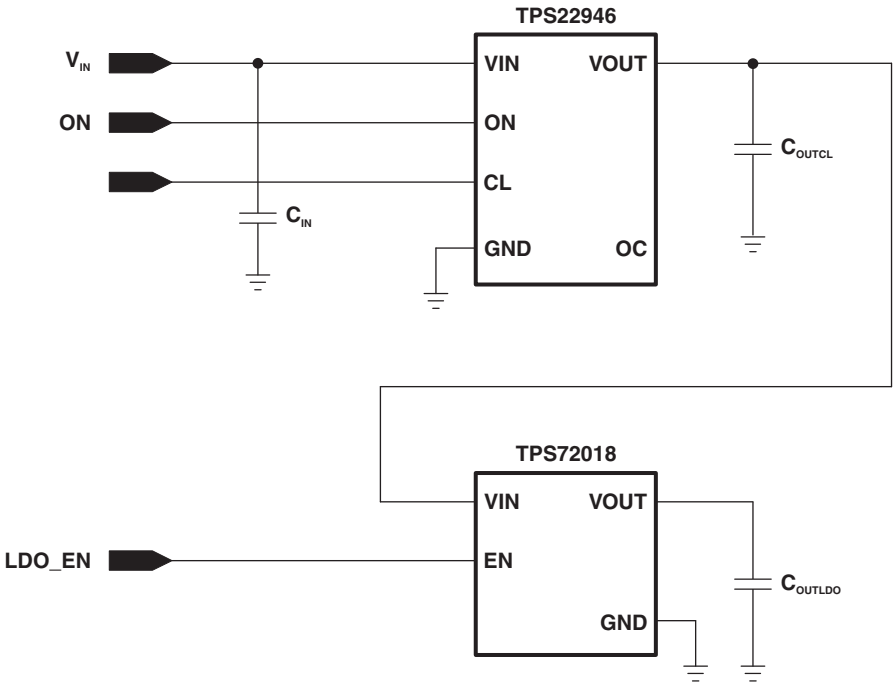

Figure 26. Inrush Current Time-out Circuit

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Feature Description (continued)

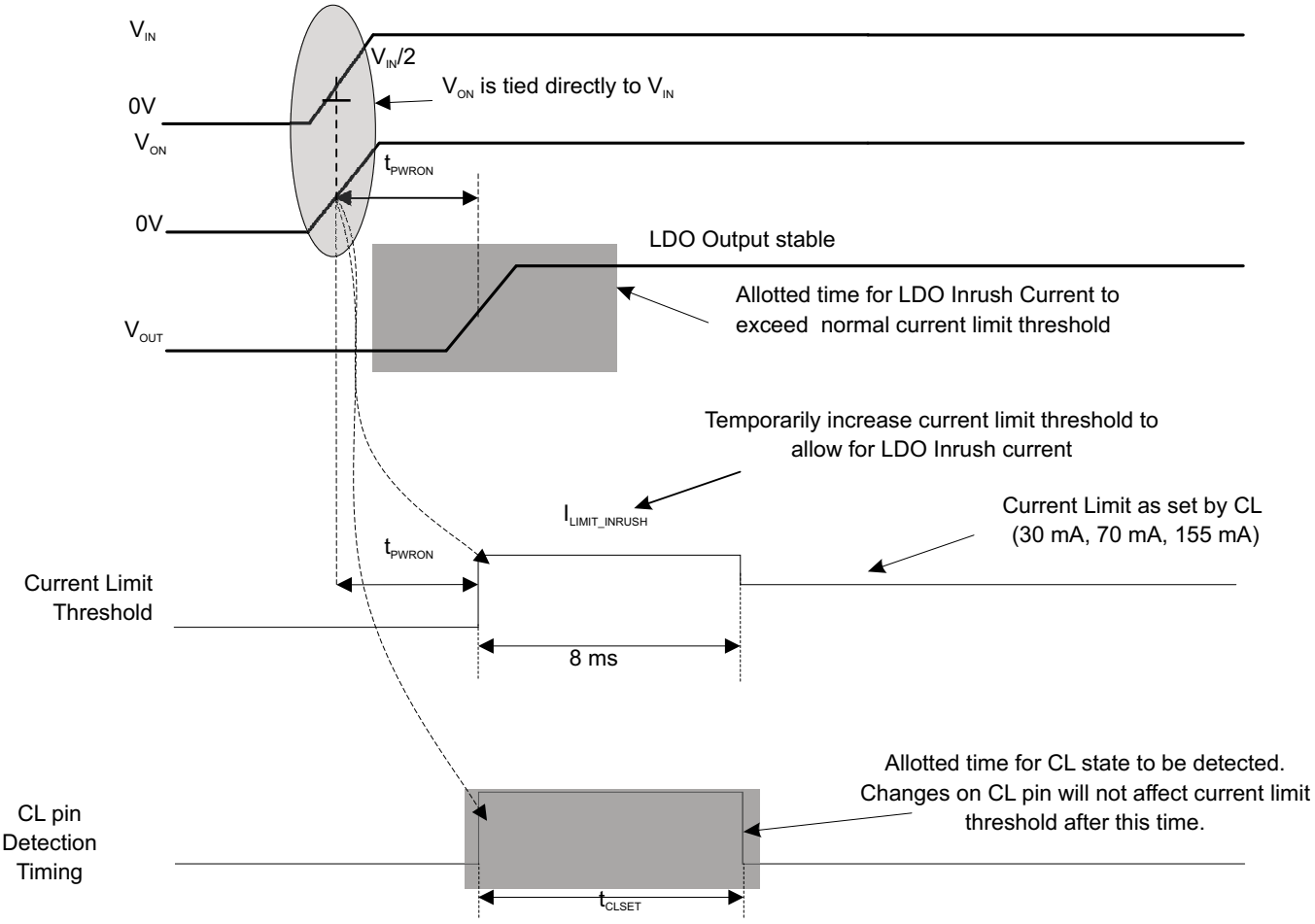

Figure 27. Inrush Current Time-out Timing

8.3.3 CL Control Pin

The TPS22946 supports three current limits: 30 mA, 70 mA, and 155 mA. The current limit selection is determined by the status of the digital input CL pin, as shown in Table 2. A high impedance, or floating, condition allows the CL pin to support a third state. The TPS22946 monitors the state of the CL pin during start-up from a disabled state, and upon start-up sets the current limit accordingly. When floating the CL pin, keep the total capacitance on the pin less than 100 pF and the resistive loading greater than 10 MΩ to ensure proper operation. Any changes to the state of the CL pin after the start-up operation has completed are ignored until the next start-up cycle.

The CL pin must be driven with logic levels referenced to VIN. The CL pin can be tied high or low on the printed wiring board (PWB) or driven by a general purpose I/O (GPIO), as long as the V_{IL} and V_{IH} recommended operating conditions are met.

Table 2. CL Control Pin

CL PIN STATUS	CURRENT LIMIT
Logic low(1)	70 mA
Float(2)	30 mA
Logic high(1)	155 mA

(1) Resistance to VCC or GND < 100 Ω
(2) Load on CL: C < 100 pF, R > 10 MΩ

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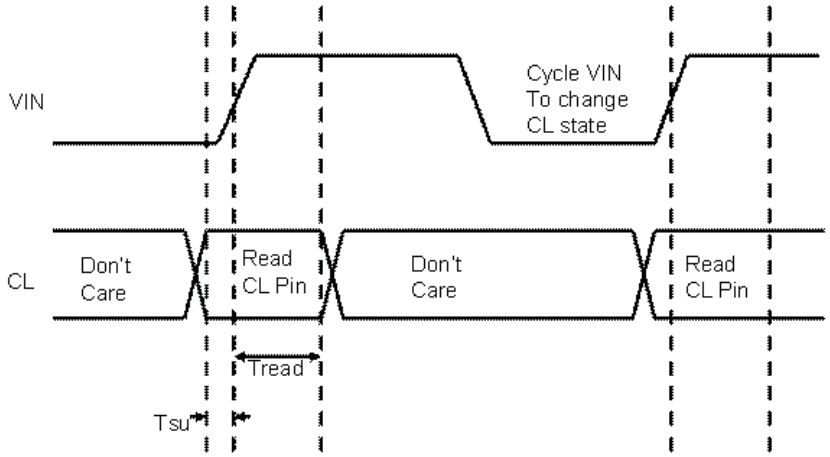

Figure 28. CL Pin Read Timing When cycling VIN (ON Pin Tied to VIN)

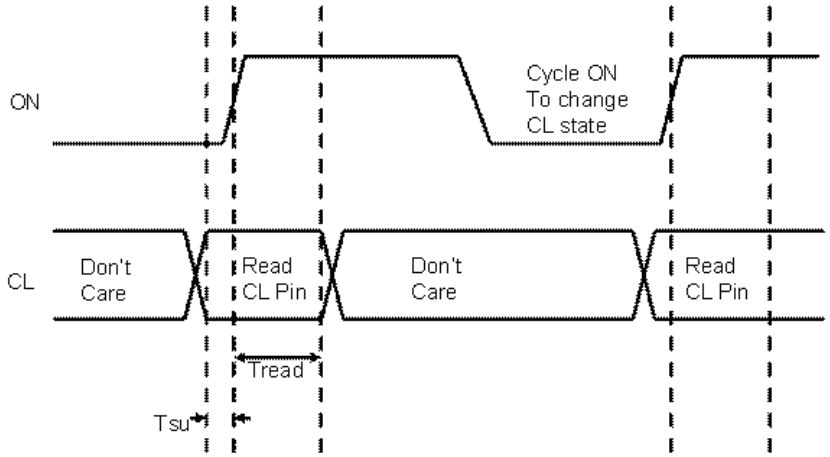

Figure 29. CL Pin Read Timing Cycling ON Pin (VIN High)

8.3.4 Overtemperature Protection

An overtemperature condition occurs when the temperature of the part is greater than 140°C. The OC flag will go low to indicate a fault. If the overtemperature condition persists for more than 6 seconds, the part times out and shuts OFF. The part must be enabled by either toggling the ON pin or the VIN pin. If the temperature falls below 130°C within 5 seconds, the part will start normal operation.

If the temperature is not constantly high above 140°C and is toggling between greater than 140°C and less than 130°C, the internal time-out timer keeps resetting. If this event occurs more than 32 times, it will cause the part to shut OFF. It can be enabled by toggling either the ON pin or the VIN pin.

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8.4 Device Functional Modes

Table 3. Function Table

ON	CL	TPS22946
L	x	V_{IN} to V_{OUT} switch is off (open)
H	x	V_{IN} to V_{OUT} switch is on (closed)
x	H(1)	Current limit set to 155 mA
x	L(1)	Current limit set to 70 mA
x	Float(2)	Current limit set to 30 mA

(1) Resistance to VCC or GND < 100 Ω
(2) Load on CL: C < 100 pF, R > 10 MΩ

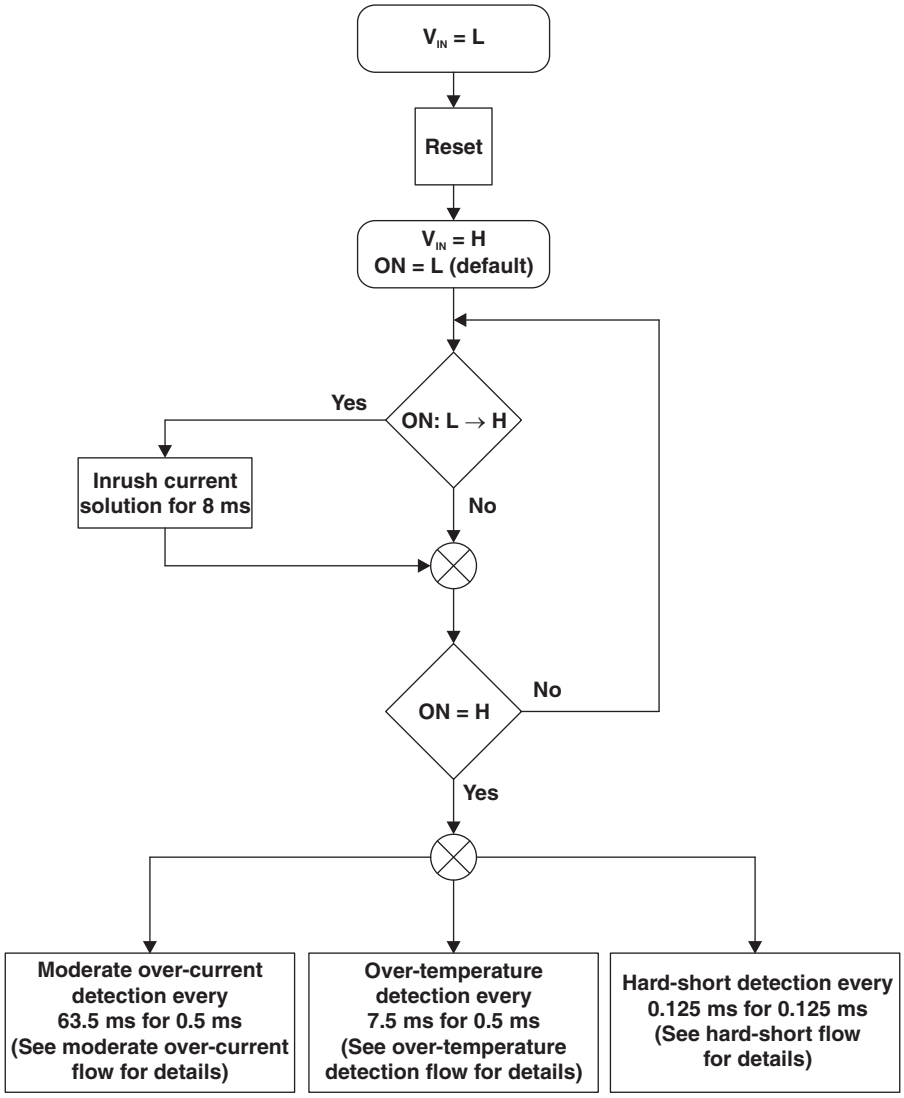

Figure 30. Functional Flow Diagram

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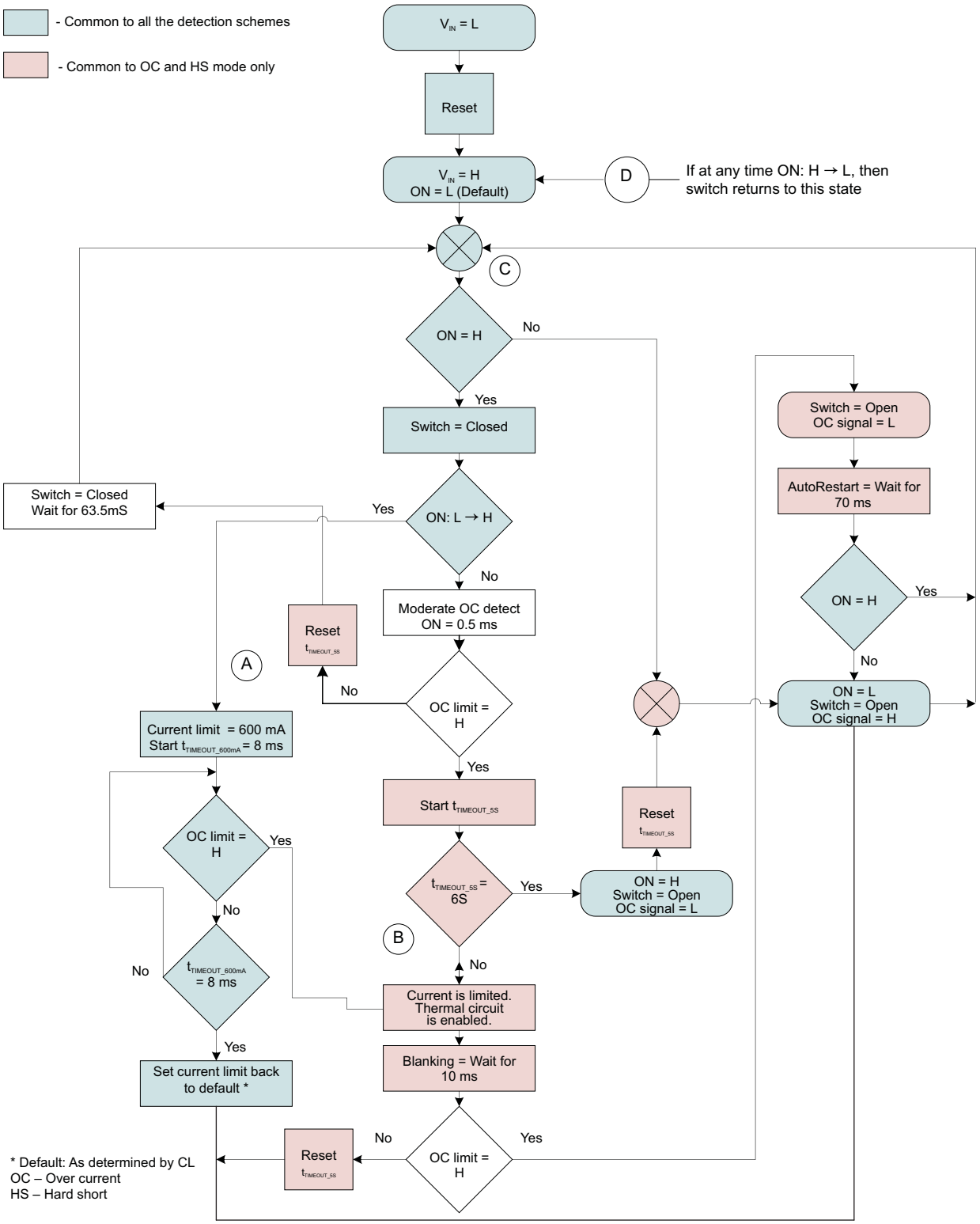

Figure 31. Moderate Overcurrent Detection Flow Diagram

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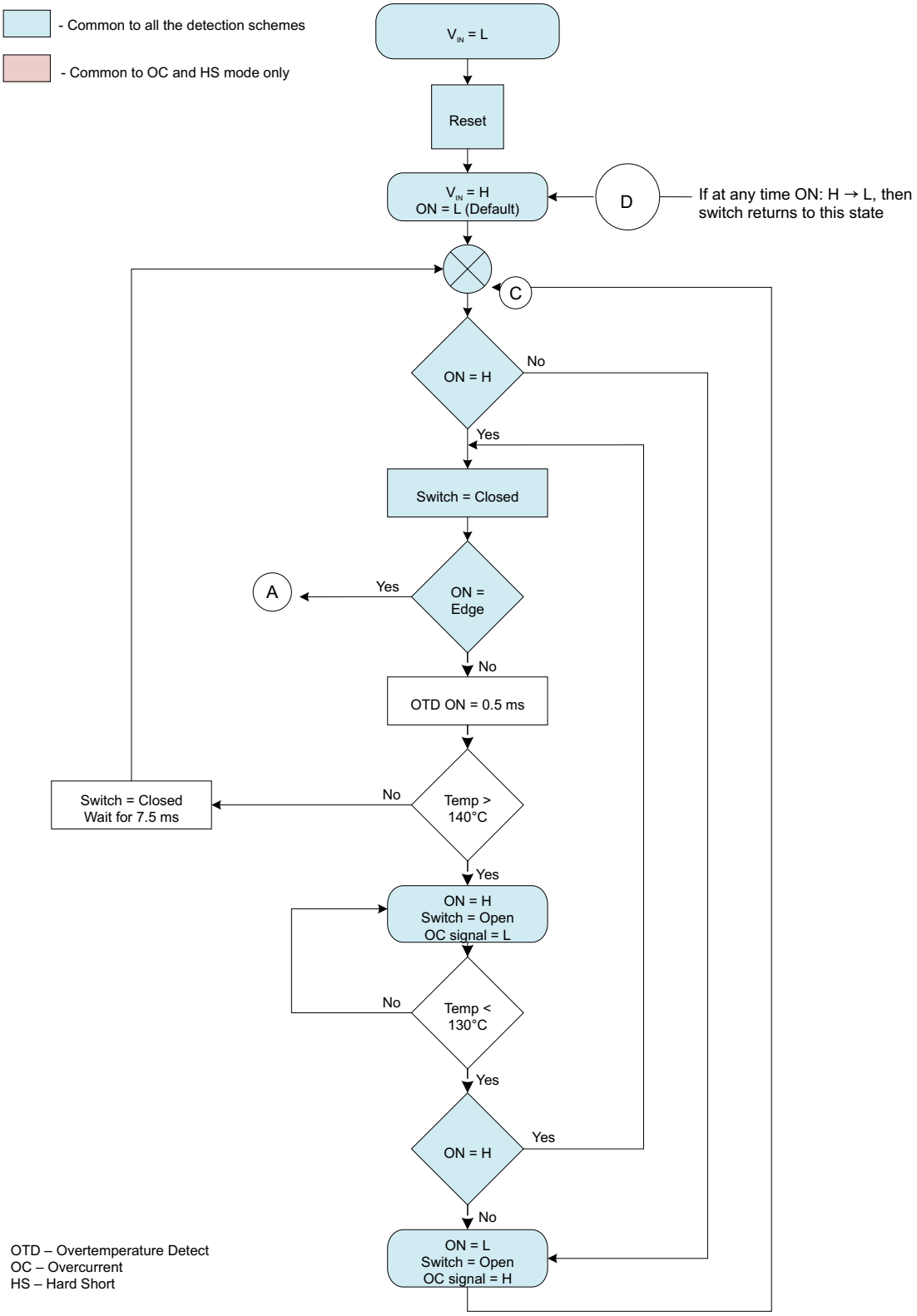

Figure 32. Overtemperature Detection Flow Diagram

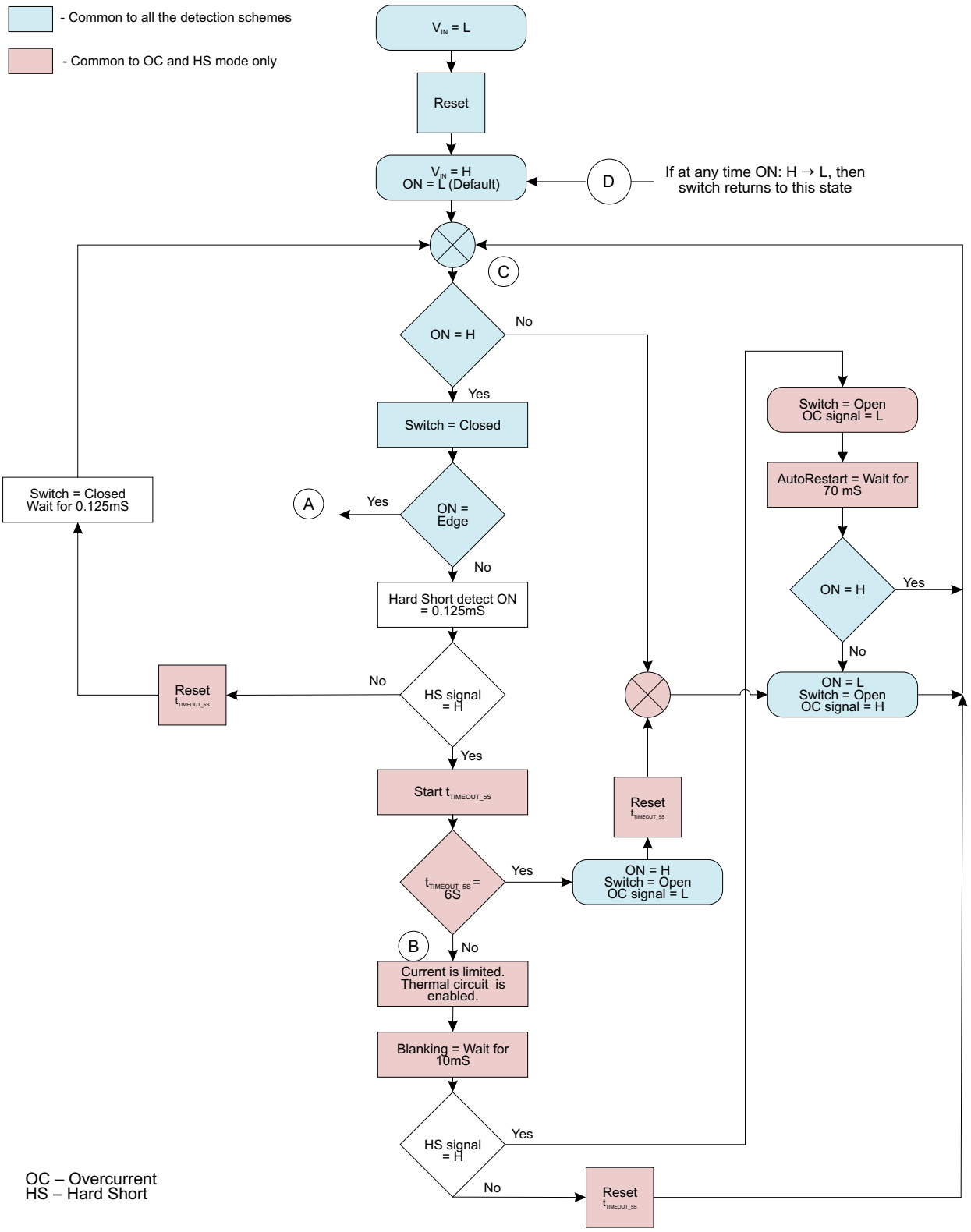

Figure 33. Hard Short-Circuit Detection Flow Diagram

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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

9.1.1 On/Off Control

The ON pin controls the state of the switch. Activating ON continuously holds the switch in the on state so long as there is no fault. A junction temperature in excess of 150°C overrides the ON control to turn off the switch. ON is active HIGH and has a low threshold making it capable of interfacing with low voltage signals. When the MOSFET is off, the body diode is disabled so no current can flow through it from the input to the output; however, the body diode does not prevent reverse current flowing.

9.2 Typical Application

This application demonstrates how the TPS22946 can be used to power a downstream load that includes a capacitive element (C_{LOAD}).

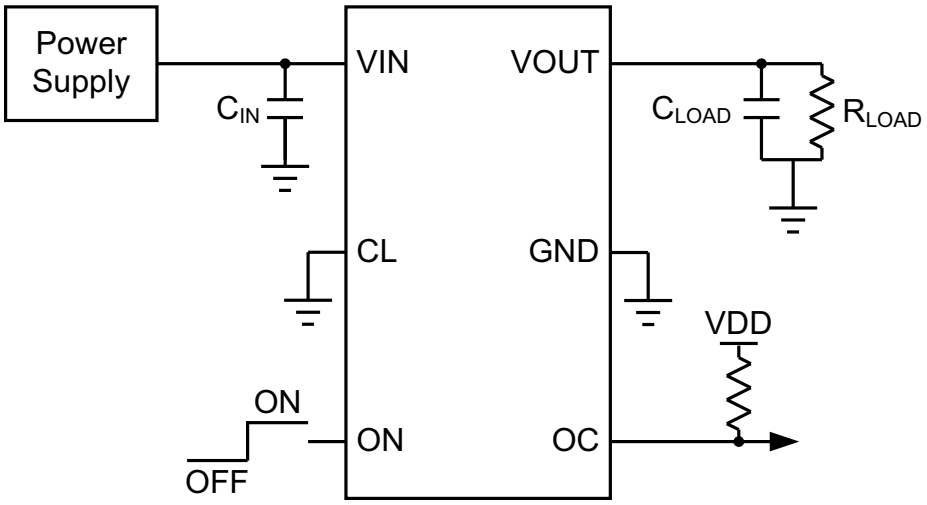

Figure 34. Typical Application Schematic

9.2.1 Design Requirements

For this design example, use the following as the input parameters.

Table 4. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
V_{IN}	3.3 V
Output capacitance (C_{LOAD})	1 µF
V_{OUT} rise time (t_R)	50 µs

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9.2.2 Detailed Design Procedure

To begin the design process, the designer must know the following:

- V_{IN} voltage
- Output capacitance (C_{LOAD})
- V_{OUT} rise time (t_R)

The TPS22946 has a 435-mA current limit during initial turnon of the switch, I_{limit_inrush}. This current limit is higher than the steady-state current limit, I_{LIM}. The purpose of this feature is to allow the inrush current that is caused by charging up the capacitor, C_{LOAD}. To calculate the inrush current that is caused by the capacitor during initial turnon, use the following equation:

$$I_{INRUSH} = C_L \times \frac{dV_{OUT}}{dt} \quad (1)$$

where

- I_{INRUSH} = amount of inrush current caused by C_{LOAD}
- C_L = capacitance on VOUT
- dt = V_{OUT} rise time
- dV_{OUT} = increase in V_{OUT} during the rise time

Using the given example values, the inrush current in this typical application will be 66-mA:

66 mA = 1 µF × 3.3 V / 50 µF (2)

The oscilloscope capture in Figure 35 shows the inrush current for the given design example.

9.2.3 Application Curve

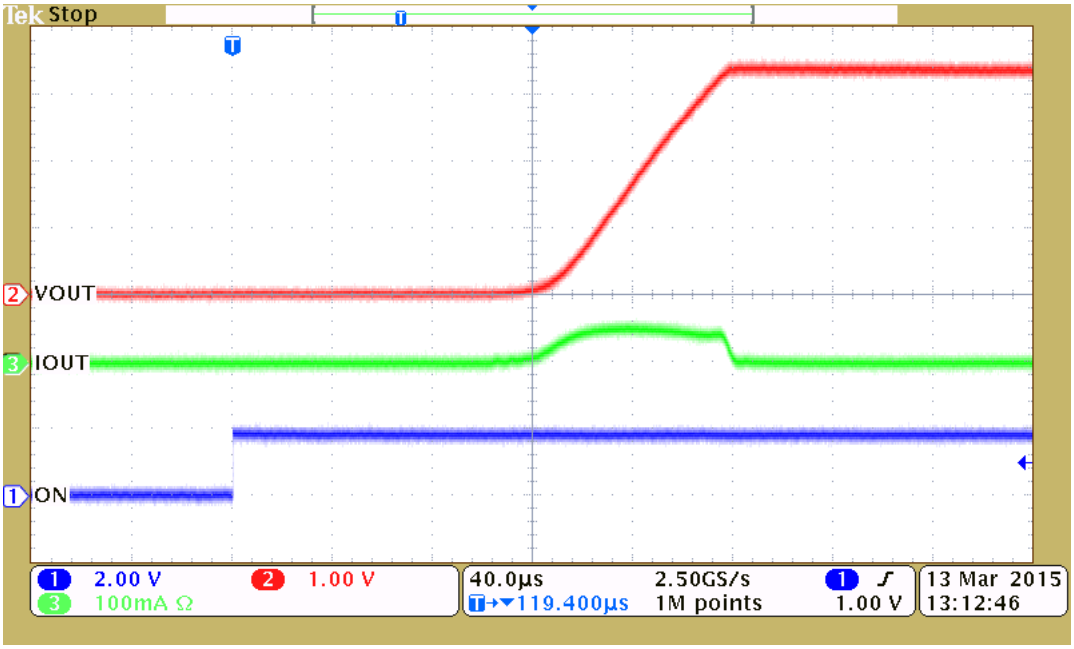

Figure 35. Inrush Current With 1-µF Output Capacitor

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10 Power Supply Recommendations

The device is designed to operate from a VIN range of 1.62 to 5.5 V. The VIN power supply should be well regulated and placed as close to the VIN terminal as possible. The power supply must be able to withstand all transient load current steps. In most situations, using the minimum recommended input capacitance of 1 uF is sufficient to prevent the supply voltage from dipping when the switch is turned on. In cases where the power supply is slow to respond to a large transient current or large load current step, additional bulk capacitance may be required on the input.

11 Layout

11.1 Layout Guidelines

- The C_{IN} capacitor should be placed as close as possible to the V_{IN} pin.
- The V_{IN} and V_{OUT} traces should be the appropriate width to carry the load current.
- The CL pin may be connected directly the GND or VIN (depending on the desired current limit). The CL pin may also be left floating.

11.2 Layout Example

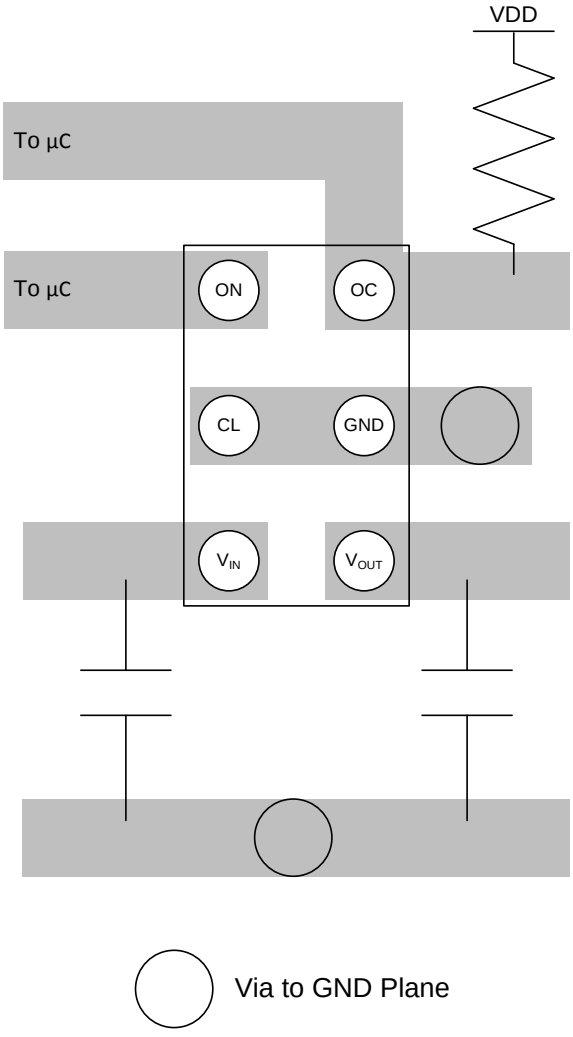

Figure 36. Layout Example

12 Device and Documentation Support

12.1 Trademarks

All trademarks are the property of their respective owners.

12.2 Electrostatic Discharge Caution

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.

12.3 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.

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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
TPS22946YZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(5H ~ 5H2)	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) 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.

(6) 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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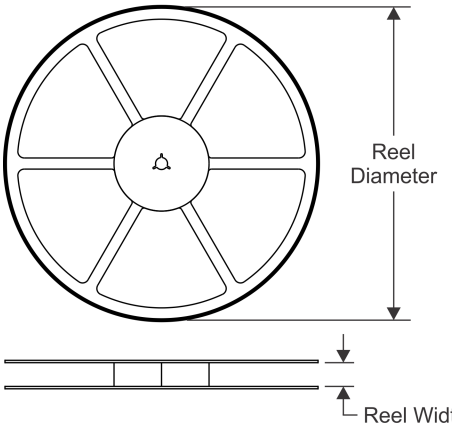
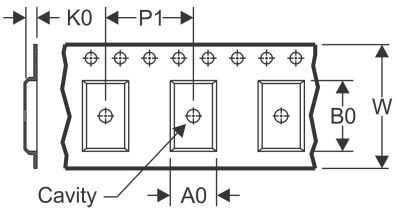
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

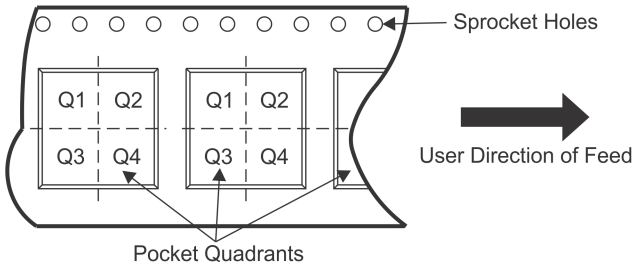


TAPE DIMENSIONS



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

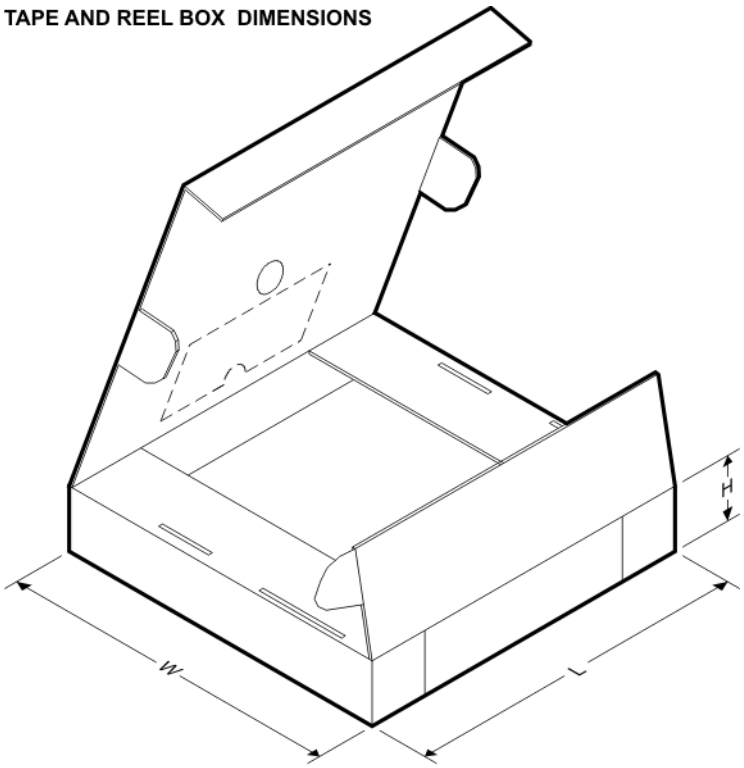
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22946YZPR	DSBGA	YZP	6	3000	178.0	9.2	1.02	1.52	0.63	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

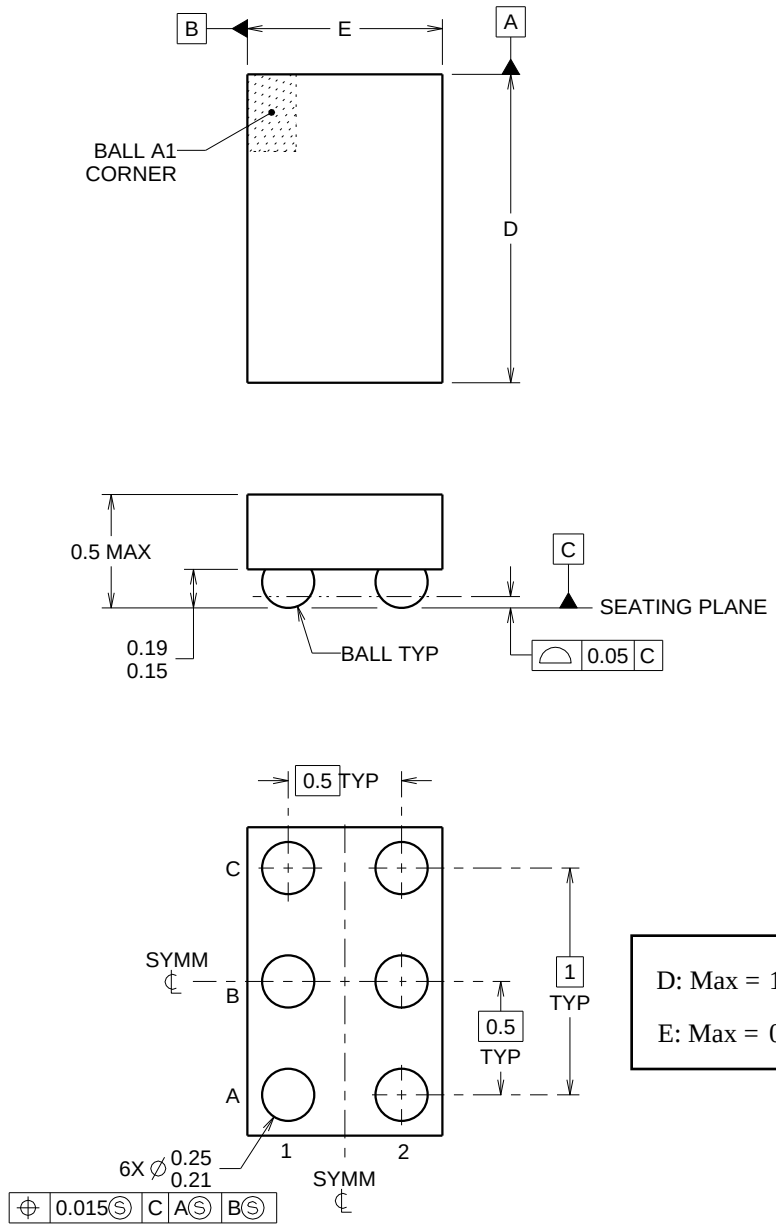
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22946YZPR	DSBGA	YZP	6	3000	220.0	220.0	35.0

PACKAGE OUTLINE

YZP0006

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



D: Max = 1.418 mm, Min =1.358 mm

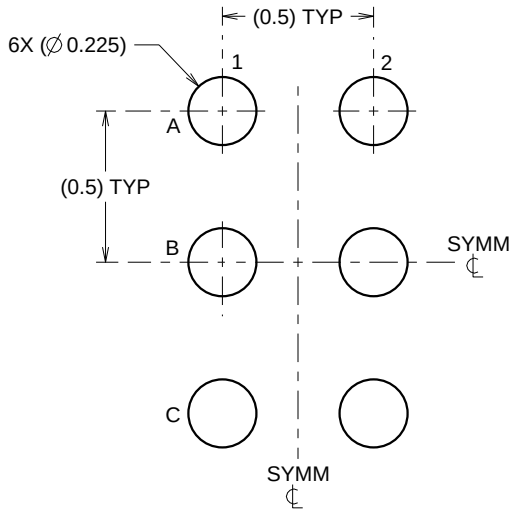
E: Max = 0.918 mm, Min =0.858 mm

4219524/A 06/2014

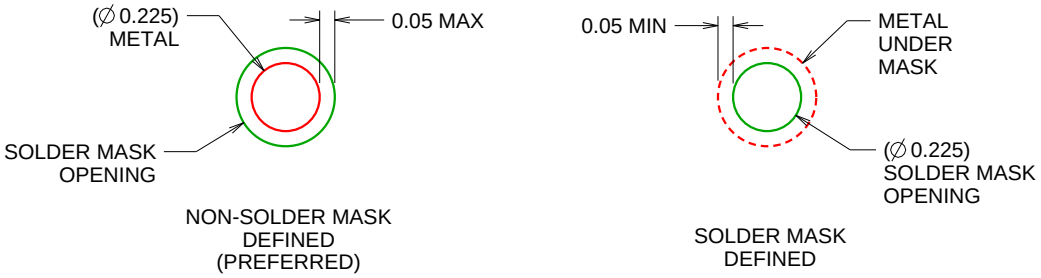
NOTES:

NanoFree Is a trademark of Texas Instruments.

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. NanoFree™ package configuration.



LAND PATTERN EXAMPLE
SCALE:40X



SOLDER MASK DETAILS
NOT TO SCALE

4219524/A 06/2014

NOTES: (continued)

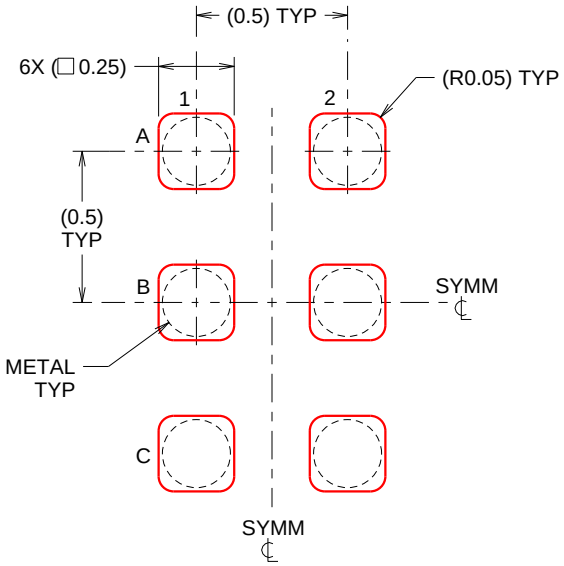
4. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SBVA017 (www.ti.com/lit/sbva017).

EXAMPLE STENCIL DESIGN

YZP0006

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:40X

4219524/A 06/2014

NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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