Dual Channel, Current-Limited, Power-Distribution Switches

Check for Samples: TPS2062C, TPS2066C, TPS2060C, TPS2064C, TPS2002C, TPS2003C

FEATURES

- **Dual Power Switch Family**
- **Rated Currents of 1 A, 1.5 A, 2 A**
- **Accurate ±20% Current-limit Tolerance**
- **Fast Overcurrent Response – 2 µs (Typical)**
- **70-mΩ (Typical) High-Side N-Channel MOSFET**
- **Operating Range: 4.5 V to 5.5 V**
- **Deglitched Fault Reporting ($\overline{\text{FLTx}}$)**
- **Output Discharge When Disabled**
- **Reverse Current Blocking**
- **Built-in Softstart**
- **Pin for Pin with Existing *TI Switch Portfolio***
- **Ambient Temperature Range: –40°C to 85°C**

APPLICATIONS

- **USB Ports/Hubs, Laptops, Desktops**
- **High-Definition Digital TVs**
- **Set Top Boxes**
- **Short-Circuit Protection**

DESCRIPTION

The TPS20xxC dual power-distribution switch family is intended for applications such as USB where heavy capacitive loads and short-circuits may be encountered. This family offers multiple devices with fixed current-limit thresholds for applications between 1 A and 2 A.

The TPS20xxC dual family limits the output current to a safe level by operating in a constant-current mode when the output load exceeds the current-limit threshold. This provides a predictable fault current under all conditions. The fast overcurrent response time eases the burden on the main 5 V supply to provide regulated power when the output is shorted. The power-switch rise and fall times are controlled to minimize current surges during turn-on and turn-off.

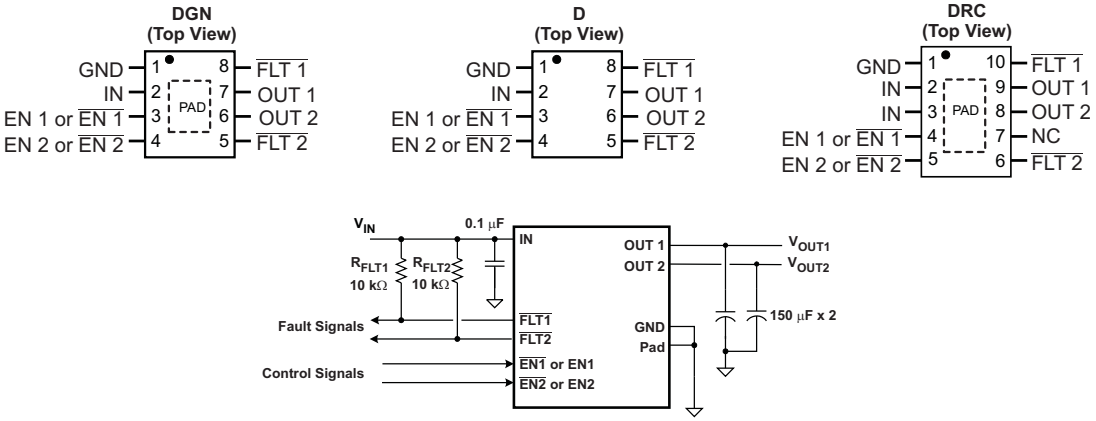


Figure 1. TYPICAL APPLICATION

Table 1. Devices (1)

RATED CURRENT	DEVICES	STATUS		
		MSOP-8 (PowerPad™)	SON -10	SOIC-8
1 A	TPS2062C and 66C	Active and Active	-	Active and Active
1.5 A	TPS2060C and 64C	Active and Active	-	-
2 A	TPS2002C and 03C	-	Preview / Preview	-

(1) For more details, see the DEVICE INFORMATION table

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.

PowerPAD is a trademark of Texas Instruments.

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.

DEVICE INFORMATION(1)(2)

MAXIMUM OPERATING CURRENT	ENABLE	OUTPUT DISCHARGE	BASE PART NUMBER	PACKAGE DEVICES(3)			MARKING
				SOIC-8 (D)	MSOP-8 (DGN) PowerPAD™	SON-10 (DRC)	
1	Low	Y	TPS2062C	√	√	–	VRBQ
1	High	Y	TPS2066C	√	√	–	VRDQ
1.5	Low	Y	TPS2060C	–	√	–	VRAQ
1.5	High	Y	TPS2064C	–	√	–	VRCQ
2	Low	Y	TPS2002C	–	–	√	VREQ
2	High	Y	TPS2003C	–	–	√	VRFQ

(1) For the most current packaging and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
(2) Package code for MSOP-8 is “DGN” and for SON is “DRC”.
(3) “–” indicates the device is not available in this package.

ABSOLUTE MAXIMUM RATINGS(1)(2)

		VALUE		UNIT
		MIN	MAX	
Voltage range on IN, OUTx, ENx or $\overline{ENx}$, $\overline{FLTx}$(3)		–0.3	6	V
Voltage range from IN to OUT		–6	6	V
Maximum junction temperature, T_J		Internally Limited		°C
ESD	Human Body Model		2	kV
	Charged Device Model		500	V
	IEC 61000-4-2, Contact / Air(4)		8 / 15	kV

(1) Absolute maximum ratings apply over recommended junction temperature range.
(2) All voltages are with respect to GND unless otherwise noted.
(3) See INPUT AND OUTPUT CAPACITANCE section.
(4) V_{OUT} was surged on a PCB with input and output bypassing per Figure 1 (except input capacitor was 22 µF) with no device failure.

THERMAL INFORMATION

THERMAL METRIC(1)(2)		D	DGN	DRC	UNITS
		8 PINS	8 PINS	10 PINS	
θ_{JA}	Junction-to-ambient thermal resistance	129.9	57.2	45.4	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	83.5	110.5	58	
θ_{JB}	Junction-to-board thermal resistance	70.4	60.7	21.1	
ψ_{JT}	Junction-to-top characterization parameter	36.6	7.8	1.9	
ψ_{JB}	Junction-to-board characterization parameter	66.9	24	21.3	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	n/a	14.3	9.1	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) For thermal estimates of this device based on PCB copper area, see the TI PCB Thermal Calculator.

RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V_{IN}	Input voltage, IN		4.5		5.5	V
V_{Enable}	Input voltage, ENx or $\overline{ENx}$		0		5.5	V
I_{OUTx}	Continuous ouput current, OUTx	TPS2062C and 66C			1	A
		TPS2060C and 64C			1.5	A
		TPS2002C and 03C			2	A
T_J	Operating junction temperature		–40		125	°C
$I_{\overline{FLTx}}$	Sink current into $\overline{FLTx}$		0		5	mA

ELECTRICAL CHARACTERISTICS(1)(2)

$T_J = T_A = 25°C$, $V_{IN} = 5$ V, $V_{ENx} = V_{IN}$ or $V_{\overline{ENx}} = 0$V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
POWER SWITCH							
$r_{DS(on)}$	On-resistance	TPS2062C and 66C (1 A)	DGN		70	84	mΩ
		TPS2062C and 66C (1 A), –40°C ≤ (T_J, T_A) ≤ 85°C	DGN		70	95	mΩ
		TPS2062C and 66C (1 A)	D		90	108	mΩ
		TPS2062C and 66C (1 A), –40°C ≤ (T_J, T_A) ≤ 85°C	D		90	122	mΩ
		TPS2060C and 64C (1.5 A)			70	84	mΩ
		TPS2060C and 64C (1.5 A), –40°C ≤ (T_J, T_A) ≤ 85°C			70	95	mΩ
		TPS2002C and 03C (2 A)			70	84	mΩ
		TPS2002C and 03C (2 A), –40°C ≤ (T_J, T_A) ≤ 85°C			70	95	mΩ
CURRENT LIMIT							
I_{OS}	Current limit, See Figure 7	TPS2062C and 66C (1 A)		1.28	1.61	1.94	A
		TPS2060C and 64C (1.5 A)		1.83	2.29	2.75	A
		TPS2002C and 03C (2 A)		2.43	2.96	3.49	A
t_{IOS}	Short-circuit response time	V_{IN} = 5 V (see Figure 6), One-half full load → $R_{(SHORT)}$ = 50 mΩ, Measure from application to when current falls below 120% of final value			2		µs
SUPPLY CURRENT							
I_{SD}	Supply current, device disabled	$I_{(OUTx)}$ = 0 mA			0.01	1	µA
I_{S1E}	Supply current, single switch enabled	$I_{(OUTx)}$ = 0 mA			60	75	µA
I_{S2E}	Supply current, both switches enabled	$I_{(OUTx)}$ = 0 mA			100	120	µA
I_{LKG}	Reverse leakage current	V_{OUT} = 5.5 V, V_{IN} = 0 V, measured I_{OUTx}			0.15	1	µA
OUTPUT DISCHARGE							
R_{PD}	Output pull-down resistance(2)	$V_{IN} = V_{(OUTx)}$ = 5 V, disabled		400	470	600	Ω

(1) Pulsed testing techniques maintain junction temperature approximately equal to ambient temperature
(2) These parameters are provided for reference only, and do not constitute part of TI's published device specifications for purposes of TI's product warranty.

ELECTRICAL CHARACTERISTICS

–40°C ≤ (T_J = T_A) ≤ 125°C, 4.5 V ≤ V_{IN} ≤ 5.5 V, V_{ENx} = V_{IN} or $V_{\overline{ENx}}$ = 0 V, I_{OUTx} = 0 A, typical values are at 5 V and 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]		MIN	TYP	MAX	UNIT
POWER SWITCH							
$r_{DS(on)}$	On-resistance	TPS2062C and 66C (1 A)	DGN		70	112	mΩ
			D		90	135	
		TPS2060C and 64C (1.5 A)			70	112	
		TPS2002C and 03C (2 A)			70	112	
ENABLE INPUT (ENx or $\overline{ENx}$)							
V_{IH}	ENx ($\overline{ENx}$), High-level input voltage	4.5 V ≤ VIN ≤ 5.5 V		2			V
V_{IL}	ENx ($\overline{ENx}$), Low-level input Voltage					0.8	
	Hysteresis	V_{IN} = 5 V			0.14		
	Leakage current	V_{ENx} = 5.5 V or 0 V, $V_{\overline{ENx}}$ = 0 V or 5.5 V		-1	0	1	µA
t_{on}	Turn-on time	V_{IN} = 5 V, C_L = 1 µF, R_L = 100 Ω, ENx ↑ or $\overline{ENx}$ ↓, See Figure 4, Figure 5, and Figure 2					ms
		1 A, 1.5 A, 2 A Rated		1.4	1.9	2.4	
t_{off}	Turn-off time	V_{IN} = 5 V, C_L = 1 µF, R_L = 100 Ω, ENx ↑ or $\overline{EN}$ ↓, See Figure 4, Figure 5, and Figure 2					ms
		1 A, 1.5 A, 2 A Rated		1.95	2.60	3.25	
t_r	Rise time, output	C_L = 1 µF, R_L = 100 Ω, see Figure 3					ms
		1 A, 1.5 A, 2 A Rated		0.58	0.82	1.15	
t_f	Fall time, output	C_L = 1 µF, R_L = 100 Ω, see Figure 3					ms
		1 A, 1.5 A, 2 A Rated		0.33	0.47	0.66	
CURRENT LIMIT							
I_{OS}	Current-limit, See Figure 7	TPS2062C/66C (1 A)		1.12	1.61	2.10	A
		TPS2060C and 64C (1.5 A)		1.72	2.29	2.86	
		TPS2002C and 03C (2 A)		2.22	2.96	3.7	
t_{IOS}	Short-circuit response time[2]	V_{IN} = 5 V (see Figure 6), One-half full load → $R_{(SHORT)}$ = 50 mΩ, measure from application to when current falls below 120% of final value			2		µs
SUPPLY CURRENT							
I_{SD}	Supply current, switch disabled	Standard conditions, $I_{(OUTx)}$ = 0 mA			0.01	10	µA
I_{S1E}	Supply current, single switch enabled	Standard conditions, $I_{(OUTx)}$ = 0 mA				90	
I_{S2E}	Supply current, both switches enabled	Standard conditions, $I_{(OUTx)}$ = 0 mA				150	
I_{LKG}	Reverse leakage current	V_{OUT} = 5.5 V, V_{IN} = 0 V, measured $I_{(OUTx)}$			0.20		
UNDERVOLTAGE LOCKOUT							
UVLO	Low-level input voltage, IN	VIN rising		3.4		4.0	V
	Hysteresis, IN[2]				0.14		V
$\overline{FLTx}$							
	Output low voltage, $\overline{FLTx}$	$I_{(\overline{FLTx})}$ = 1 mA				0.2	V
	Off-state leakage	$V_{(\overline{FLTx})}$ = 5.5 V				1	µA
	$\overline{FLTx}$ deglitch	$\overline{FLTx}$ overcurrent assertion/deassertion		7	10	13	ms

(1) Pulsed testing techniques maintain junction temperature approximately equal to ambient temperature
(2) These parameters are provided for reference only, and do not constitute part of TI's published device specifications for purposes of TI's product warranty.

ELECTRICAL CHARACTERISTICS (continued)

–40°C ≤ (T_J = T_A) ≤ 125°C, 4.5 V ≤ V_{IN} ≤ 5.5 V, V_{ENx} = V_{IN} or $V_{\overline{ENx}}$ = 0 V, I_{OUTx} = 0 A, typical values are at 5 V and 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS(1)	MIN	TYP	MAX	UNIT
OUTPUT DISCHARGE					
Output pull-down resistance(3)	V_{IN} = 5 V, V_{OUT} = 5 V, disabled	300	470	800	Ω
	V_{IN} = 4 V, V_{OUT} = 5 V, disabled	350	560	1200	
THERMAL SHUTDOWN					
Junction thermal shutdown threshold	In current limit	135			°C
	Not in current limit	155			
Hysteresis(3)			20		°C

(3) These parameters are provided for reference only, and do not constitute part of TI's published device specifications for purposes of TI's product warranty.

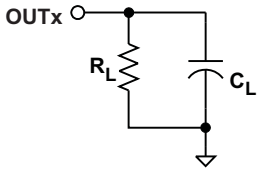


Figure 2. Output Rise / Fall Test Load

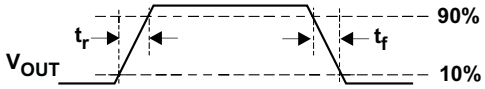


Figure 3. Power-On and Off Timing

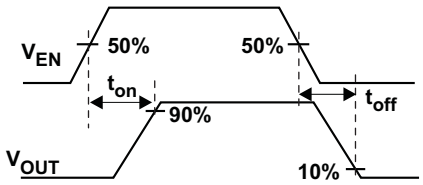


Figure 4. Enable Timing, Active High Enable

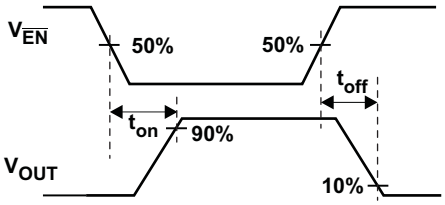


Figure 5. Enable Timing, Active Low Enable

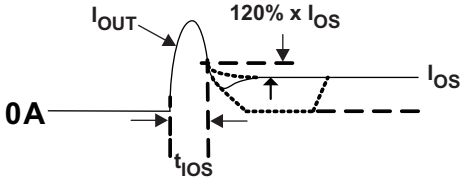


Figure 6. Output Short Circuit Parameters

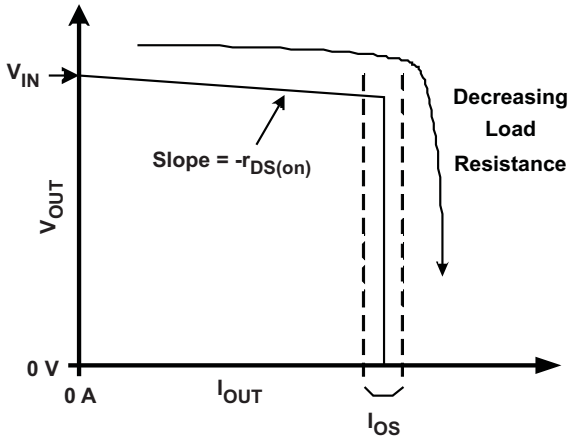
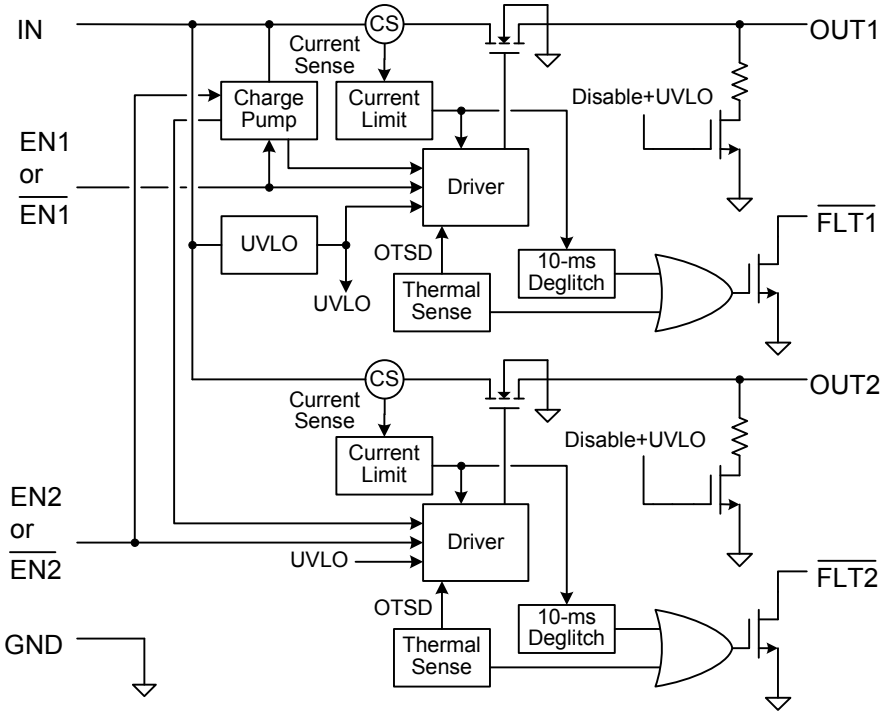


Figure 7. Output Characteristic Showing Current Limit

FUNCTIONAL BLOCK DIAGRAM



DEVICE INFORMATION

PIN FUNCTIONS – MSOP-8 PACKAGES

NAME	TPS2066C/64C	TPS2062C/60C	I/O	DESCRIPTION
GND	1	1	Pwr	Ground connection
IN	2	2	I	Input voltage and power-switch drain; connect a 0.1 µF or greater ceramic capacitor from IN to GND close to the IC
EN1	3	-	I	Enable input channel 1, logic high turns on power switch
$\overline{EN1}$	-	3	I	Enable input channel 1, logic low turns on power switch
EN2	4	-	I	Enable input channel 2, logic high turns on power switch
$\overline{EN2}$	-	4	I	Enable input channel 2, logic low turns on power switch
$\overline{FLT2}$	5	5	O	Active-low open-drain output, asserted during overcurrent, or overtemperature conditions on channel 2
OUT2	6	6	O	Power-switch output channel 2, connected to load
OUT1	7	7	O	Power-switch output channel 1, connected to load
$\overline{FLT1}$	8	8	O	Active-low open-drain output, asserted during over-current, or overtemperature conditions on channel 1
PowerPAD™	PAD	PAD	Pwr	Internally connected to GND; used to heat-sink the part to the circuit board traces. Connect PAD to GND plane as a heatsink.

PIN FUNCTIONS – SOIC-8 PACKAGES

NAME	TPS2066C	TPS2062C	I/O	DESCRIPTION
GND	1	1	Pwr	Ground connection
IN	2	2	I	Input voltage and power-switch drain; connect a 0.1 µF or greater ceramic capacitor from IN to GND close to the IC
EN1	3	-	I	Enable input channel 1, logic high turns on power switch
$\overline{EN1}$	-	3	I	Enable input channel 1, logic low turns on power switch
EN2	4	-	I	Enable input channel 2, logic high turns on power switch
$\overline{EN2}$	-	4	I	Enable input channel 2, logic low turns on power switch
$\overline{FLT2}$	5	5	O	Active-low open-drain output, asserted during overcurrent, or overtemperature conditions on channel 2
OUT2	6	6	O	Power-switch output channel 2, connected to load
OUT1	7	7	O	Power-switch output channel 1, connected to load
$\overline{FLT1}$	8	8	O	Active-low open-drain output, asserted during overcurrent, or overtemperature conditions on channel 1

PIN FUNCTIONS – SON-10 PACKAGES

NAME	TPS2003C	TPS2002C	I/O	DESCRIPTION
GND	1	1	Pwr	Ground connection
IN	2, 3	2, 3	I	Input voltage and power-switch drain; connect a 0.1 µF or greater ceramic capacitor from IN to GND close to the IC
EN1	4	–	I	Enable input channel 1, logic high turns on power switch
$\overline{EN1}$	–	4	I	Enable input channel 1, logic low turns on power switch
EN2	5	–	I	Enable input channel 2, logic high turns on power switch
$\overline{EN2}$	–	5	I	Enable input channel 2, logic low turns on power switch
$\overline{FLT2}$	6	6	O	Active-low open-drain output, asserted during overcurrent, or overtemperature conditions on channel 2
NC	7	7		No connect – leave floating.
OUT2	8	8	O	Power-switch output channel 2, connect to load
OUT1	9	9	O	Power-switch output channel 1, connect to load
$\overline{FLT1}$	10	10	O	Active-low open-drain output, asserted during overcurrent, or overtemperature conditions on channel 1
PowerPAD™	PAD	PAD	Pwr	Internally connected to GND; used to heat-sink the part to the circuit board traces. Connect PAD to GND plane as a heatsink.

TYPICAL CHARACTERISTICS

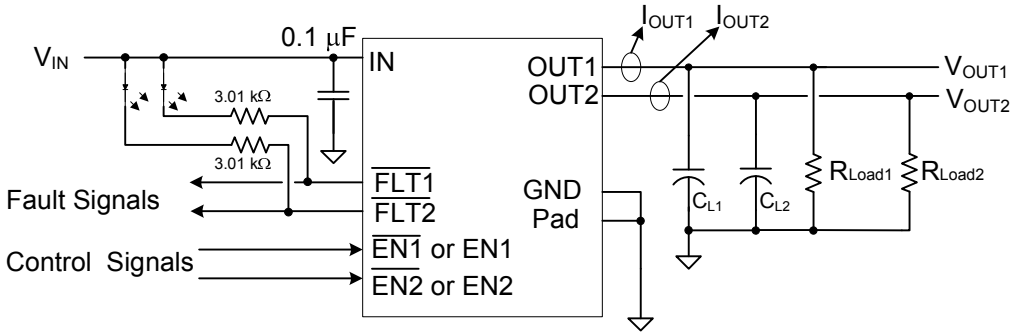


Figure 8. Test Circuit for System Operation in Typical Characteristics Section

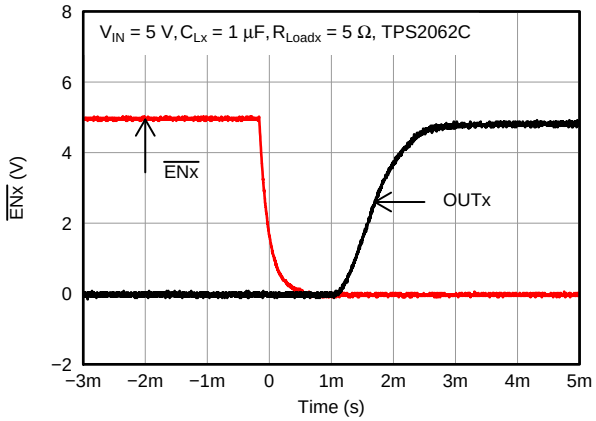


Figure 9. TPS2062C Turn on Delay and Rise Time With 1-µF Load

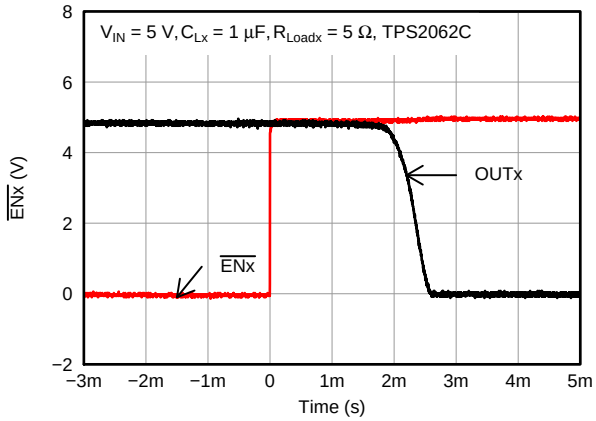


Figure 10. TPS2062C Turn off Delay and Fall Time With 1-µF Load

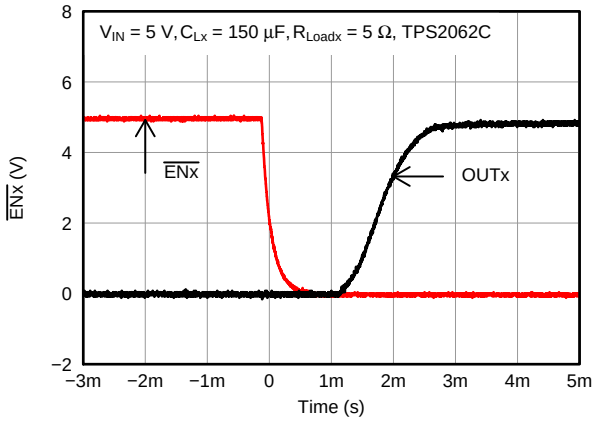


Figure 11. TPS2062C Turn on Delay and Rise Time With 150-µF Load

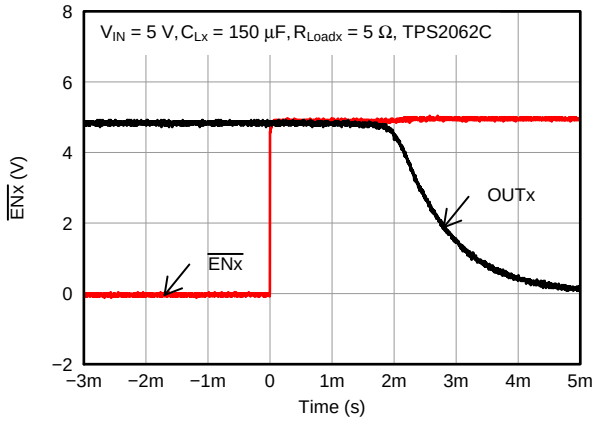


Figure 12. TPS2062C Turn off Delay and Fall Time With 150-µF Load

TYPICAL CHARACTERISTICS (continued)

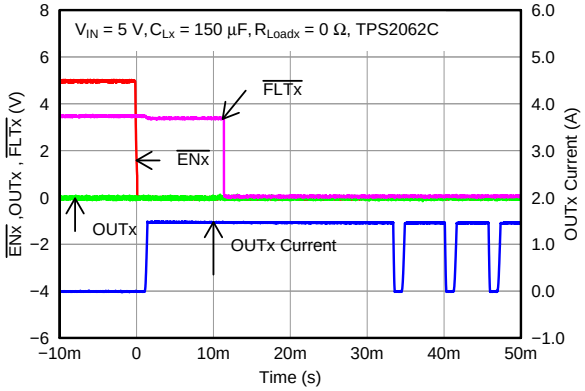


Figure 13. TPS2062C Enable Into Short

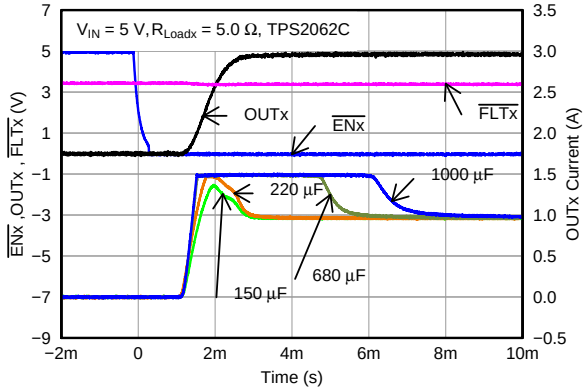


Figure 14. TPS2062C Inrush Current With Different Load Capacitance

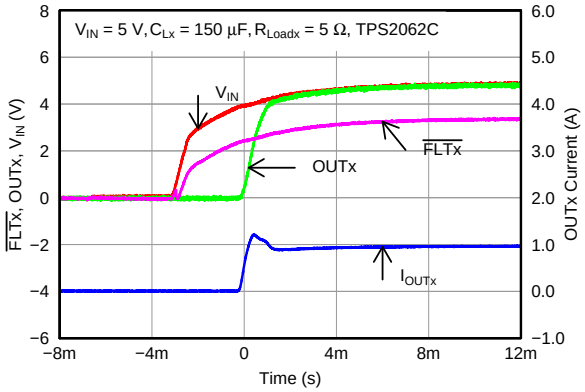


Figure 15. TPS2062C Power Up – Enabled

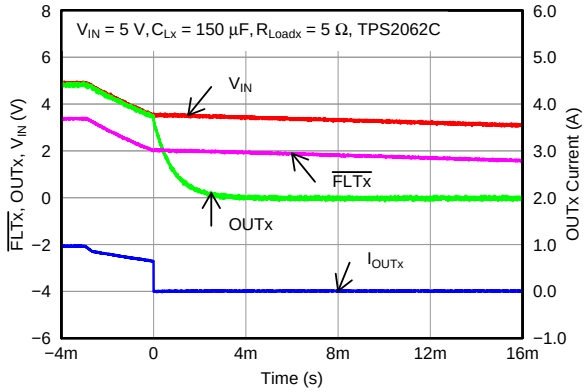


Figure 16. TPS2062C Power Down – Enabled

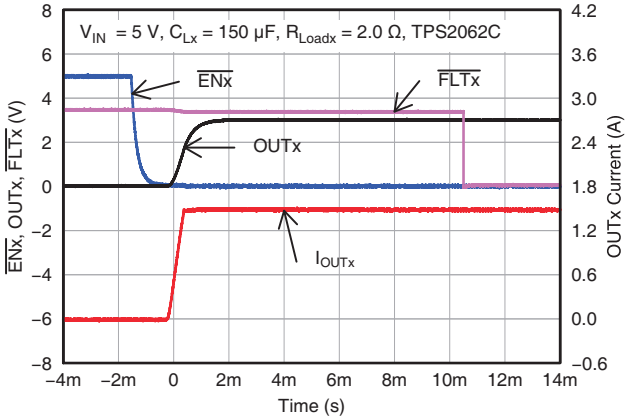


Figure 17. TPS2062C Enable With 2-Ω Load

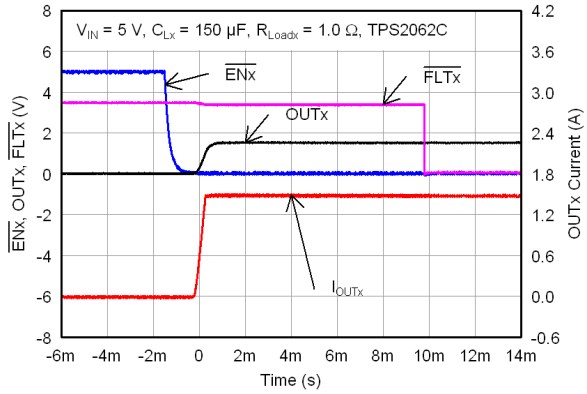


Figure 18. TPS2062C Enable With 1-Ω Load

TYPICAL CHARACTERISTICS (continued)

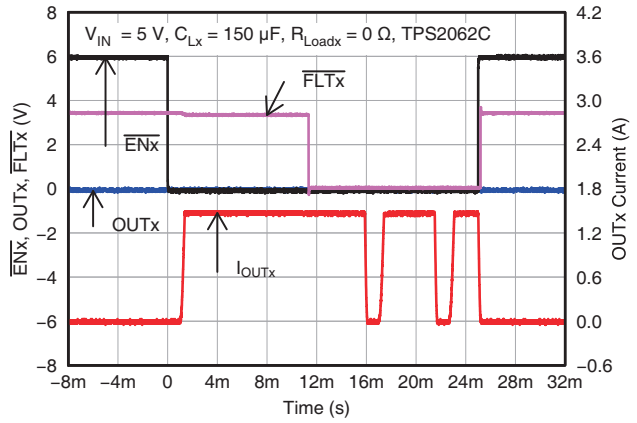


Figure 19. TPS2062C Enable/Disable into Output Short

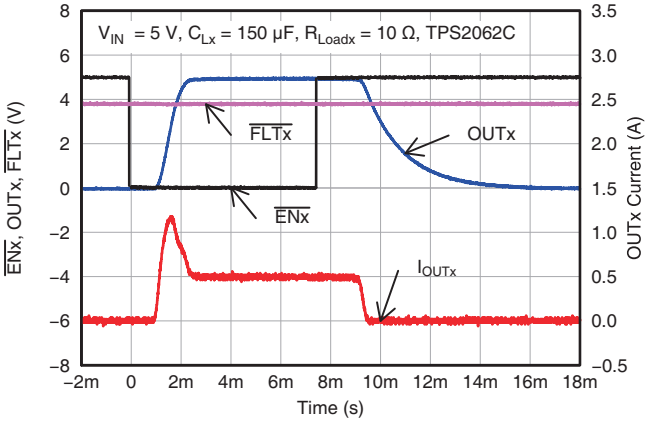


Figure 20. TPS2062C Enable/Disable into 10-Ω Load

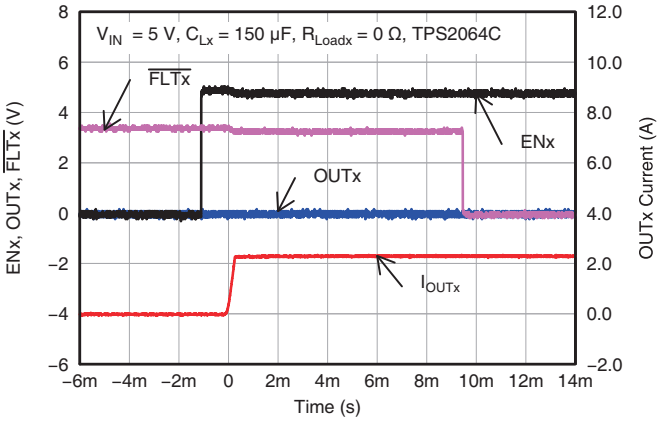


Figure 21. TPS2064C Enable into Short

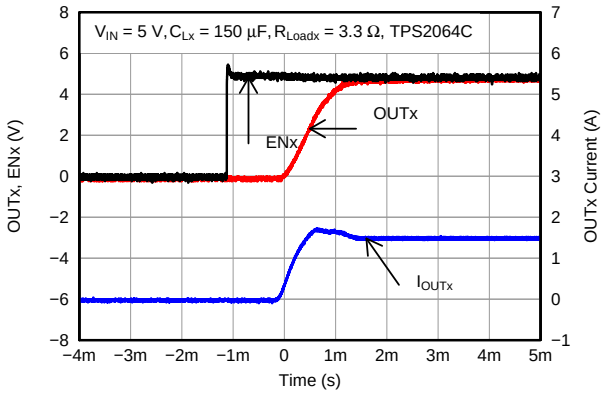


Figure 22. TPS2064C Enable into 3.3 Ω and 150-µF Laod

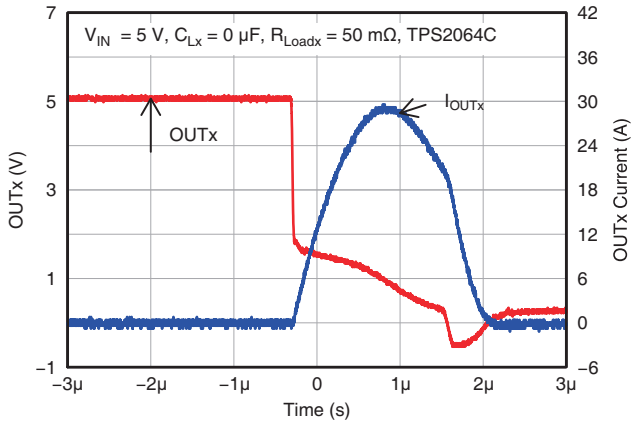


Figure 23. TPS2064C Short Applied

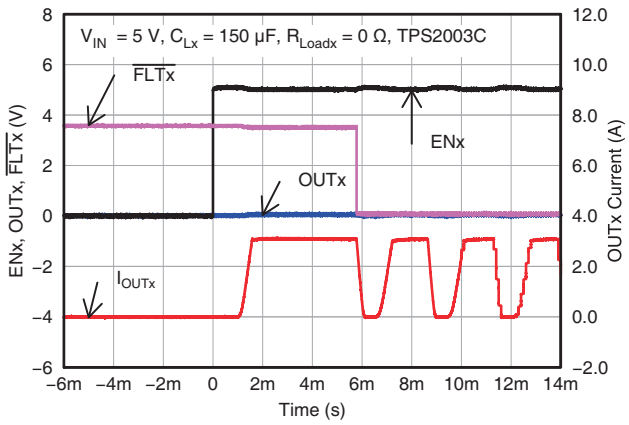


Figure 24. TPS2003C Enable into Short

TYPICAL CHARACTERISTICS (continued)

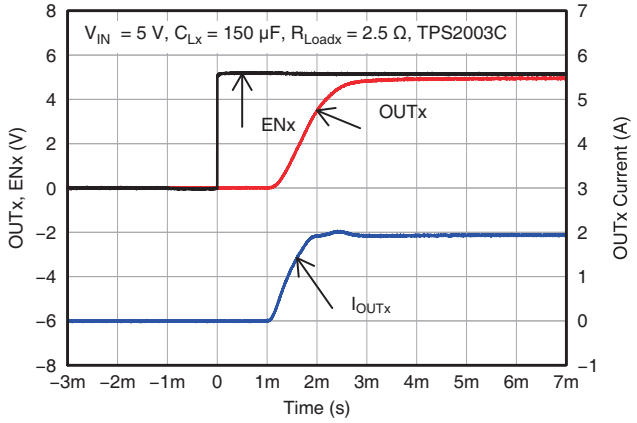


Figure 25. TPS2003C Enable into 2.5 Ω and 150-µF Laod

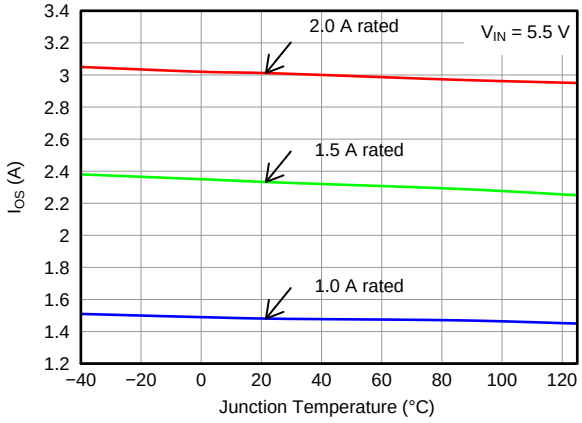


Figure 26. Current Limit (I_{OS}) vs Temperature

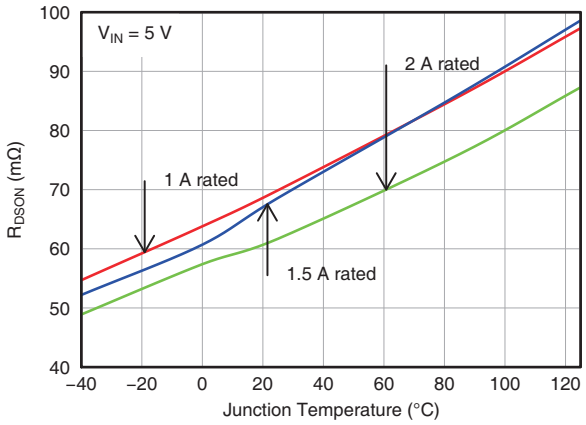


Figure 27. Input - output Resistance ($R_{DS(ON)}$) vs Temperature

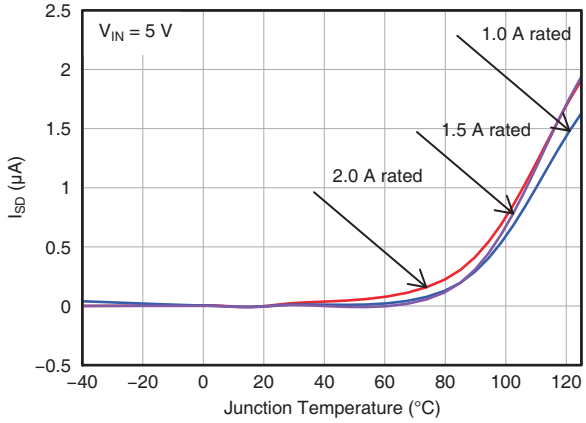


Figure 28. Supply Current (Device Disable) - I_{SD} vs Temperature

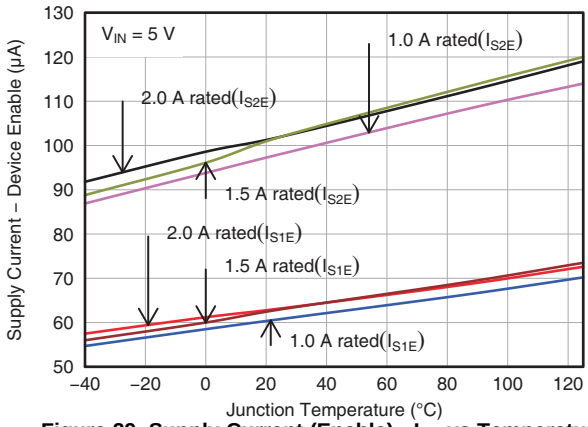


Figure 29. Supply Current (Enable) - I_{SE} vs Temperature

DETAILED DESCRIPTION

OVERVIEW

The TPS20xxC dual are current-limited, power-distribution switches providing between 1 A and 2 A of continuous load current in 5-V circuits. These parts use N-channel MOSFETs for low resistance, maintaining output voltage load regulation. They are designed for applications where short circuits or heavy capacitive loads will be encountered. Device features include UVLO, ON/OFF control (Enable), reverse blocking when disabled, output discharge when disabled, overcurrent protection, over-temperature protection, and deglitched fault reporting. They are pin for pin with existing *TI Switch Portfolio*.

UNDERVOLTAGE LOCKOUT (UVLO)

The undervoltage lockout (UVLO) circuit disables the power switch when the input voltage is below the UVLO threshold. Built-in hysteresis prevents unwanted on/off cycling due to input voltage drop from large current surges. $\overline{\text{FLTx}}$ is high impedance when the TPS20xxC dual is in UVLO.

ENABLE (ENx or $\overline{\text{ENx}}$)

The logic input of ENx or $\overline{\text{ENx}}$ disables all of the internal circuitry while maintaining the power switch OFF. The supply current of the device can be reduced to less than 1 µA when both switches are disabled. A logic low input on $\overline{\text{ENx}}$ or a logic high input on ENx enables the driver, control circuits, and power switch of corresponding channel.

The ENx or $\overline{\text{ENx}}$ input voltage is compatible with both TTL and CMOS logic levels. The $\overline{\text{FLTx}}$ is immediately cleared and the output discharge circuit is enabled when the device is disabled.

DEGLITCHED FAULT REPORTING

$\overline{\text{FLTx}}$ is an open-drain output that asserts (active low) during an overcurrent or overtemperature condition on each corresponding channel. The $\overline{\text{FLTx}}$ output remains asserted until the fault condition is removed or the channel is disabled. The TPS20xxC dual eliminates false $\overline{\text{FLTx}}$ reporting by using internal delay circuitry after entering or leaving an overcurrent condition. The “deglitch” time is typically 10 ms. This ensures that $\overline{\text{FLTx}}$ is not accidentally asserted under overcurrent conditions with a short time, such as starting into a heavy capacitive load. Over temperature conditions are not deglitched. The $\overline{\text{FLTx}}$ pin is high impedance when the device is disabled and in undervoltage lockout (UVLO). The fault circuits are independent so that another channel continues to operate when one channel is in a fault condition.

OVERCURRENT PROTECTION

The TPS20xxC dual responds to overloads by limiting each channel output current to the static I_{OS} levels shown in the *Electrical Characteristics* table. When an overload condition is present, the device maintains a constant current (I_{OS}) and reduces the output voltage accordingly, with the output voltage falling to (I_{OS} x R_{SHORT}). Three possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before voltage is applied to IN. The device senses over-current and immediately switches into a constant-current output. In the second condition, a short or an overload occurs while the device is enabled. At the instant a short -circuit occurs, high currents may flow for several microseconds (t_{IOS}) before the current-limit circuit reacts. The device operates in constant-current mode after the current-limit circuit has responded. In the third condition, the load is increased gradually beyond the recommended operating current. The current is permitted to rise until the current-limit threshold is reached. The devices are capable of delivering current up to the current-limit threshold without damage. Once the threshold is reached, the device switches into constant-current mode. For all of the above three conditions, the device may begin thermal cycling if the overcurrent condition persists.

OVERTEMPERATURE PROTECTION

The TPS20xxC dual includes per channel overtemperature protection circuitry, which activates at 135°C (min) junction temperature while in current limit. There is an overall thermal shutdown of 155°C (min) junction temperature when the TPS20xxC dual is not in current limit. The device remains off until the junction temperature cools 20°C and then restarts. Thermal shutdown may occur during an overload due to the relatively large power dissipation $[(V_{IN} – V_{OUT}) \times I_{OS}]$ driving the junction temperature up. The power switch cycles on and off until the fault is removed. This topology allows one channel to continue normal operation even if the other channel is in an over-temperature condition.

SOFTSTART, REVERSE BLOCKING AND DISCHARGE OUTPUT

The power MOSFET driver incorporates circuitry that controls the rise and fall times of the output voltage to limit large current and voltage surges on the input supply, and provides built-in soft-start functionality.

The TPS20xxC dual power switch will block current from OUT to IN when turned off by the UVLO or disabled.

The TPS20xxC dual includes an output discharge function on each channel. A 470Ω (typ.) discharge resistor will dissipate stored charge and leakage current on OUTx when the device is in UVLO or disabled. However as this circuit is biased from IN, the output discharge will not be active when IN voltage is close to 0 V.

APPLICATION INFORMATION

INPUT AND OUTPUT CAPACITANCE

Input and output capacitance improves the performance of the device. For all applications, a 0.1 µF or greater ceramic bypass capacitor between IN and GND is recommended as close to the device as possible for local noise de-coupling. The actual capacitance should be optimized for the particular application. This precaution reduces ringing on the input due to power-supply transients. Additional input capacitance may be needed on the input to reduce the overshoot voltage from exceeding the absolute maximum voltage of the device during heavy transients.

A 120 µF minimum output capacitance is required when implementing USB standard applications. Typically this uses a 150 µF electrolytic capacitor. If the application does not require 120 µF of output capacitance, a minimum of 10 µF ceramic capacitor on the output is recommended in order to reduce the transient negative voltage on OUTx pin caused by load inductance during a short circuit. The transient negative voltage should be less than 1.5 V for 10 µs.

POWER DISSIPATION AND JUNCTION TEMPERATURE

It is good design practice to estimate power dissipation and maximum expected junction temperature of the TPS20xxC dual. The system designer can control choices of package, proximity to other power dissipating devices, and printed circuit board (PCB) design based on these calculations. These have a direct influence on maximum junction temperature. Other factors such as airflow and maximum ambient temperature are often determined by system considerations.

Addition of extra PCB copper area around these devices is recommended to reduce the thermal impedance and maintain the junction temperature as low as practical.

The following procedure requires iteration because power loss is due to the two internal MOSFETs $2 \times I^2 \times r_{DS(on)}$, and $r_{DS(on)}$ is a function of the junction temperature. As an initial estimate, use the $r_{DS(on)}$ at 125°C from the typical characteristics, and the preferred package thermal resistance for the preferred board construction from the thermal parameters section.

$$T_J = T_A + [(2 \times I_{OUT}^2 \times r_{DS(on)} \times \theta_{JA}]$$

Where:

I_{OUT} = rated OUT pin current (A)
$r_{DS(on)}$ = Power switch on-resistance at an assumed T_J (Ω)
T_A = Maximum ambient temperature (°C)
T_J = Maximum junction temperature (°C)
θ_{JA} = Thermal resistance (°C/W)

If the calculated T_J is substantially different from the original assumption, look up a new value of $r_{DS(on)}$ and recalculate.

If the resulting T_J is not less than 125°C, try a PCB construction and/or package with lower θ_{JA}.

REVISION HISTORY

Changes from Original (October 2011) to Revision A **Page**

- Changed devices TPS2062C and TPS2066C MSOP-8 package From: Preview to Active 1
- Changed the I_{OS} current limit values for TPS2062C and 66C (1 A). 3
- Changed the I_{OS} current limit values for TPS2062C/66C (1 A). 4

Changes from Revision A (March 2012) to Revision B **Page**

- Changed device TPS2060C MSOP-8 package From: Preview to Active 1

Changes from Revision B (March 2012) to Revision C **Page**

- Changed devices TPS2062C and TPS2066C SOIC-8 package From: Preview to Active 1
- Changed the TPS2062C and 66C $r_{DS(on)}$ D package TYP value From: 84 to 90 mΩ and added the MAX value 3
- Changed the TPS2062C and 66C $r_{DS(on)}$ D package TYP value From: 84 to 90 mΩ 4

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)
TPS2002CDRCR	PREVIEW	SON	DRC	10	3000	TBD	Call TI	Call TI	
TPS2002CDRCT	PREVIEW	SON	DRC	10	250	TBD	Call TI	Call TI	
TPS2003CDRCR	PREVIEW	SON	DRC	10	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
TPS2003CDRCT	PREVIEW	SON	DRC	10	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
TPS2060CDGN	ACTIVE	MSOP-PowerPAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2060CDGNR	ACTIVE	MSOP-PowerPAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2062CD	PREVIEW	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPS2062CDGN	ACTIVE	MSOP-PowerPAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2062CDGNR	ACTIVE	MSOP-PowerPAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2062CDR	PREVIEW	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPS2064CDGN	ACTIVE	MSOP-PowerPAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2064CDGNR	ACTIVE	MSOP-PowerPAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2066CD	PREVIEW	SOIC	D	8	75	TBD	Call TI	Call TI	
TPS2066CDGN	ACTIVE	MSOP-PowerPAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2066CDGNR	ACTIVE	MSOP-PowerPAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	
TPS2066CDR	PREVIEW	SOIC	D	8	2500	TBD	Call TI	Call TI	

(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.

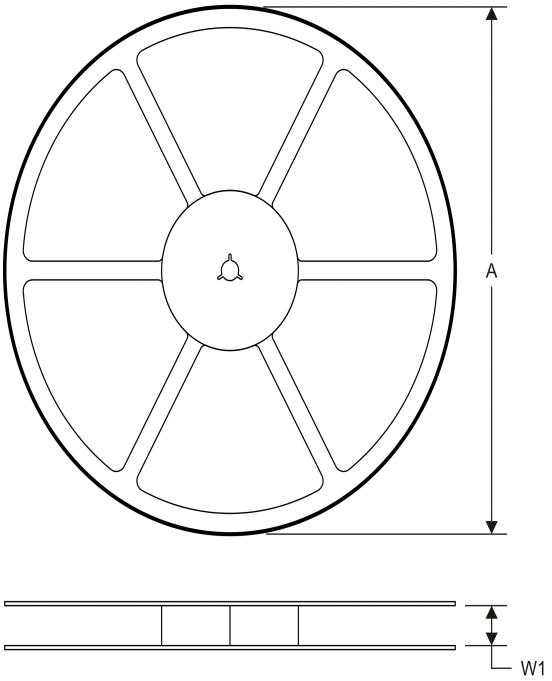
OBSOLETE: TI has discontinued the production of the device.

(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)

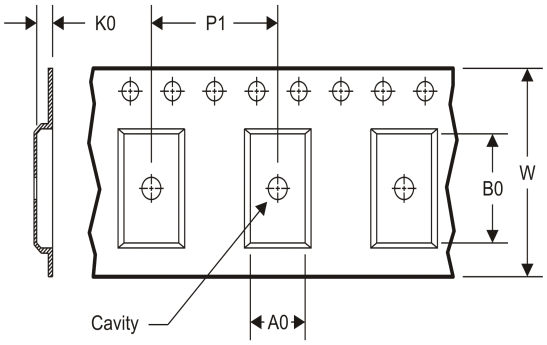
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



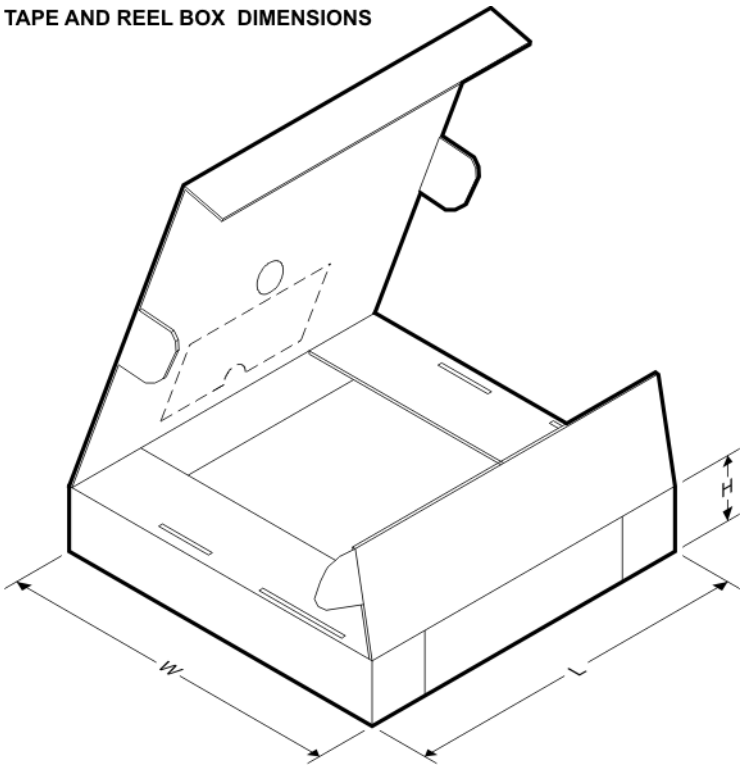
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
TPS2060CDGNR	MSOP-Power PAD	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS2062CDGNR	MSOP-Power PAD	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS2064CDGNR	MSOP-Power PAD	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS2066CDGNR	MSOP-Power PAD	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

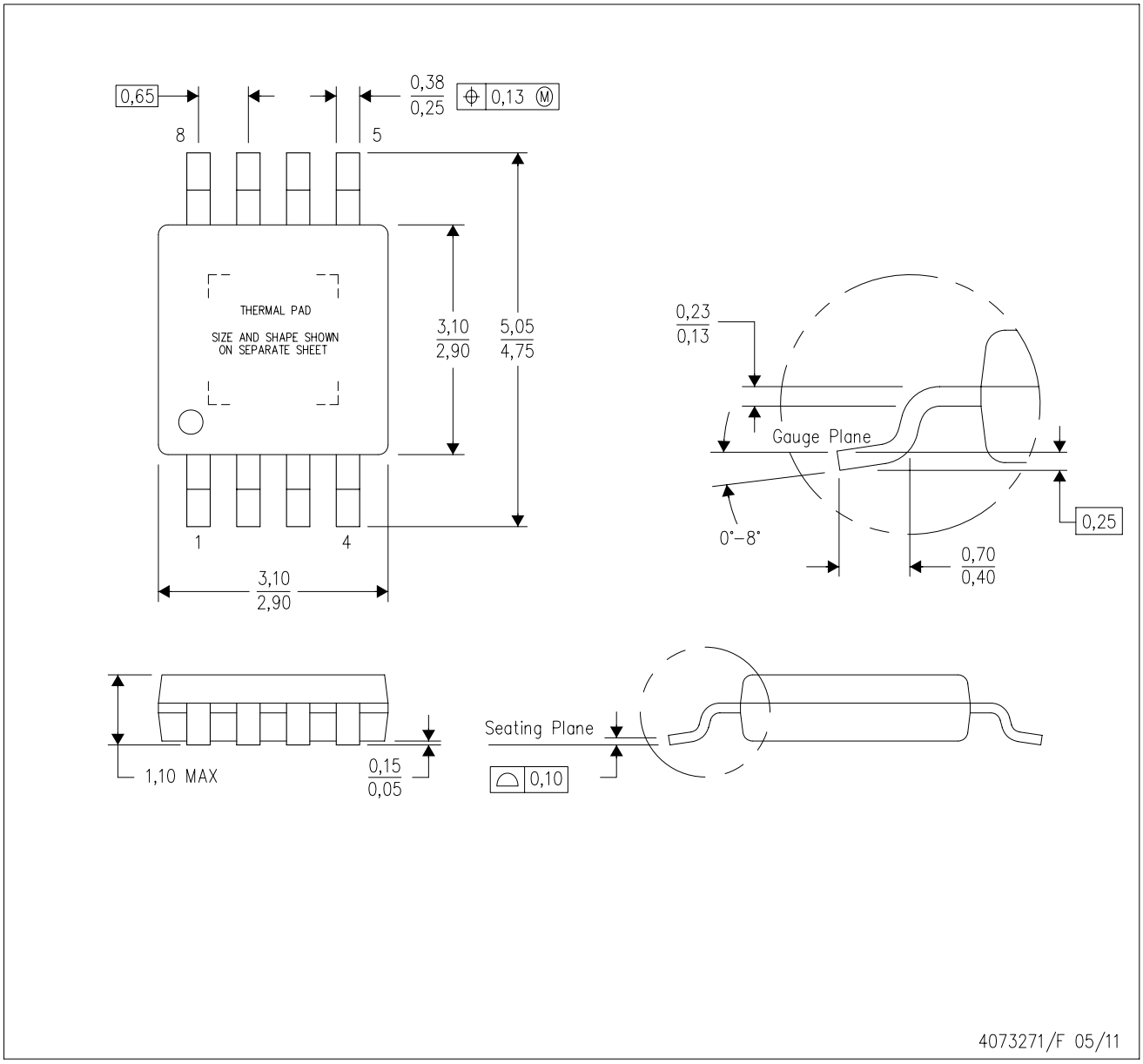
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS2060CDGNR	MSOP-PowerPAD	DGN	8	2500	364.0	364.0	27.0
TPS2062CDGNR	MSOP-PowerPAD	DGN	8	2500	364.0	364.0	27.0
TPS2064CDGNR	MSOP-PowerPAD	DGN	8	2500	360.0	162.0	98.0
TPS2066CDGNR	MSOP-PowerPAD	DGN	8	2500	364.0	364.0	27.0

DGN (S–PDSO–G8) PowerPAD™ PLASTIC SMALL OUTLINE



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.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Falls within JEDEC MO–187 variation AA–T

PowerPAD is a trademark of Texas Instruments.

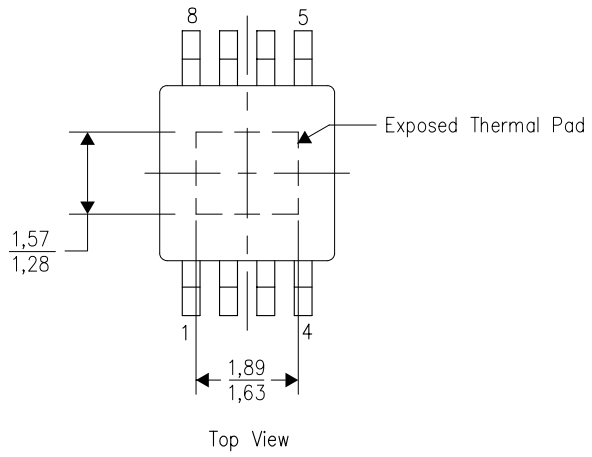
DGN (S–PDSO–G8) PowerPAD™ PLASTIC SMALL OUTLINE

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached to a printed circuit board (PCB). The thermal pad must be soldered directly to the PCB. After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



Top View

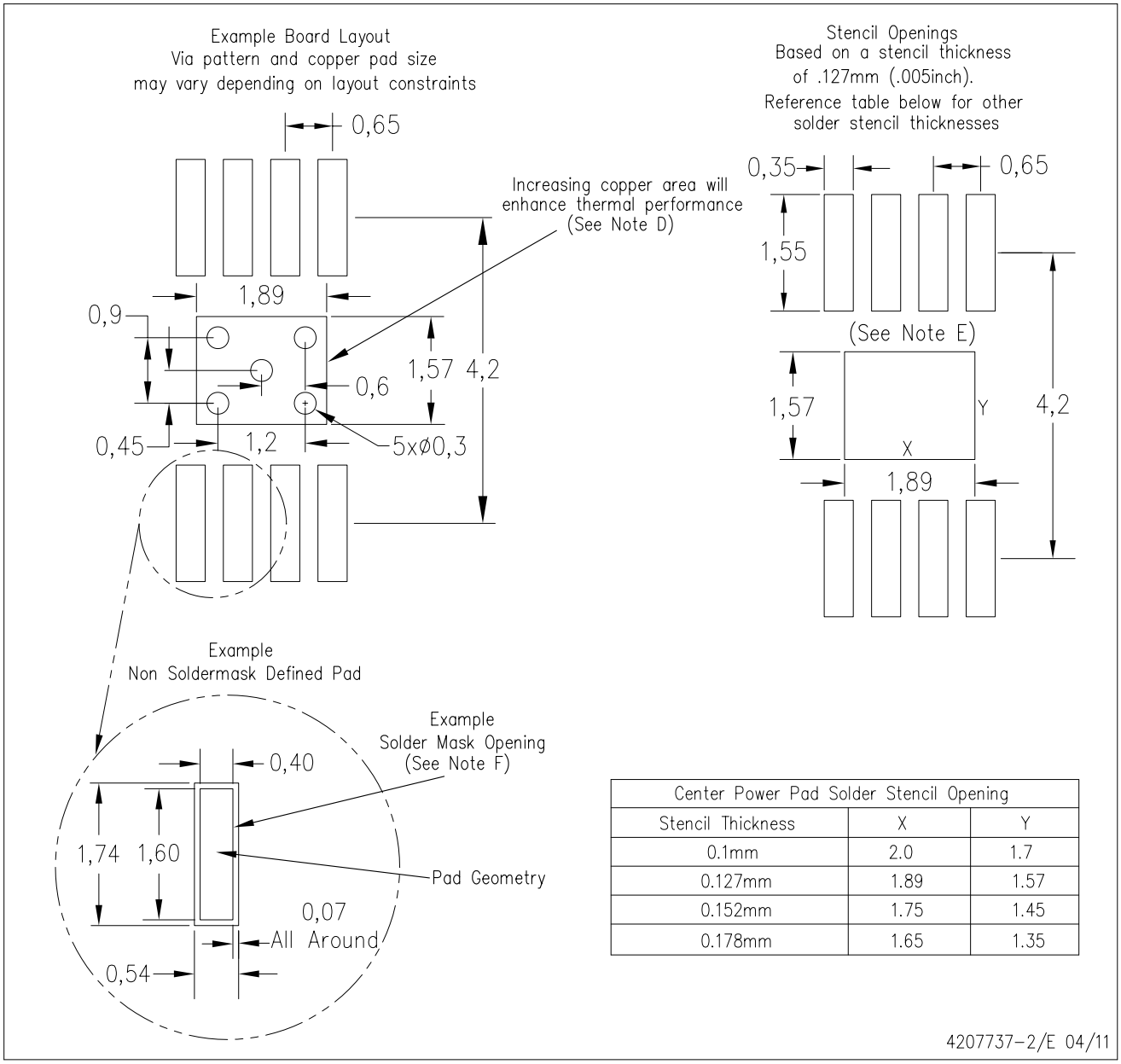
Exposed Thermal Pad Dimensions

4206323–2/I 12/11

NOTE: All linear dimensions are in millimeters

PowerPAD is a trademark of Texas Instruments

DGN (R–PDSO–G8) PowerPAD™ PLASTIC SMALL OUTLINE

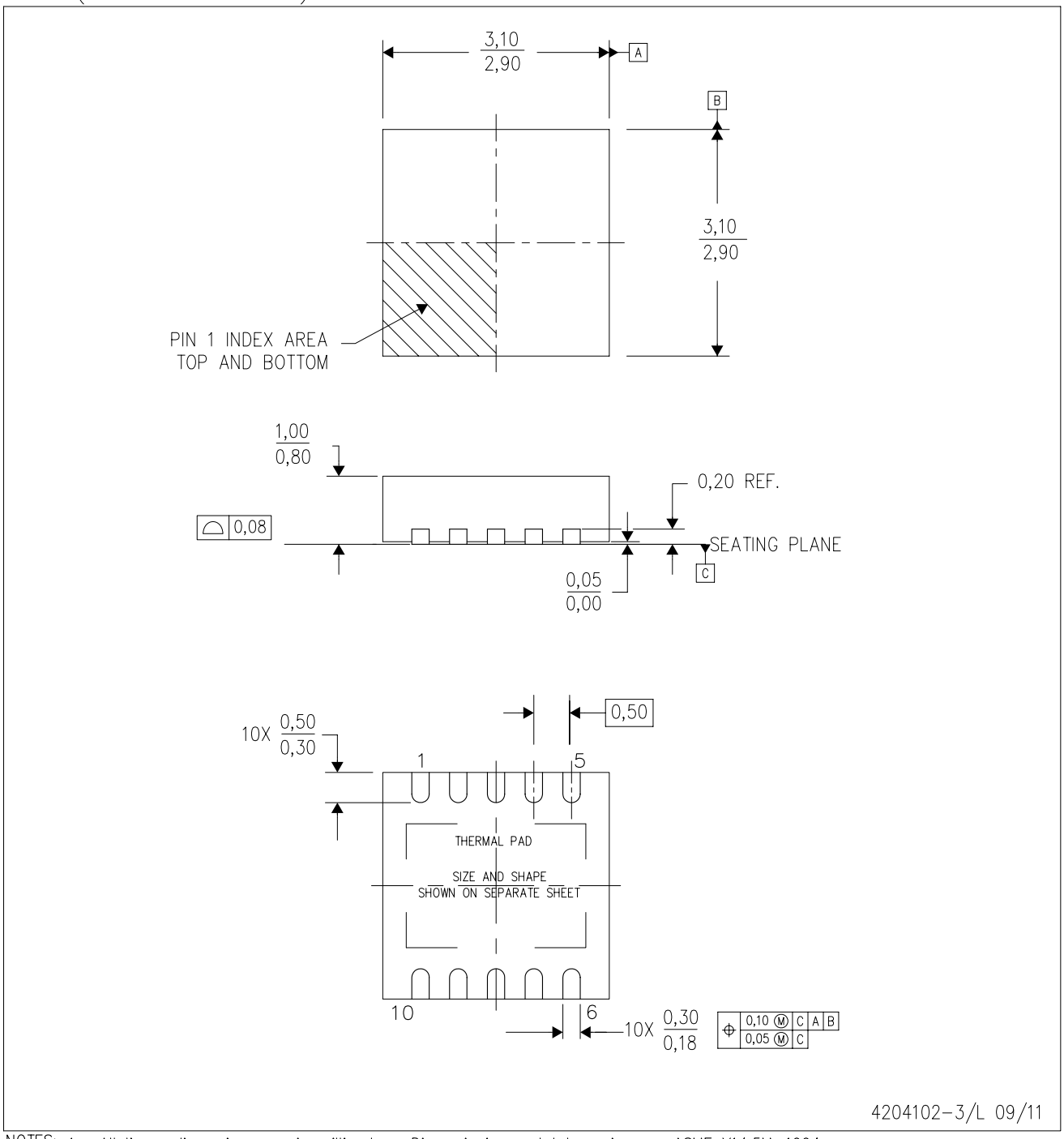


Center Power Pad Solder Stencil Opening		
Stencil Thickness	X	Y
0.1mm	2.0	1.7
0.127mm	1.89	1.57
0.152mm	1.75	1.45
0.178mm	1.65	1.35

4207737–2/E 04/11

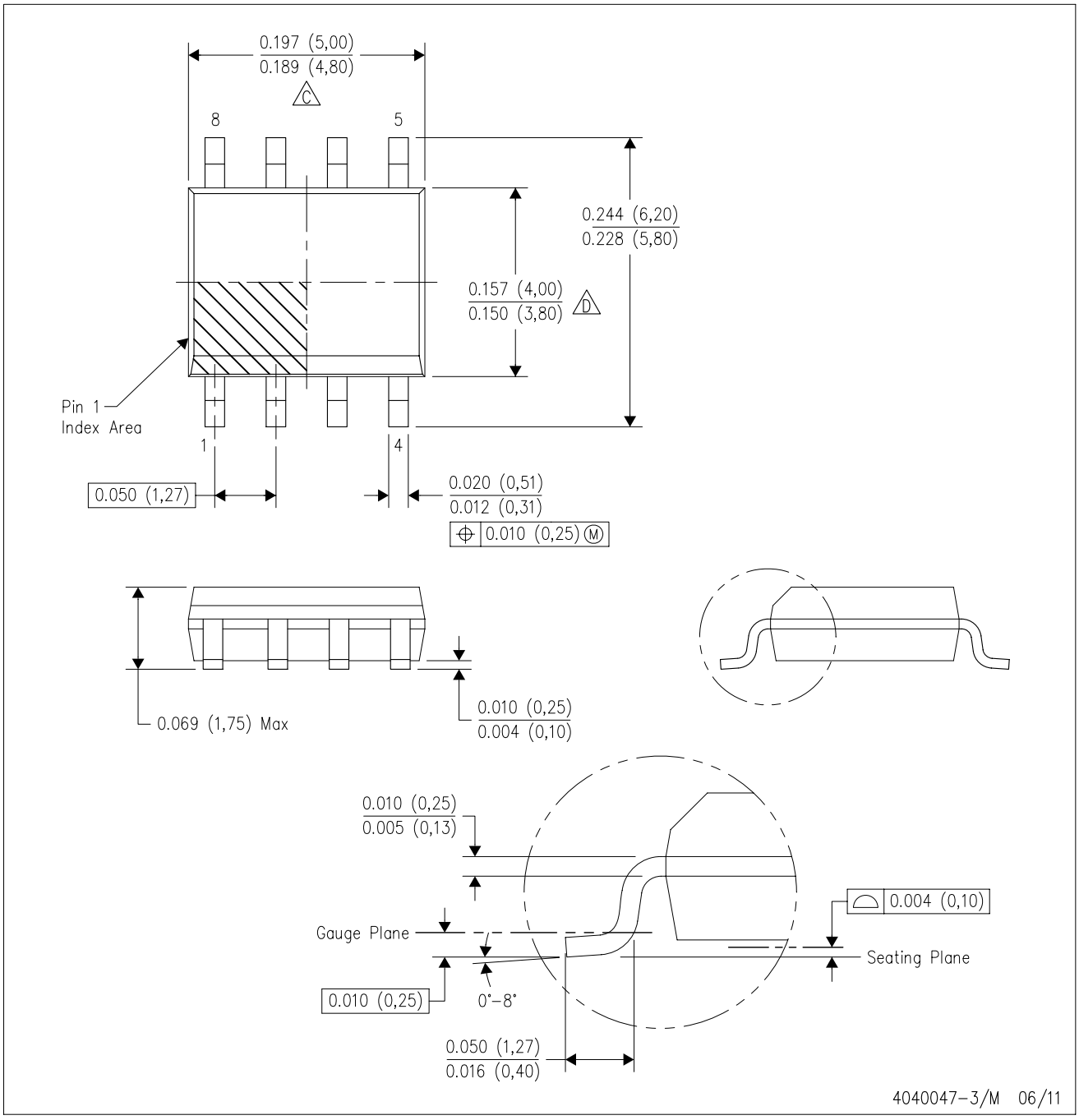
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>. 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.
F. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DRC (S–PVSON–N10) PLASTIC SMALL OUTLINE NO–LEAD



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Small Outline No–Lead (SON) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance, if present.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions, if present

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AA.

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