

3-V to 20-V High-Current Load Switch

Check for Samples: [TPS2590](#)

FEATURES

- Integrated Pass MOSFET
- 3-V to 20-V Bus Operation
- Programmable Fault Timer
- Programmable Fault Current
- Programmable Hard Current Limit
- Fast Disable
- Thermal Shutdown
- Load Fault Alert
- Latching and Auto-retry Operation
- 4-mm x 4-mm QFN
- -40°C to 125°C Junction Temperature Range
- UL Listed - File Number E169910

APPLICATIONS

- RAID Arrays
- Telecommunications
- Plug-In Circuit Boards
- Disk Drive
- Notebooks / Netbooks

DESCRIPTION

The TPS2590 provides highly integrated hot-swap power management and superior protection in applications where the load is powered by voltages between 3.0 V and 20 V. This device is intended for systems where a voltage bus must be protected to prevent load shorts from interrupting or damaging other system components. The TPS2590 is in a 16-pin QFN package.

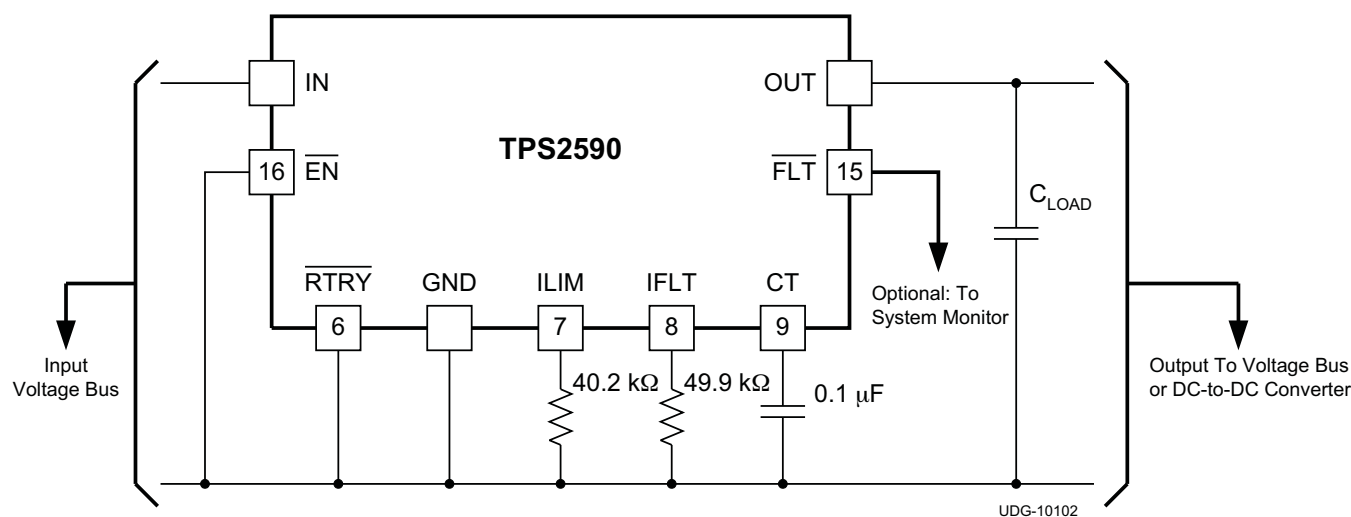
The TPS2590 has multiple programmable protection features. Load protection is accomplished by a non-current limiting fault threshold, a hard current limit threshold, and a fault timer. The dual current thresholds allow the system to draw high current for short periods without causing a voltage droop at the load. An example of this is a disk drive startup. This technique is ideal for loads that experience brief high demand, but benefit from protection levels consistent with average current draw.

Hotswap MOSFET protection is provided by power limit circuitry which protects the internal MOSFET against SOA related failures.

The TPS2590 provides a fault indicator output and allows latch off or retry on fault.

12-V, 3.5-A Application

Figure 1.



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2009–2011, Texas Instruments Incorporated

ORDERING INFORMATION

DEVICE	JUNCTION TEMPERATURE	PACKAGE	ORDERING CODE	MARKING
TPS2590	-40°C to 125°C	RSA (4-mm x 4-mm QFN)	TPS2590RSA	TPS2590

ABSOLUTE MAXIMUM RATINGSover operating free-air temperature range (unless otherwise noted) ⁽¹⁾ ⁽²⁾

		UNIT
Input voltage range IN, OUT	-0.3 to 25	V
Voltage range $\overline{FLT}$	-0.3 to 20	
Voltage IFAULT, ILIM	1.75	
Voltage CT	3.0	
Output sink current $\overline{FLT}$	10	mA
Input voltage range, $\overline{EN}$	-0.3 to 6	V
Input current, $\overline{RTRY}$ ($\overline{RTRY}$ internally clamped to 3 V) $\overline{RTRY} = 0$ V	35	uA
Voltage range CT ⁽³⁾ , IFLT ⁽³⁾ , ILIM ⁽³⁾ , $\overline{RTRY}$	-0.3 to 3	V
ESD rating, HBM	2.5 k	
ESD rating, CDM	400	
Operating junction temperature range, T _J	Internally Limited	°C
Storage temperature range, T _{stg}	-65 to 150	

(1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to GND.

(3) Do not apply voltage to pin.

DISSIPATION RATINGS ⁽¹⁾ ⁽²⁾ ⁽³⁾ ⁽⁴⁾

PACKAGE	θ_{JA} LOW K, °C/W	θ_{JA} HIGH K, °C/W	θ_{JA} BEST 4, °C/W
RSA	211	55	50

(1) Tested per JEDEC JESD51, natural convection. The definitions of high-k and low-k are per JESD 51-7 and JESD 51-3.

(2) Low-k (2 signal - no plane, 3 in. by 3 in. board, 0.062 in. thick, 1 oz. copper) test board with the pad soldered, and an additional 0.12 in. of top-side copper added to the pad.

(3) High-k is a (2 signal – 2 plane) test board with the pad soldered.

(4) The best case thermal resistance is obtained using the recommendations per SLMA002A (2 signal - 2 plane with the pad connected to the plane).

RECOMMENDED OPERATING CONDITIONS

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

PARAMETER	MIN	NOM	MAX	UNIT
Input voltage range IN, OUT	3		20	V
Voltage range $\overline{EN}$	0		5	
Voltage range $\overline{FLT}$	0		20	
Output sink current $\overline{FLT}$	0		1	mA
Voltage range $\overline{RTRY}$	0		3	V
CCT	100 p		10 m	F
Junction temperature	-40		125	°C

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
IN						
	UVLO	V _{IN} ↑	2.6	2.85	2.9	V
		Hysteresis		150		mV
	Bias current	$\overline{\text{EN}} = 2.4 \text{ V}$		25	100	μA
		$\overline{\text{EN}} = 0 \text{ V}$		3.9	5	mA
OUT						
	RON	R _{VIN-VOUT} , I _{VOUT} < I _{RLIM} or I _{VOUT} < (I _{SET} × 1.25), 1 A ≤ I _{VOUT} ≤ 4.5 A		29.5	42.0	mΩ
	Power limit	V _{IN} : 12 V, C _{OUT} = 1000 μF, $\overline{\text{EN}}$: 3 V → 0 V	3	5	7.5	W
	Reverse diode voltage	V _{OUT} > V _{IN} , $\overline{\text{EN}} = 5 \text{ V}$, I _{IN} = - 1 A		0.77	1.0	V
IFLT						
I _{FLT}	Fault current threshold	I _{VOUT} ↑, I _{CT} : sinking → sourcing, pulsed test (R _{RFLT} = 200 kΩ)	0.8	1	1.2	A
		I _{VOUT} ↑, I _{CT} : sinking → sourcing, pulsed test (R _{RFLT} = 100 kΩ)	1.8	2	2.2	
		I _{VOUT} ↑, I _{CT} : sinking → sourcing, pulsed test (R _{RFLT} = 49.9 kΩ)	3.6	4	4.4	
ILIM						
	Current limit program I _{VOUT} , V _{VIN-VOUT} = 0.3 V, pulsed test	R _{RLIM} = 100 kΩ	1.6	2	2.4	A
		R _{RLIM} = 66.5 kΩ	2.6	3	3.4	
		R _{RLIM} = 40.2 kΩ	4.6	5	5.4	
CT						
	Charge/discharge current	I _{CT} sourcing, V _{CT} = 1 V	29	35	41	μA
		I _{CT} sinking, V _{CT} = 1 V	1.0	1.4	1.8	
	Threshold voltage	V _{CT} ↑	1.3	1.4	1.5	V
		V _{CT} ↓	0.1	0.16	0.3	
	ON/OFF fault duty cycle	V _{VOUT} = 0 V	2.8	3.7	4.6	%

ELECTRICAL CHARACTERISTICS (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$\overline{\text{EN}}$						
	Threshold voltage	$V_{\overline{\text{EN}}} \downarrow$	0.8	1.0	1.5	V
		Hysteresis	50	150	250	mV
	Input bias current	$V_{\overline{\text{EN}}} = 2.4 \text{ V}$ (sinking)	-1.5	0	0.5	μA
		$V_{\overline{\text{EN}}} = 0.2 \text{ V}$ (sourcing)	-2	1	0.5	
	Turn on propagation delay	$V_{\text{IN}} = 3.3 \text{ V}$, $I_{\text{LOAD}} = 1 \text{ A}$, $V_{\overline{\text{EN}}} : 2.4 \text{ V} \rightarrow 0.2 \text{ V}$, $V_{\text{OUT}}: \uparrow$ 90% $\times V_{\text{IN}}$		350	500	μs
	Turn off propagation delay	$V_{\text{IN}} = 3.3 \text{ V}$, $I_{\text{LOAD}} = 1 \text{ A}$, $V_{\overline{\text{EN}}} : 0.2 \text{ V} \rightarrow 2.4 \text{ V}$, $V_{\text{OUT}}: \downarrow$ 10% $\times V_{\text{IN}}$		10	20	
$\overline{\text{FLT}}$						
	VOUT LOW	$V_{\text{CT}} = 1.8 \text{ V}$, $I_{\overline{\text{FLT}}} = 1 \text{ mA}$		0.2	0.4	V
	Leakage current	$V_{\overline{\text{FLT}}} = 18 \text{ V}$			1	μA
$\overline{\text{RTRY}}$						
	Low threshold voltage	Auto Retry Mode			0.8	V
	High threshold	Latch mode	2.0			
	Input bias current	$V_{\overline{\text{RTRY}}} = 3.0 \text{ V}$	-1.0	0.2	1.0	mA
		$V_{\overline{\text{RTRY}}} = 0.2 \text{ V}$	-50	-25	0	
Thermal Shutdown						
	Thermal shutdown	T_{J}		160		$^{\circ}\text{C}$
		Hysteresis		10		

DEVICE INFORMATION

TPS2590 Functional Block Diagram

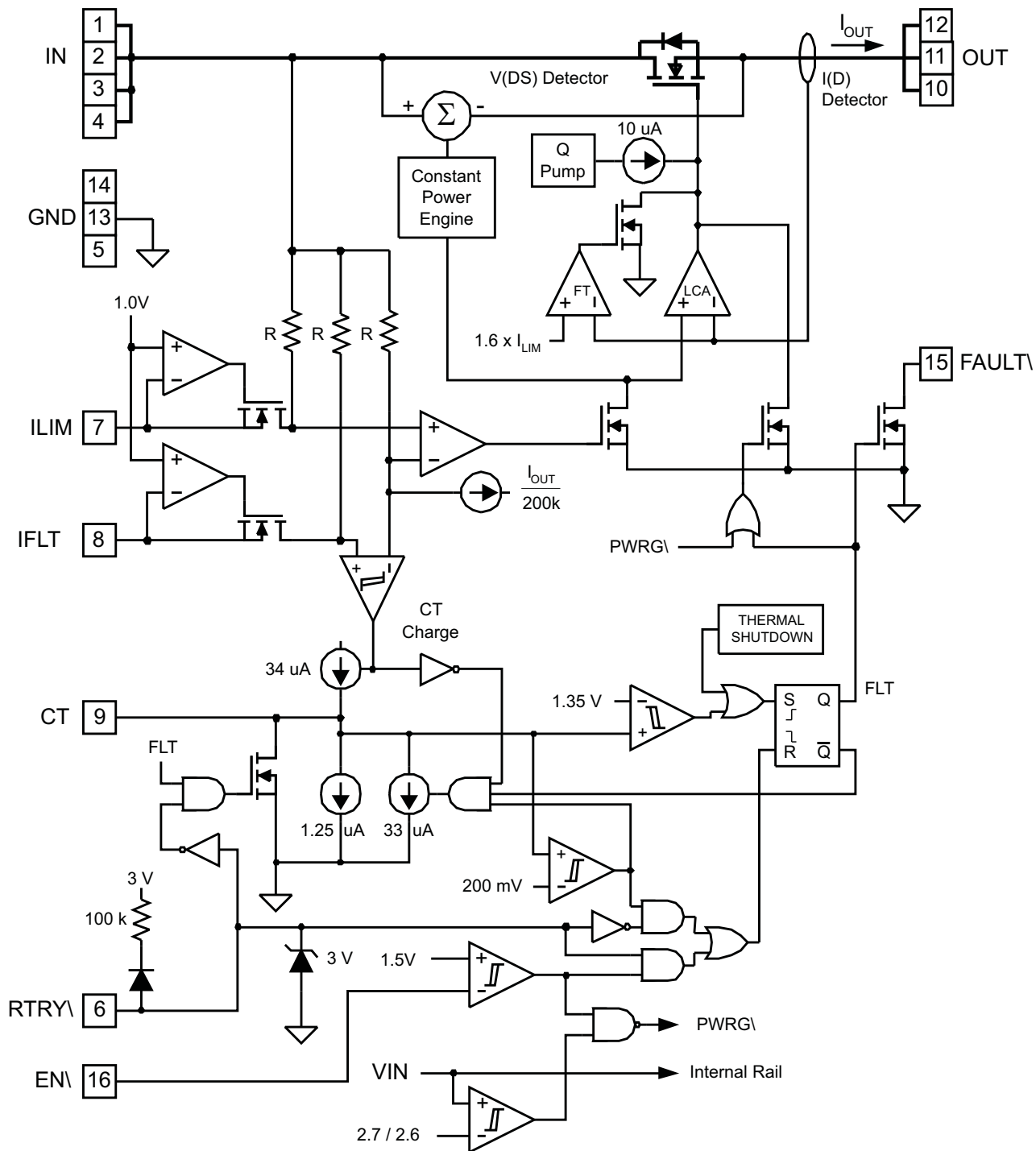
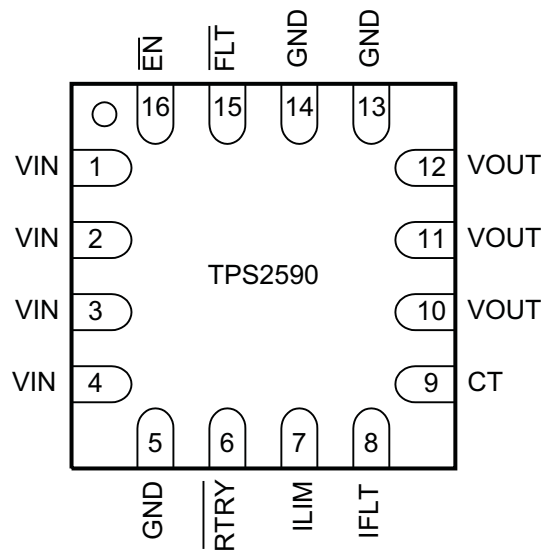


Figure 2.

TPS2590 PINOUT



TERMINAL FUNCTIONS

FUNCTION	TPS2590	DESCRIPTION
$\overline{\text{EN}}$	16	Device is enabled when this pin is pulled low.
IN	1-4	Power In and control supply voltage.
$\overline{\text{RTRY}}$	6	If low, the TPS2590 will attempt to restart after an overcurrent fault. If floating (high) the device will latch off after an overcurrent fault and will not attempt to restart until EN or Vin is cycled off and on.
ILIM	7	A resistor to ground sets the current limit level.
IFLT	8	A resistor to ground sets the fault current level.
CT	9	A capacitor to ground sets the fault time.
GND	5, 13, 14	GND
OUT	10, 11, 12	Output to the load.
$\overline{\text{FLT}}$	15	Fault low indicated the fault time has expired and the FET is switched off.

PIN DESCRIPTION

CT: Connect a capacitor from CT to GND to set the fault time. The fault timer starts when the fault current threshold is exceeded, charging the capacitor with 36 μA from GND towards an upper threshold of 1.4 V. If the capacitor reaches the upper threshold, the internal pass MOSFET is turned off. The MOSFET will stay off until EN is cycled if a latching version is used. If an auto-retry version is used, the capacitor will discharge at 5 μA to 0.2 V and then re-enable the pass MOSFET. When the device is disabled, CT is pulled to GND through a 100-k Ω resistor.

The timer period must be chosen long enough to allow the external load capacitance to charge. The fault timer period is selected using the following formula where T_{FAULT} is the minimum timer period in seconds and C_{CT} is in Farads.

$$C_{\text{CT}} = \frac{T_{\text{FAULT}}}{38.9 \times 10^3} \quad (1)$$

This equation does not account for component tolerances. In autoretry versions, the second and subsequent retry timer periods will be approximately 85 % as long as the first retry period.

In autoretry versions, the fault timer discharges the capacitor for a nominal t_{SD} in seconds with C_{CT} in Farads per the following equation.

$$t_{SD} = 1.0 \times 10^6 \times C_{CT} \quad (2)$$

The nominal ratio of on-to-off times represents about a 3% duty cycle when a hard fault is present on the output of an autoretry version part.

FLT: Open-drain output that pulls low on any condition that causes the output to open. These conditions are either an overload with a fault time-out, or a thermal shutdown. FLT becomes operational before UV, when VIN is greater than 1 V. IFLT may not be set below 1 A to maintain the Fault Current Limit threshold accuracy listed in Electrical Characteristics. Some parts may not current limit or fault as expected.

GND: This is the most negative voltage in the circuit and is used as reference for all voltage measurements unless otherwise specified.

IFLT: A resistor connected from this pin to ground sets the fault current threshold (I_{FAULT}). Currents between the fault current threshold and the current limit are permitted to flow unimpeded for the period set by the fault timer programmed on CT. This permits loads to draw momentary surges while maintaining the protection provided by a lower average-current limit.

The fault timer implemented by CT starts charging CT when current through V_{IN} exceeds I_{FAULT} . If the current doesn't drop below the I_{FAULT} level before V_{CT} reaches its upper threshold, the output will be shut off. The fault current resistor is set by the following formula where I_{FAULT} is in Amperes and R_{RFLT} is in Ohms.

$$R_{RFLT} = \frac{200k\Omega}{I_{FAULT}} \quad (3)$$

ILIM: A resistor connected from this pin to ground sets I_{LIM} . The TPS2590 will limit current to I_{LIM} . If the current doesn't drop below the I_{FAULT} level before the timer times out then the output will be shut off. R_{LIM} is set by the formula:

$$R_{LIM} = \frac{201k\Omega}{I_{LIM}} \quad (4)$$

I_{LIM} must be set sufficiently larger than I_{FAULT} to ensure that I_{LIM} could never be less than I_{FAULT} , even after taking tolerances into account.

EN: When this pin is pulled low, the IC is enabled. The input threshold is hysteretic, allowing the user to program a startup delay with an external RC circuit. EN is pulled to VIN by a 10-MΩ resistor, pulled to GND by 16.8 MΩ and is clamped to ground by a 7-V Zener diode. Because high impedance pullup/down resistors are used to reduce current draw, any external FET controlling this pin should be low leakage.

IN: Input voltage to the TPS2590. The recommended operating voltage range is 3 V to 18 V. All VIN pins should be connected together and to the power source.

OUT: Output connection for the TPS2590. When switched on the output voltage will be approximately:

$$V_{OUT} = V_{IN} - 0.04 \times I_{OUT} \quad (5)$$

All OUT pins should be connected together and to the load.

RTRY: When pulled low the TPS2590 will attempt to restart after a fault. If left floating or pulled high the TPS2590 will latch off after a fault. This pin is internally clamped at 3 V and is pulled to the internal 3-V supply by a diode in series with a 100-kΩ resistor.

TYPICAL CHARACTERISTICS

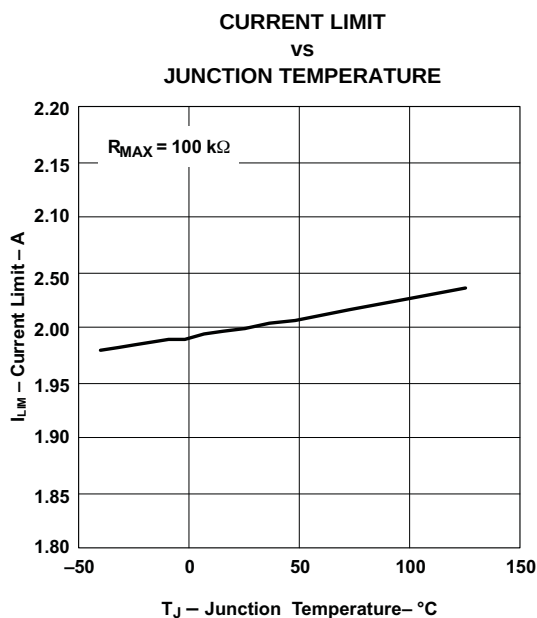


Figure 3.

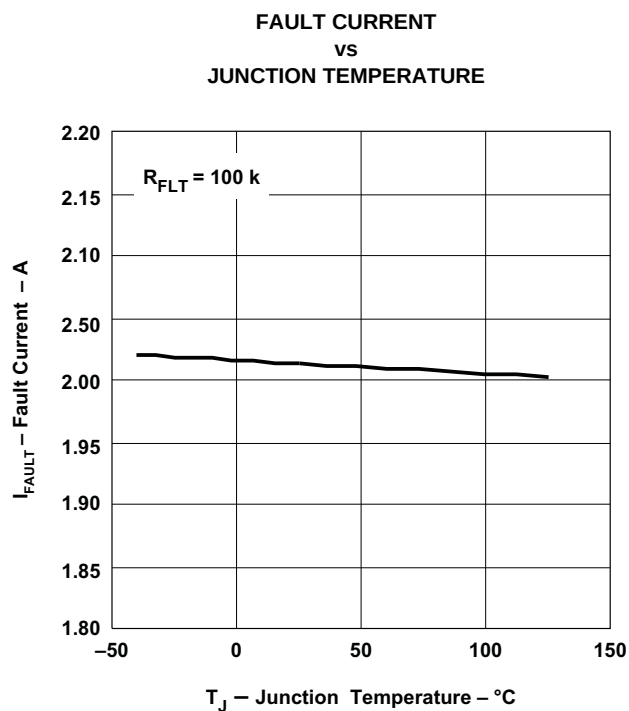


Figure 4.

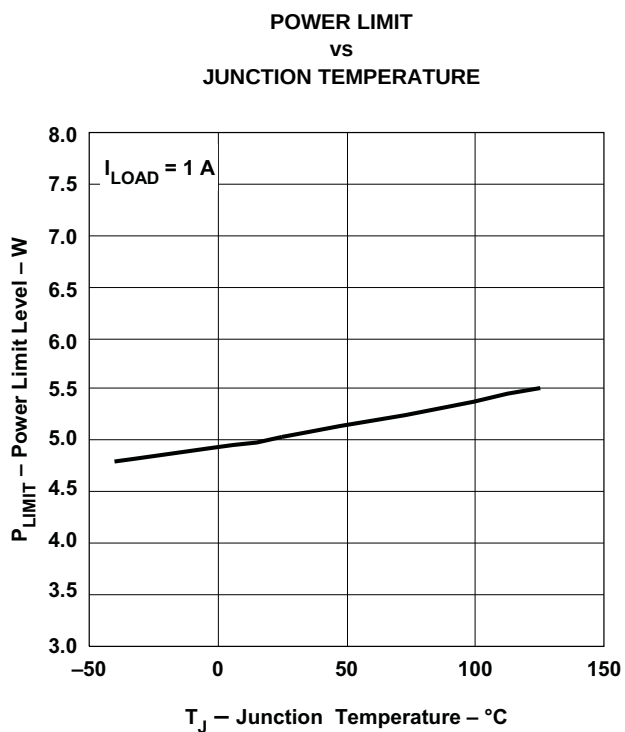


Figure 5.

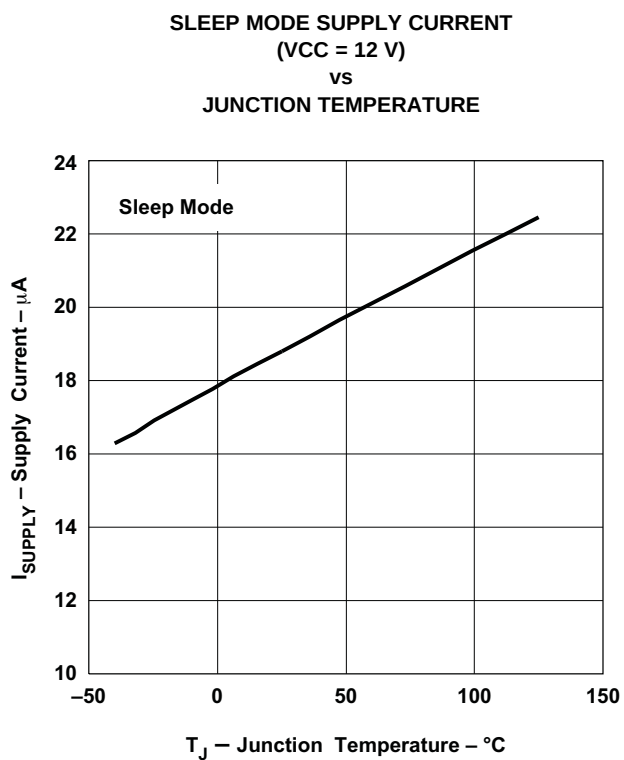


Figure 6.

TYPICAL CHARACTERISTICS (continued)

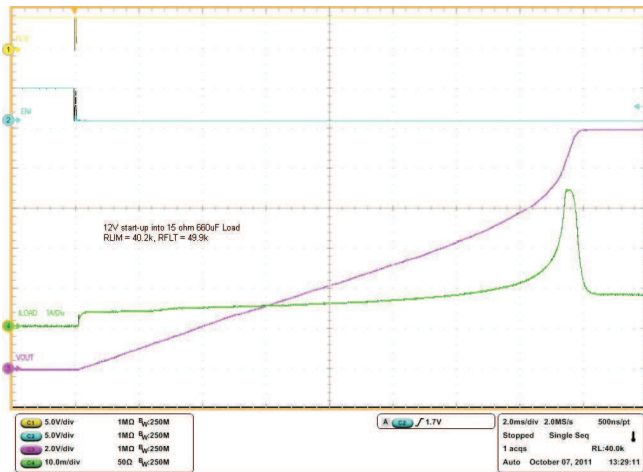


Figure 7. 12-V Startup into 15-Ω, 700-μF Load

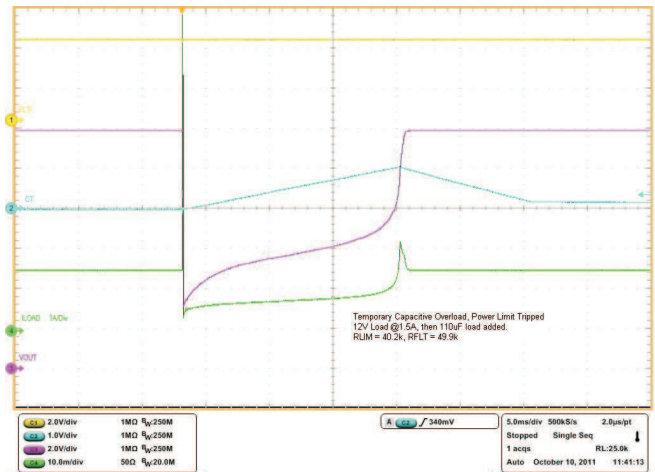


Figure 8. 12-V Input Added to an 8-Ω Load

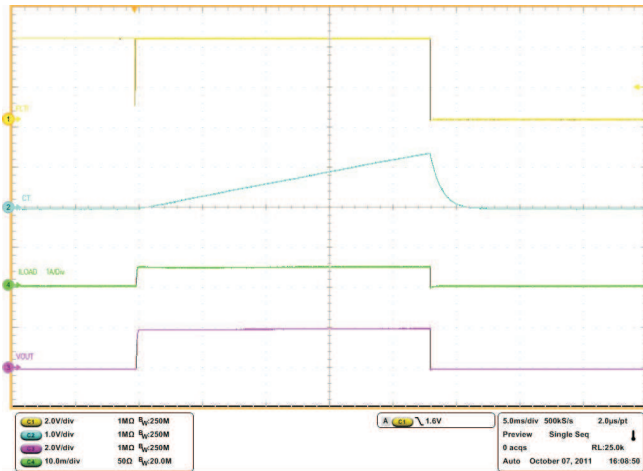


Figure 9. Failed Startup into a 4-Ω Load

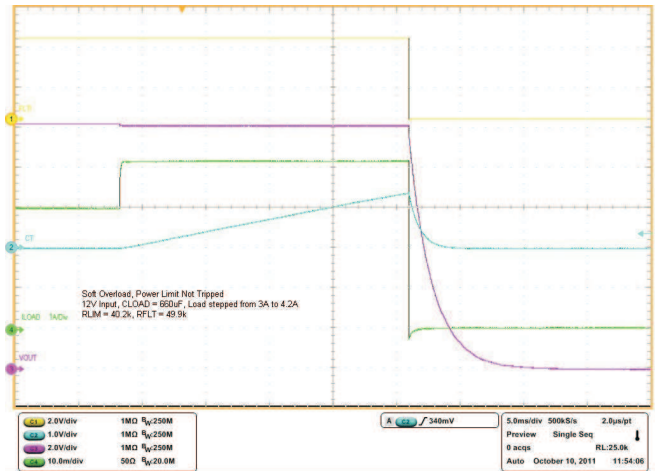


Figure 10. 12-V Soft Overload, 3-A to 4.2-A, Power Limit Not Tripped

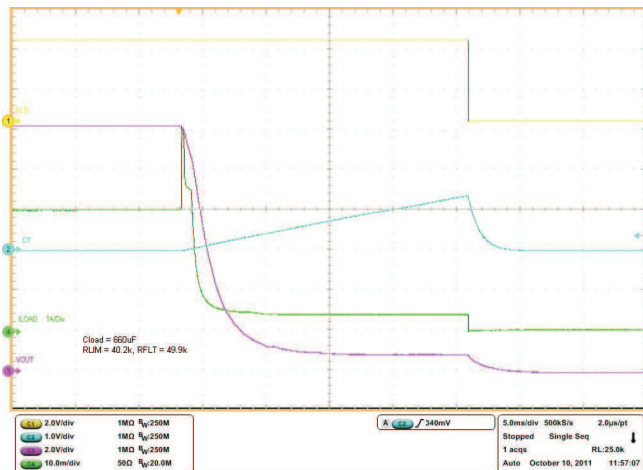


Figure 11. Firm Overload, 3-A to 5.4 A, Power Limit Tripped

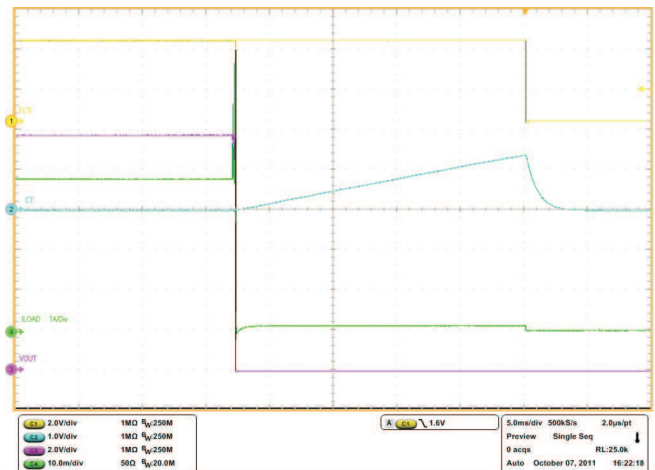


Figure 12. 12-V Hard Overload, 3.6-A Load then Short

TYPICAL CHARACTERISTICS (continued)

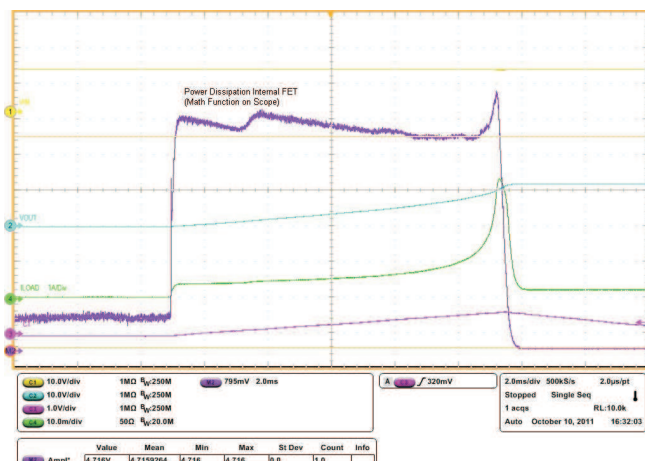


Figure 13. Power Dissipation During 12-V Startup into a 60-Ω, 660-μF Load

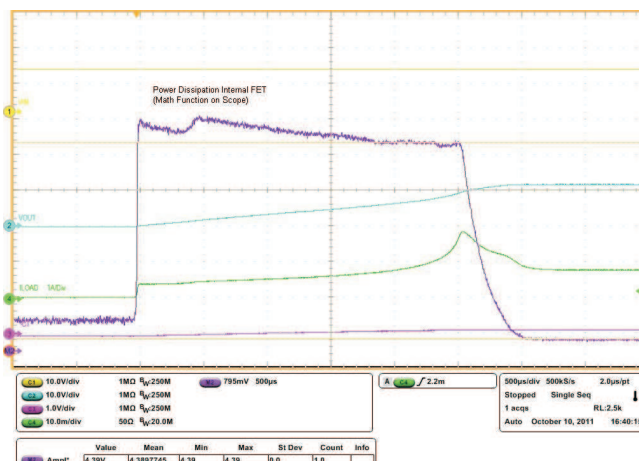


Figure 14. Power Dissipation During 12-V Startup into a 15-Ω, 110-μF Load

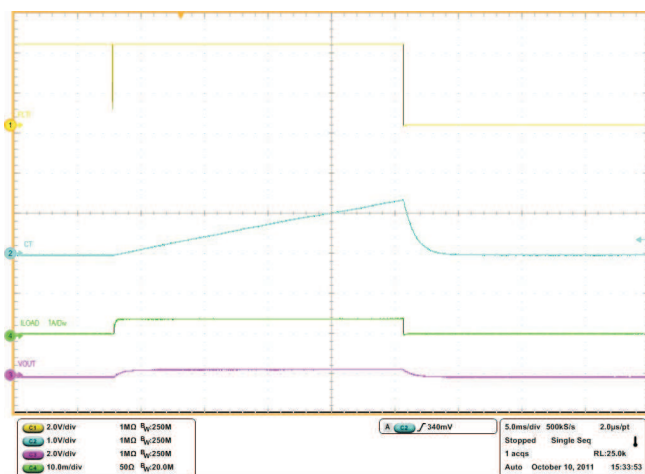


Figure 15. Startup into a 1-Ω Load

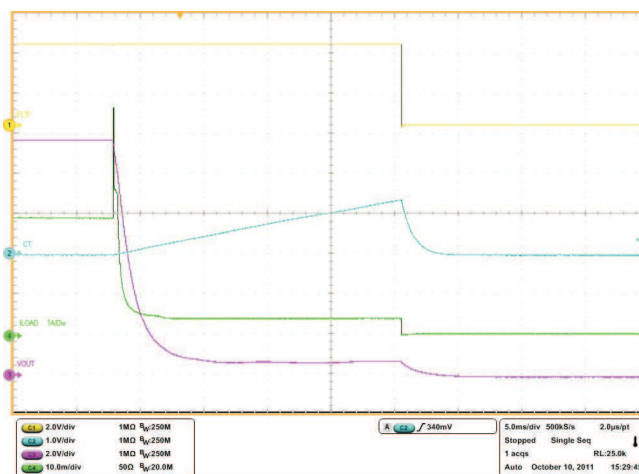


Figure 16. Firm Overload, Load Stepped From 3.8 A to 5.5 A

TYPICAL CHARACTERISTICS (continued)

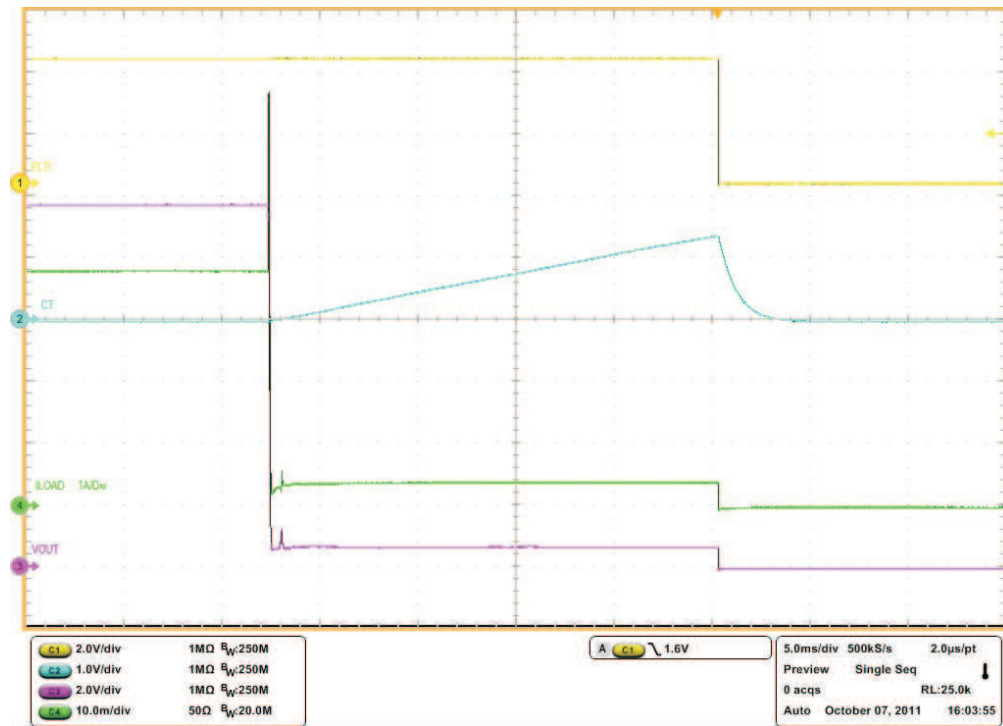


Figure 17. Hard Overload, Load Stepped from 3.8 A to 7.1 A

APPLICATION INFORMATION

Maximum Load at Startup

The power limiting function of the TPS2590 provides very effective protection for the internal FET. Expectedly, there is a supply voltage dependent maximum load which the device will be able to power up. Loads above this level may cause the device to shut off current before startup is complete. Neglecting any load capacitance, the maximum load (minimum load resistance) is calculated using the equation;

$$R_{\text{MIN}} = \frac{V_{\text{IN}}^2}{12} \quad (6)$$

Adding load capacitance may reduce the maximum load which can be present at start up.

If $\overline{\text{EN}}$ is tied to GND at startup and IN does not ramp quickly the TPS2590 may momentarily turn off then on during startup. This can happen if a capacitive load momentarily pulls down the input voltage below the UV threshold. If necessary, this can be avoided by delaying EN assertion until VIN is fully up.

Transient Protection

The need for transient protection in conjunction with hot-swap controllers should always be considered. When the TPS2590 interrupts current flow, input inductance generates a positive voltage spike on the input and output inductance generates a negative voltage spike on the output. Such transients can easily exceed twice the supply voltage if steps are not taken to address the issue. Typical methods for addressing transients include;

- Minimizing lead length/inductance into and out of the device.
- Transient Voltage Suppressors (TVS) on the input to absorb inductive spikes.
- Schottky diode across the output to absorb negative spikes.
- A combination of ceramic and electrolytic capacitors on the input and output to absorb energy.

The following equation estimates the magnitude of these voltage spikes:

Where;

$$V_{\text{SPIKE(absolute)}} = V_{\text{NOM}} + I_{\text{LOAD}} \times \sqrt{\frac{L}{C}} \quad (7)$$

- V_{NOM} equals the nominal supply voltage.
- I_{LOAD} equals the load current.
- C equals the capacitance present at the input or output of the TPS2590.
- L equals the effective inductance seen looking into the source or the load.

The inductance due to a straight length of wire equals approximately.

Where;

$$L_{\text{straightwire}} \approx 0.2 \times L \times \ln\left(\frac{4 \times L}{D} - 0.75\right) \text{ (nH)} \quad (8)$$

- L equals the length of the wire.
- D equals wire diameter.

Some applications may require the addition of a TVS to prevent transients from exceeding the absolute ratings if sufficient capacitance cannot be included.

REVISION HISTORY

Changes from Original (July 2009) to Revision A	Page
Changed , fixed typo in Application 1	1
Changes from Revision A (July 2010) to Revision B	Page
- Added UL Listed - File Number E169910 1 - Changed , updated application diagram 1	1
Changes from Revision B (August 2010) to Revision C	Page
- Added updated IFLT description 7 - Changed Current Limit vs Junction Temperature graph 8	7 8
Changes from Revision C (September 2011) to Revision D	Page
- Changed Figure 7 through Figure 17. 8 - Changed Figure 7 through Figure 17. 9 - Changed Figure 7 through Figure 17. 10 - Changed Figure 7 through Figure 17. 11	8 9 10 11

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)
TPS2590RSAR	ACTIVE	QFN	RSA	16	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
TPS2590RSAT	ACTIVE	QFN	RSA	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	

⁽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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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

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
TPS2590RSAR	QFN	RSA	16	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
TPS2590RSAT	QFN	RSA	16	250	180.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

TAPE AND REEL BOX DIMENSIONS

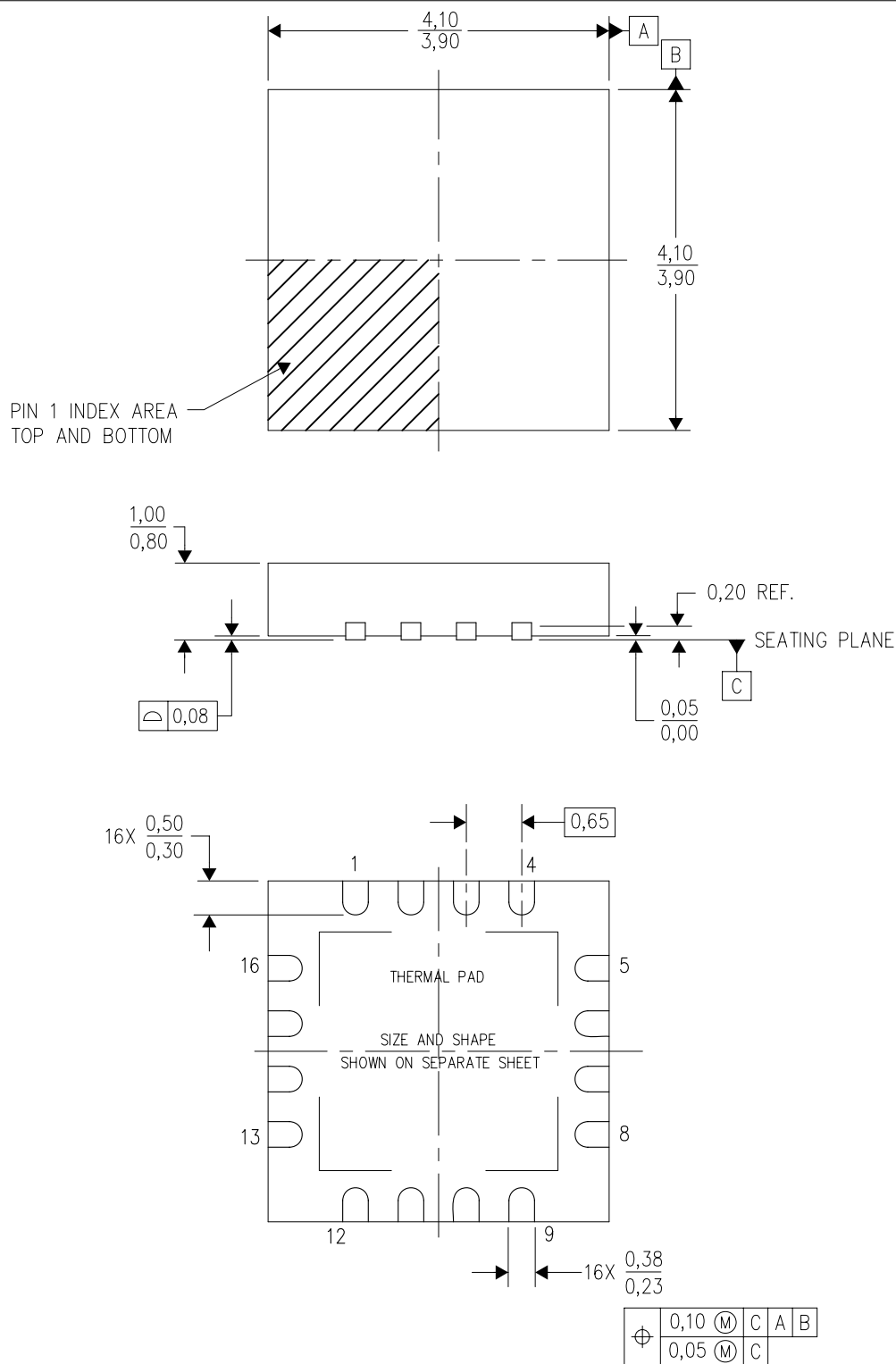


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS2590RSAR	QFN	RSA	16	3000	367.0	367.0	35.0
TPS2590RSAT	QFN	RSA	16	250	210.0	185.0	35.0

RSA (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4205141/D 06/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - Quad Flatpack, No-leads (QFN) package configuration.
 - The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - Falls within JEDEC MO-220.

RSA (S-PVQFN-N16)

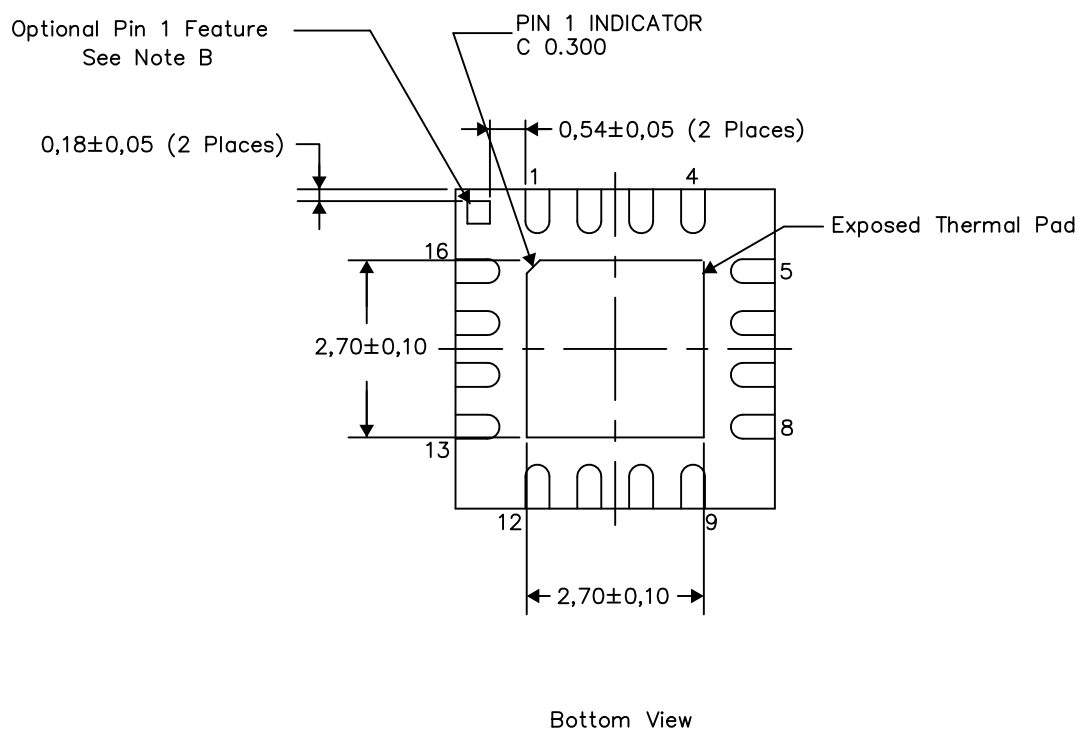
PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (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 information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

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



Exposed Thermal Pad Dimensions

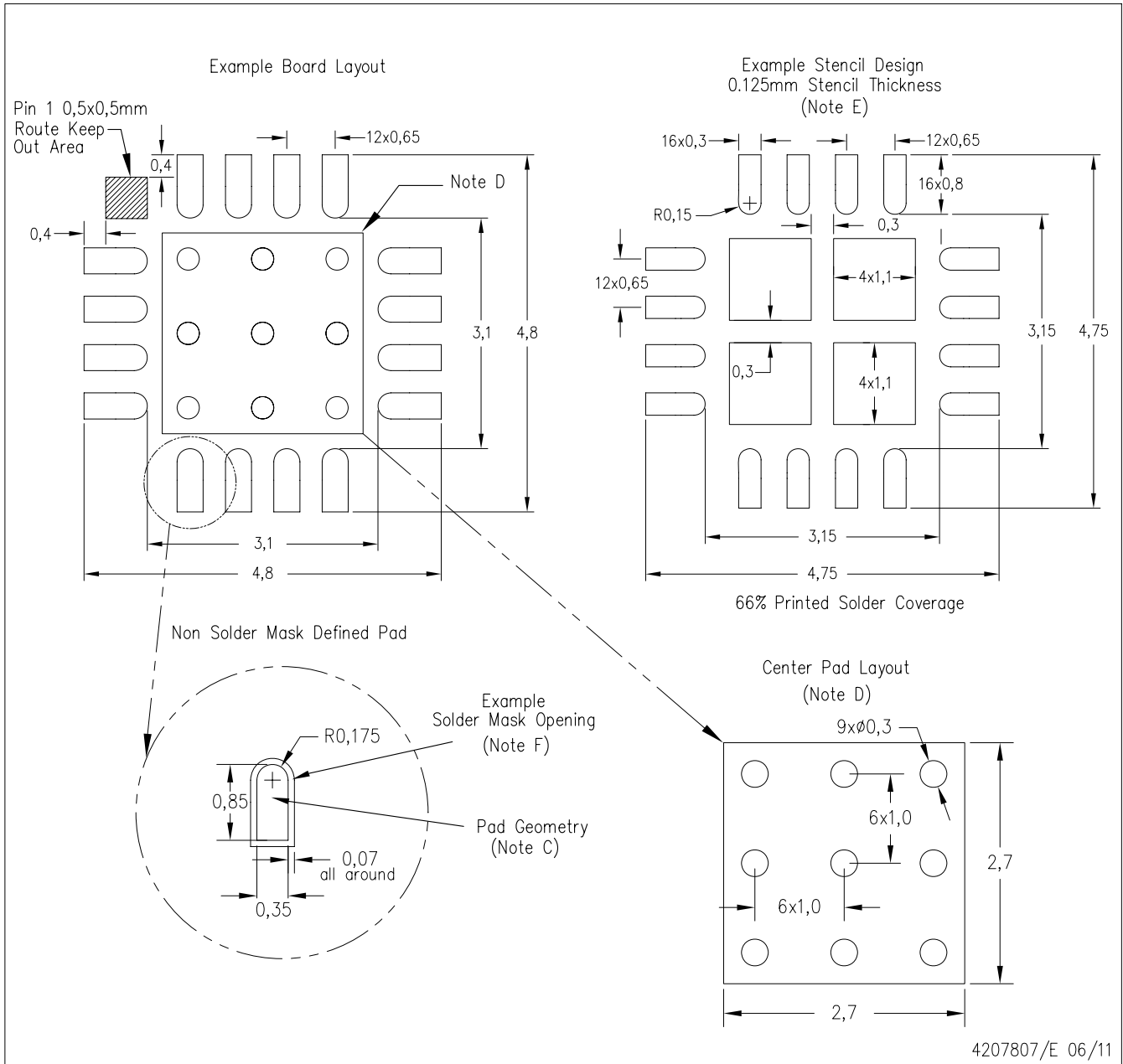
4206364/L 08/12

NOTES:

- A. All linear dimensions are in millimeters
- B. The Pin 1 Identification mark is an optional feature that may be present on some devices
In addition, this Pin 1 feature if present is electrically connected to the center thermal pad and therefore should be considered when routing the board layout.

RSA (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN Packages, Texas Instruments Literature No. SLUA271, 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>>.
 - 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. Refer to IPC 7525 for stencil design considerations.
 - F. Customers should contact their board fabrication site for solder mask tolerances.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46C and to discontinue any product or service per JESD48B. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community e2e.ti.com