PERICOM®

PI5PD2560/2561

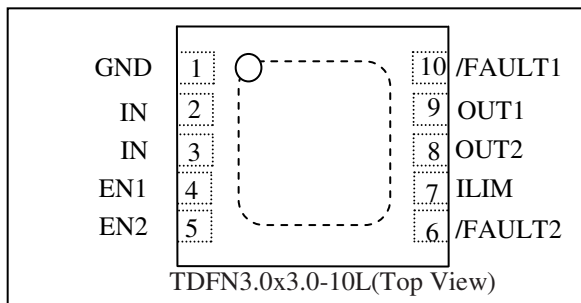# Dual Channel, Adjustable Current -Limited Power Switch

Features

- Two separate current limiting channels
- Meets USB Current-Limiting Requirement
- ±7.5% Current-Limit Accuracy at 2.8A
- Adjustable Current Limit, 250mA-2.8A (typ)
- Fast Over-current Response - 3.5μS (typ)
- 44mΩ High-Side MOSFET
- Operating Range: 2.5 V to 5.5V
- 2μA Maximum Standby Supply Current
- Reverse Input-Output Voltage Protection
- Built-in Soft-Start
- 15 kV / 8 kV System-Level ESD Capable
- Device Package: TDFN 3x3-10L
- UL Listed – File No. E341484
- CB Certified

Applications

- USB Ports/Hubs
- Digital TV
- Set-Top Boxes
- VOIP Phones
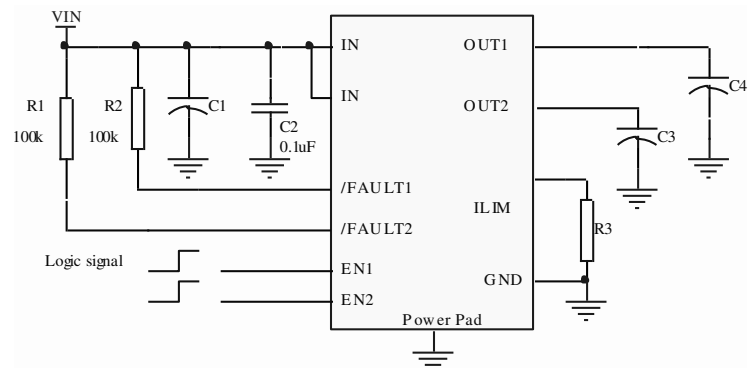
Pin Configuration

TDFN3.0x3.0-10L(Top View)

Description

The PI5PD2560/2561 is dual-channel power-distribution switch intended for applications where precision current limiting is required or heavy capacitive loads and short circuits are encountered. These devices offer a programmable current-limit threshold between 250 mA and 2.8A (typ) per channel via an external resistor. The power-switch rise and fall times are controlled to minimize current surges during turn on/off.

Each channel of the PI5PD2560/2561 devices limit the output current to a safe level by switching into a constant-current mode when the output load exceeds the current-limit threshold.

The FAULTx logic output for each channel independently asserts low during over-current or over temperature.

Typical Application Circuit

Pin Description

Pin No.	Pin Name		Type	Description
	PI5PD2560	PI5PD2561		
1	GND		-	Ground.
2, 3	IN		I	Power input voltage.
4	/EN1	EN1	I	Enable input, logic low/high turns on channel one power switch.
5	/EN2	EN2	I	Enable input, logic low/high turns on channel two power switch.
6	/FAULT2		O	Active-low open-drain output, asserted during over-current or over-temperature condition occur on channel 2
7	ILIM		I	External resistor used to set current-limit threshold; recommended 20 kΩ ≤ RILIM ≤ 187 kΩ.
8	OUT2		O	Power switch output for channel two
9	OUT1		O	Power switch output for channel one
10	/FAULT1		O	Active-low open-drain output, asserted during over-current or over-temperature condition occur on channel 1

Maximum Ratings

Storage Temperature	-65°C to +150°C
Supply Voltage to Ground Potential	-0.5V to +6.0V
DC Input Voltage	-0.5V to V$_{DD}$+0.5V
Voltage range from IN to OUTx	-0.5V to +6.0V
Control Input Voltage (VINx)	-0.5V to +6.0V
Continuous total power dissipation[1]	2400mW
Continuous FAULTx sink current	25mA
Power Dissipation	0.5W
ESD: HBM Mode	4000V
CDM Mode	500V
ESD-system level (contact/air)	8kV/15kV

Note:

1. Stresses greater than those listed under MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

2. The JEDEC high-K (2s2p) board used to derive this data was a 3in × 3in, multilayer board with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom of the board.

Recommended operation conditions

Symbol	Parameter		Conditions	Min	Typ	Max	Unit
V$_{IN}$	Input Voltage		-	2.5	-	5.5	V
V$_{ENx}$	Input Voltage	PI5PD2560	-	0	-	5.5	V
V/$_{ENx}$		PI5PD2561	-	0	-	5.5	
V$_{IH}$	High-level input voltage on ENx		-	1.1	-	-	V
V$_{IL}$	Low-level input voltage on ENx		-	-	-	0.66	V
I$_{OUTx}$	Continuous output current per channel, OUTx		-	0	-	2.5	A
I$_{FAULTx}$	Continuous /FAULTx sink current		-	-	-	10	mA
R$_{ILIM}$	Recommended resistor limit range		-	20	-	187	kΩ
T$_A$	Operating Temperature Range		-	-40	-	85	ºC

DC Electrical Characteristics

$V_{I(IN)}$= 5.0V; T_A=-40°C to +85°C; unless otherwise specified.

Sym	Description	Test Conditions[1]		Min	Typ	Max	Unit
Power Switch							
$R_{DS(on)}$	Static drain-source on-state resistance	-		-	44	70	mΩ
t_r	Rise time, output	$V_{I(IN)}$ = 5.0V	$C_L = 1\mu F$, $R_L = 100\Omega$	1	2	4	ms
		$V_{I(IN)}$ = 2.5V		0.5	1	3	
t_f	Fall time, output	$V_{I(IN)}$ = 5.0V		0.3	0.5	1.0	
		$V_{I(IN)}$ = 2.5V		0.2	0.4	0.6	
t_{IOS}	Response time to short circuit	V_{IN} = 5.0 V	-	-	3.5	-	µs
Enable ENx							
V_{IH}	High-level input voltage	$2.5\ V \le V_{I(IN)} \le 5.5\ V$		1.1	-	-	V
V_{IL}	Low-level input voltage	$2.5\ V \le V_{I(IN)} \le 5.5\ V$		-	-	0.6	
t_{on}	Turn on time	$C_L = 1\mu F, R_L = 100\Omega$		-	-	5	ms
t_{off}	Turn off time			-	-	2	
Current Limit							
I_{OS}	Current-limit threshold @ $V_{OUTx} = V_{IN} * 0.8$	R_{ILIM}=20kΩ		2590	2800	3005	mA
		R_{ILIM}=61.9kΩ		800	900	1005	
		R_{ILIM}=100kΩ		400	560	645	
I_{OC_TRIP}	Overcurrent trip threshold	V_{IN} = 5 V, current ramp ($\le$ 100 A/s) on OUT ,RILIM=20.0kΩ		2700	3160	3600	
		V_{IN} = 5 V, current ramp ($\le$ 100 A/s) on OUT ,RILIM=100kΩ		450	650	800	
t_{IOS}	Response time to short circuit	V_{IN} = 5.0V		-	3.5	-	µs
Supply Current							
I_{STB}	Input supply current at output disable	No load on OUT, V_{EN}=disable T_A =25°C		-	0.1	2	µA
I_{SS}	Input supply current at output enable	No load on OUT, V_{EN}=5.0V , T_A =25°C	R_{ILIM}=20kΩ	-	100	125	
			R_{ILIM}=100kΩ	-	85	110	
I_{REV}	Reverse Leakage Current	V_{OUTx}=5.5V, V_{IN}=0V， T_A=25°C		-	0.01	1.0	
Under Voltage Lockout							
UVLO	Low-level input voltage	V_{IN} Rising		-	2.35	2.45	V
	Hysteresis for low-level input voltage	T_A=25°C		-	35	-	mV
/FAULTx FLAG							
V_{OL}	Output low voltage	$I_{/FAULTx}$ =1mA		-	-	180	mV
I_{OFF}	Off-state leakage	$V_{/FAULTx}$ =5.5V		-	-	1	µA
T_D	/FAULTx deglitch	FAULTx assertion or de-assertion due to over-current condition		4	9	15	ms
Thermal Shutdown							
OTSD2	Thermal shutdown threshold	-		-	155	-	°C
OTSD	Thermal shutdown threshold in current-limit	-		-	135	-	
	Hysteresis	-		-	20	-	

Note:

Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.
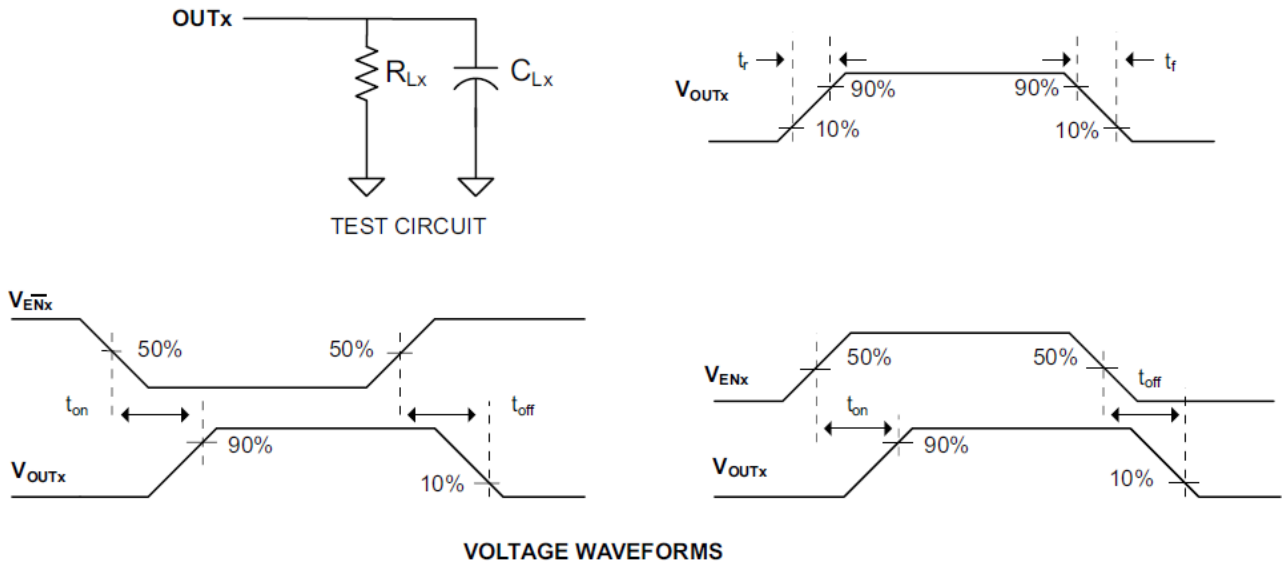
PARAMETER MEASUREMENT INFORMATION

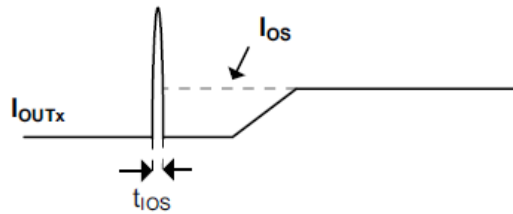**Figure1 Test Circuit and Voltage Waveforms**

Figure2 Response Time to Short Circuit Waveform
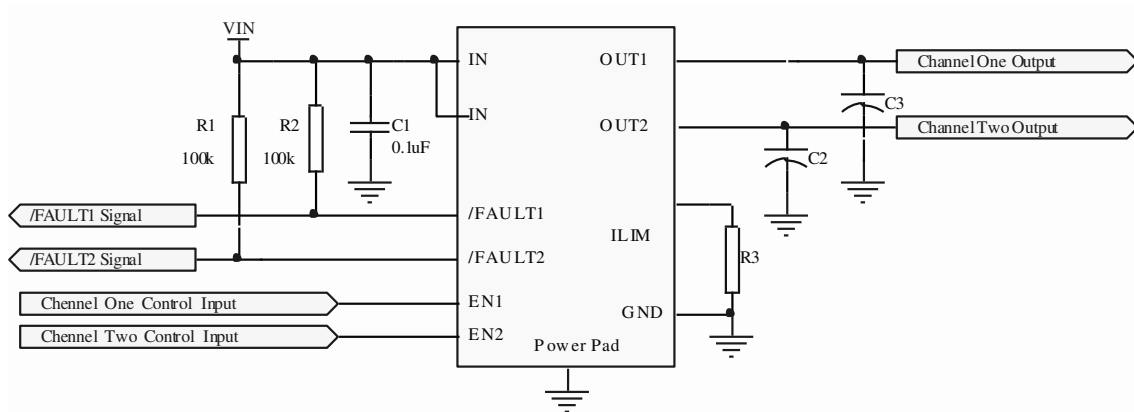
TYPICAL CHARACTERISTICS

Figure3. Typical Characteristics Reference Schematic
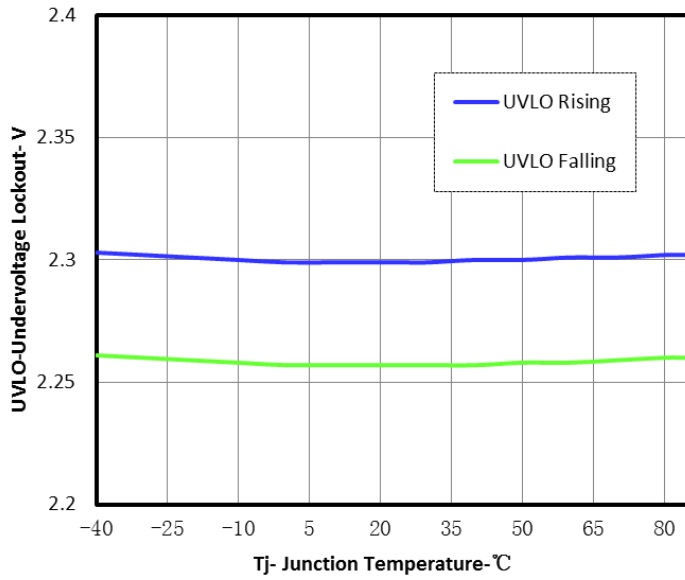
TYPICAL CHARACTERISTICS (Continued)
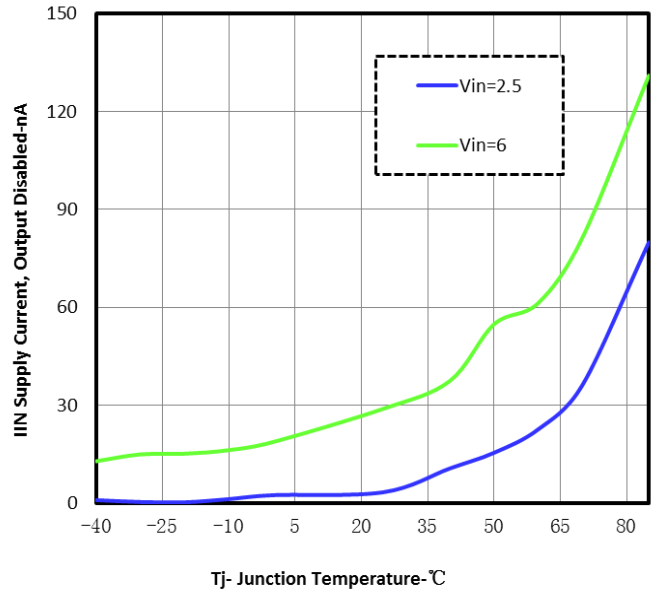
Figure 4. UVLO – Under voltage Lockout – V

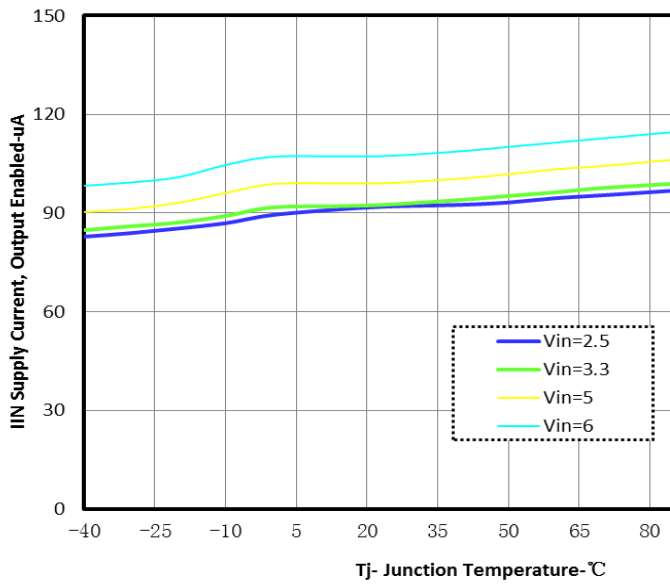**Figure 5. IIN – Supply Current, Output Disabled – nA**
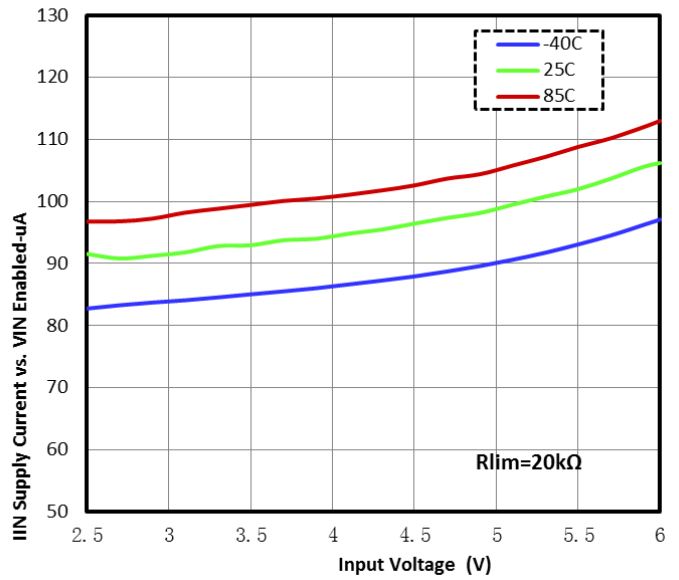
Figure 6. IIN – Supply Current, Output Enabled – μA

Figure 7. IIN – Supply Current, Output Enabled – μA
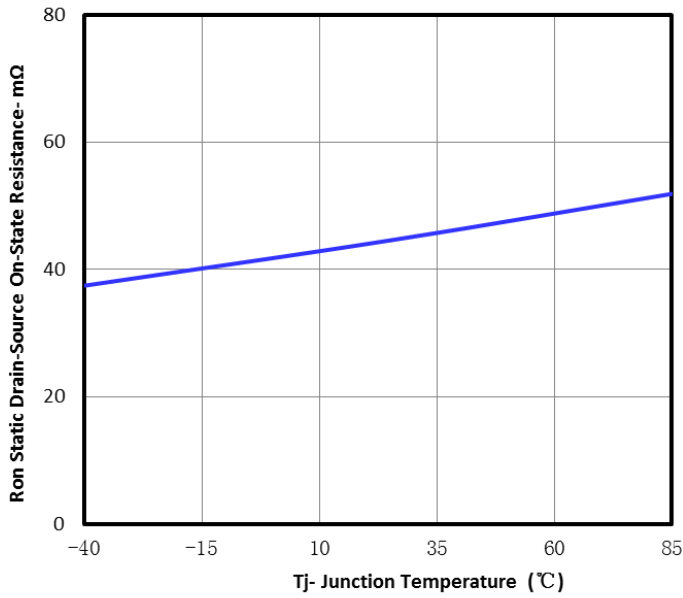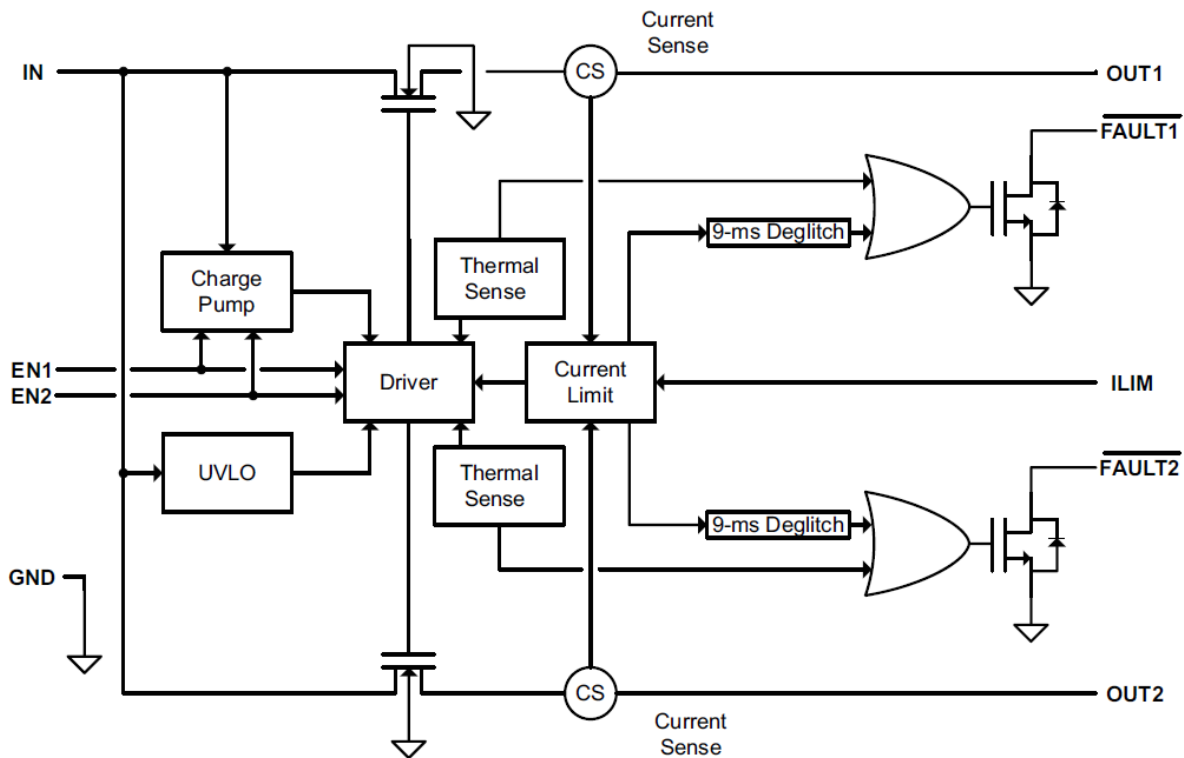
TYPICAL CHARACTERISTICS (Continued)

Figure 8. MOSFET rDS(on) Vs. Junction Temperature

Functional Description

Block Diagram

Overview

The PI5PD2560/2561 are a dual-channel, current-limited power-distribution switch using N-channel MOSFETs for applications where short circuits or heavy capacitive loads will be encountered. This device allows the user to program the current-limit threshold between 250 mA and 2.8 A (typ) per channel via an external resistor. This device incorporates an internal charge pump and gate drive circuitry necessary to drive the N-channel MOSFETs. The charge pump supplies power to the driver circuit for each channel and provides the necessary voltage to pull the gate of the MOSFET above the source. The charge pump operates from input voltages as low as 2.5 V and requires little supply current. The driver controls the gate voltage of the power switch. The driver incorporates circuitry that controls the rise and fall times of the output voltage to limit large current and voltage surges and provides built-in soft-start functionality. Each channel of the PI5PD2560/2561 limit the output current to the programmed current-limit threshold I_{OS} during an over-current or short-circuit event by reducing the charge pump voltage driving the N-channel MOSFET and operating it in the linear range of operation. The result of limiting the output current to I_{OS} reduces the output voltage at OUTx because the N-channel MOSFET is no longer fully enhanced.

Over-current Conditions

When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly.

The PI5PD2560/2561 thermal cycles if an overload condition is present long enough to activate thermal limiting in any of the above cases. The device turns off when the junction temperature exceeds 135°C (min) while in current limit. The device remains off until the junction temperature cools 20°C (typ) and then restarts. The PI5PD2560/2561 cycles on/off until the overload is removed.

/FAULTx Response

The /FAULTx open-drain outputs are asserted (active low) on an individual channel during an over-current or Over temperature condition. The PI5PD2560/2561 assert the FAULTx signal until the fault condition is removed and the device resumes normal operation on that channel. The PI5PD2560/2561 are designed to eliminate false FAULTx reporting by using an internal delay "deglitch" circuit (9-ms typ) for over-current conditions without the need for external circuitry. This ensures that FAULTx is not accidentally asserted due to normal operation such as starting into a heavy capacitive load. The deglitch circuitry delays entering and leaving current-limited induced fault conditions. The FAULTx signal is not deglitched when the MOSFET is disabled due to an over temperature condition but is deglitched after the device has cooled and begins to turn on. This unidirectional deglitch prevents FAULTx oscillation during an overt temperature event.

Under-voltage Lockout (UVLO)

The under-voltage lockout (UVLO) circuit disables the power switch until the input voltage reaches the UVLO turn-on threshold. Built-in hysteresis prevents unwanted on/off cycling due to input voltage droop during turn on.

Enable (ENx OR /ENx)

The logic enables control the power switches and device supply current. The supply current is reduced to less than 2µA when a logic high is present on /ENx or when a logic low is present on ENx. A logic low input on /ENx or a logic high input on ENx enables the driver, control circuits, and power switches. The enable inputs are compatible with both TTL and CMOS logic levels.

Thermal Sense

The PI5PD2560/2561 self protect by using two independent thermal sensing circuits that monitor the operating temperature of the power switch and disable operation if the temperature exceeds recommended operating conditions. Each channel of the PI5PD2560/2561 operate in constant-current mode during over-current conditions, which increases the voltage drop across the power switch. The power dissipation in the package is proportional to the voltage drop across the power switch, which increases the junction temperature during an over-current condition. The first thermal sensor (OTSD) turns off the individual power switch channel when the die temperature exceeds 135°C (min) and the channel is in current limit. Hysteresis is built into the thermal sensor, and the switch turns on after the device has cooled approximately 20°C.

The PI5PD2560/2561 also have a second ambient thermal sensor (OTSD2). The ambient thermal sensor turns off both power switch channels when the die temperature exceeds 155°C (min) regardless of whether the power switch channels are in current limit and will turn on the power switches after the device has cooled approximately 20°C. The PI5PD2560/2561 continue to cycle off and on until the fault is removed.

APPLICATION INFORMATION

INPUT AND OUTPUT CAPACITANCE

Input and output capacitance improves the performance of the device; the actual capacitance should be optimized for the particular application. For all applications, a 0.1µF or greater ceramic bypass capacitor between IN and GND is recommended as close to the device as possible for local noise decoupling. This precaution reduces ringing on the input due to power-supply transients. Additional larger input capacitance with low ESR is needed on the input to reduce voltage overshoot from exceeding the absolute maximum voltage of the device during heavy transient conditions. This is especially important during bench testing when long, inductive cables are used to connect the evaluation board to the bench power supply.

Output capacitance is not required, but placing a high-value electrolytic capacitor on the output pin is recommended when large transient currents are expected on the output.

PROGRAMMING THE CURRENT-LIMIT THRESHOLD

The over-current threshold is user programmable via an external resistor, RILIM. RILIM sets the current-limit threshold for both channels. The PI5PD2560/2561 use an internal regulation loop to provide a regulated voltage on the ILIM pin. The current-limit threshold is proportional to the current sourced out of ILIM. The recommended 1% resistor range for RILIM is 20 kΩ ≤ RILIM ≤ 187 kΩ to ensure stability of the internal regulation loop. Many applications require that the minimum current limit is above a certain current level or that the maximum current limit is below a certain current level, so it is important to consider the tolerance of the over-current threshold when selecting a value for RILIM. The following equations calculates the resulting overcurrent threshold for a given external resistor value (RILIM). The traces routing the RILIM resistor to the PI5PD2560/2561 should be as short as possible to reduce parasitic effects on the current-limit accuracy.

$$I_{OS}max\ (mA) = \frac{52850V}{R_{ILIM}{}^{0.957}k\Omega}$$

$$I_{OS}nom\ (mA) = \frac{56000V}{R_{ILIM}k\Omega}$$

$$I_{OS}min\ (mA) = \frac{61200V}{R_{ILIM}{}^{1.056}k\Omega}$$
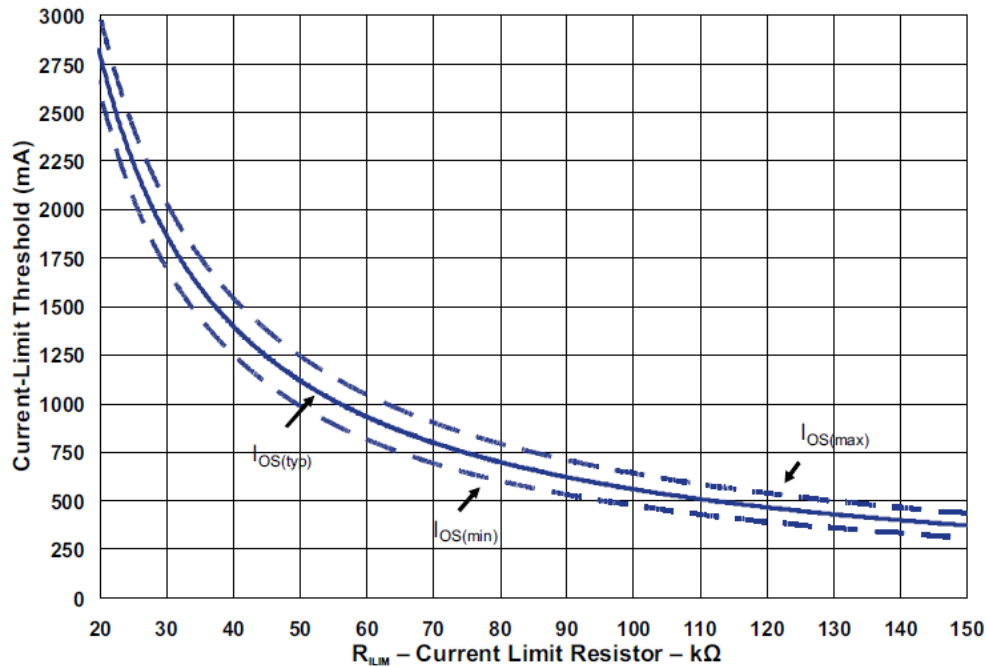
Figure 9. Current-Limit Threshold vs. RILIM

APPLICATION 1: DESIGNING ABOVE A MINIMUM CURRENT LIMIT

Some applications require that current limiting cannot occur below a certain threshold. For this example, assume that 2 A must be delivered to the load so that the minimum desired current-limit threshold is 2000 mA. Use the IOS equations and Figure 9 to select RILIM.

$$\mathbf{I_{OS}max\ (mA) = 2000mA}$$

$$\mathbf{I_{OS}min\ (mA) = \frac{61200V}{R_{ILIM}{}^{1.056}k\Omega}}$$

$$\mathbf{R_{ILIM}\ (k\Omega) = \left[\frac{61200V}{I_{Osmin}\ mA}\right]^{\frac{1}{1.056}}}$$

$$\mathbf{R_{ILIM}\ (k\Omega) = 25.52k\Omega}$$

Select the closest 1% resistor less than the calculated value: RILIM = 25.5 kΩ. This sets the minimum current-limit threshold at 2A. Use the IOS equations, Figure 9, and the previously calculated value for RILIM to calculate the maximum resulting current-limit threshold

$$\mathbf{R_{ILIM}\ (k\Omega) = 25.52k\Omega}$$

$$\mathbf{I_{OS}max\ (mA) = \frac{52850V}{R_{ILIM}{}^{0.957}k\Omega}}$$

$$\mathbf{I_{OS}max\ (mA) = \frac{52850V}{25.5^{0.957}k\Omega}}$$

$$\mathbf{I_{OS}max\ (mA) = 2382mA}$$

The resulting maximum current-limit threshold is 2382 mA with a 25.5 kΩ resistor

APPLICATION 2: DESIGNING BELOW A MAXIMUM CURRENT LIMIT

Some applications require that current limiting must occur below a certain threshold. For this example, assume that the desired upper current-limit threshold must be below 1000 mA to protect an up-stream power supply. Use the IOS equations and Figure 9 to select RILIM.

$I_{OS}max\ (mA) = 1000mA$

$$I_{OS}max\ (mA) = \frac{52850V}{R_{ILIM}^{0.957}k\Omega}$$

$$R_{ILIM}\ (k\Omega) = \left[\frac{52850V}{I_{OSmax}mA}\right]^{\frac{1}{0.957}}$$

$R_{ILIM}\ (k\Omega) = 63.16k\Omega$

Select the closest 1% resistor greater than the calculated value: RILIM = 63.4 kΩ. This sets the maximum current-limit threshold at 1000 mA. Use the IOS equations, Figure 9, and the previously calculated value for RILIM to calculate the minimum resulting current-limit threshold

$R_{ILIM}\ (k\Omega) = 63.4k\Omega$

$$I_{OS}min\ (mA) = \frac{61200V}{R_{ILIM}^{1.056}k\Omega}$$

$$I_{OS}min\ (mA) = \frac{61200V}{63.4^{1.056}k\Omega}$$

$I_{OS}min\ (mA) = 765mA$

The resulting minimum current-limit threshold is 765 mA with a 63.4 kΩ resistor.

ACCOUNTING FOR RESISTOR TOLERANCE

The previous sections described the selection of R_{ILIM} given certain application requirements and the importance of understanding the current-limit threshold tolerance. The analysis focused only on the PI5PD2560A/2561A performance and assumed an exact resistor value. However, resistors sold in quantity are not exact and are bounded by an upper and lower tolerance centered around a nominal resistance. The additional R_{ILIM} resistance tolerance directly affects the current-limit threshold accuracy at a system level. The following table shows a process that accounts for worst-case resistor tolerance assuming 1% resistor values. Step one follows the selection process outlined in the application examples above. Step two determines the upper and lower resistance bounds of the selected resistor. Step three uses the upper and lower resistor bounds in the IOS equations to calculate the threshold limits. It is important to use tighter tolerance resistors, e.g. 0.5% or 0.1%, when precision current limiting is desired.

Desired Nominal Current Limit (mA)	Ideal Resistor (kΩ)	Closest 1% Resistor (kΩ)	Resistor Tolerance		Actual Limits		
			1% low (kΩ)	1% high(kΩ)	IOS MIN (mA)	IOS Nom (mA)	IOS MAX (mA)
300	186.7	187	185.1	188.9	241.6	299.5	357.3
400	140	140	138.6	141.4	328	400	471.4
600	93.3	93.1	92.2	94	504.6	601.5	696.5
800	70	69.8	69.1	70.5	684	802.3	917.6
1000	56	56.2	55.6	56.8	859.9	996.4	1129.1
1200	46.7	46.4	45.9	46.9	1052.8	1206.9	1356.3
1400	40	40.2	39.8	40.6	1225	1393	1555.9
1600	35	34.8	34.5	35.1	1426.5	1609.2	1786.2
1800	31.1	30.9	30.6	31.2	1617.3	1812.3	2001.4
2000	28	28	27.7	28.3	1794.7	2000	2199.3
2200	25.5	25.5	25.2	25.8	1981	2196.1	2405.3
2400	23.3	23.2	23	23.4	2188.9	2413.8	2633
2600	21.5	21.5	21.3	21.7	2372.1	2604.7	2831.9
2800	20	20	19.8	20.2	2560.4	2800	3034.8

AUTO-RETRY FUNCTIONALITY

Some applications require that an overcurrent condition disables the part momentarily during a fault condition and re-enables after a pre-set time. This auto-retry functionality can be implemented with an external resistor and capacitor. During a fault condition, FAULTx pulls ENx low disabling the part. The part is disabled when ENx is pulled below the turn-off threshold, and FAULTx goes high impedance allowing CRETRY to begin charging. The part re-enables when the voltage on ENx reaches the turn-on threshold, and the auto-retry time is determined by the resistor/capacitor time constant. The part will continue to cycle in this manner until the fault condition is removed.
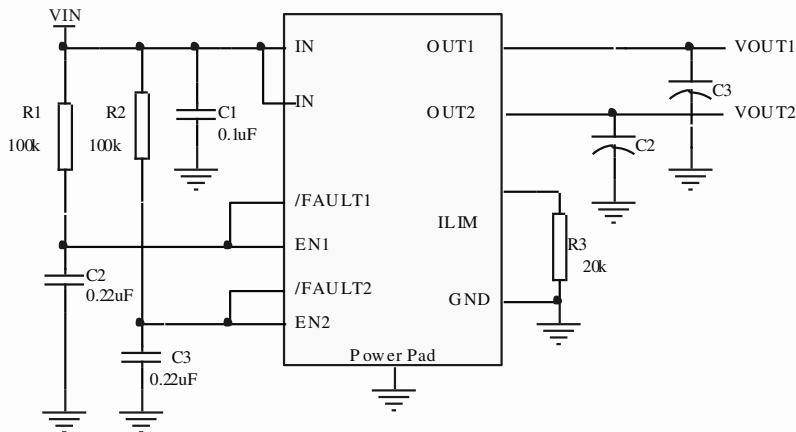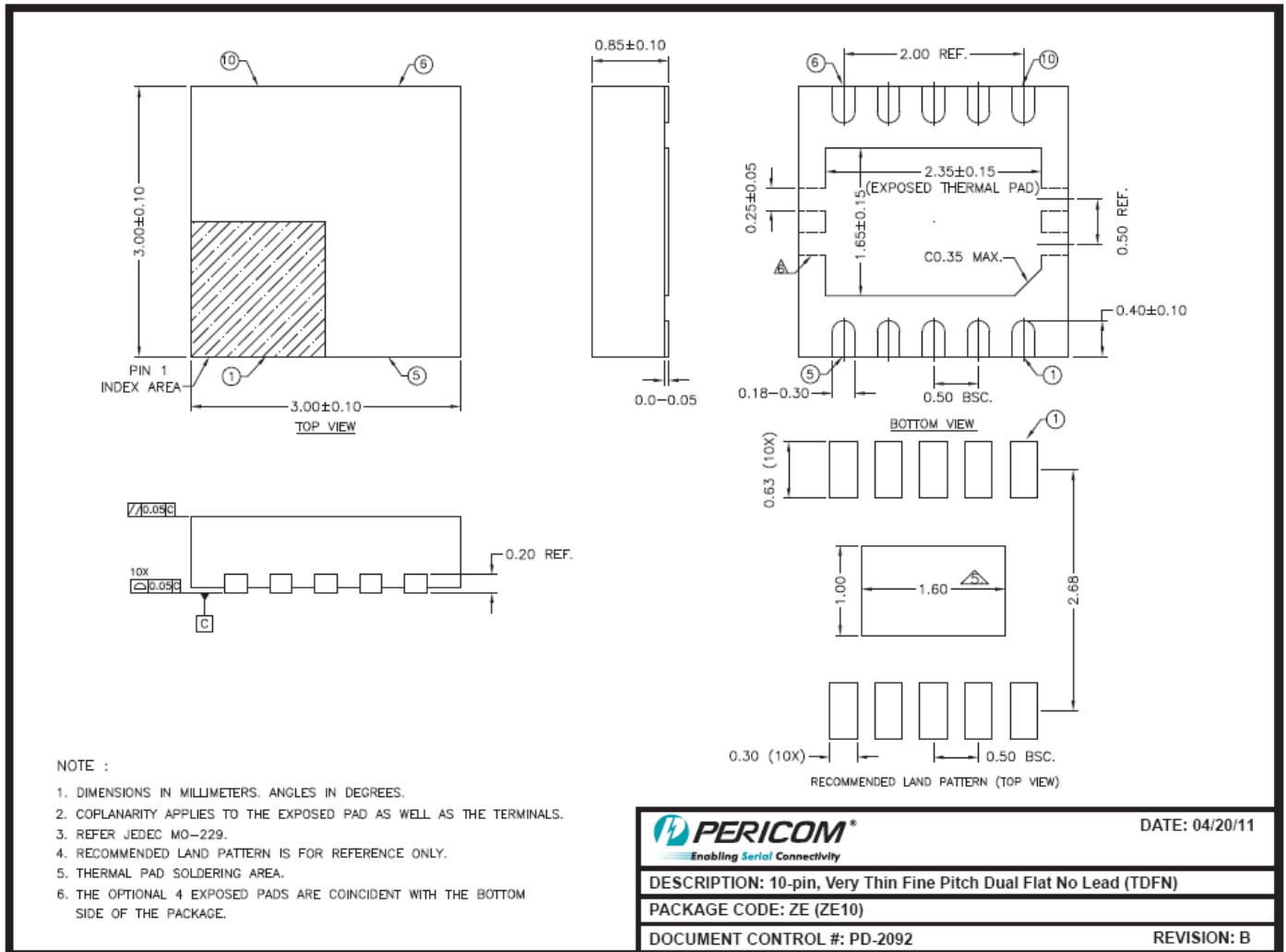

Figure 10.Auto-Retry Functionality

Some applications require auto-retry functionality and the ability to enable/disable with an external logic signal. The figure below shows how an external logic signal can drive EN through RFAULT and maintain auto-retry functionality. The resistor/capacitor time constant determines the auto-retry time-out period.
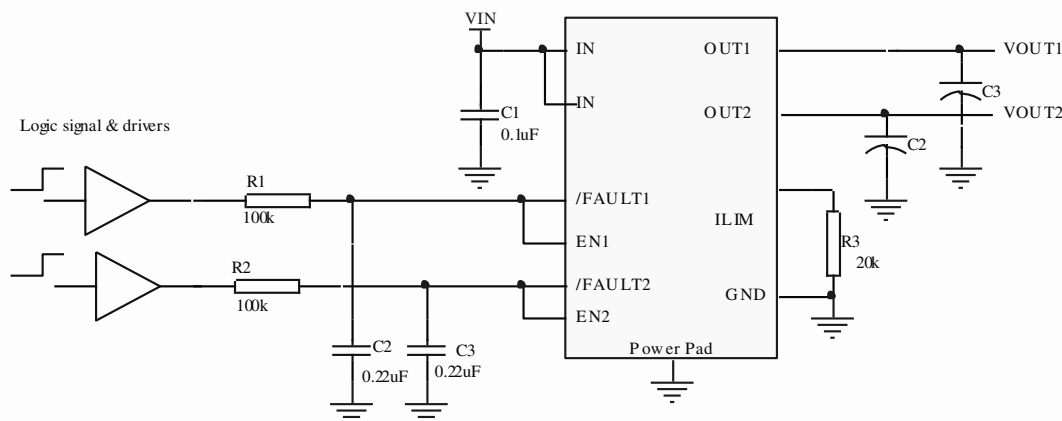
Figure 11.Auto-Retry Functionality With External EN Signal

Mechanical Information

TDFN 3.0x3.0-10L

NOTE :

1. DIMENSIONS IN MILLIMETERS. ANGLES IN DEGREES.
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
3. REFER JEDEC MO-229.
4. RECOMMENDED LAND PATTERN IS FOR REFERENCE ONLY.
5. THERMAL PAD SOLDERING AREA.
6. THE OPTIONAL 4 EXPOSED PADS ARE COINCIDENT WITH THE BOTTOM SIDE OF THE PACKAGE.

		DATE: 04/20/11
PERICOM Enabling Serial Connectivity		
DESCRIPTION: 10-pin, Very Thin Fine Pitch Dual Flat No Lead (TDFN)		
PACKAGE CODE: ZE (ZE10)		
DOCUMENT CONTROL #: PD-2092		REVISION: B

Ordering Information

Part No.	Package Code	Package
PI5PD2560ZEEX	ZE	Lead free and Green 10-pin TDFN3.0x3.0 Tape & reel
PI5PD2561ZEEX	ZE	Lead free and Green 10-pin TDFN3.0x3.0 Tape & reel

Note:
- E = Pb-free and Green
- Adding X Suffix= Tape/Reel