General Description

The TD9525 series of power switches are designed for USB applications. The 62mΩ N-channel MOSFET power switch satisfies the voltage drop requirements of USB specification.

The protection features include current-limit protection, short-circuit protection, and over-temperature protection.

The device limits the output current at current limit threshold level. When V_{OUT} drops below V_{IN}-1V, the devices limit the current to a lower and safe level. The over-temperature protection limits the junction temperature below 140°C in case of short circuit or over load conditions.

Other features include a deglitched OCB output to indicate the fault condition and an enable input to enable or disable the device.

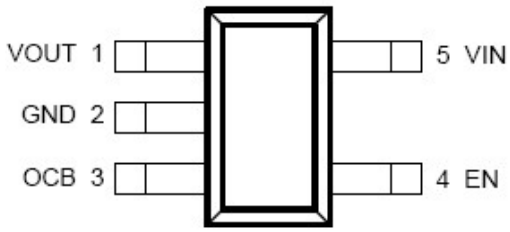
Features

- 62mΩ Power Switch On Resistance
- Wide Supply Voltage Range: 2.7V to 5.5V
- Fix Current Limit Protection
- Fast Over current Response: 2us (typ.)
- Over-Temperature Protection
- Fault Indication Output
- Enable Input
- Built-in Soft-Start
- Reverse Input-Output Voltage Protection: 25mV(typ.)
- Lead Free and Green Devices Available (RoHS Compliant)

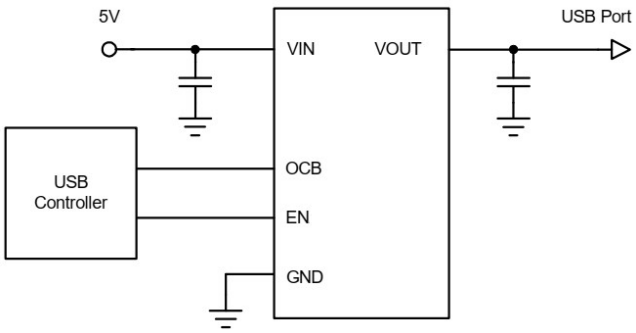
Applications

- Notebook and Desktop Computers
- USB Ports
- High-Side Power Protection Switchs
- MHL Ports

Pin Configuration



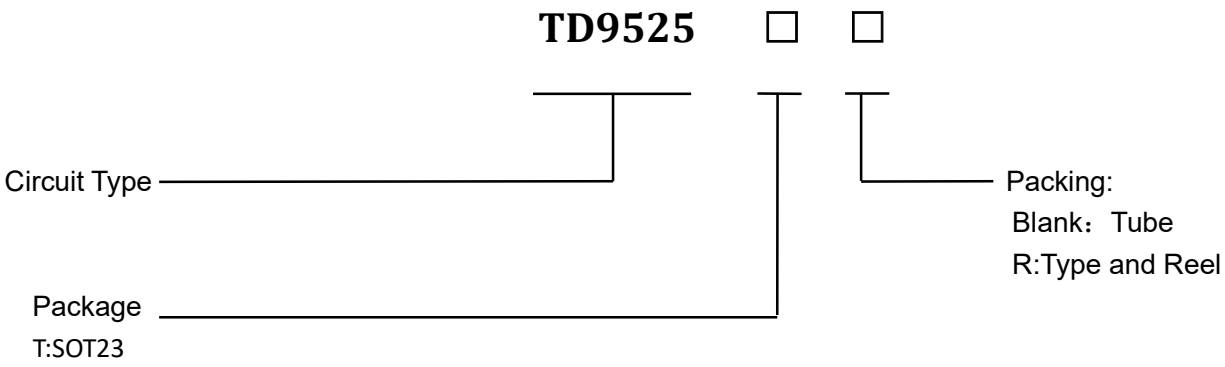
Simplified Application Circuit



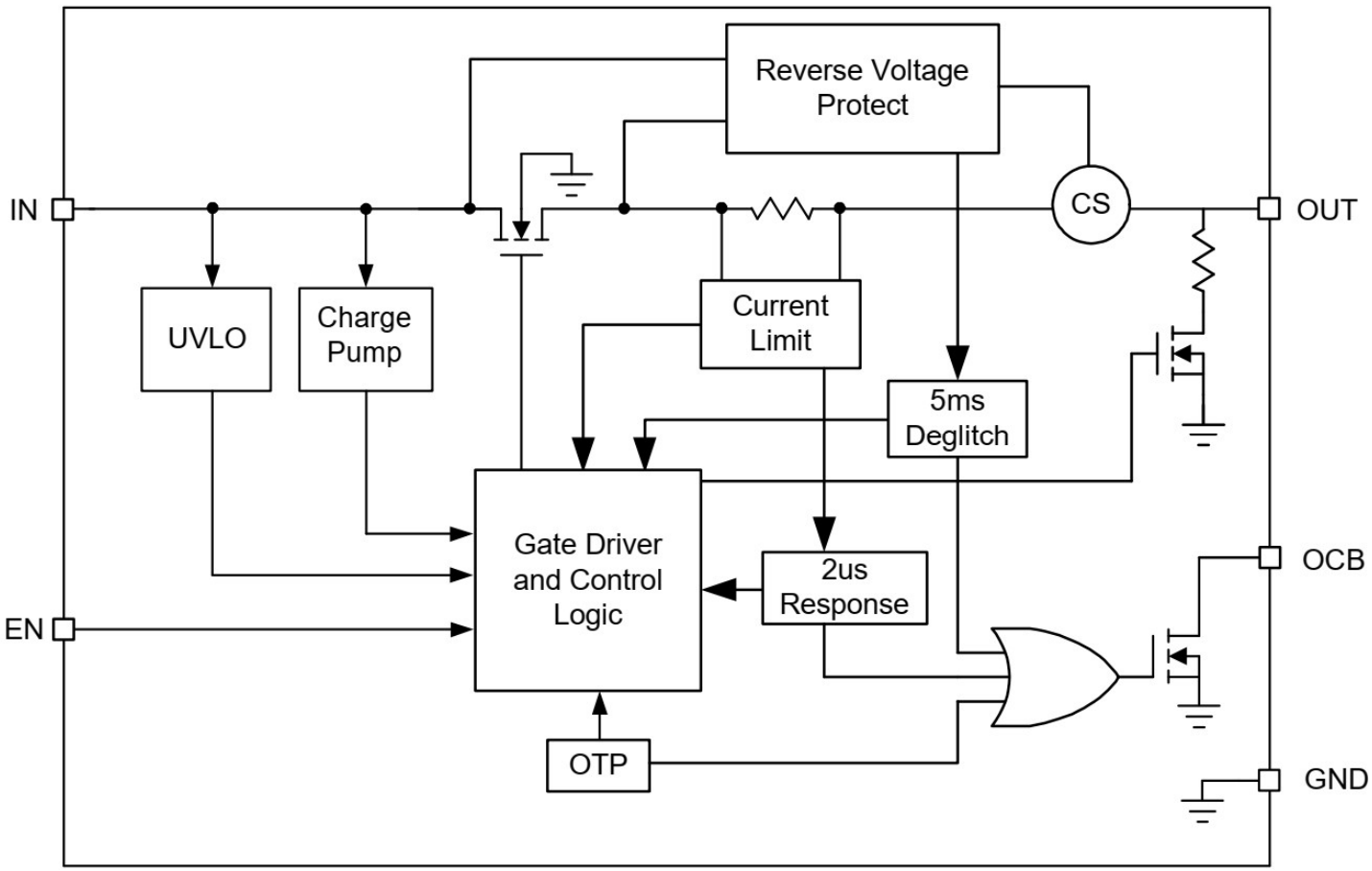
Pin Description

Pin NO.	Name	Function
1	VOUT	Output Voltage Pin. The output voltage follows the input voltage. When EN is low the output voltage is discharged by an internal resistor.
2	GND	Ground pin.
3	OCB	Fault Indication Pin. This pin goes low when a current limit or an over-temperature condition is detected after a 12ms deglitch time.
4	EN	Enable Input. Pull this pin to high to enable the device and pull this pin to low to disable device. The EN pin cannot be left floating.
5	VIN	Power Supply Input. Connect this pin to external DC supply.

Ordering Information



Functional Block Diagram



Functional Block Diagram of TD9525

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN}	Input Voltage (VIN to GND)	-0.3 to 7	V
V_{OUT}	VOUT to GND Voltage	-0.3 to 7	V
V_{EN}	EN to GND Voltage	-0.3 to 7	V
V_{OCB}	OCB to GND Voltage	-0.3 to 7	V
T_J	Maximum Junction Temperature	150	℃
T_{STG}	Storage Temperature	-65 to 150	℃
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)	260	℃
θ_{JA}	Junction-to-Ambient Resistance in free air	260	℃/W
θ_{JC}	Junction-to-Case Resistance in free air	130	℃/W

Note1: 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 rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Symbol	Parameter	Range	Unit
V_{IN}	VIN Input Voltage (VIN to GND)	2.7 to 5.5	V
I_{OUT}	OUT Output Current	0 to 2	A
T_A	Ambient Temperature	-40 to 85	℃
T_J	Junction Temperature	-40 to 125	℃

Note2: Refer to the typical application circuit.

Electrical Characteristics

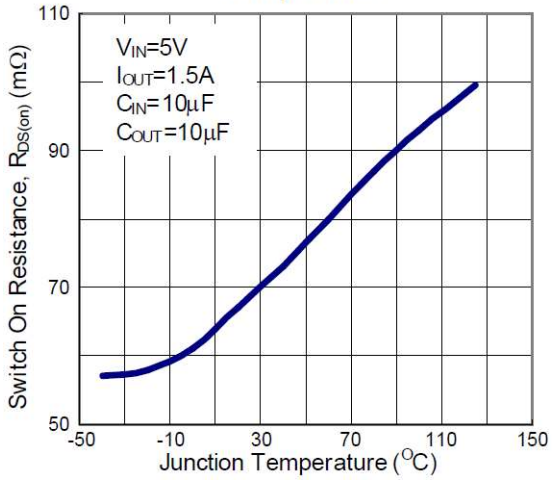
Unless otherwise specified, these specifications apply over V_{IN}=5V, V_{EN} =5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

Symbol	Parameter	Test	Min	Typ	Max	Unit
SUPPLY CURRENT						
I_{VIN}	VIN Supply Current	No load, V_{EN} =0V	-	-	1	μA
		No load, V_{EN} =5V	-	65	-	μA
I_{leak}	Reverse Leakage Current	V_{IN}=GND, V_{OUT}=5V, V_{EN}=0V	-	-	1	μA
POWER SWITCH						
$R_{DS(ON)}$	Power Switch On Resistance	I_{OUT}=1.5A, T_A= 25°C	-	62	78	mΩ
UNDER-VOLTAGE LOCKOUT						
	VIN UVLO Threshold Voltage	V_{VIIN} rising	1.7	-	2.65	V
	VIN UVLO Hysteresis		-	0.2	-	V
CURRENT LIMIT AND SHORT CIRCUIT PROTECTIONS						
I_{LIM}	Current Limit Threshold	V_{IN}= to 5.5V， T_A=25°C	2.1	2.5	2.9	A
I_{SHORT}	Short-Circuit Output Current	V_{IN}= to 5.5V	-	1.5	-	A
OCB OUTPUT PIN						
	OCB Output Low Voltage	I_{OCB}=5mA	-	0.2	0.4	V
	OCB Leakage Current	V_{OCB} =5V	-	-	1	μA
$t_{D(OCB)}$	OCB Deglitch Time	OCB assertion, T_A= -40 ~ 85 °C	5	12	20	ms
EN INPUT PIN						
V_{IH}	Input Logic High	V_{IN}=2.7V to 5V	1.4	-	-	V
V_{IL}	Input Logic Low	V_{IN}=2.7V to 5V	-	-	0.6	V
	Input Current		-	-	1	μA
	VOUT Discharge Resistance	V_{EN} =0V	-	150	-	Ω
$t_{D(ON)}$	Turn on Delay Time		-	80	-	μs
$t_{D(OFF)}$	Turn off Delay Time		-	5	-	μs

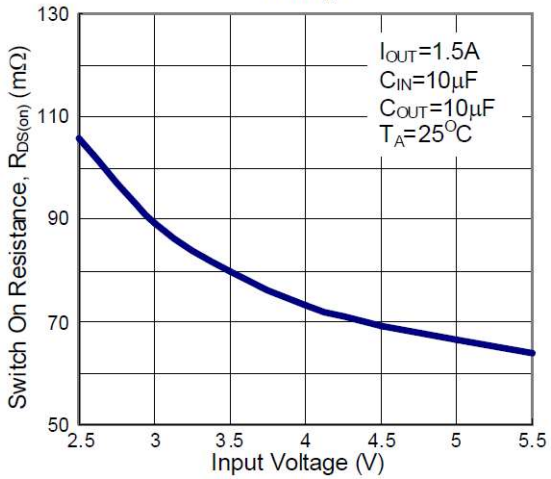
t_{SS}	Soft-Start Time	No load, C_{OUT}=1 μ F, V_{IN}=5V	500	-	200	μ s
		V_{IN}=3.3V,C_{IN}=1uF,C_{OUT}=1uF,RL=10Ω	500	-	200	μ s
OVERT-TEMPERATURE PROTECTION (OTP)						
T_{OTP}	Over-Temperature Threshold	T_J rising	-	140	-	℃
	Over-Temperature Threshold Hysteresis		-	20	-	℃
REVERSE VOLTAGE PROTECT						
I_{REV}	Reverse current trip point	Enable reverse current protection	150	200	-	mA
V_{REV}	Reverse voltage comparator trip point	V_{IN} -V_{OUT}, disable reverse current protection	-	25	-	mV
T_{REV}	Output Reverse Voltage Deglitch Time	V_{IN}=5V	3	5	7	ms

Typical Operating Characteristics

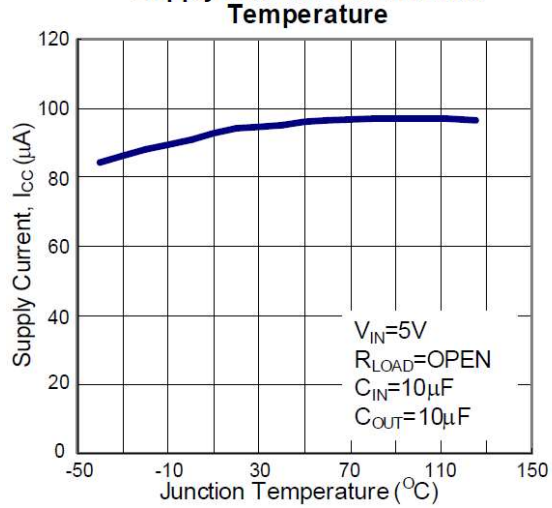
Switch On Resistance vs. Junction Temperature



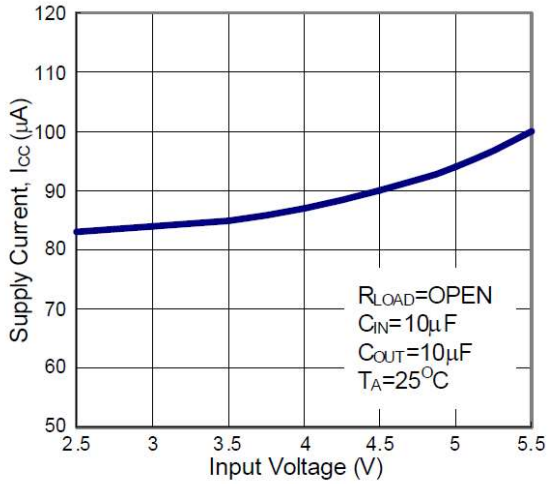
Switch On Resistance vs. Input Voltage



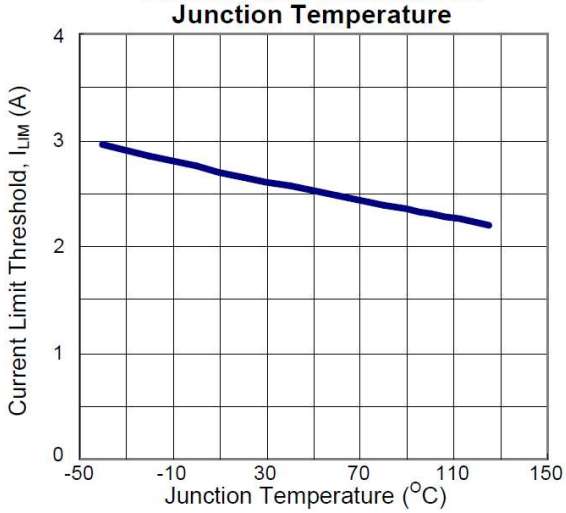
Supply Current vs. Junction Temperature



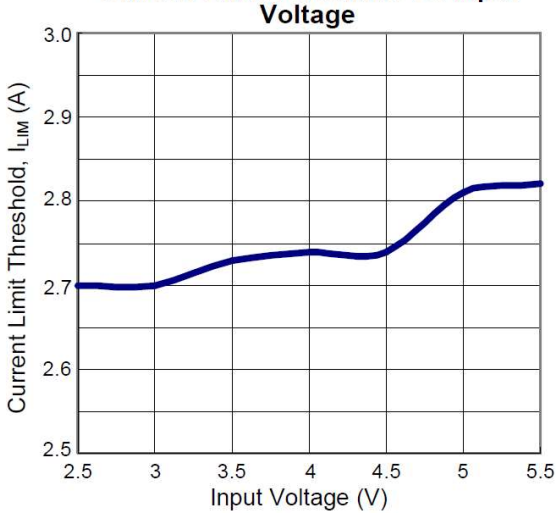
Supply Current vs. Input Voltage



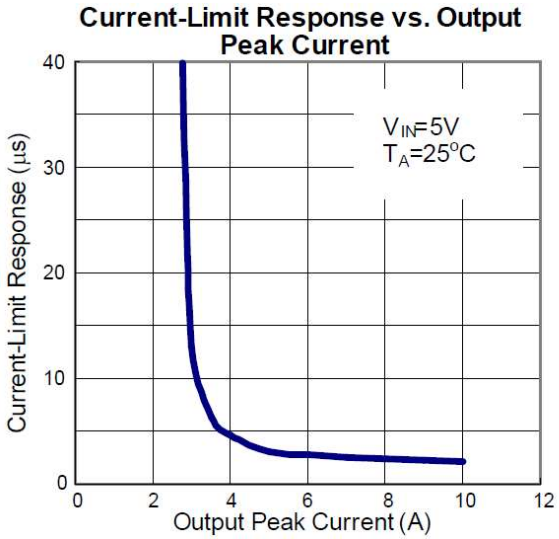
Current Limit Threshold vs. Junction Temperature

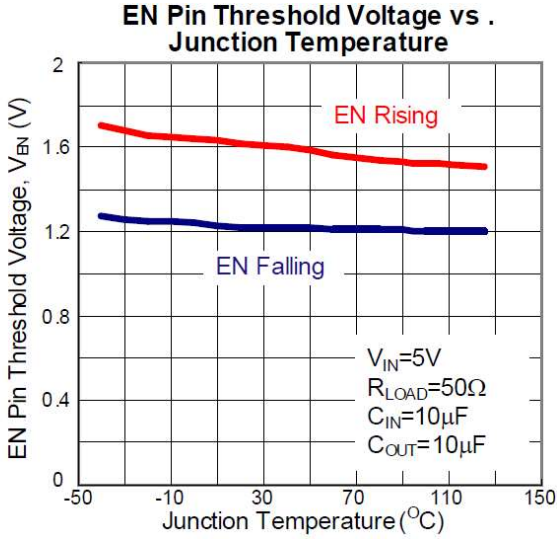


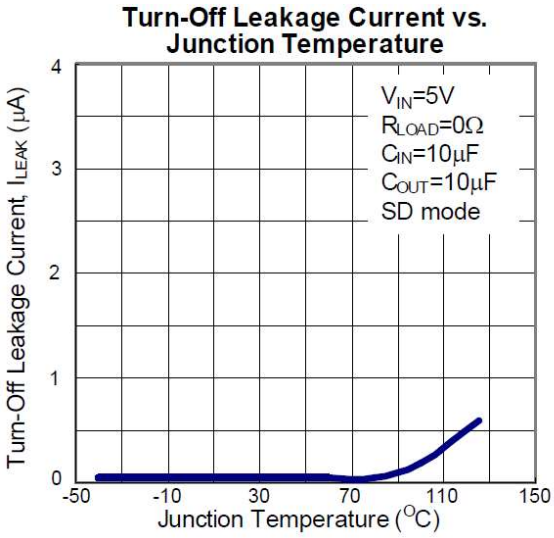
Current Limit Threshold vs. Input Voltage

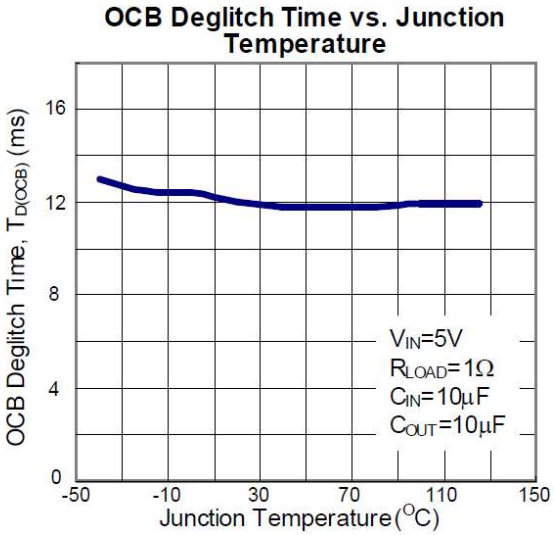


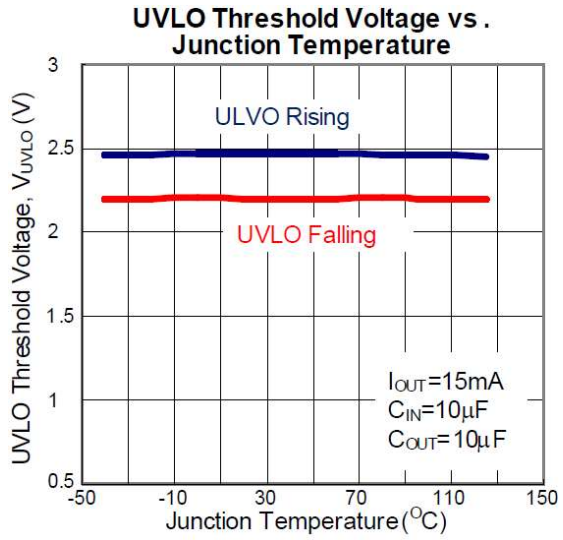
Typical Operating Characteristics (Cont.)

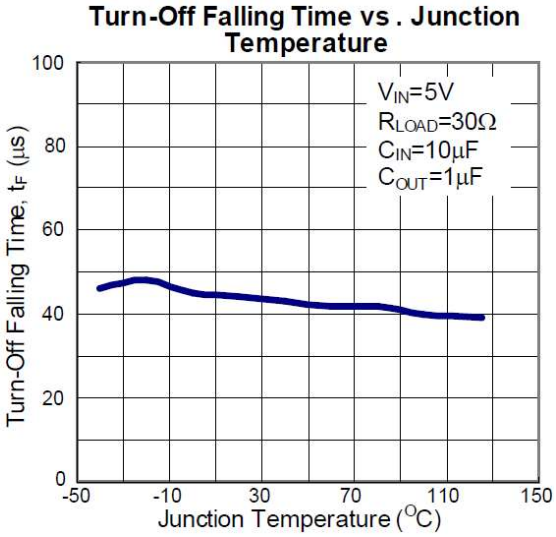




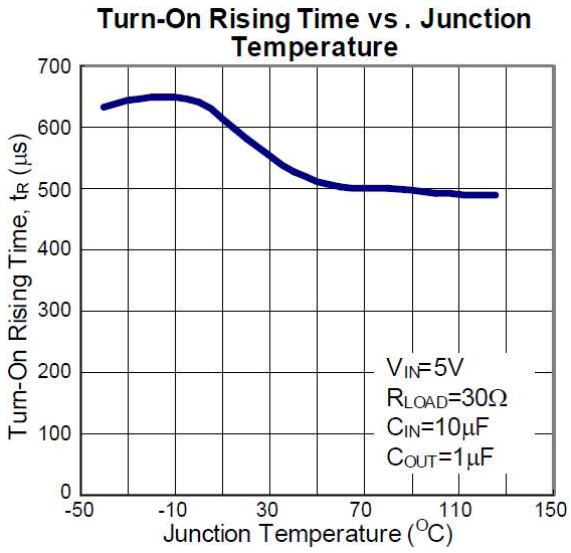






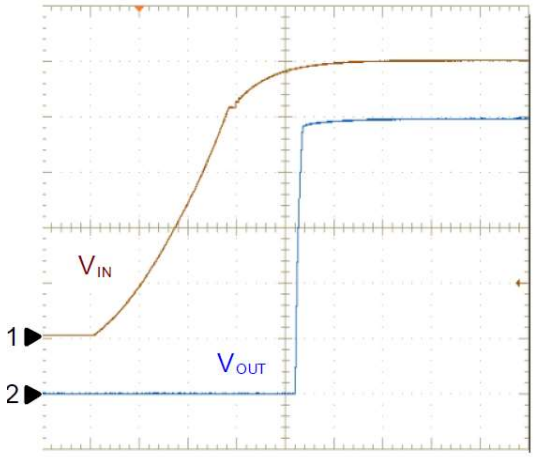


Typical Operating Characteristics (Cont.)



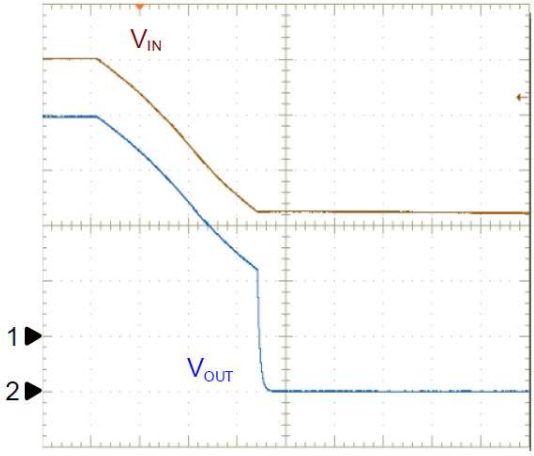
Operating Waveforms(Cont.)

UVLO at Rising



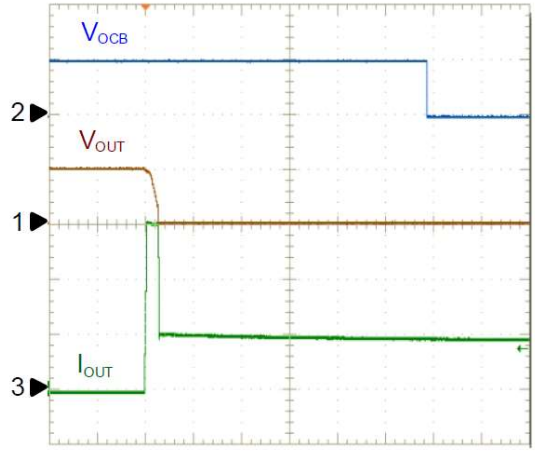
V_{IN}=5V,C_{OUT}=10μF/Electrolytic,
C_{IN}=10μF/Electrolytic,R_{LOAD}=30Ω
CH1:V_{IN},1V/Div, DC
CH2:V_{OUT},1V/Div, DC
TIME:4ms/Div

UVLO at Falling



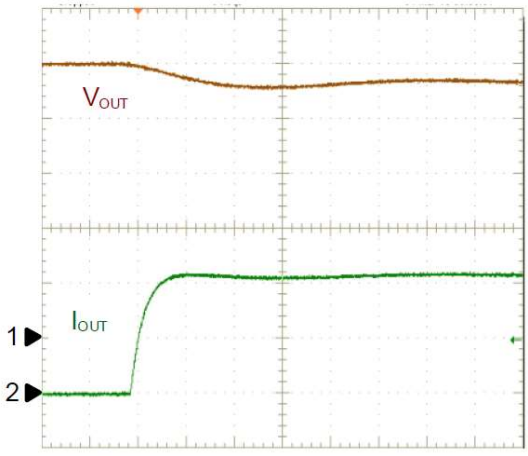
V_{IN}=5V,C_{OUT}=10μF/Electrolytic,
C_{IN}=10μF/Electrolytic,R_{LOAD}=30Ω
CH1:V_{IN},1V/Div, DC
CH2:V_{OUT},1V/Div, DC
TIME:4ms/Div

OCB Response with Ramped Load



V_{IN}=5V,C_{OUT}=10μF/Electrolytic,
C_{IN}=10μF/Electrolytic
CH1:V_{OUT},5V/Div, DC
CH2:V_{OCB},5V/Div, DC
CH3:I_{OUT},1A/Div, DC
TIME:2ms/Div

Load-Transient Response



V_{IN}=5V,C_{OUT}=10μF/Electrolytic,
C_{IN}=10μF/Electrolytic,I_{OUT}=0 to 2A
CH1:V_{OUT},1V/Div, DC
CH2:I_{OUT},1A/Div, DC
TIME:2μs/Div

Parameter Measurement Information

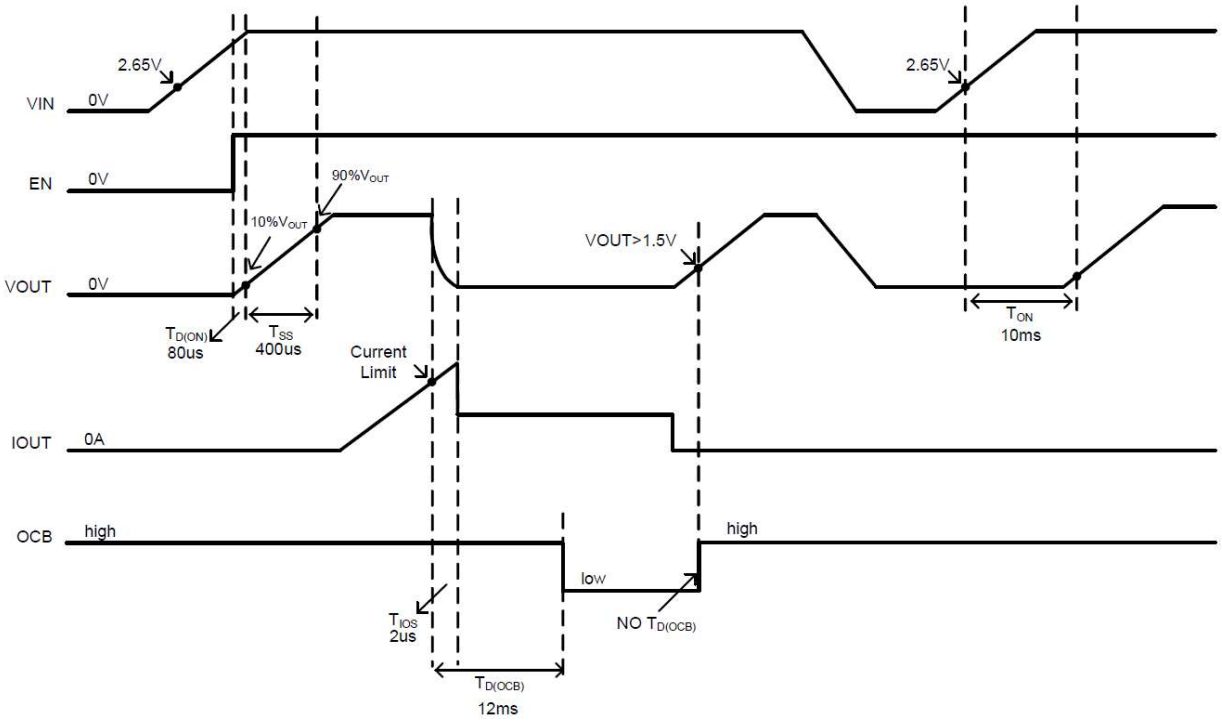


Figure 1. Sequence of Power On & Current Limit & OCB Indicate

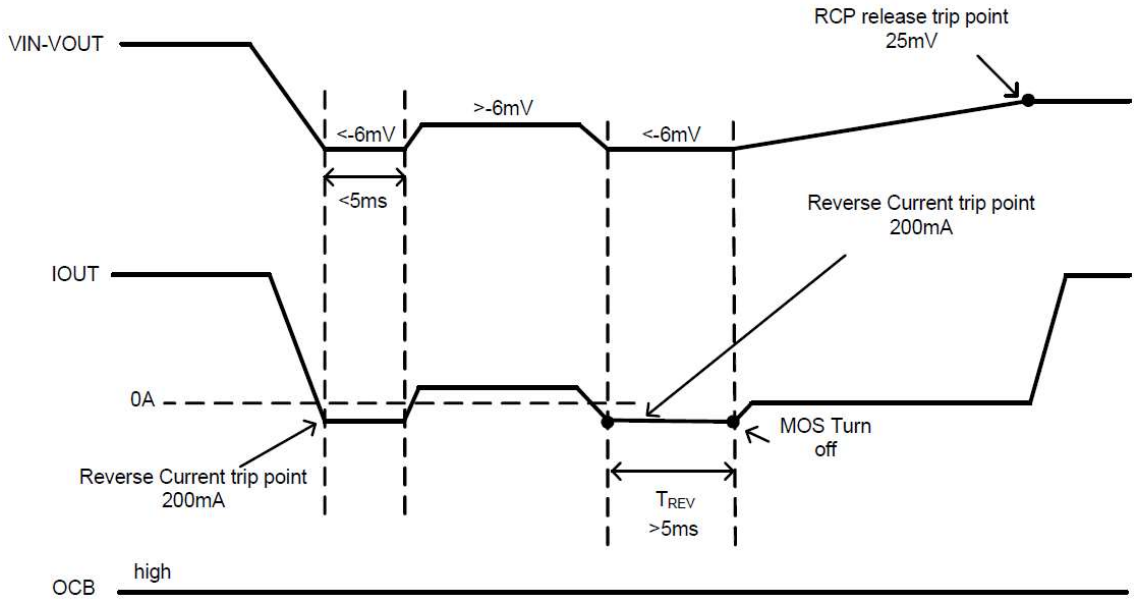
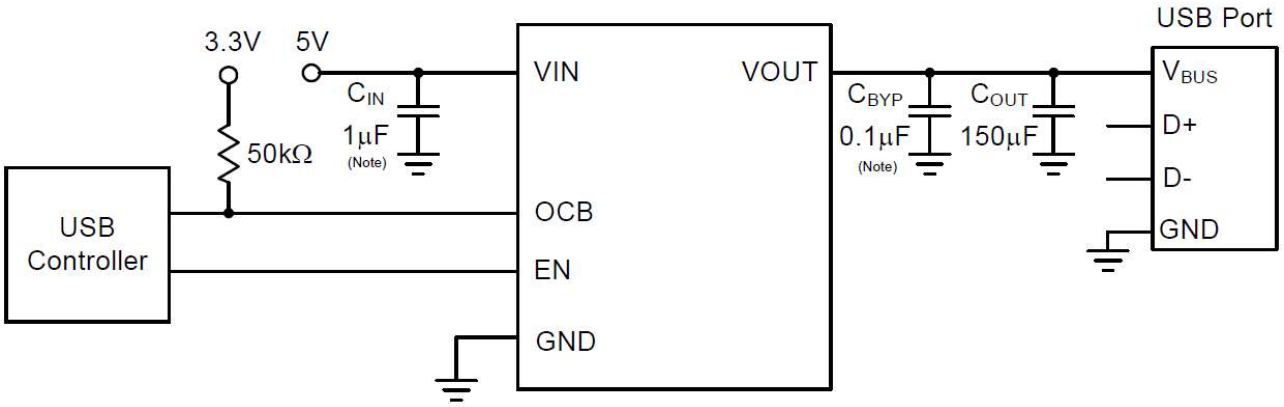


Figure 2. Reverse Current trip point & Recovery

Typical Application Circuit



Note: The C_{IN} is typically 1 μF. However, the parasitic inductance before VIN pin could cause voltage spike to damage internal circuitry. If voltage spike, especially during short circuit or hot plug-in of large capacitance load, on VIN exceeds VIN's absolute maximum rating, adding at least 10μF/MLCC capacitor at VIN is strongly recommended.

Function Description

VIN Under-Voltage Lockout (UVLO)

The TD9525 series of power switches have a built-in under-voltage lockout circuit to keep the output shutting off until internal circuitry is operating properly. The UVLO circuit has hysteresis and a de-glitch feature so that it will typically ignore undershoot transients on the input. When input voltage exceeds the UVLO threshold, the output voltage starts a soft-start to reduce the inrush current.

Power Switch

The power switch is an N-channel MOSFET with a low $R_{DS(ON)}$. The internal power MOSFET does not have the body diode. When IC is off, the MOSFET prevents a current flowing from the VOUT back to VIN and VIN to VOUT.

Current-Limit Protection

The TD9525 power switch provide the current-limit protection function. During current limit, the device limit output current at current limit threshold. For reliable operation, the device should not be operated in current limit for extended period.

Short-Circuit Protection

When the output voltage drops below V_{IN}-1V, which is caused by an over-load or a short-circuit, the devices limit the output current down to a safe level. The short-circuit current limit is used to reduce the power dissipation during short-circuit conditions. If the junction temperature reaches over-temperature threshold, the device will enter the thermal shutdown.

OCB Output

The TD9525 power switch provide an open-drain output to indicate that a fault has occurred. When any of current-limit or over-temperature protection occurs for a deglitch time of $t_{D(OCB)}$, the OCB goes low. If fault condition release, OCB will goes high when VOUT > 1.5V(see Figure 1). Since the OCB pin is an open-drain output, connecting a resistor to a pull high voltage is necessary.

Enable/Disable

Pull the EN below 0.6V will disable the device, and pull EN above 1.4V will enable the device. When the IC is disabled, the supply current is reduced to less than 1μA. The enable input is compatible with both TTL and CMOS logic levels. The EN pin cannot be left floating.

Over-Temperature Protection

When the junction temperature exceeds 140°C, the internal thermal sense circuit turns off the power FET and allows the device to cool down. When the device's junction temperature cools by 20°C, the internal thermal sense circuit will enable the device, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the IC in the event of over temperature conditions. For normal operation, the junction temperature cannot exceed T_J=+125°C.

Reverse-Voltage Protection

The reverse voltage protection feature turns off the N-channel MOSFET when a reverse current of (VOUT - VIN)/ $R_{DS(on)}$) over 200mA(typ.) for 5ms (typ) deglitch time(see Figure 2). The TD9525 device allows the N-channel MOSFET immediately turn on once the output voltage goes lower than the input voltage by 25 mV (typ)(see Figure 2). This prevents damage to devices on the input side of the TD9525 by preventing significant current from sinking into the input capacitance.

Application Information

Input Capacitor

A 10µF or higher ceramic bypass capacitor from VIN to GND, located near the TD9525, is strongly recommended to suppress the ringing during over-load or short-circuit fault event.

When the load current trips the SCP threshold in an over load condition such as a short circuit, hot plug-in or heavy load transient the IC immediately turns off the internal power switch that will cause VIN ringing due to the inductance between power source and VIN. Without the bypass capacitor, the output short may cause sufficient ringing on the input to damage internal control circuitry.

Input capacitor is especially important to prevent V_{IN} from ringing too high in some applications where the inductance between power source to VIN is large (ex, an extra bead is added between power source line to VIN for EMI reduction), additional input capacitance may be needed on the input to reduce voltage overshoot from exceeding the absolute maximum voltage of the device during over load conditions.

Output Capacitor

A low-ESR 150 µ F aluminum electrolytic between OUT and GND is strongly recommended to reduce the voltage droop during hot-attachment of downstream peripheral.

Higher-value output capacitor is better when the output load is heavy. Additionally, bypassing the output with a 0.1uF ceramic capacitor improves the immunity of the device to short-circuit transients.

Layout Consideration

The PCB layout should be carefully performed to maximize thermal dissipation and to minimize voltage drop, droop and EMI. The following guidelines must be considered:

1.Please place the input capacitors near the VIN pin as close as possible.

2.Output decoupling capacitors for load must be placed near the load as close as possible for decoupling high frequency ripples.

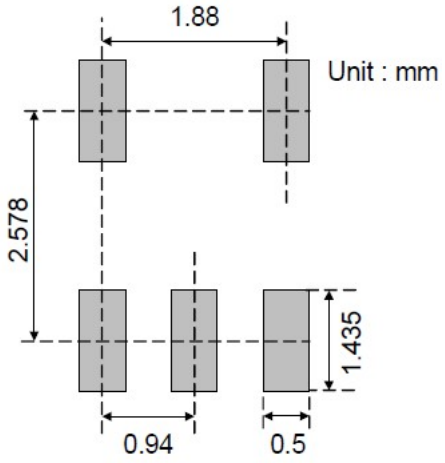
3.Locate TD9525 and output capacitors near the load to reduce parasitic resistance and inductance for excellent load transient performance.

4.The negative pins of the input and output capacitors and the GND pin must be connected to the ground plane of the load.

5.Keep IN and OUT traces as wide and short as possible.

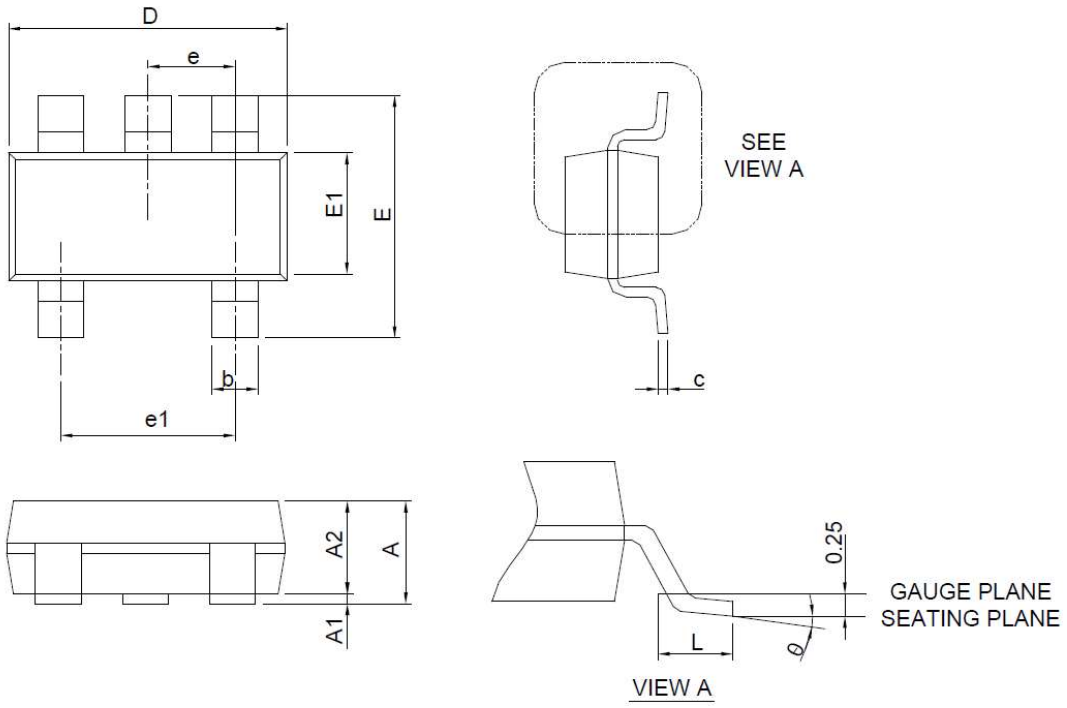
6.The traces routing the R_{ILIM} resistor to the TD9525 should be as short as possible to reduce parasitic effects on the current limit accuracy.

Recommended Minimum Footprint



Package Information

SOT23-5 Package Outline Dimensions



Symbol	SOT-23-5			
	MILLMETER		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.45		0.057
A1	0.00	0.15	0.000	0.006
A2	0.90	1.30	0.035	0.051
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95BSC		0.037BSC	
e1	1.90BSC		0.075BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Design Notes