Power-Distribution Switches with Soft Start TD9527

General Description

The TD9527 is a power-distribution switch with some protection functions. The device incorporates a N channel MOSFET power switch that is controlled by an enable logic pin and has a SS pin dedicated to soft start ramp-up rate control that can be used in application where the inrush current is concerned.

The device integrates some protection features, including current-limit protection, short-circuit protection, over temperature protection, and UVLO. The current-limit and short-circuit protection can protect down-stream devices from catastrophic failure by limiting the output current at current-limit threshold during over-load or short-circuit events. When VOUT drops below VIN-1V, the devices limit the output current to a lower and safe level. The overtemperature protection function shuts down the N-channel MOSFET power switch when the junction temperature rises beyond 150°C and will automatically turns on the power switch when the temperature drops by 50°C. The UVLO function keeps the power switch in off state until there is a valid input voltage present. The current limit in TD9527 can be set by connecting resistor from the current limit adjustable pin ISET to ground.

The device is available in lead free ESOP-8 package.

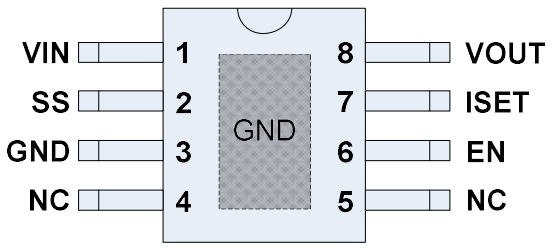
Features

- 84mΩ High Side MOSFET
- Soft Start Time Programmable by External Capacitor
- Wide Supply Voltage Range: 4.5V to 24V
- Current Limit Protections
- Under Voltage Lockout Protection
- Over- temperature Protection
- Logic Level Enable Input
- Current Limit setting
- Lead Free and Green Devices Available (RoHS Compliant)

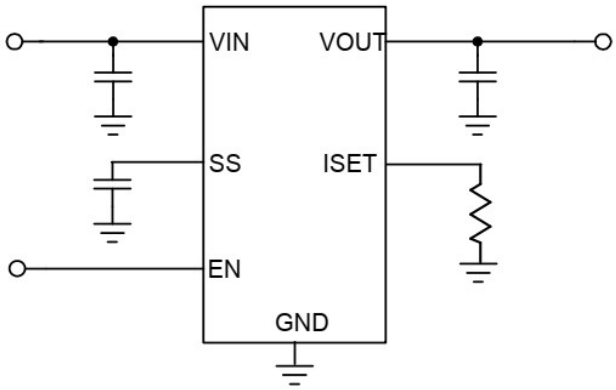
Applications

- TFT LCD Modules
- Notebook and Desktop Computers
- USB Ports
- High-side Power Protection Switches

Pin Configuration



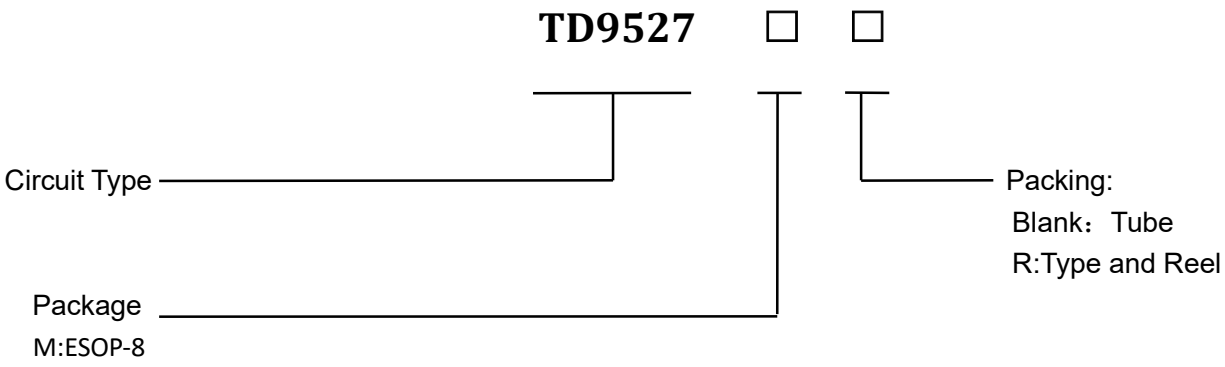
Simplified Application Circuit



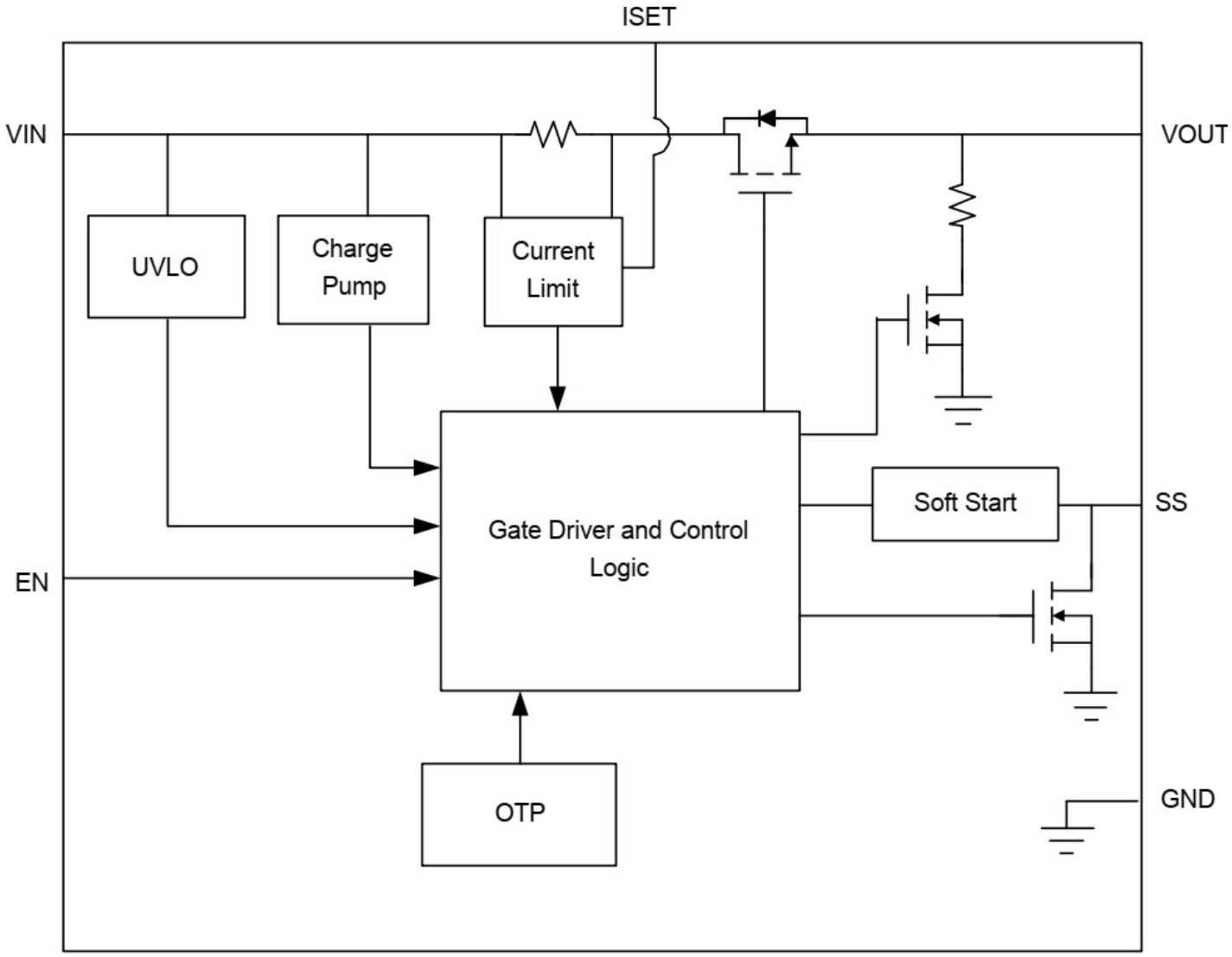
Pin Description

Pin NO.	Name	Function
1	VIN	Power Supply Input. Connect this pin to external DC supply.
2	SS	Soft Start Control Pin. Connect a capacitor to GND to control the soft start rate.
3,9	GND	Ground pin.
4	NC	No connection.
5	NC	No connection.
6	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.
7	ISET	Connect a resistor to GND to adjust OCP level.
8	VOUT	Output Voltage Pin. The output voltage follows the input voltage. When EN is low the output voltage is discharged by an internal resistor.

Ordering Information



Functional Block Diagram



Functional Block Diagram of TD9527

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN}	Input Voltage (VIN to GND)	-0.3 to 26.5	V
V_{OUT}	VOUT to GND Voltage	-0.3 to 26.5	V
V_{EN}	EN to GND Voltage	-0.3 to 7	V
V_{ISET}	ISET to GND Voltage	-0.3 to 7	V
V_{SS}	SS to GND Voltage	-0.3 to 7	V

I_{OUT}	IOUT output current	Setting by R_{ISET}	A
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	50	℃/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)	4.5 to 24	V
C_{SS_MIN}	Minimum SS Pin Soft-Start Capacitor	1	nF
T_A	Ambient Temperature	-40 to 85	℃
T_J	Junction Temperature	-40 to 125	℃

Note2: Refer to the typical application circuit.

Electrical Characteristics

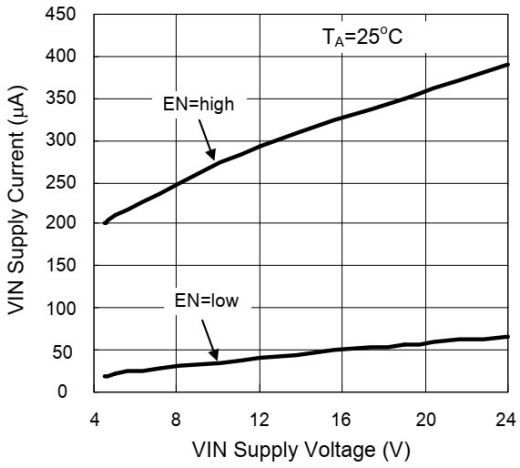
Unless otherwise specified, these specifications apply over V_{IN}=12V, V_{EN} =5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

Symbol	Parameter	Test	Min	Typ	Max	Unit
SUPPLY CURRENT						
I_{VIN}	VIN Supply Cur rent	No load, V_{EN} =0V	-	30	50	μA
		No load, V_{EN} =5V	-	250	400	μA
I_{leak}	Leakage Current	V_{OUT}=GND, V_{EN}=0V	-	-	1	μA
POWER SWITCH						
$R_{DS(ON)}$	Power Switch On Resistance	I_{OUT}=2A, T_A= 25°C, V_{IN}=12V	-	84	95	mΩ
		I_{OUT}=2A, V_{IN}=12V	-	84	105	mΩ
UNDER-VOLTAGE LOCKOUT						
	VIN UVLO Threshold Voltage	V_{VIIN} rising	3.7	-	4.3	V
	VIN UVLO Hysteresis		-	0.25	-	V
CURRENT LIMIT AND SHORT CIRCUIT PROTECTIONS						
	Short Circuit Voltage Threshold		-	1	-	V
V_{ISET}	Current Limit Voltage		-	0.6	-	V
I_{OC}	Over Current Trip Threshold	R_{ISET}=82kΩ, T_A=25°C	5.2	6.2	7.5	A
		R_{ISET}=330kΩ, T_A=25°C	1.0	1.2	1.4	A
	Over Current Trip Threshold	R_{ISET}=82kΩ~330kΩ, T_A=25°C	-20	-	+20	%

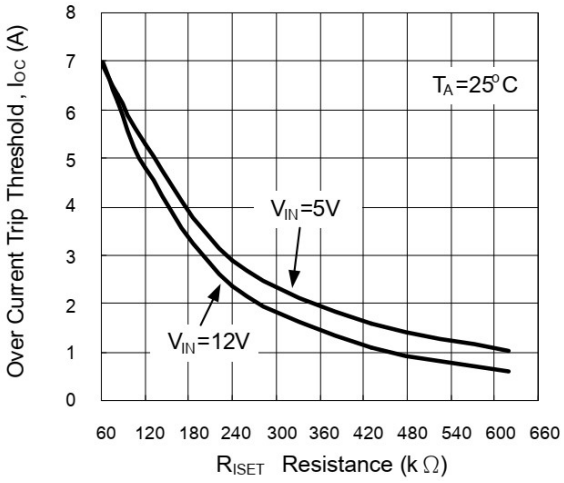
	Accuracy					
	Short Circuit Current		-	0.1	-	A
SOFT-START CONTROL PIN						
I_{SS}	SS Current	VIN=12V,	1	2	3	μA
t_{SS}	Soft-Start Time	V_{IN}=12V, No load, C_{OUT}=1uF, CSS =1nF	-	0.5	-	ms
		V_{IN}=12V, No load, C_{OUT}=1uF, CSS =open	1	2	3	ms
	Soft-Start Discharge Resistance	V_{EN} =0V	-	250	-	Ω
EN INPUT PIN						
V_{IH}	Input Logic High		2	-	-	V
V_{IL}	Input Logic Low		-	-	0.6	V
	Input Current		-	-	1	μA
	VOUT Discharge Resistance	V_{EN} =0V	-	50	-	Ω
$t_{D(ON)}$	Turn on Delay Time		-	300	-	μs
$t_{D(OFF)}$	Turn off Delay Time		-	3	-	μs
OVERT-TEMPERATURE PROTECTION (OTP)						
T_{OTP}	Over-Temperature Threshold	T_J rising	-	150	-	℃
	Over-Temperature Threshold Hysteresis	T_J falling	-	50	-	℃

Typical Operating Characteristics

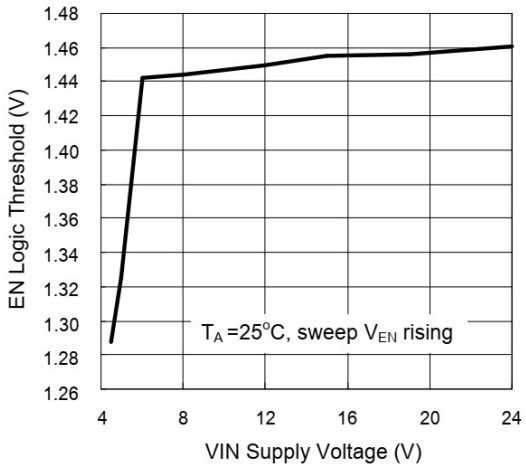
VIN Supply Current vs. VIN Supply Voltage



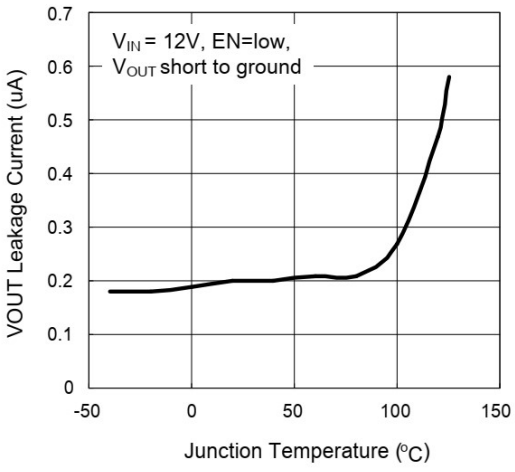
Over Current Trip Thrshold vsR_{ISET} Resistance



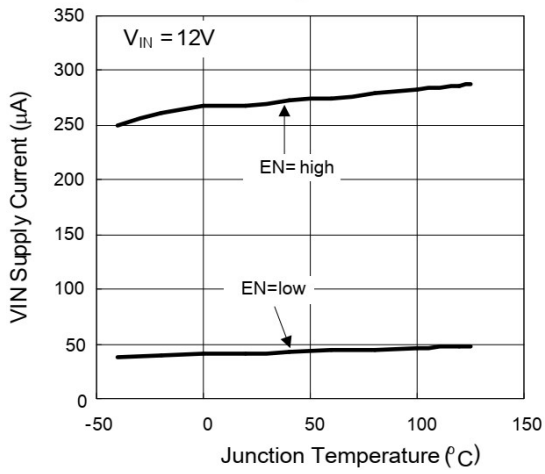
EN Logic Threshold Voltage vs. VIN Supply Voltage



VOUT Leakage Current vs. Junction Temperature



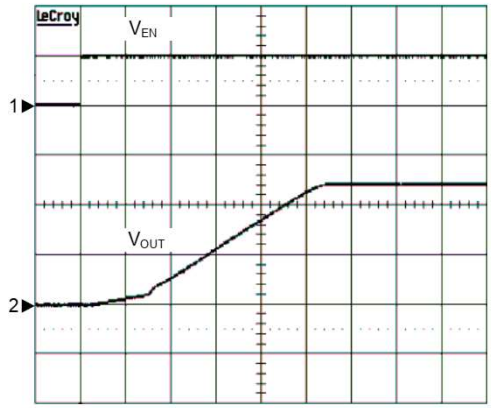
VIN Supply Current vs Junction Temperature



Operating Waveforms

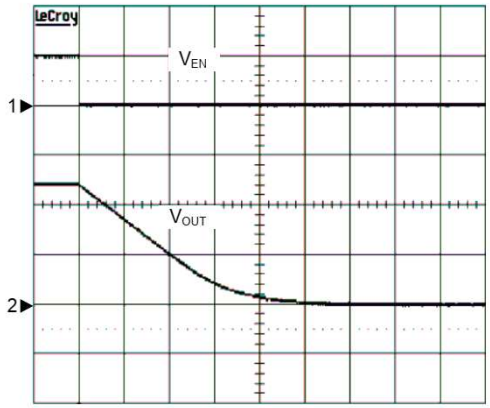
The test condition T_A= 25°C unless otherwise specified.

Turn On Response



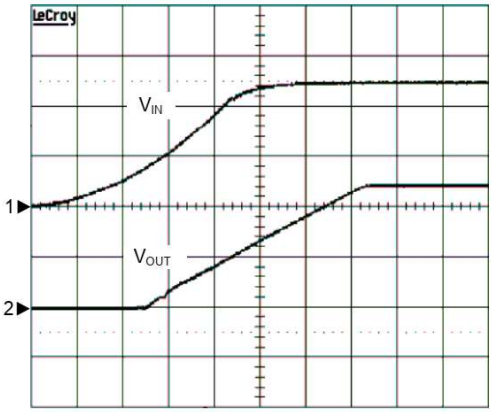
V_{IN} =12V, C_{IN} =10uF/MLCC, C_{OUT} =33µF/Electrolytic, No R_{LOAD}, C_{SS}=4.7nF
CH1: V_{EN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
TIME: 1ms/Div

Turn Off Response



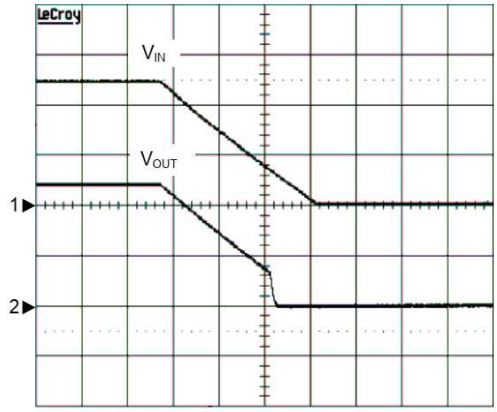
V_{IN} =12V, C_{IN} =10uF/MLCC, C_{OUT} =33µF/Electrolytic, No R_{LOAD}, C_{SS}=4.7nF
CH1: V_{EN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
TIME: 2ms/Div

UVLO at Rising



V_{IN} =12V, C_{IN} =10uF/MLCC, C_{OUT} =33µF/Electrolytic, No R_{LOAD}, C_{SS}=47nF
CH1: V_{IN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
TIME: 5ms/Div

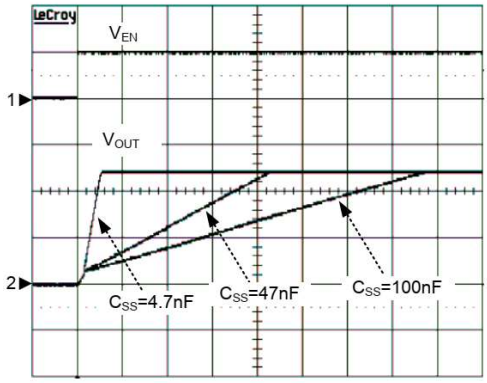
UVLO at Falling



V_{IN} =12V, C_{IN} =10uF/MLCC, C_{OUT} =33µF/Electrolytic, No R_{LOAD}, C_{SS}=47nF
CH1: V_{IN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
TIME: 5ms/Div

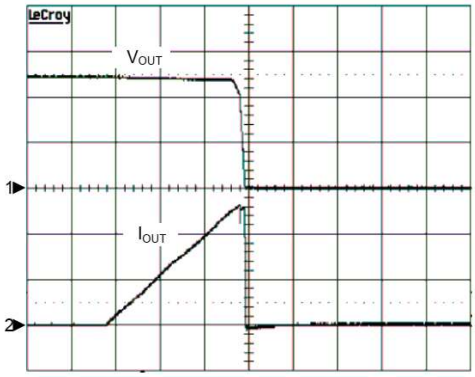
Operating Waveforms(Cont.)

Softstart with Different C_{SS} Capacitor



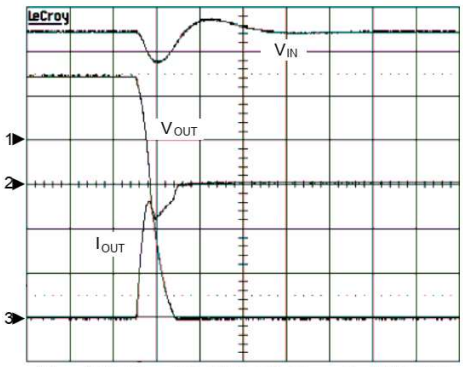
V_{IN}=12V, C_{IN}=10uF/MLCC, C_{OUT} =33μF/Electrolytic, No R_{LOAD}, C_{SS}=4.7/47/100nF
CH1: V_{EN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
TIME: 10ms/Div

Over Current Response with Ramped Load



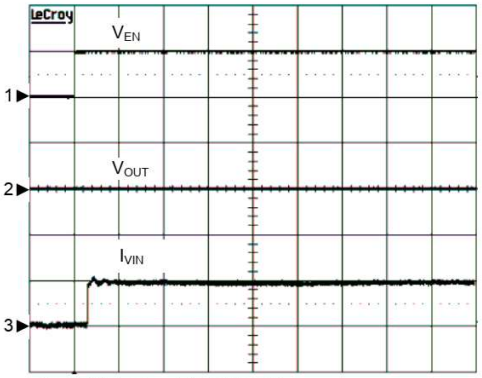
V_{IN}=12V, C_{IN}=10uF/MLCC, C_{OUT} =33μF/ Electrolytic, R_{ISET}=200kΩ
CH1: V_{OUT}, 5V/Div, DC
CH2: I_{OUT}, 1A/Div, DC
TIME: 1ms/Div

Short Circuit Response



V_{IN}=12V, C_{IN}=47uF/ MLCC, C_{OUT}=1μF/ MLCC, R_{ISET}=200kΩ, V_{EN}=5V, VOUT short to ground
CH1: V_{IN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
CH3: I_{OUT}, 10A/Div, DC
TIME: 2μs/Div

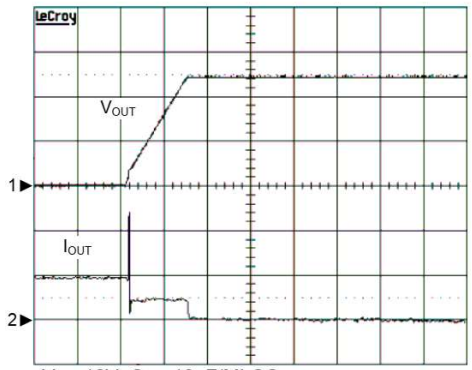
Device Enabled into Short Circuit



V_{IN}=12V, C_{IN}=10uF/MLCC,
VOUT short to ground then EN power on
CH1: V_{EN}, 5V/Div, DC
CH2: V_{OUT}, 5V/Div, DC
CH3: I_{VIN}, 100mA/Div, DC
TIME: 1ms/Div

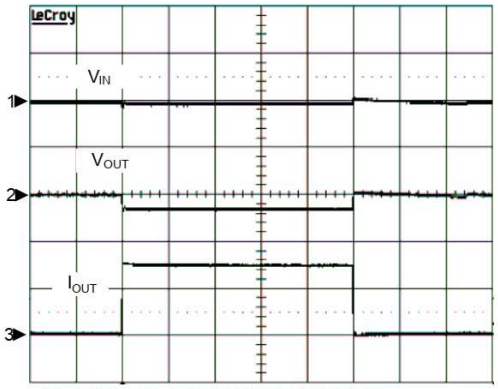
Operating Waveforms(Cont.)

Short Circuit Release



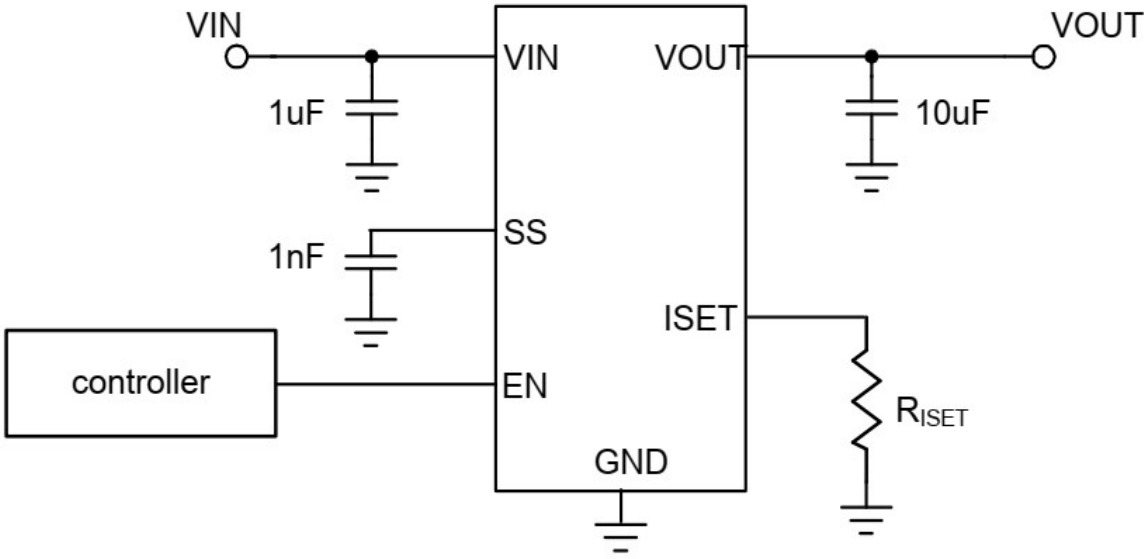
V_{IN} =12V, C_{IN} =10uF/MLCC,
C_{OUT} =120μF/Electrolytic, No R_{LOAD}, C_{SS}=47nF
CH1: V_{EN}, 5V/Div, DC
CH2: I_{OUT}, 100mA/Div, DC
TIME: 20ms/Div

Load Transient



V_{IN}=12V, C_{IN}=120uF/ Electrolytic,C_{OUT} =33μF/ Electrolytic,R_{ISET}=200kΩ,I_{OUT}=0-3-0A
CH1 : V_{IN} , 1V/Div, Offset=12V
CH2 : V_{OUT} , 1V/Div, Offset=12V
CH3 : I_{OUT}, 2A/Div, DC
TIME: 1ms/Div

Typical Application Circuit



Function Description

Under-voltage Lockout (UVLO)

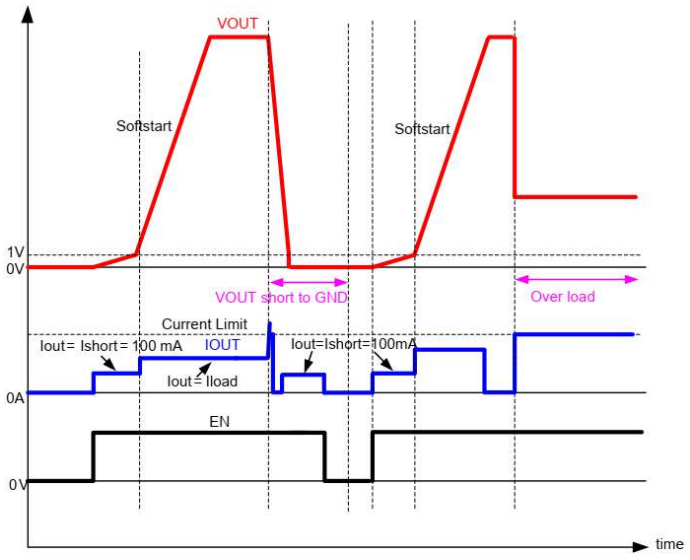
The TD9527 power switch is built-in an under-voltage lockout circuit to keep the output shuts off until internal circuitry is operating properly. The UVLO circuit has hysteresis and a de-glitch feature so that it will typically ignore undershoot transients on the input. When input voltage exceeds the UVLO threshold, the output voltage starts a soft-start to reduce the inrush current.

Current Limit Protection

The TD9527 power switch provides the current limit protection. During current limit, the devices limit output current at current limit threshold. For reliable operation, the device should not be operated in current limit for extended period time.

Short Circuit Protection

When the output voltage drops below VIN-4V, which is caused by the over load or short-circuit, or at the very beginning of the soft start when VOUT<1V, 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 condition. If the junction temperature is over the thermal shutdown temperature, the device will enter the thermal shutdown.



Soft-Start

The TD9527 provides an adjustable soft-start circuitry to control rise rate of the output voltage and limit the current surge during start-up. The soft-start ramp-up rate is controlled by a capacitor from SS pin to ground. the soft start time can be calculated by this following equation:

$t_{SS} = 0.1(C_{SS} \times V_{IN})/I_{SS}$

where,

t_{SS} is soft-start time of V_{OUT} rising from 0 to 100%, of which unit is second.

C_{SS} is the value of the capacitor connected from SS pin to GND, of which unit is micro-Farad.

V_{IN} is the amplitude of input voltage applied to this device, of which unit is volt. I_{SS} is the SS pin charge current.

If the SS pin is left floating the soft start time is 2ms when V_{IN}=12V.

Enable/Disable

Pull the EN below 0.6V to disable the device and pull EN above 2V to enable the device. When the IC is disabled the supply current is reduced to less than 30μA. 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 150°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 50°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.

Application Information

Input Capacitor

A 1μF or higher ceramic bypass capacitor from VIN to GND, located near the TD9527, is strongly recommended to suppress the ringing during over-load or short-circuit fault event. Without the bypass capacitor, the over-load or output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry. Input capacitor is especially important to prevent VIN from ringing too high in some applications where the inductance between power source to VIN is large due to poor PCB layout or purposely adding an inductive component in front of VIN pin.

When the VIN's supply voltage is higher, say 19V or 24V, it is required to add some adequate amount of capacitance of input capacitor into VIN pin for overshoot suppression because a slight ringing of VIN is most likely to exceed VIN's absolute maximum rating, or else the device could be burnout during over load conditions

Output Capacitor

A low-ESR 10 μ F MLCC, aluminum electrolytic or tantalum between VOUT 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 0.1 μ F ceramic capacitor improves the immunity of the device to short-circuit transients.

Soft-Start Capacitor

The TD9527 has a built-in adjustable soft-start control for user to set an optimum soft-start time for the application. The soft-start time can be calculated by the equation, described in the paragraph of Soft-Start in Functional Description section. Please note that there is minimum value of soft start capacitor in different VIN input voltage. Please make sure the C_{SS} is in the recommended value.

Current Limit Setting

The current limit can be set by connecting resistor from the current limit adjustable pin ISET to ground. The required value of resistor RISET for current limit is calculated as follows:

$$R_{ISET} = 510000 / I_{LIM}$$

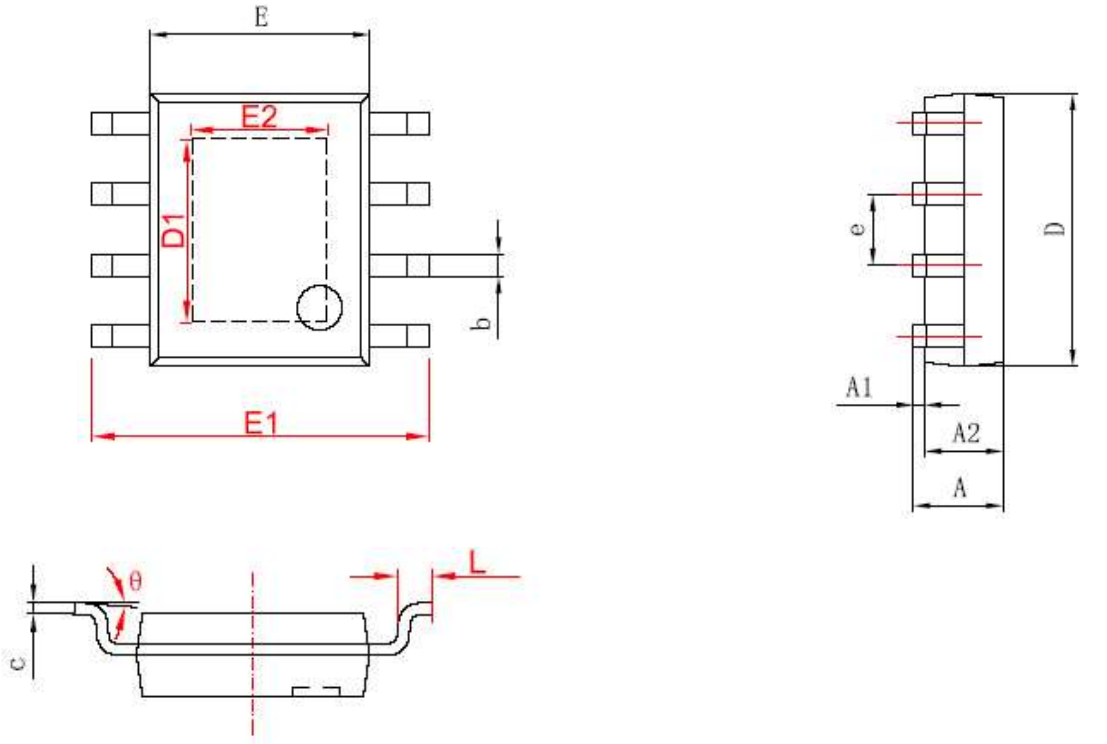
Layout Consideration

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 TD9527 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 VIN and VOUT traces as wide and short as possible.

Package Information

ESOP-8 Package Outline Dimensions



	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Design Notes