17V, 50mΩ $R_{ds(on)}$ Power Switch with Programmable Soft-start

FEATURES

- 2.7V to 17V Input Voltage Range
- Low Rds(on): 50mΩ at V_{IN}=12V typical
- Low Operation Current: 48μA typical at V_{IN}=12V
- Low Shutdown Current:
- 2.5μA typical at V_{IN}=12V
- 0.8μA typical at V_{IN}=5V
- Externally Programmable Soft-start Time
- Output Auto Discharge Function
- Over Current Protection
- Output Short Protection
- Thermal Shutdown Protection
- Input Over Voltage Protection (OVP)
- TMI6250I: PDFN3x2-6 Package

GENERAL DESCRIPTION

The TMI6250I is single channel line power switch with low on-resistance. Input voltage range could support from 2.7V to 17V. The switch is controlled by an active high enable pin. A programmable soft-start function could be used to set the proper rising time to reduce inrush current caused by large load capacitance. Current protection and thermal shutdown function protect the device against over current and high junction temperature.

TMI6250I is available in a space-saving PDFN3x2-6L package.

APPLICATIONS

- Flat Panel Television and Monitor
- Digital Set Top Boxes
- Industrial Systems
- Distributed Power Systems
- Surveillance Systems

TYPICAL APPILCATION

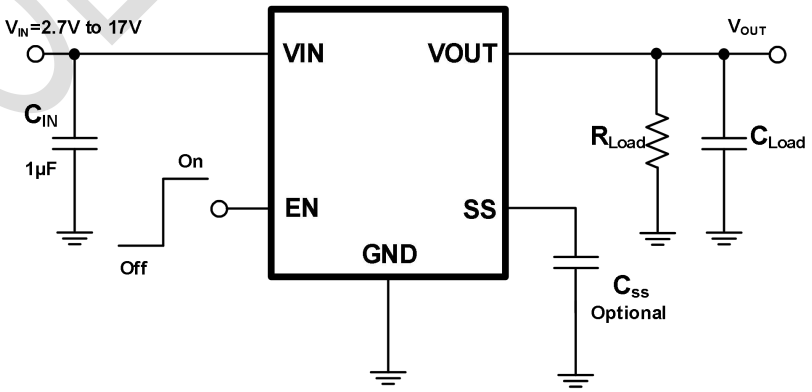
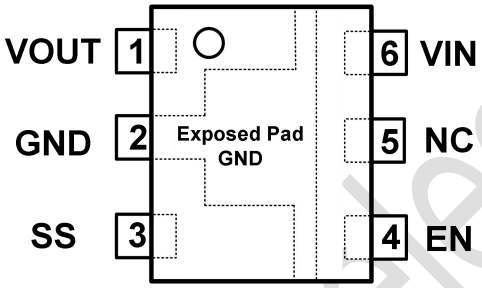


Figure 1. Typical Application Circuits

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Min	Max	Unit
Input Supply Voltages	-0.3	20	V
V_{OUT}, EN Voltages	-0.3	20	V
SS pin Voltage	-0.3	6.0	V
Storage Temperature Range	-65	150	°C
Junction Temperature (Note 2)	-40	150	°C
Power Dissipation		830	mW
Lead Temperature Soldering, 10sec		260	°C

PIN CONFIGURATION



PDFN3x2-6
TMI6250I

Top Mark: TOHXXX (TOH: Device Code, XXX: Inside Code) for TMI6250I

Part Number	Package	Top Mark	Quantity/Reel
TMI6250I	PDFN3x2-6	TOHXXX	3000

TMI6250I devices are Pb-free and RoHS compliant.

PIN FUNCTIONS

Pin	Name	Function
1	VOUT	Switch output pin.
2	GND	Ground pin.
3	SS	Soft-Start program pin. Connect a capacitor to Ground to set Soft-start time. Floating this pin is default soft-start time.
4	EN	Drive this pin to a logic-high to enable the IC. Drive to a logic-low to disable the IC and enter micro-power shutdown mode. Don't float this pin.
5	NC	No connection internal.
6	VIN	Power supply pin.
Exposed Pad	GND	Exposed thermal pad. It is connected to ground.

ESD RATING

Items	Description	Value	Unit
V_{ESD_HBM}	Human Body Model for all pins	±2000	V
V_{ESD_CDM}	Charge Device Model for all pins	±1000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
Voltage Range	V_{IN}	2.7	17	V
T_J	Operating Junction Temperature Range	-40	125	°C
I_{OUT}	Output Current(T_A=25°C)	0	5	A

THERMAL RESISITANCE (Note 3)

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance of PDFN3x2-6	120	°C/W
θ_{JC}	Junction-to-case(top) thermal resistance of PDFN3x2-6	32	°C/W

ELECTRICAL CHARACTERISTICS

(V_{IN}=12V, V_{EN}=5V, T_A = 25°C, unless otherwise noted.)

Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		2.7		17	V
UVLO Threshold		2.25	2.40	2.65	V
UVLO Hysteresis			0.15		V
OVP Threshold			18.5		V
OVP Hysteresis			0.8		V
Operation Current	V_{IN}=12V, V_{EN}=5V, I_{OUT}=0A		48	110	μA
Shutdown Current	V_{IN}=12V, V_{EN}=0V		2.5	6	μA
	V_{IN}=5V, V_{EN}=0V		0.8	1.5	μA
Soft-start Time	V_{IN}=12V, SS pin is floating		0.15		ms
	V_{IN}=12V, C_{SS}=4.7nF		1.1		ms
	V_{IN}=12V, C_{SS}=10nF		2.4		ms
Switch On-Resistance	V_{IN}=12V, I_{OUT}=1A, T_A=25°C		50	80	mΩ
Switch On-Resistance (Note 4)	V_{IN}=5V, I_{OUT}=1A, T_A=25°C		55	90	mΩ
Over Current Limit	V_{IN}=12V, V_{EN}=5V	6			A
Over Current Protect Deglitch Time(Note 4)	Time from I_{OUT}>I_{OCP} to MOSFET turns off		3.5		ms
Over Current Recovery Time(Note 4)	Time from OCP to V_{OUT} start rising		180		ms
Output Short Current Limit(Note 4)			15		A
Output Short Protect Deglitch Time(Note 4)	Time from I_{OUT}>I_{SC} to MOSFET turns off		3		μs
Output Auto Discharge Current	V_{IN}=12V, V_{EN} =0V		30		mA
EN Rising Threshold	V_{IN}=12V	0.8	1.0	1.2	V
EN Falling Threshold	V_{IN}=12V	0.7	0.9	1.1	V
EN Hysteresis Voltage			0.1		V
Thermal Shutdown Threshold (Note 4)			155		°C
Thermal Shutdown Hysteresis (Note 4)			30		°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times \theta_{JA}$.

Note 3: Measured on JESD51-7, 4-layer PCB.

Note 4: Guaranteed by design.

FUNCTION DESCRIPTION

Input Under-Voltage-Lock-Out

The TMI6250I is single channel line power switch with low on-resistance N-channel MOSFET that reduces drop out voltage through the device. Input voltage range could support from 2.7V to 17V. When V_{IN} voltage is higher than Under voltage lockout rising threshold, the device could be turned on by EN pin. When V_{IN} voltage is lower than Under voltage lockout rising threshold minus UVLO hysteresis, the device is turned off.

Input Over Voltage Protection

TMI6250I has input over voltage protection function to prevent output from high voltage damage. When V_{IN} voltage is higher than fixed OVP threshold 18.5V typically, the MOSFET turns off immediately. When V_{IN} voltage drops down to the OVP threshold minus hysteresis, TMI6250I restarts to turn on again.

Enable ON/OFF and Auto-discharge Function

TMI6250I is controlled by an active high enable pin. When V_{IN} voltage is exceeds UVLO threshold and the EN pin is higher than EN rising threshold, the internal MOSFET starts turning on and the current starts flowing from V_{IN} to V_{OUT}. When EN is lower than EN falling threshold, the MOSFET is turned off and output discharge circuits discharges V_{OUT} with 30mA typical discharging current.

Programmable Soft-start Time

A programmable soft-start function could be used to set the proper rising time to reduce inrush current caused by large load capacitance. The external capacitors attached on SS pin to ground program soft-start time. When SS pin is floating, after device is enabled, V_{OUT} rises up with default minimum soft-start time.

Within 50ms after the soft-start is completed, in order to support applications with large output capacitors and prevent output drops caused by OCP protection during power on, The process is in constant current state.

Over Current Protection

The device has over current protection and output short protection function to protect over current condition or output short condition. When the current flowing through the device is larger than over current limitation I_{OCP} and the OCP duration time is larger than t_{OCP} 3.5ms typical, the MOSFET is turned off immediately. After typical 180ms OCP recovery time, the MOSFET restart turning on automatically. If the over current is continuous, the MOSFET is turned off again.

The OCP deglitch time avoid the MOSFET is turned off unexpectedly in load current transient condition, however, it cannot turn off MOSFET during output short condition with large short current. TMI6250I adds the second output short protection to prevent short current. If the short current is larger than I_{SC} typical 15A, the MOSFET is turned off within 3μs to shut off short current. After the short-circuit protection, the chip will try to restart, when the output is still in the short-circuit

state, it will enter the state of repeated over temperature , and return to normal operation after the short-circuit release.

Thermal Shutdown Protection

The device also has thermal shutdown function. It can protect the device against thermal damage due to high junction temperature. When the device junction temperature is higher than thermal shutdown threshold 155°C typically, the MOSFET is turned off immediately, and when junction temperature drops thermal shutdown hysteresis value, the MOSFET turns on again.

FUNCTIONAL BLOCK DIAGRAM

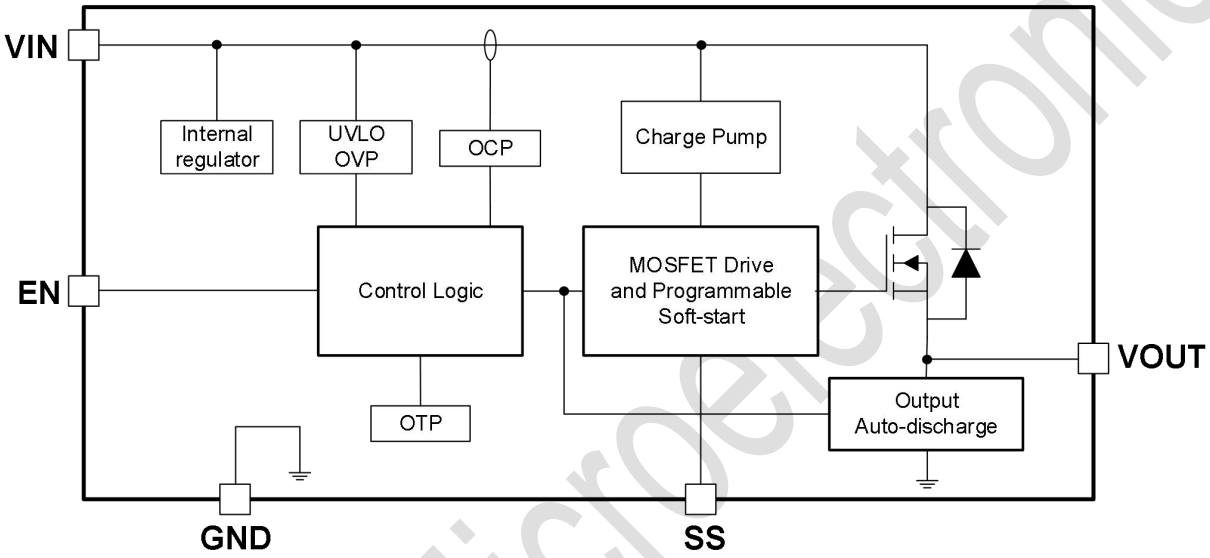


Figure 2. TMI6250I Block Diagram

APPLICATION INFORMATION

Input and Output Capacitors

A 1μF effective ceramic capacitor as input capacitor placed close to V_{IN} pin is usually sufficient. increase the input effective capacitance to 10μF or greater, used to reduce input voltage spikes and surge current during switching or load current transients. For high-current applications, Such as output short circuit, over current protection, input voltage jump and output voltage jump scenarios.

In transient protection, for example output short to ground or over current protection, the current flow from input to output side is interrupts very quickly, the input side inductance could generate a positive voltage spike on the input. The peak amplitude of the transient voltage spike is dependent on the value of inductance in series to the input side and the value of input capacitor. As shown in Figure 1, before MOSFET in TMI6250I turns off, the current flow from TMI6250I is I_{MAX}, the energy in input inductance L_{IN} is: $\frac{1}{2}\times I_{MAX}^2\times L_{IN}$.

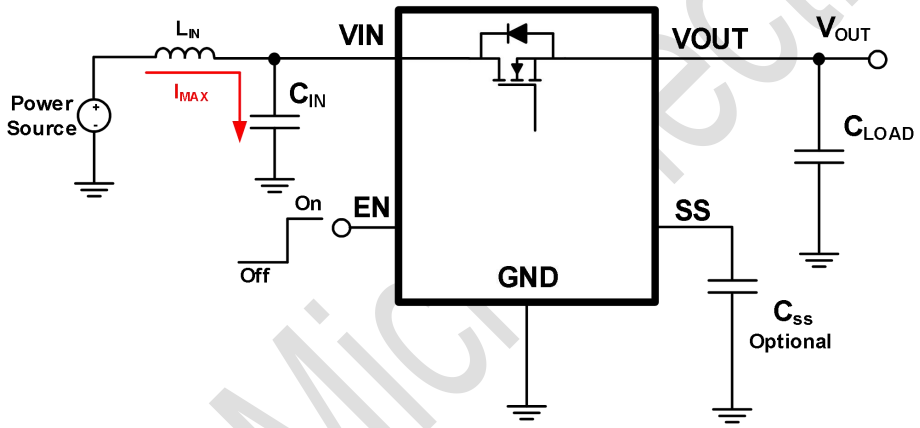


Figure 3. Influence of input inductance and input capacitance

When protection is responded and MOSFET is turned off, the energy in input inductance will transmit to input capacitance, so we have:

$$\frac{1}{2}\times I_{MAX}^2\times L_{IN}=\frac{1}{2}\times \Delta V_{IN\_spike}^2\times C_{IN}$$

$$\Delta V_{IN\_spike}=I_{MAX}\times\sqrt{\frac{L_{IN}}{C_{IN}}}$$

In the case of output hot short to ground, the current flow from TMI6250I is rising rapidly and the value is very large. The large value C_{IN} is needed to absorb input voltage spike caused by input parasitic inductance. In some application, the additional transient voltage suppressor is required on input side to prevent the device from exceeding the absolute maximum ratings.

In output side, the capacitor is the load capacitance. If the load capacitor in output side is larger than input side capacitance, the V_{OUT} voltage may exceed V_{IN} voltage when input power supply is removed and it cause that current flows through body diode of MOSFET in TMI6250I from V_{OUT} to V_{IN}. If there is requirement of reverse current limitation to input side in the system application, higher input capacitance than output capacitance is recommended in practical application.

Programming Soft-start Capacitor

The capacitor C_{SS} on SS pin to GND sets the output rising slew rate and soft-start time also. With floating SS pin, the minimum soft-start time is provided. The larger C_{SS} capacitance, the longer soft-start time. In practical application, when there are large output load capacitors, the device may enter thermal shutdown with large soft-start time since the power consumption on MOSFET is too high during power up process. Meanwhile, with small soft-start time, the over current protection may happen during soft-start process since large inrush current with large output capacitance. The table 1 provide typical measured soft-start time with different input voltage and C_{SS} value for the reference.

Table 1. Soft-start Time Table

C_{SS}	Soft-start time (μs) 10% to 90%, C_{Load}=0.1μF, C_{IN}=1μF, I_O=0.5A				
	V_{IN}=3.3V	V_{IN}=5V	V_{IN}=9V	V_{IN}=12V	V_{IN}=17V
NC	100	120	140	150	190
1nF	110	125	190	235	360
2.2nF	146	202	348	442	666
4.7nF	376	536	886	1132	1652
6.8nF	565	792	1290	1628	2392
10nF	836	1148	1852	2470	3226

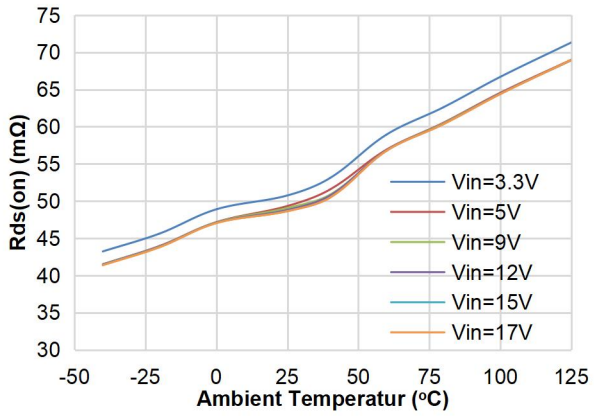
Layout Consideration

When laying out the printed circuit board, the Following checking should be used to ensure proper operation of the TMI6250I. Check the following in your layout:

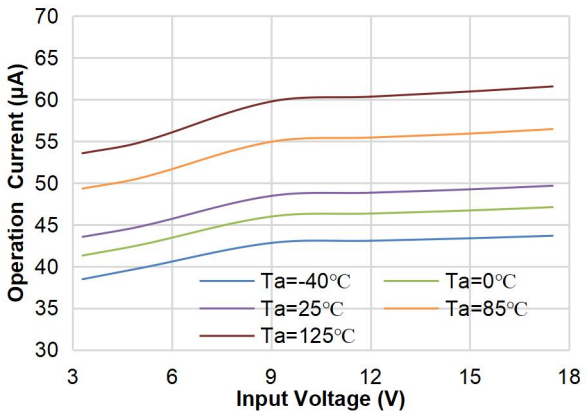
1. The power traces V_{IN} and V_{OUT} must be as short and wide as possible to minimize input inductance and input voltage spike value during over current protection condition.
2. The V_{IN} pin must be bypassed with low ESR ceramic capacitors to ground. The typical recommended bypass capacitance is effective value 1μF or larger ceramic with X5R or X7R. The capacitor must be placed as close to the V_{IN} pin as possible.

TYPICAL PERFORMANCE CHARACTERISTICS

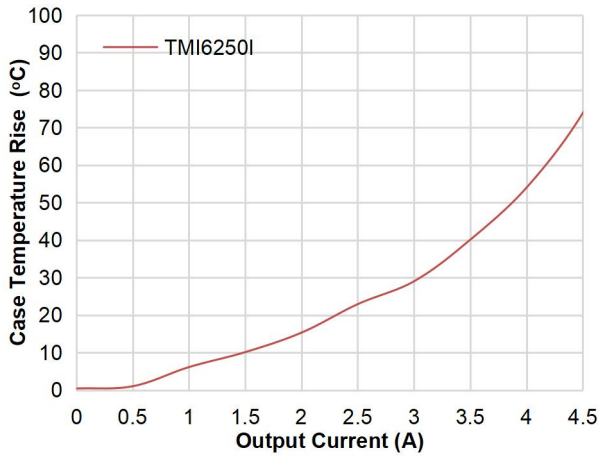
$R_{DS(ON)}$ vs. Temperature



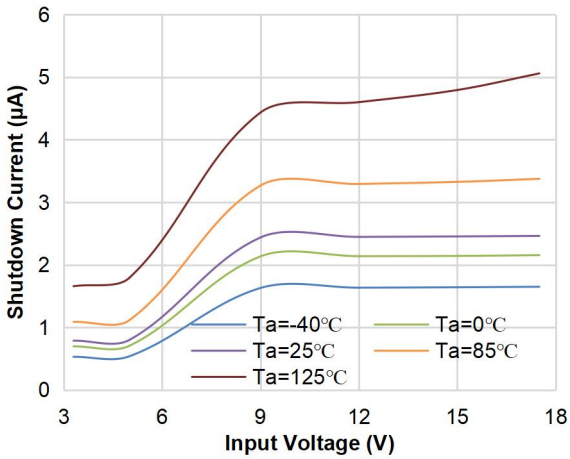
Operation Current vs. Input Voltage



Temperature Rise vs. Output Current

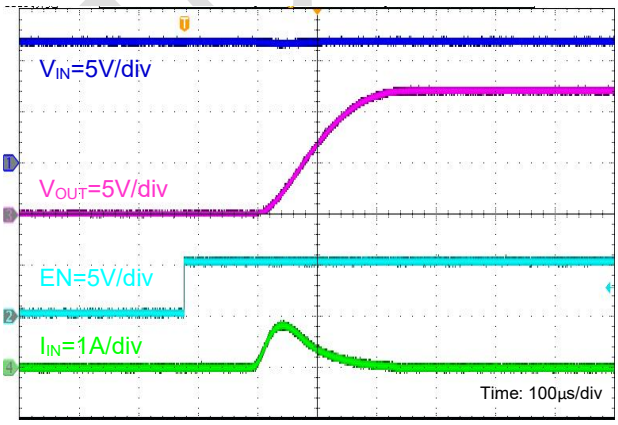


Shutdown Current vs. Input Voltage



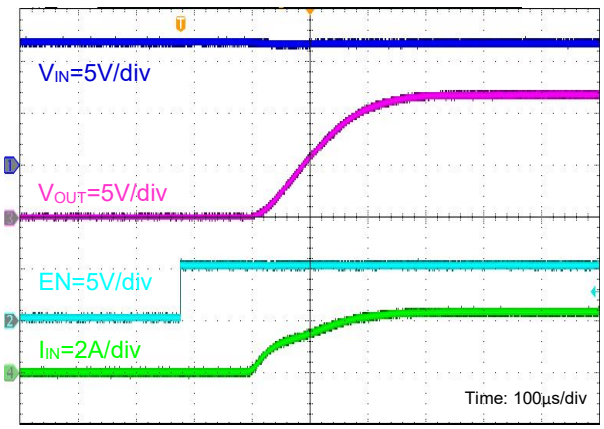
Soft-start

V_{IN} =12V, C_{SS} = NC, C_{Load}=10μF, No Load



Soft-start

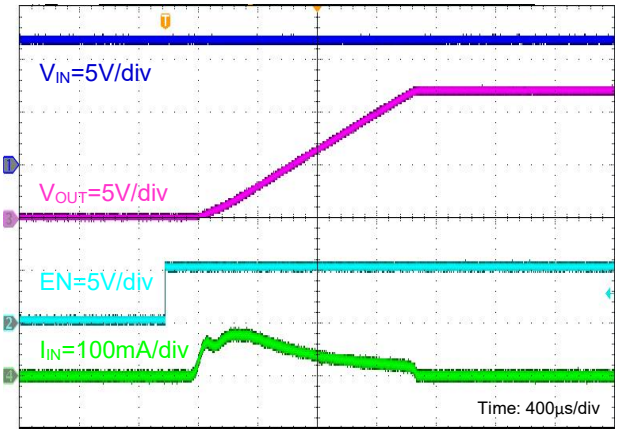
V_{IN} =12V, C_{SS} = NC, C_{Load}=10μF, R_{Load}=5Ω



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

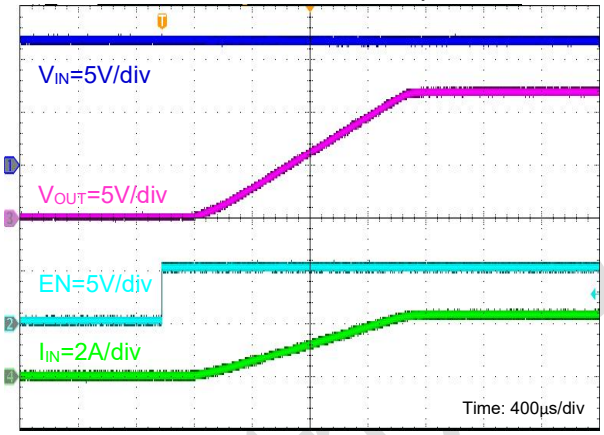
Soft-start

V_{IN} =12V, C_{SS} = 4.7nF, C_{Load}=10μF, No Load



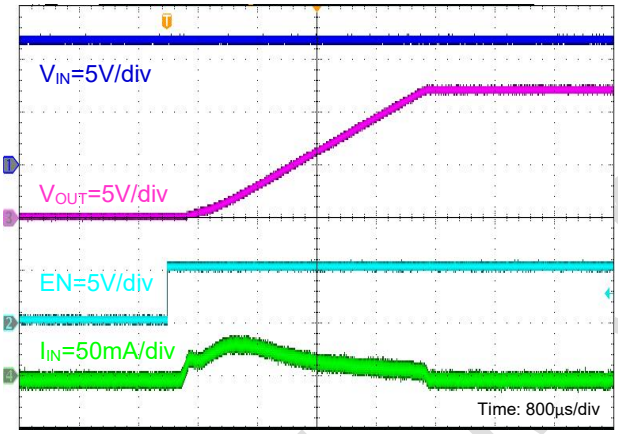
Soft-start

V_{IN} =12V, C_{SS} = 4.7nF, C_{Load}=10μF, R_{Load}=5Ω



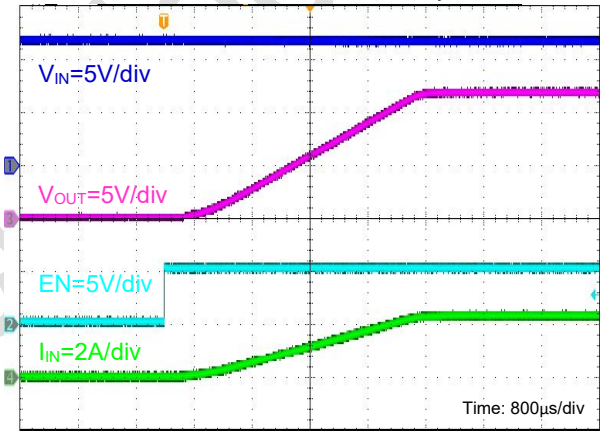
Soft-start

V_{IN} =12V, C_{SS} = 10nF, C_{Load}=10μF, No Load



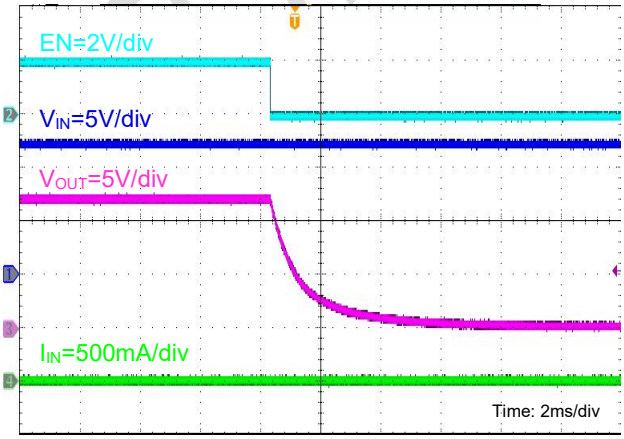
Soft-start

V_{IN} =12V, C_{SS} = 10nF, C_{Load}=10μF, R_{Load}=5Ω



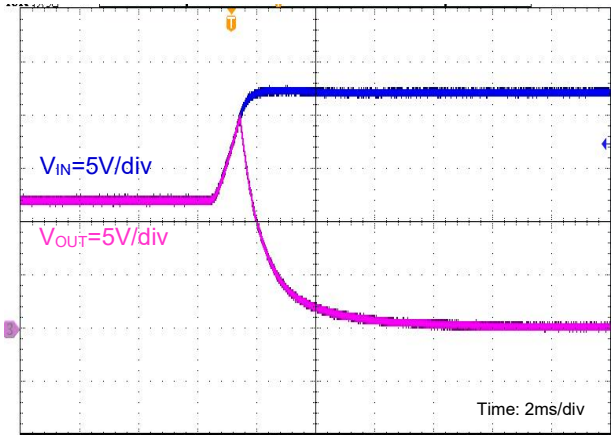
EN disable

V_{IN} =12V, C_{SS} = 10nF, C_{Load}=10μF, No Load



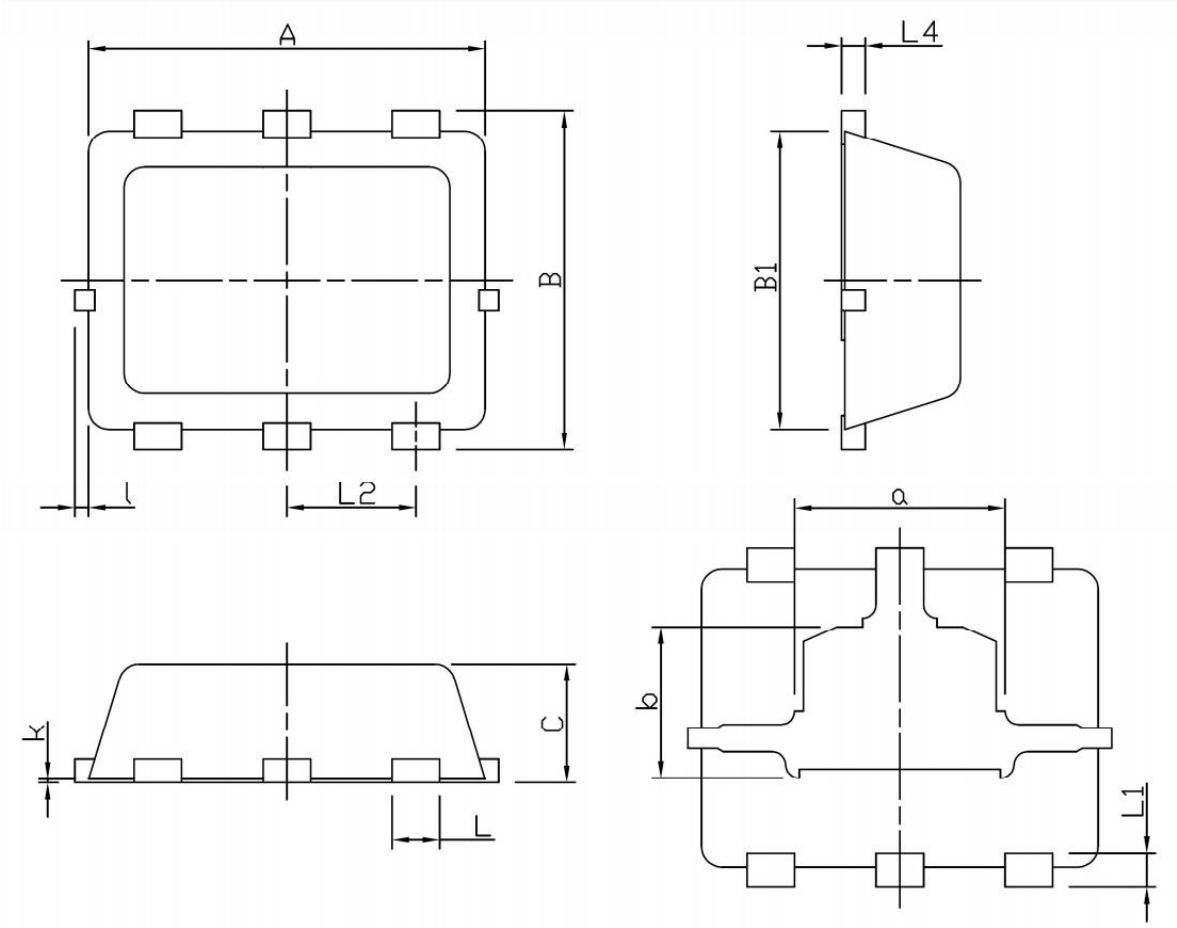
Input OVP

V_{IN} =12V to 22V, C_{SS} = 10nF, C_{Load}=10μF, No Load



PACKAGE INFORMATION

PDFN3x2-6



Unit: mm

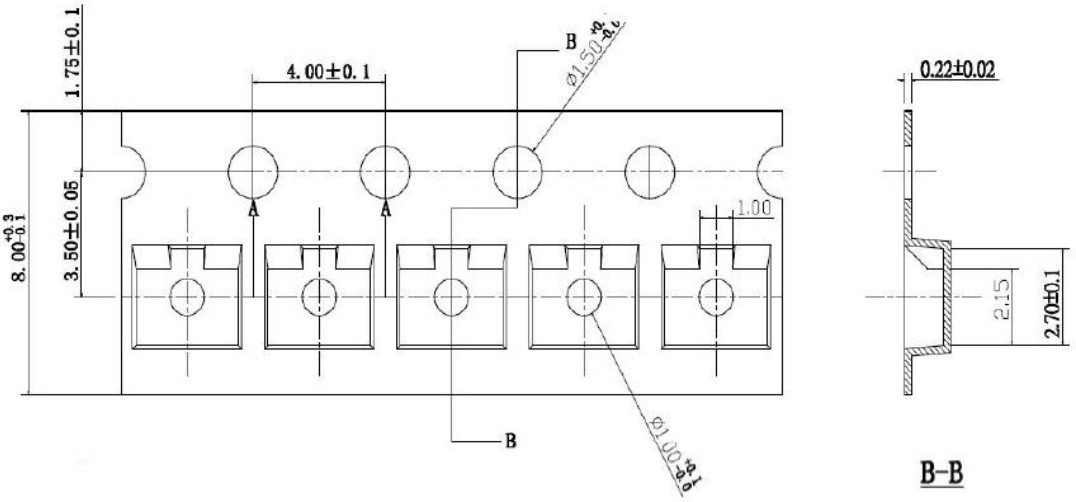
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	Typ	Max		Min	Typ	Max
A	2.82	2.92	3.02	L2	0.85	0.95	1.05
B	2.30	2.50	2.70	L4	0.102	0.152	0.202
B1	2.10	2.20	2.30	a	1.45	1.55	1.65
C	0.65	0.85	1.05	b	1.015	1.115	1.215
L	0.30	0.35	0.40	k	0.00	-	0.05
L1	-	0.25	-	l	-	-	0.15

Note:

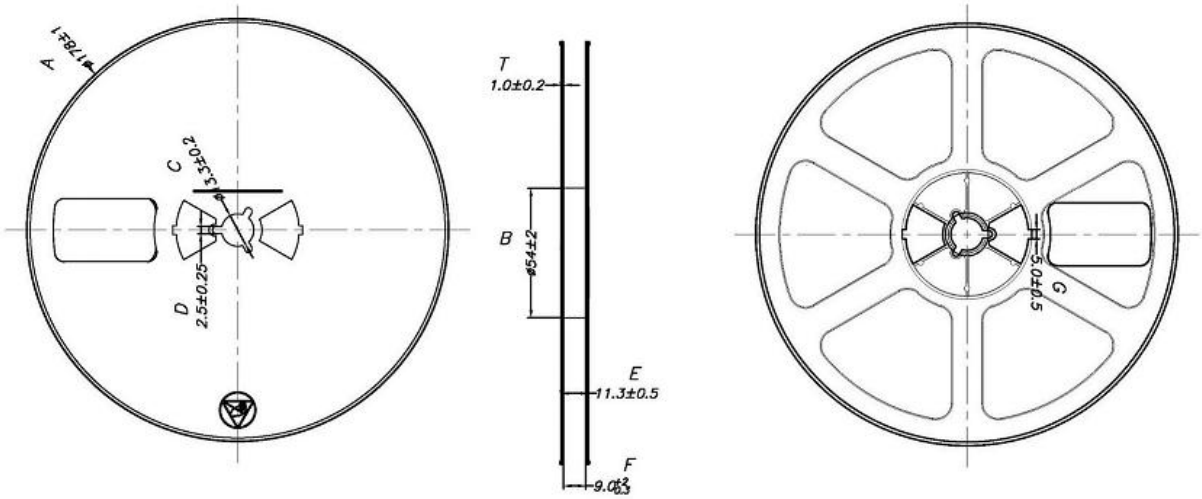
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

TAPE AND REEL INFORMATION

TAPE DIMENSIONS:



REEL DIMENSIONS:



Note:

1) All Dimensions are in Millimeter
2) Quantity of Units per Reel is 3000
3) MSL level is level 3.

Important Notification

This document only provides product information. TOLL Microelectronic Inc. reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and to discontinue any product without notice at any time.

TOLL Microelectronic Inc. cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a TOLL Microelectronic inc. product. No circuit patent licenses are implied.

http:// www.toll-semi.com