6.4V OVP, 60mΩ $R_{ds(on)}$ Power Switch with Programmable Soft-start

FEATURES

- 2.7V to 6V Input Operation Voltage Range
- 6.4V Input Over Voltage Protection
- 20V Maximum Input Voltage
- Low $R_{ds(on)}$: 60mΩ typical
- Low Operation Current: 42μA typical at V_{IN}=5V
- Low Shutdown Current: 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
- SOT23-5 Package

GENERAL DESCRIPTION

The TMI6241 is a single channel line power switch with low on-resistance. Input voltage range could support from 2.7V to 6V with maximum 20V input voltage stress. TMI6241 has fast input over voltage protection function with typic 6.4V threshold. 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.

This device is available in a space-saving SOT23-5 package.

APPLICATIONS

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

TYPICAL APPILCATION

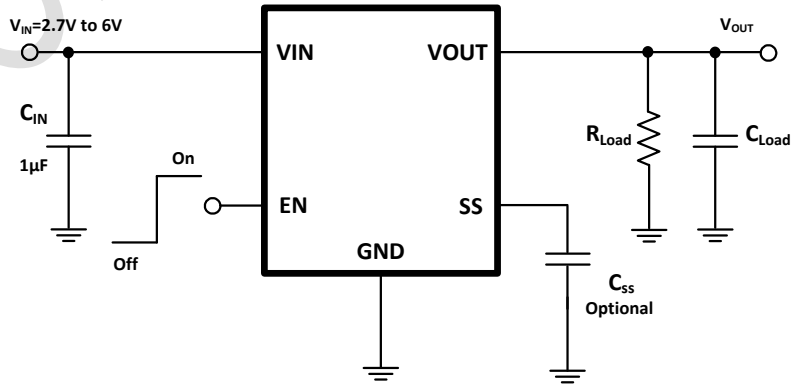
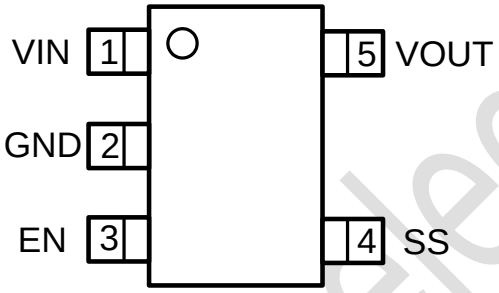


Figure 1. Typical Application Circuits

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Min	Max	Unit
Input Supply Voltages	-0.3	20	V
VOUT, 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		600	mW
Lead Temperature Soldering, 10sec		260	°C

PIN CONFIGURATION



SOT23-5

Top Mark: TOBXXX (TOB: Device Code, XXX: Inside Code)

Part Number	Package	Top Mark	Quantity/Reel
TMI6241	SOT23-5	TOBXXX	3000

TMI6241 devices are Pb-free and RoHS compliant.

PIN FUNCTIONS

Pin	Name	Function
1	VIN	Power supply pin.
2	GND	Ground pin.
3	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.
4	SS	Soft-Start program pin. Connect a capacitor to Ground to set Soft-start time. Floating this pin is default soft-start time.
5	VOUT	Switch output pin.

ESD RATING

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	±2000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
Voltage Range	IN	2.7	6	V
T_J	Operating Junction Temperature Range	-40	125	°C

THERMAL RESISITANCE (Note 3)

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance	240	°C/W
θ_{JC}	Junction-to-case(top) thermal resistance	62	°C/W

ELECTRICAL CHARACTERISTICS

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

Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		2.7		6	V
UVLO Threshold		2.25	2.40	2.65	V
UVLO Hysteresis			0.15		V
OVP Threshold		6.0	6.4	6.8	V
OVP Hysteresis			0.25		V
Operation Current	V_{IN}=5V, V_{EN}=5V, I_{OUT}=0A		42	110	μA
Shutdown Current	V_{IN}=5V, V_{EN}=0V		0.8	1.5	μA
Soft-start Time	V_{IN}=5V, SS pin is floating		0.3		ms
	V_{IN}=5V, C_{SS}=10nF		2.5		ms
Switch On-Resistance (Note 4)	V_{IN}=5V, I_{OUT}=1A		60	95	mΩ
Switch Current Limit (Note 4)		4			A
Output Auto Discharge Current	V_{IN}=5V, V_{EN} =0V		30		mA
EN Rising Threshold		0.8	1.0	1.2	V
EN Falling Threshold		0.7	0.9	1.1	V
EN Hysteresis Voltage			0.1		V
Hiccup Cycle Time after Over Current (Note 4)			220		ms
Thermal Shutdown Threshold (Note 4)			145		°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, 2-layer PCB.

Note 4: Guaranteed by design.

FUNCTION DESCRIPTION

Input Under-Voltage-Lock-Out

The TMI6241 is a 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 6V. MI6241 has fast input over voltage protection function with typic 6.4V threshold. When VIN voltage is higher than Under voltage lockout rising threshold, the device could be turned on by EN pin. When VIN voltage is lower than Under voltage lockout rising threshold minus UVLO hysteresis, the device is turned off.

Input Over Voltage Protection

TMI6241 has input over voltage protection function to prevent output from high voltage damage. When VIN voltage is higher than fixed OVP threshold 6.4V typically, the MOSFET turns off immediately. When VIN voltage drops down to the OVP threshold minus hysteresis, TMI6241 restart to turn on again.

Enable ON/OFF and Auto-discharge Function

TMI6241 is controlled by an active high enable pin. When VIN 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 VIN to VOUT. When EN is lower than EN falling threshold or input OVP status, the MOSFET is turned off and output discharge circuits discharges VOUT 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, VOUT rises up with default minimum soft-start time.

Over Current Protection

The device has current limit function to protect over current condition or output short condition. When the current flowing through the device is larger than over current limitation, the MOSFET is turned off immediately. After hiccup cycle time, the MOSFET restart turning on automatically, if the over current or short condition is continuous, the MOSFET is turned off again.

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, the MOSFET is turned off immediately, and when junction temperature drops thermal shutdown hysteresis value, the MOSFET turns on again.

FUNCTIONAL BLOCK DIAGRAM

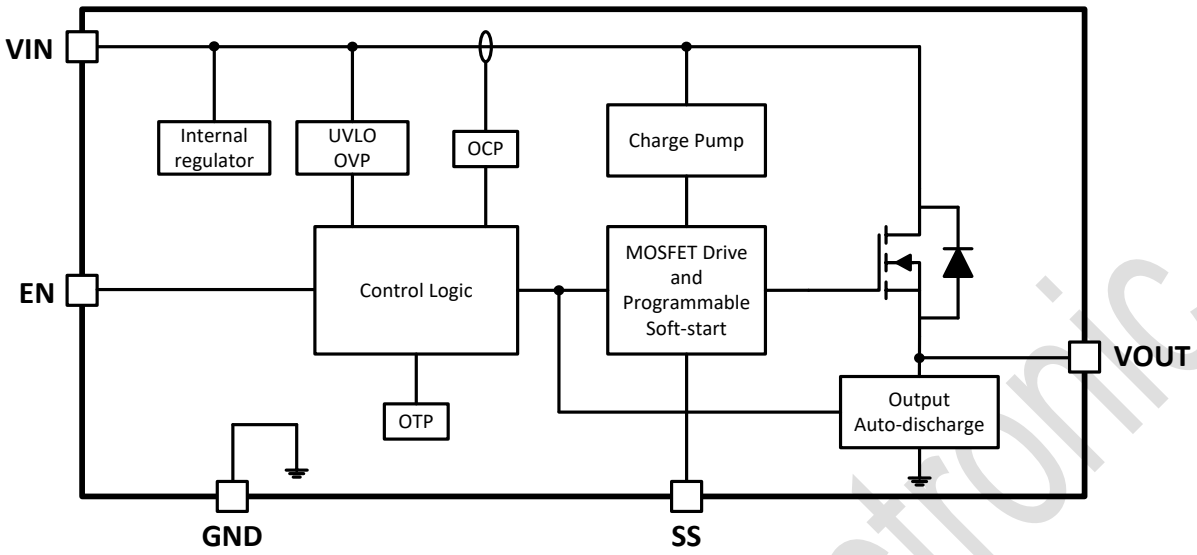


Figure 2. TMI6241 Block Diagram

APPLICATION INFORMATION

Input and Output Capacitors

The input capacitor of TMI6241 is needed to reduce input voltage drop caused by input inrush current during switch turning on or load current transient and to reduce input voltage spike during MOSFET turn-off transient with OCP. In normal design a 1μF effective value ceramic capacitor as input capacitor placed close to VIN pin is usually sufficient. Higher value of input capacitance can be used to limit voltage drop and spike in high current application.

In output side, the capacitor is the load capacitance. If the load capacitor in output side is larger than input side capacitance, the VOUT voltage may exceed VIN voltage when input power supply is removed and it cause that current flows through body diode of MOSFET in TMI6241 from VOUT to VIN. 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	
	VIN=3.3V	VIN=5V
NC	190	300
1nF	195	305
2.2nF	253	426
4.7nF	784	1293
6.8nF	1172	1962
10nF	1682	2504

Layout Consideration

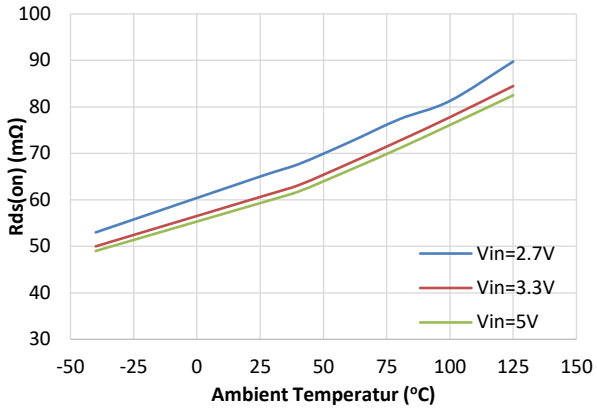
When laying out the printed circuit board, the Following checking should be used to ensure proper operation of the TMI6241. Check the following in your layout:

1. The power traces VIN and VOUT must be as short and wide as possible to minimize input inductance and input voltage spike value during over current protection condition.

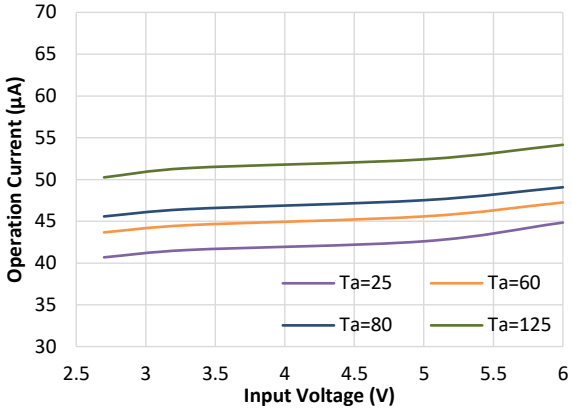
2. The VIN pin must be bypassed with low ESR ceramic capacitors to ground. The typical recommended bypass capacitance is effective value 1μF or larger ceramic with X5R or X7R. The capacitor must be placed as close to the VIN pin as possible.

TYPICAL PERFORMANCE CHARACTERISTICS

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

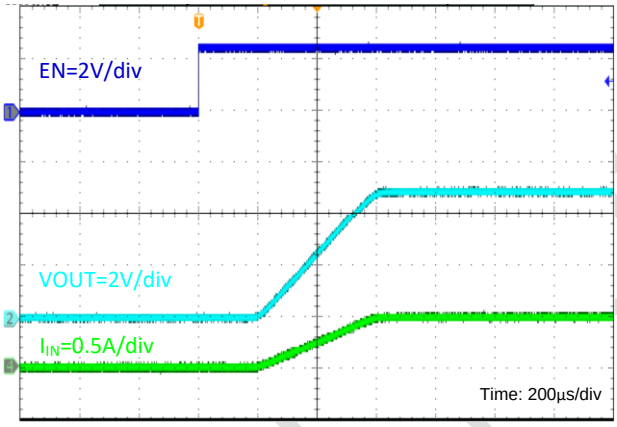


Operation Current vs. Input Voltage



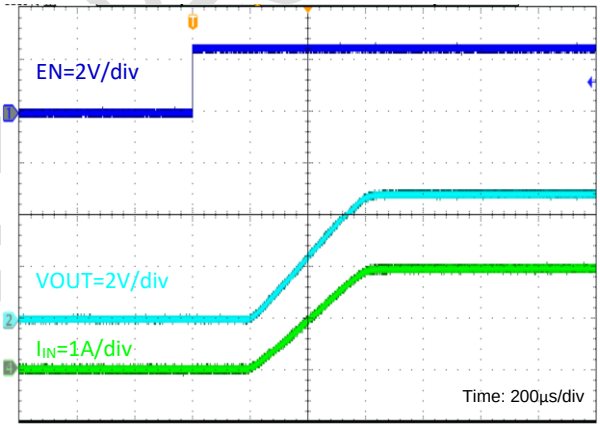
Soft-start

V_{IN} =5V, C_{SS} = NC, C_{Load}=1μF, R_{LOAD}=10Ω



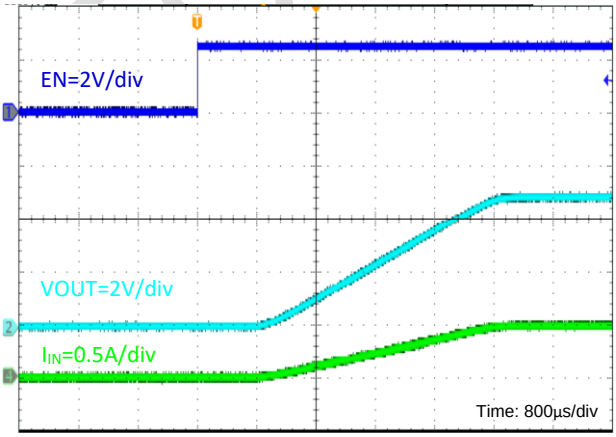
Soft-start

V_{IN} =5V, C_{SS} = NC, C_{Load}=1μF, R_{LOAD}=2.5Ω



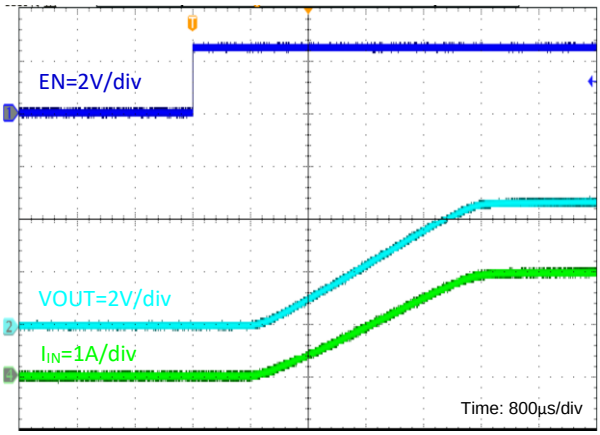
Soft-start

V_{IN} =5V, C_{SS} = 10nF, C_{Load}=1μF, R_{LOAD}=10Ω



Soft-start

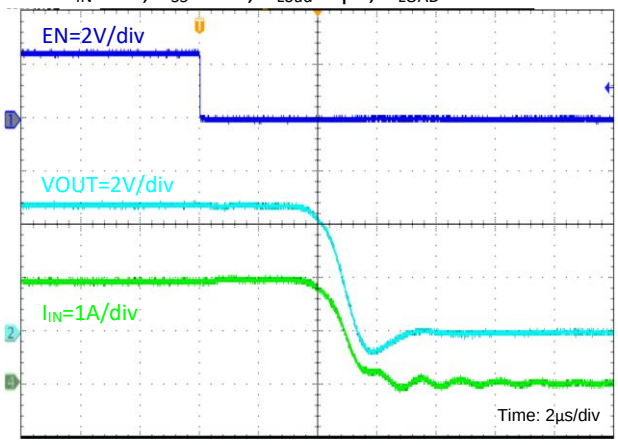
V_{IN} =5V, C_{SS} = 10nF, C_{Load}=1μF, R_{LOAD}=2.5Ω



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

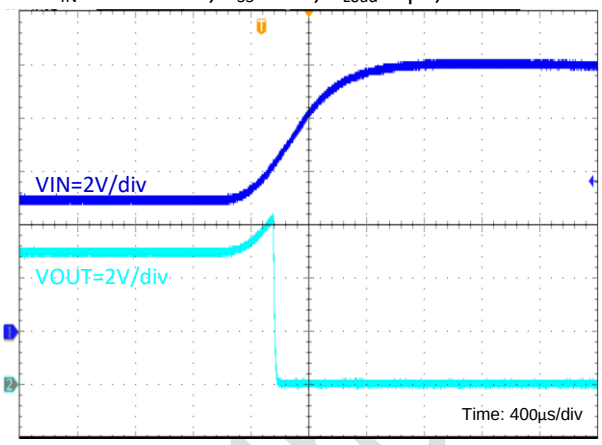
EN disable

V_{IN} =5V, C_{SS} = NC, C_{Load}=1μF, R_{LOAD}=10Ω



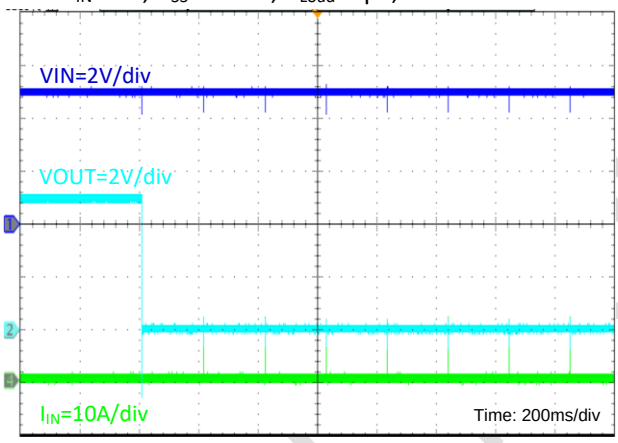
Input OVP

V_{IN} =5V to 10V, C_{SS} = NC, C_{Load}=1μF, No Load



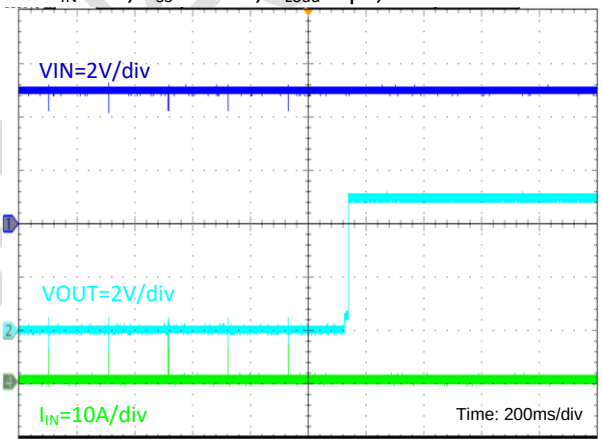
Output Short Entry

V_{IN} =5V, C_{SS} = 10nF, C_{Load}=1μF, No Load



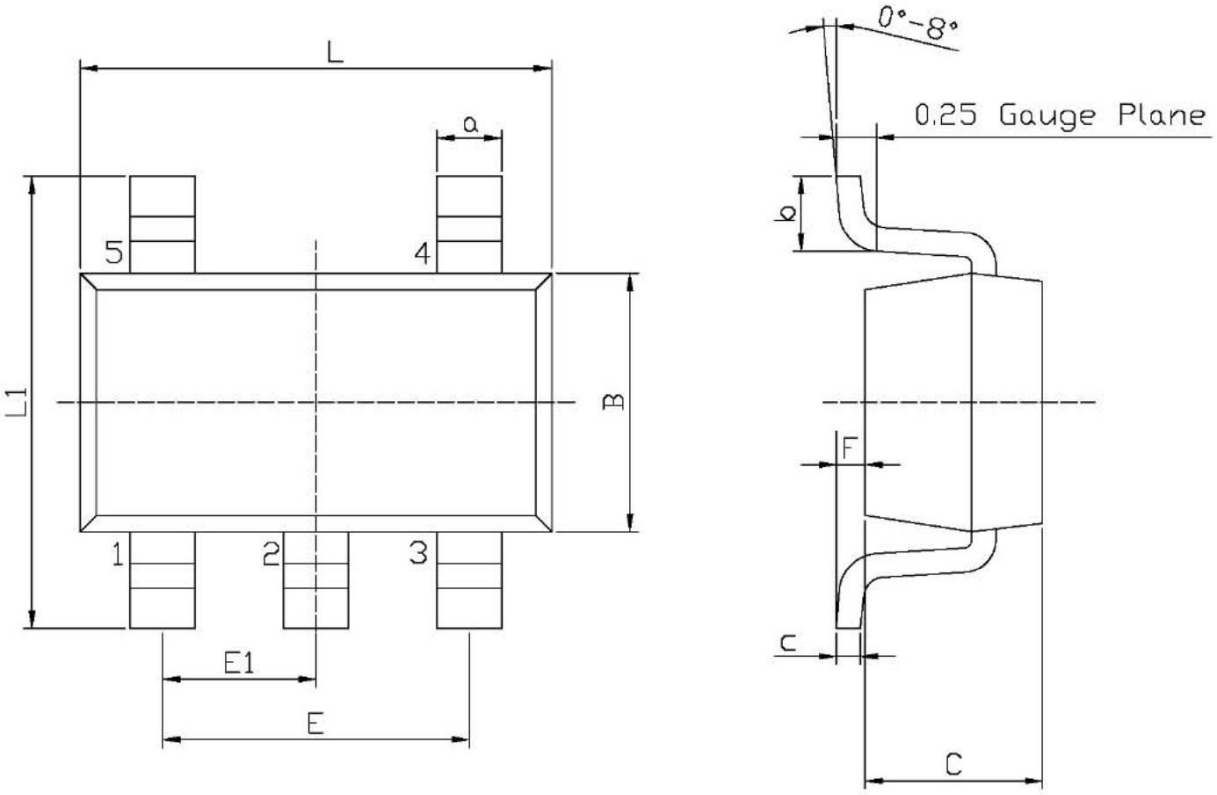
Output Short Release

V_{IN} =5V, C_{SS} = 10nF, C_{Load}=1μF, No Load



PACKAGE INFORMATION

SOT23-5



Unit: mm

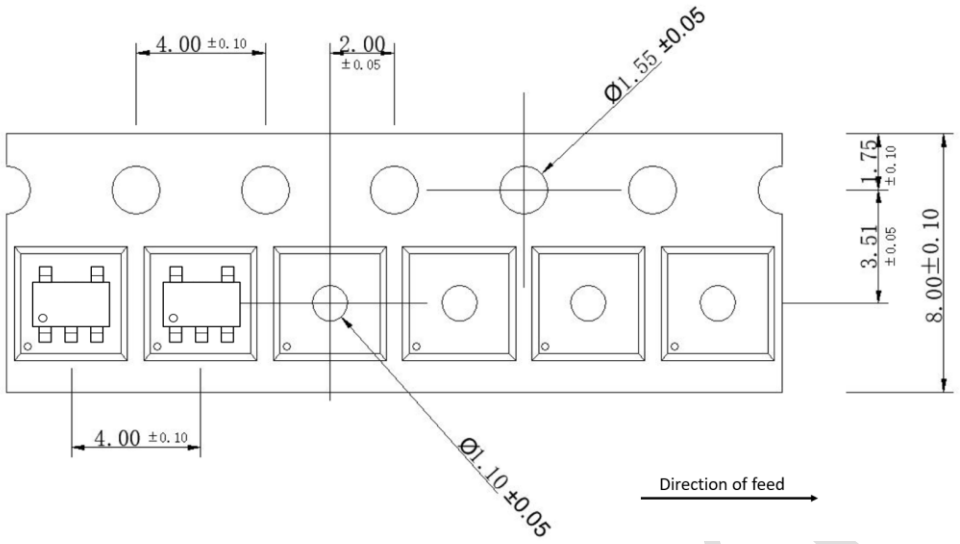
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	Typ	Max		Min	Typ	Max
L	2.82	2.92	3.02	E1	0.85	0.95	1.05
B	1.50	1.60	1.70	a	0.35	0.425	0.50
C	0.90	1.10	1.30	c	0.10	0.15	0.20
L1	2.60	2.80	3.00	b	0.35	0.45	0.55
E	1.80	1.90	2.00	F	0	0.075	0.15

Note:

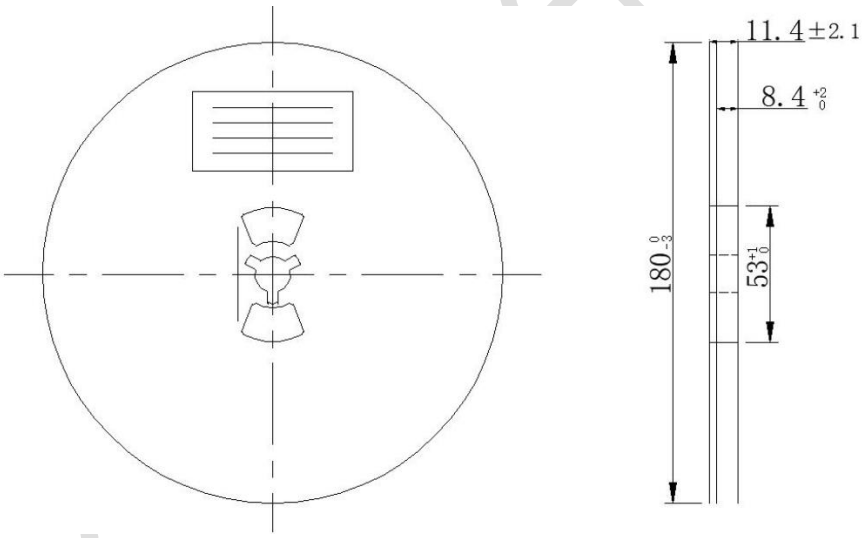
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top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