Adjustable Current Limited Power Distribution Switch TJ2100

FEATURES

- 105mΩ High-Side MOSFET
- 2.7V to 5.5V Operating Range
- Adjustable Current Limit : 200mA to 3.0A(Typ.)
- ±10% Current-Limit Accuracy at 1.5A(Typ.)
- Fold-back Short Circuit Protection
- 90uA Typical On-State Supply Current
- 1uA Maximum Standby Supply Current
- Independent Open-drain Fault Flag Pin
- Thermal Shutdown Protection
- Under Voltage Lockout(UVLO)
- TJ2100H : Active High version
- TJ2100L : Active Low version
- TJ2100A : Fixed Enable version

APPLICATION

- USB Peripherals
- General Purpose Power Switching
- ACPI Power Distribution
- Notebook PCs
- PDAs
- Hot Plug-in Power Supplies

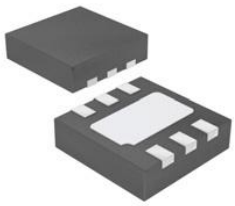
DESCRIPSION

The TJ2100X is single-channel High-Side MOSFET switch optimized for adjustable current limited power distribution requiring circuit protection.

The TJ2100X series support the following USB requirements. The TJ2100 series supply up to 2.5A as required by USB downstream devices. Maximum continuous current can be different on the types of package and ambient temperature. Switch's low on-resistance meets USB voltage drop requirement. Flag output indicate fault condition to the local USB controller. Soft-start prevents the transient voltage drop on the upstream port that can occur when the switch is enabled in bus-powered applications. Under voltage lockout (UVLO) feature disables the output switches until a valid input voltage. Also the TJ2100 include thermal shutdown to prevent switch failure from high-current loads.

SOT23-6L PKG

DFN2X2-6L PKG



ORDERING INFORMATION

Device	Package
TJ2100HGSF6	SOT23-6L
TJ2100LGSF6	
TJ2100AGSF6	
TJ2100HGQ	DFN2X2-6L
TJ2100LGQ	
TJ2100AGQ	

Absolute Maximum Ratings (Note 1)

Characteristic	Symbol	Min	Max	Unit
Supply Voltage	V_{IN}	-0.3	6.0	V
Enable Input Voltage (Note 2)	V_{EN}	-0.3	6.0	V
Fault Flag Voltage	V_{FLG}	-	6.0	V
Fault Flag Current	I_{FLAG}	-	25	mA
Output Voltage	V_{OUT}		6.0	V
Output Current	I_{OUT}		Internally Limited	
Storage Temperature Range	T_{STG}	-65	150	℃

Operating Ratings (Note 3),(Note 4)

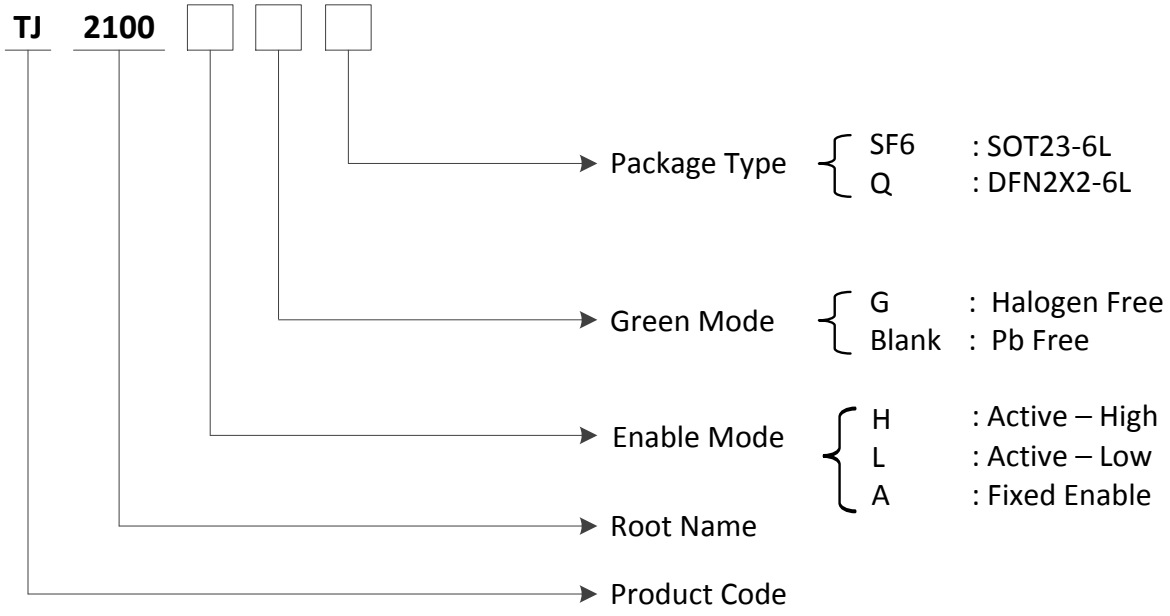
Characteristic		Symbol	Min	Max	Unit
Supply Voltage		V_{IN}	2.7	5.5	V
Ambient Temperature Range		T_A	-40	+80	℃
Operating Junction Temperature Range		T_J	-40	125	℃
Thermal Resistance Junction-to-Ambient	SOP23-6L (Note 5)	θ_{JA}	250		$^oC/W$
	DFN2x2-6L(Note 6)	θ_{JA}	165		$^oC/W$

Note:

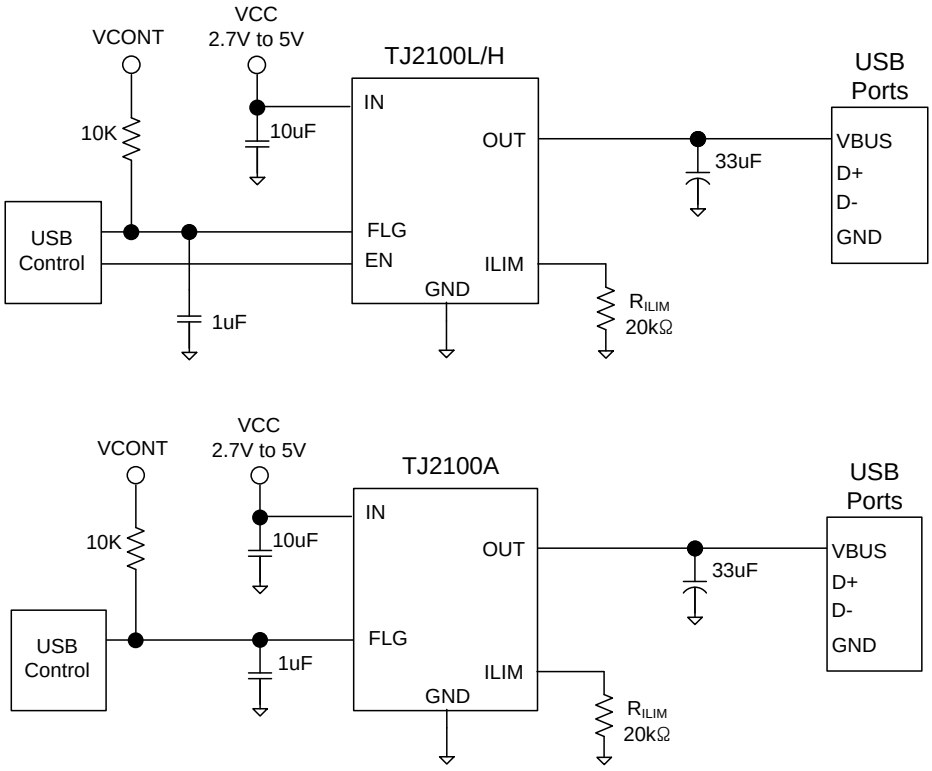
1. Exceeding the absolute maximum ratings may damage the device.
2. It is recommended for V_{EN} voltage not to exceed V_{IN} voltage.
3. The device is not guaranteed to function outside its operating rating.
4. Devices are ESD sensitive. Handling precautions are recommended.
5. Test Condition for SOT23-6L : Copper Area = 35mm^2 , Board Size = 430 mm X 430mm, 1.6T
6. Test Condition for DFN2x2-6L : Copper Area = 35mm^2 , Board Size = 430 mm X 430mm, 1.6T

Ordering Information

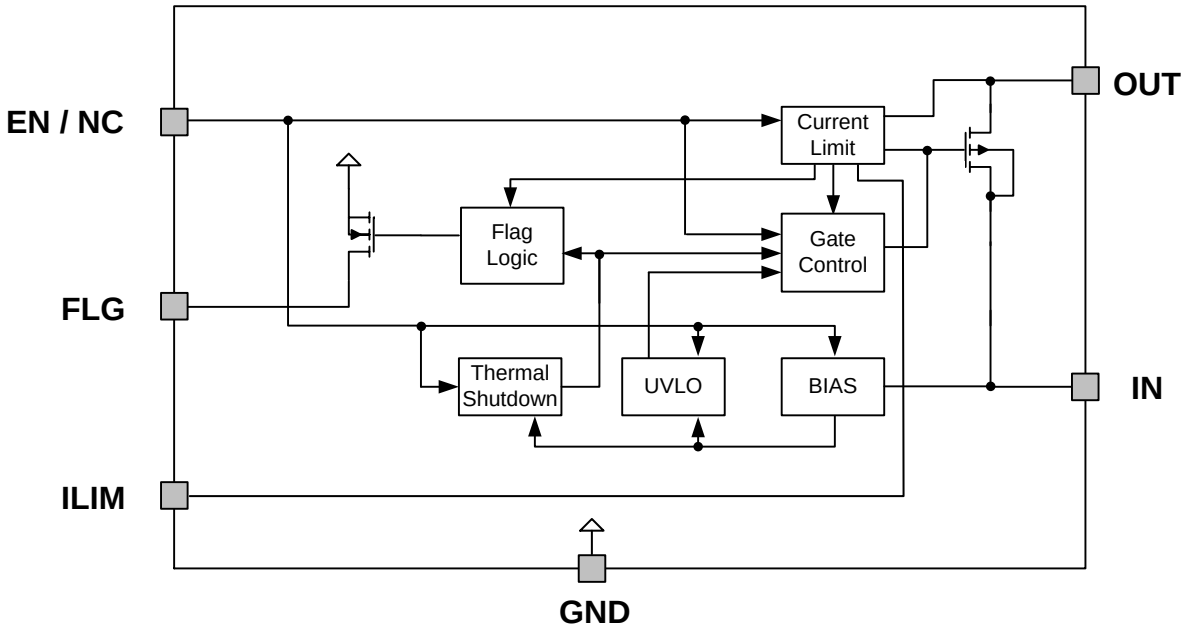
Package	Oder No.	Description	Marking	Compliance	Status
SOT23-6L	TJ2100LGSF6	Adjustable , Active Low	2100LG	RoHS, Green	Contact Us
DFN2X2-6L	TJ2100LGQ	Adjustable , Active Low	2100LG	RoHS, Green	Contact Us
SOT23-6L	TJ2100HGSF6	Adjustable , Active High	2100HG	RoHS, Green	Contact Us
DFN2X2-6L	TJ2100HGQ	Adjustable , Active High	2100HG	RoHS, Green	Contact Us
SOT23-6L	TJ2100AGSF6	Adjustable, Fixed Enable	2100AG	RoHS, Green	Contact Us
DFN2X2-6L	TJ2100AGQ	Adjustable, Fixed Enable	2100AG	RoHS, Green	Contact Us



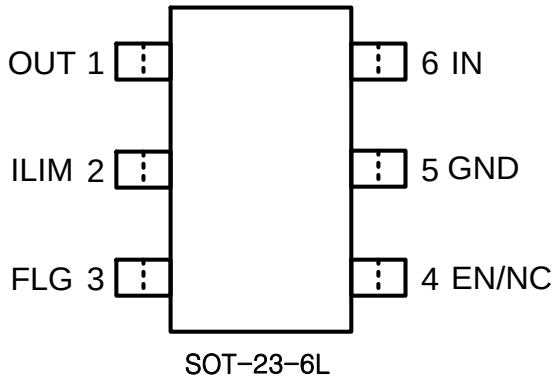
TYPICAL APPLICATION CIRCUIT



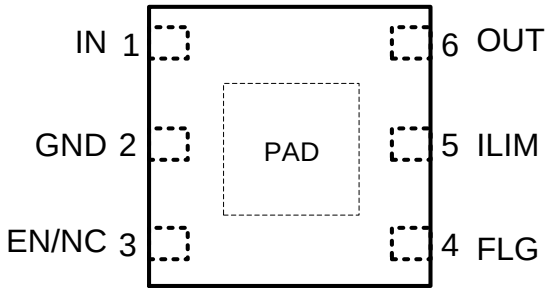
FUNCTION BLOCK DIAGRAM



PIN CONFIGURATION



SOT−23−6L



DFN2X2-6L

PIN DESCRIPTION

Pin Name	Pin No.		Pin Description & Function
	SOT23-6L	DFN2X2-6L	
OUT	1	6	Switch Output: Output MOSFET source. Typically connect to switched side of load.
ILIM	2	5	Current Limit Set. External resistor used to set current limit threshold.
FLG	3	4	Fault Flag: Active-low, open-drain output. Indicates Short circuit current, UVLO and Thermal shutdown.
EN / NC	4	3	Enable: Logic-Compatible enable input. (H: active high, L: active low). Do not float. NC: No internal connection at fixed enable type. (Note 7)
GND	5	2	Ground
IN	6	1	Supply Input: Output MOSFET drain. Also supplies IC's internal circuitry. Connect to positive supply.

Note:

7. The NC pin in TJ2100A is recommended to tie at Ground.

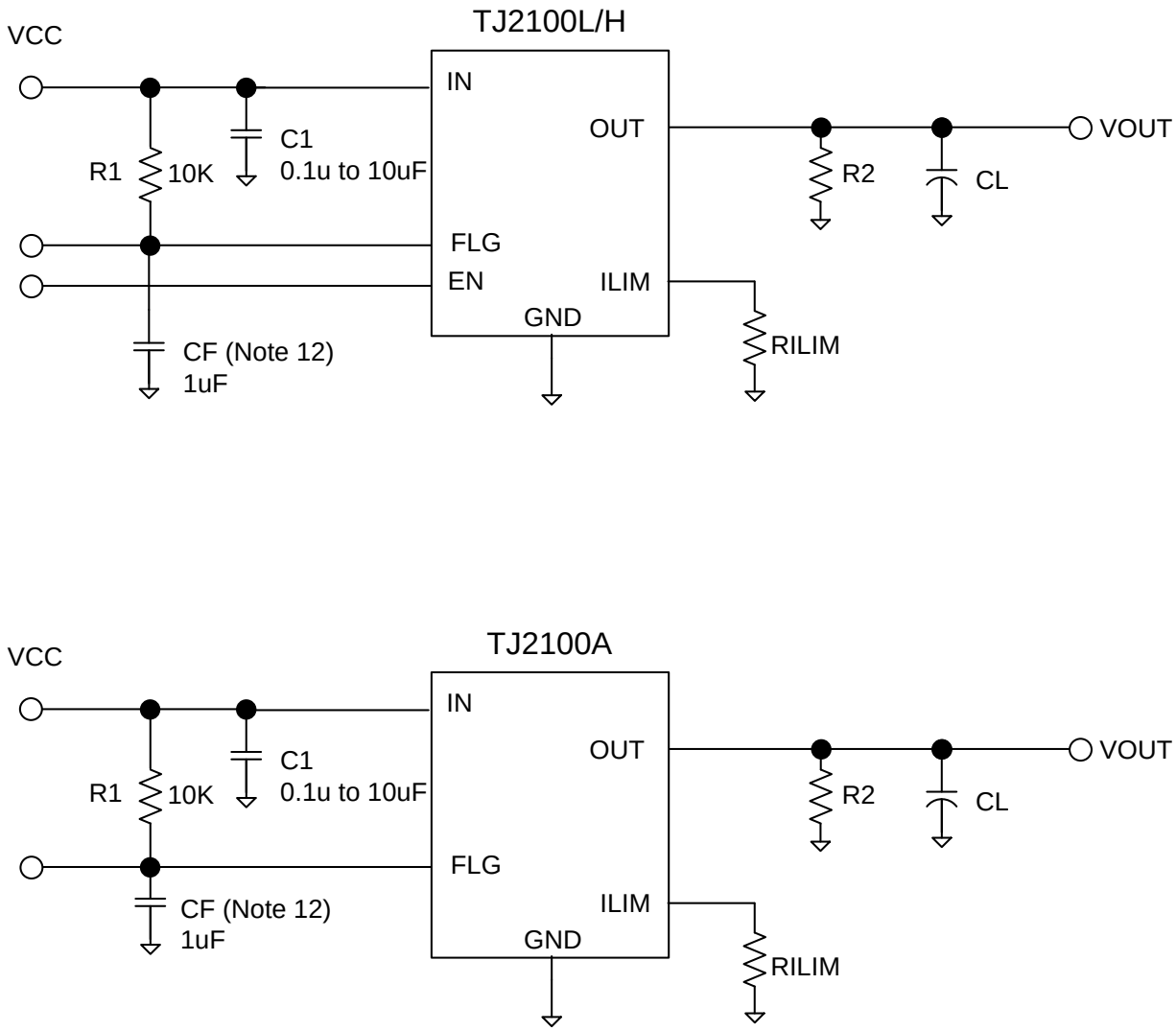
ELECTRICAL CHARACTERISTICS (Under the conditions of V_{IN}=+5V and T_A=25℃)

PARAMETER	Symbol	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	V_{IN}		2.7		5.5	V
Recommended Maximum Continuous Current (Note 8)	I_{OUT}	SF6 package		2.3		A
		Q package		2.9		A
Supply Current	I_{CC}	Enable off ,OUT=Open		0.05	1	uA
		Enable on, OUT=Open		80	150	uA
Enable Input Threshold Voltage	V_{EN}	(Note 9)	0.8		2.0	V
Enable Input Current	I_{EN}	V_{EN} = 0V to 5.5V	-1	0.01	1	uA
Enable Input Capacitance	C_{EN}			1		pF
Switch Resistance	$R_{DS(ON)}$	V_{IN}=5V, I_{OUT}=1.0A		105	125	mΩ
		V_{IN}=3.3V, I_{OUT}=1.0A		125	150	mΩ
Output Turn-On Delay	T_{DON}	RL=5Ω each output, CL=1uF		70		us
Output Turn-On Rise Time	T_R	RL=5Ω each output, CL=1uF		60		us
Output Turn-Off Delay	T_{DOFF}	RL=5Ω each output, CL=1uF		5		us
Output Turn-On Fall Time	T_F	RL=5Ω each output, CL=1uF		10		us
Output leakage Current	I_{LEAK}	V_{ENX}≤0.8V		0.01	5	uA
Current Limit Threshold (Note 11)	I_{LIM}	R_{ILIM} = 12kΩ		2070		mA
		R_{ILIM} = 20kΩ		1223		
		R_{ILIM} = 49.9kΩ		484		
		R_{ILIM} = 121kΩ		196		
Short Circuit Current Limit	I_{SC}	R_{ILIM} = 12kΩ , VOUT=0V		1446		mA
		R_{ILIM} = 20kΩ, VOUT=0V		859		
		R_{ILIM} = 49.9kΩ, VOUT=0V		338		
		R_{ILIM} = 121kΩ, VOUT=0V		137		
Over-Temperature Shutdown Threshold	T_{TS}	Temperature increasing switch		150		°C
		Temperature decreasing switch		130		°C
Error Flag Output Resistance	R_{FO}	V_{IN}=5V, I_L=10mA		10		Ω
		V_{IN}=3.3V, I_L=10mA		15		Ω
Error Flag Off Current	I_{FOH}	V_{FLAG}=5V		0.01	10	uA
UVLO Threshold	UVLO	V_{IN} = increasing	2.00	2.15	2.4	V
		V_{IN} = decreasing	1.85	2.00	2.25	V
Overcurrent Flag Response Delay	T_{DFOV}	V_{IN}=5V, apply V_{OUT}=0V until FLG low		7		ms
Current Limit Response Time	T_{LIM}	(Note 10)		1		us

Note:

8. Maximum ambient temperature is a function of device junction temperature and system level considerations, such as load current, power dissipation and board layout.
9. OFF is VEN≤0.8V and ON is VEN≥2.0V for the TJ2100H. OFF is VEN≥2.0V and ON is VEN≤0.8V for the TJ2100L.
10. T_{LIM} is the response time to operate current limit when the peak value of the current is increased more than set limit value.
11. It is recommended that current limit level set to 1.5 times more than constant current for a stable power supply.

Test Circuit

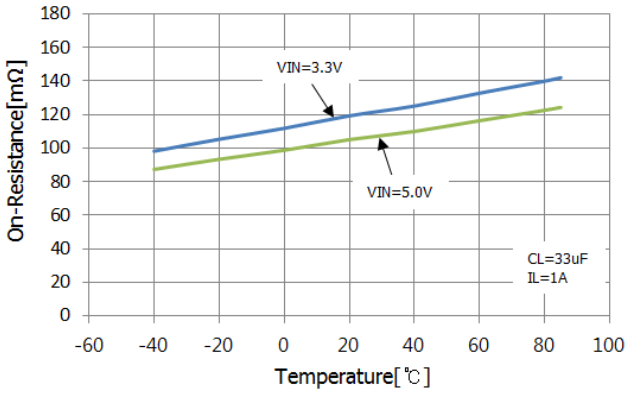


Note:

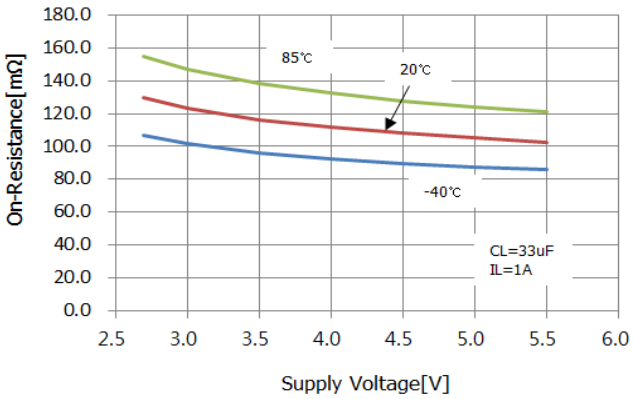
12. When the CF should be omitted, it is highly recommended to apply 2.2uF or higher capacitance for C1.

TYPICAL PERFORMANCE CHARACTERISTICS

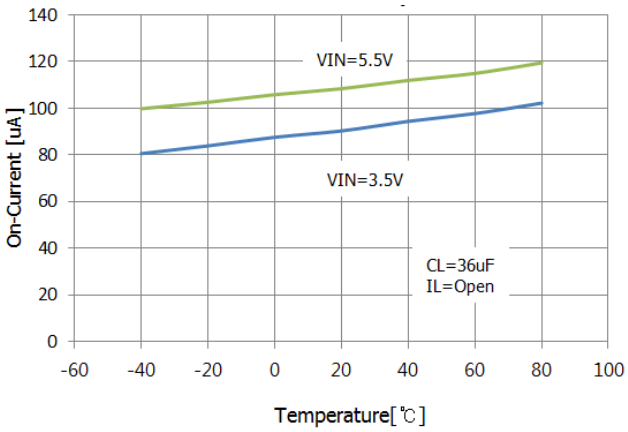
ON-Resistance vs. Temperature



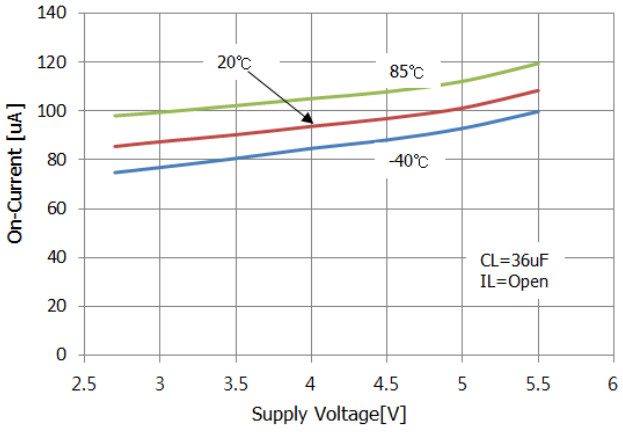
ON-Resistance vs. Supply Voltage



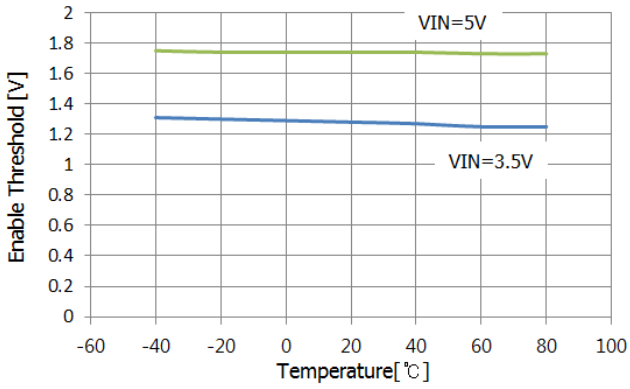
On - Current vs. Temperature



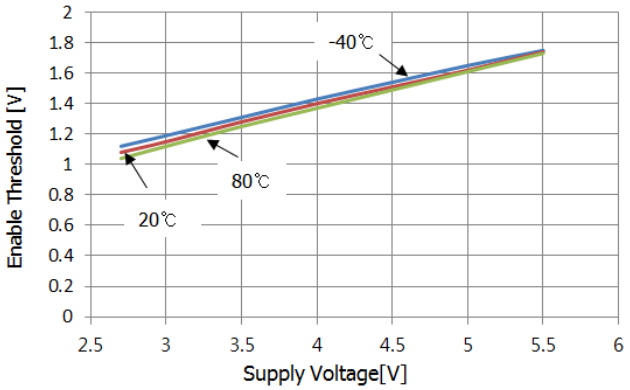
On - Current vs. Supply Voltage



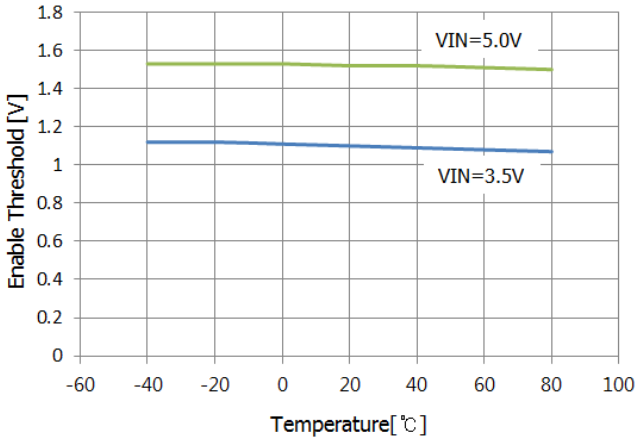
Enable ON Threshold vs. Temperature



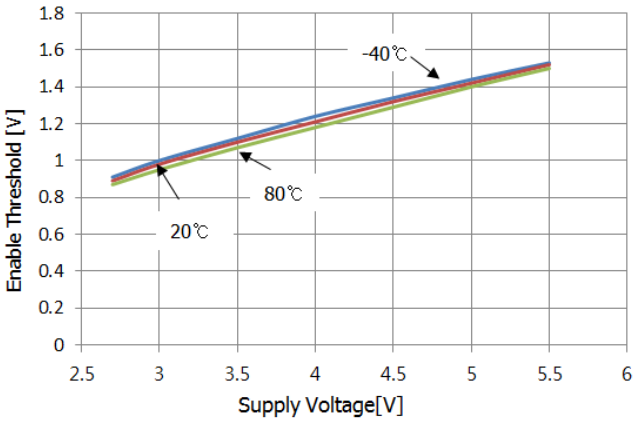
Enable ON Threshold vs. supply Voltage



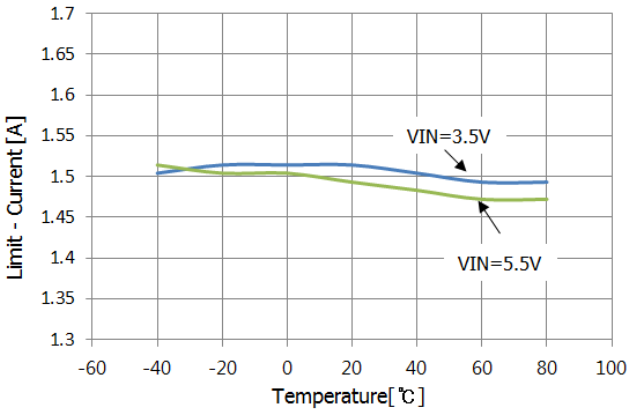
Enable OFF Threshold vs. Temperature



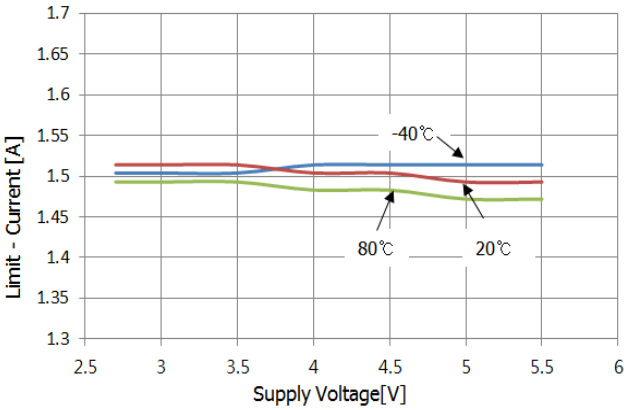
Enable OFF Threshold vs. supply Voltage



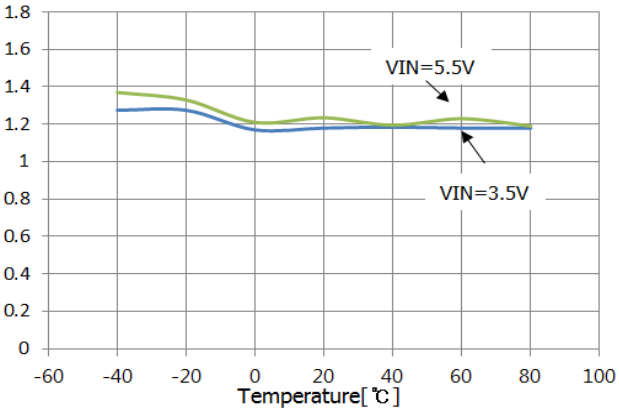
Current Limit Threshold vs. Temperature



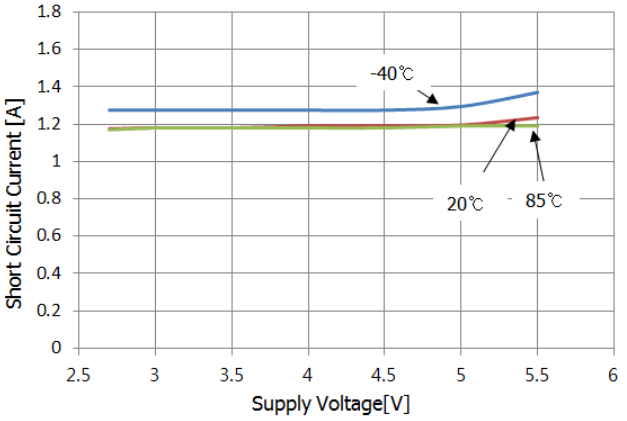
Current Limit Threshold vs. Supply Voltage



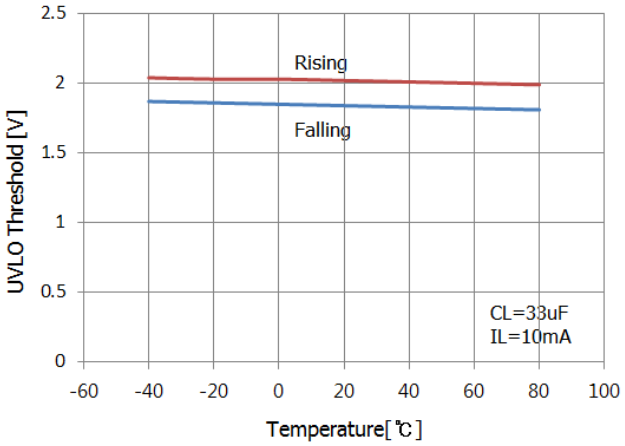
Short Circuit Current vs. Temperature



Short Circuit Current vs. Supply Voltage



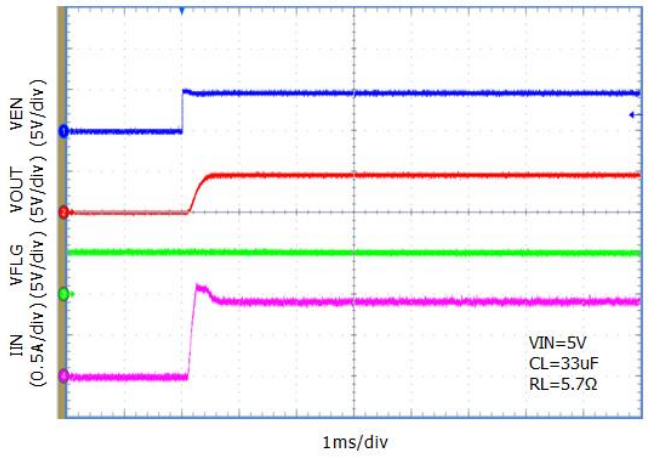
UVLO vs. Temperature



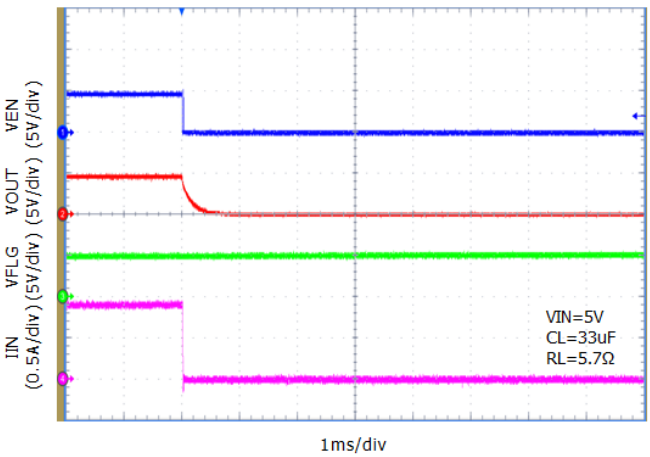
TYPICAL OPERATING CHARACTERISTICS

- V_{IN}=5V, V_{EN}=5V, T_A=25°C, RLIM=15kΩ, CIN=10uF unless otherwise noted

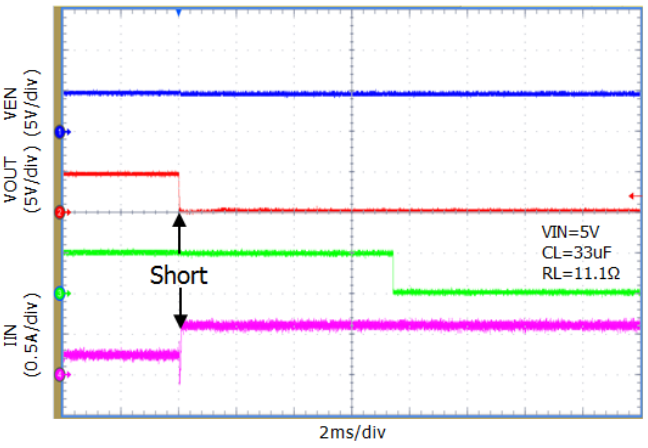
Turn – ON (TJ2100H)



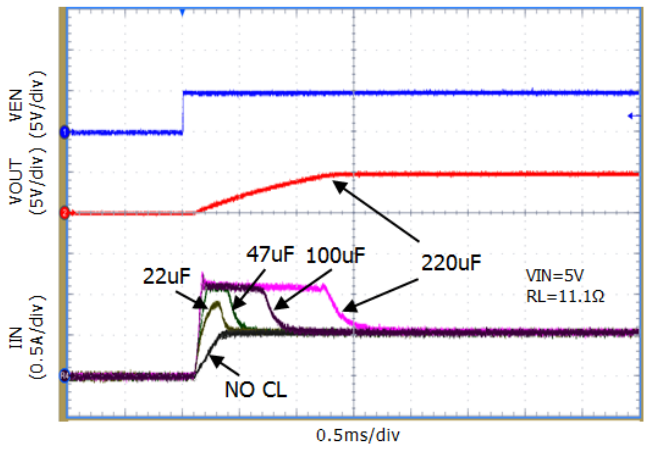
Turn – OFF (TJ2100H)



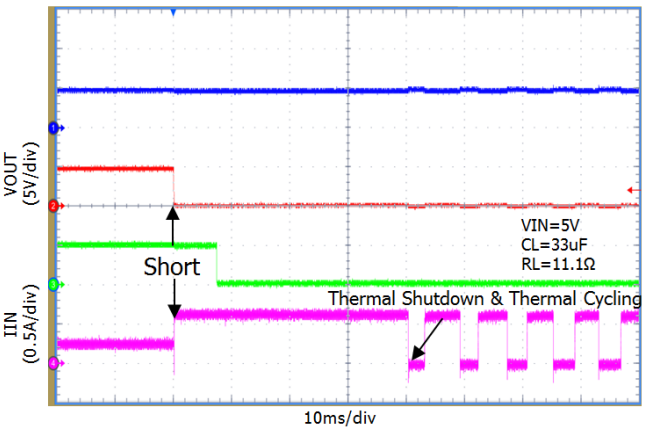
Stepped Short(TJ2100H)



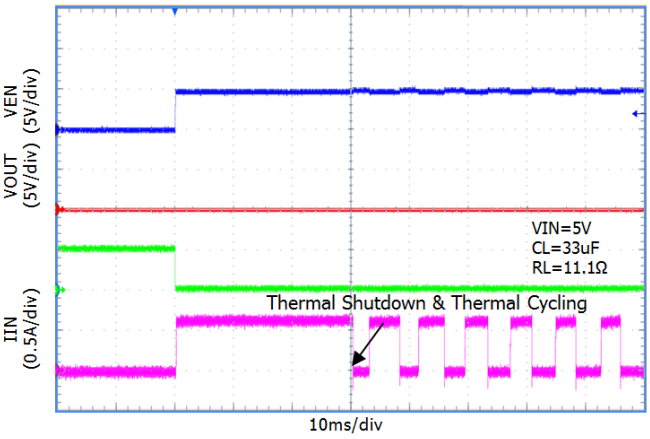
Inrush Current Response(TJ2100H)



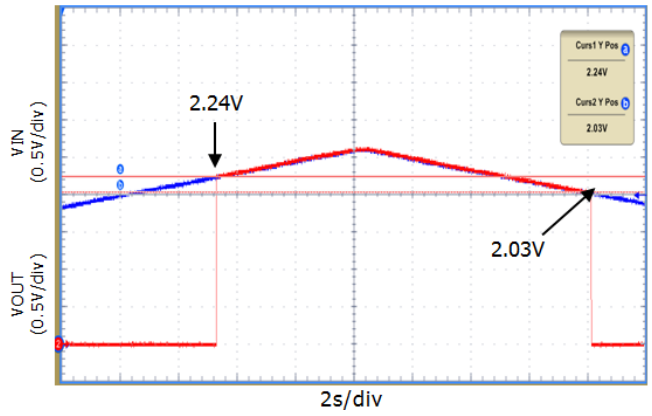
Stepped Short(TJ2100H)



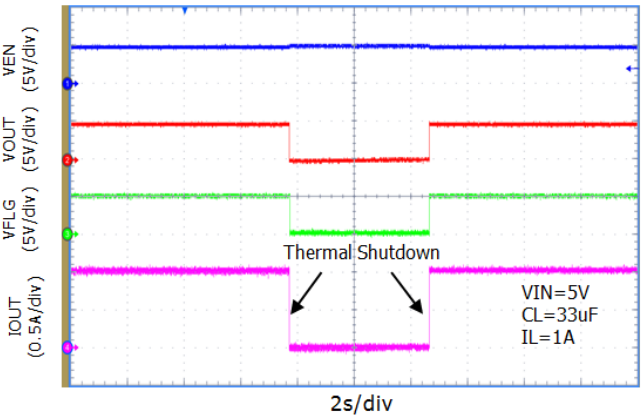
Enable into Short(TJ2100H)



UVLO(TJ2100H)



Thermal Shutdown(TJ2100H)



Function Description

Supply Filtering

A 0.1uF to 10uF bypass capacitor from IN pin to GND pin is recommended to control power supply transients. Recommend X5R or X7R dielectrics when using ceramic capacitors for input/output. Without this bypass capacitor, an output short can cause ringing from supply lead inductance on the input and damage the internal control circuitry.

Input or output transients must not exceed the absolute maximum supply voltage ($V_{IN(MAX)}$ = 6V).

Power Dissipation

The device's junction temperature depends on several factors such as the load, PCB layout, ambient temperature, and package type. Equations that can be used to calculate power dissipation of each channel and junction temperature are found below:

$P_D=R_{DS(ON)} \times I_{OUT}^2$

Total power dissipation of the device will be the summation of P_D for both channels. To relate this to junction temperature, the following equation can be used:

$T_J=P_D \times \Theta_{JA} + T_A$

Where:

T_J = Junction temperature

T_A = Ambient temperature

Θ_{JA}= Thermal resistance of the package

Enable/Shutdown

The EN control pin must be driven to a logic high or logic low for a clearly defined signal input. And if it is the pin of the fixed enable type must be fixed by connecting to GND. Floating these control lines may cause unpredictable operation.

Fault Flag

The FLG signal is open-drained output of N-channel MOSFET, the FLG output is pulled low to signal the following fault conditions: input under voltage, output short to GND and thermal shutdown. Also a 1uF capacitor is recommended to be placed directly next to the FLG pin. It is to prevent the glitches.

Soft-Start Condition

The TJ2100 has high impedance when off, which gradually shifts to low impedance as the chip turns on. This prevents an inrush current from causing voltage drops that result from charging a capacitive load and can pull the USB voltage bus below specified levels. This satisfies the USB voltage droop requirements for bus-powered applications.

The TJ2100 can provide inrush current limiting for applications with large load capacitances where C_L >10uF.

Current Sense

A sense MOSFET monitors the current supplied to the load. The sense MOSFET measures current more efficiently than conventional resistance methods. When an overload or short circuit is encountered, the current-sense circuitry sends a control signal to the driver. The driver in turn reduces the gate-source voltage and drives the power MOSFET into its saturation region, which switches the output into a constant-current mode and holds the current constant while varying the voltage on the load. When operating region of power MOSFET is close to saturation region, ON resistance of power MOSFET is made significantly increase. It can cause the operation of thermal protection before reaching to current limit level.

Over-Current and Short-Circuit Protection

The TJ2100 features an over-current protection circuitry to protect the device against overload conditions. The current limit threshold is user programmable via an external resistor. The TJ2100 provides an adjustable current limit threshold between 200mA and 3.0A(Typ.). The recommended 1% resistor range for R_{ILIM} is 8.9kΩ to 121kΩ. It protects the output MOSFET switch from damage due to undesirable short circuit conditions of excess inrush current often encountered during hot plug-in. Also the TJ2100 is including a fold back current limiting function for short-circuit protection. In the event of an output short-circuit condition, the current flowing through the switch is about 25~40% smaller than the current limit threshold(I_{LIM}). A short circuit current limit condition will signal the error flag. These features can protect the load system effectively at any accidental circumstances.

The following equations can be used to calculate the resulting current limit threshold and short circuit current for determining external resistor value (R_{ILIM}). However, in the equation do not considered tolerance factors like that processing variation from part to part, as well as variations in the voltage at IN and OUT, plus the operating temperature. Therefore current limit may be operated more than the calculated value.

When input voltage oscillates by external factors, input current also oscillates. It can cause the malfunction to current limit operation. In case of the peak value of current is increased more than set limit value, the current limit function of TJ2100 operates. Then the RMS value of the current limit may operate lower than a targeted level.

Equations for current limit:

$$I_{LIM(min)} = \frac{26117.8}{{R_{ILIM}}^{1.06} k\Omega} \qquad I_{LIM(nom)} = \frac{26117.8}{{R_{ILIM}}^{1.02} k\Omega} \qquad I_{LIM(max)} = \frac{26117.8}{{R_{ILIM}}^{0.99} k\Omega}$$

$$I_{SC(nom)} = \frac{18248.3}{{R_{ILIM}}^{1.02} k\Omega}$$

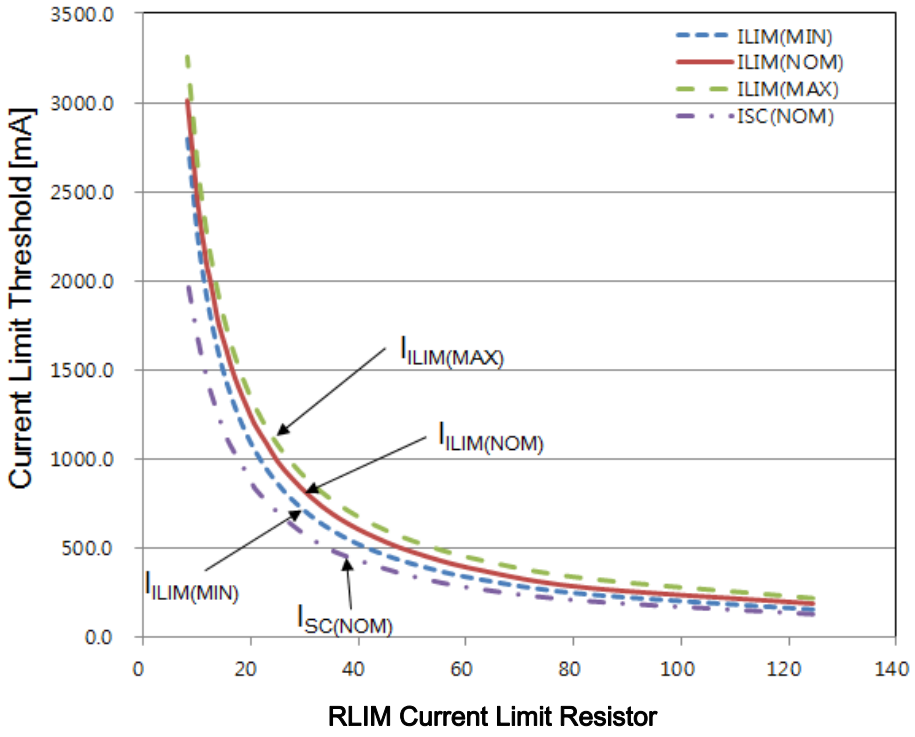


Table 1. Recommended R_{ILIM} Resistor Selections

Desired Nominal Current Limit(mA)	Calculated R_{ILIM}(kΩ)	Calculated I_{SC}(mA)	Actual Limits(mA)				
			R_{ILIM}(kΩ)	$I_{LIM(MIN)}$	$I_{LIM(NOM)}$	$I_{LIM(MAX)}$	I_{SC}(nom)
200	118.69	139.7	124.50	157.1	181	220.2	131.00
300	79.76	209.6	82.60	242.6	279	330.5	204.50
400	60.16	279.5	62.20	327.7	380	437.6	272.50
500	48.34	349.3	49.90	414.0	481	544.3	344.00
600	40.43	419.2	41.40	504.6	585	654.8	419.50
700	34.76	489.1	35.46	594.6	687	763.3	482.50
800	30.49	559.0	31.09	683.5	789	869.4	556.00
900	27.17	628.8	27.59	775.8	894	978.6	633.00
1000	24.50	698.7	24.91	864.5	989	1082.7	703.00
1100	22.31	768.6	22.86	946.9	1091	1178.8	768.00
1200	20.49	838.4	20.68	1053.1	1197	1301.8	838.00
1300	18.94	908.3	19.21	1138.7	1296	1400.4	924.00
1400	17.62	978.2	17.72	1240.4	1402	1516.9	994.00
1500	16.46	1048.0	16.53	1335.3	1502	1625.0	1060.00
1600	15.45	1117.9	15.50	1429.5	1608	1731.8	1118.00
1700	14.56	1187.8	14.58	1525.3	1698	1840.0	1190.00
1800	13.77	1257.6	13.82	1614.4	1782	1940.1	1256.00
1900	13.06	1327.5	13.10	1708.6	1898	2045.7	1322.00
2000	12.42	1397.4	12.42	1807.9	2006	2156.5	1386.00
2100	11.84	1467.2	11.80	1908.7	2086	2268.7	1456.00
2200	11.31	1537.1	11.24	2009.7	2202	2380.6	1528.00
2300	10.83	1607.0	10.84	2088.4	2272	2467.5	1576.00
2400	10.38	1676.9	10.37	2188.8	2380	2578.2	1642.00
2500	9.98	1746.7	9.98	2279.6	2478	2677.9	1698.00

Thermal Shutdown Protection

Thermal shutdown limits the TJ2100 junction temperature and protects the device from damage as a result of overheated.

Thermal protection turns off when the TJ2100's junction temperature 150℃ reached, allowing it to cool down until 130℃. The TJ2100 is reactivated when a junction temperature drops to approximately 130℃. It depends on the power dissipation, thermal resistance, and ambient temperature.

Under Voltage Lockout

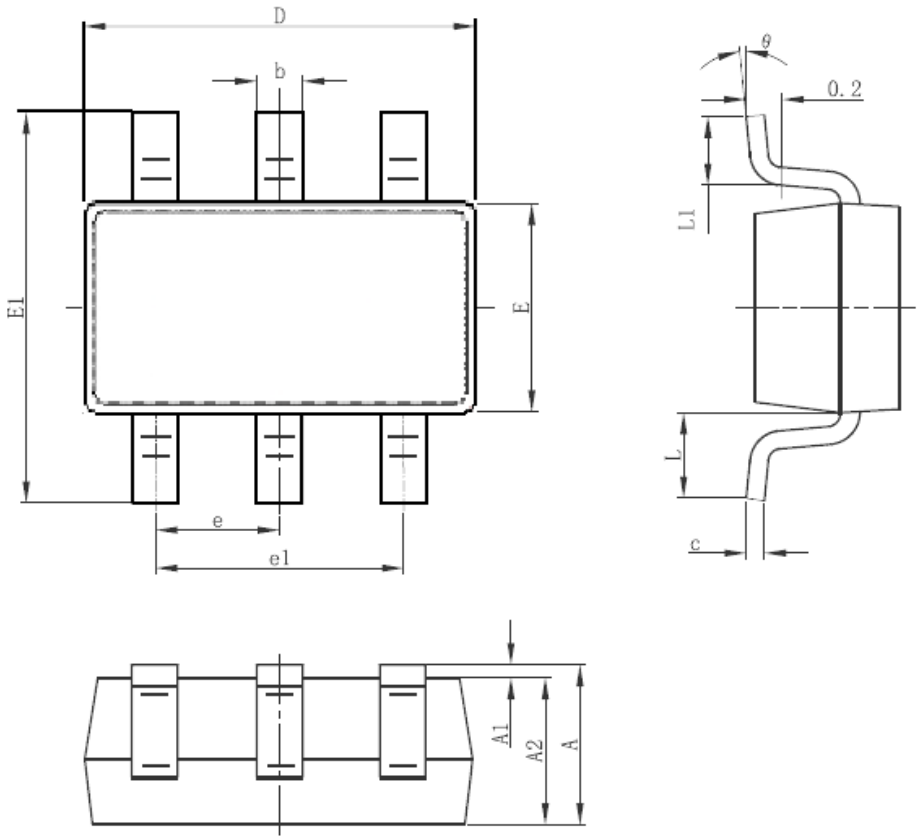
Under Voltage Lockout (UVLO) prevents the output MOSFET from turning on until V_{IN} exceeds approximately 2.25V. After the switch turns on, if the voltage drops below 2.05V typically, UVLO shuts off the output MOSFET. Under voltage detection functions only when the switch is enabled.

Printed Circuit Layout

The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.

PACKAGE OUTLINE SPECIFICATION

SOT23-6L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°