1A, 6V，1.5MHz, 40uA I_Q Synchronous Step-Down Converter

Features

- 2.7V to 6.0V operating input range
- Up to 1A output current
- Up to 92% peak efficiency
- Internal soft-start
- 1.5MHz switching frequency
- Input under voltage lockout
- Hot-plug in protection
- Short circuit protection
- Thermal protection
- Available in a SOT23-5 package

Applications

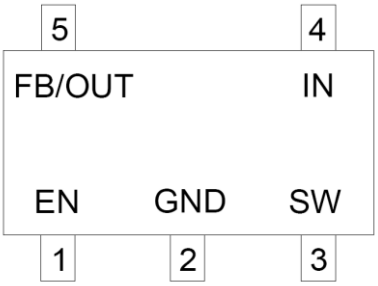
- 5V or 3.3V Point of Load Conversion
- Set Top Boxes
- Telecom/Networking Systems
- Storage Equipment
- GPU/DDR Power Supply

General Description

The FS1401S is a monolithic buck switching regulator based on constant on-time (COT) control for fast transient response. Operating with an input range of 2.7V-6.0V, The FS1401S delivers 1A of continuous output current with integrated P-Channel and N-Channel MOSFETs. The internal synchronous power switches provide high efficiency. At light loads, the regulator operate in low frequency to maintain high efficiency and low output ripples.

The FS1401S guarantees robustness with hiccup output short-circuit protection, FB short-circuit protection, start-up current run-away protection, input under voltage lockout and hot-plug in, and thermal protection. The FS1401S is available in a 5-pin SOT23-5 package, which provides a compact solution with minimal external components.

Pin Configurations



SOT23-5L

Absolute Maximum Ratings[1)]

Parameter	Symbol	Ratings	Unit
IN Pin Voltage	V_{IN}	-0.3 to 7V	V
FB Pin Voltage	V_{FB}	-0.3 to 7V	
EN Pin Voltage	V_{EN}	-0.3 to 7V	
SW Pin Voltage	V_{sw}	-0.3 to 7V	
Junction Temperature[2)]	T_J	150	℃
Operating Junction Temperature	T_{opr}	-40 to + 125	
Storage Temperature Range	T_{stg}	-65 to + 150	
Lead Temperature	T_{solder}	260	

Electrical Characteristics

(VIN=5V, TA=25℃, unless otherwise stated.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.7		6.0	V
V_{IN} Under Voltage Lockout Threshold	V_{UVLO}	V_{IN} rising	2.3	2.5	2.7	V
V_{IN} Under Voltage Lockout Hysteresis	V_{UVLO_HYST}	V_{IN} falling		200		mV
V_{IN} Hot-plug in Protection Threshold	V_{IN_OVP}	V_{IN} rising	6.1	6.6		V
V_{IN} Hot-plug in Protection Hysteresis	$V_{IN\_OVP\_HYST}$	V_{IN} falling		600		mV
Shutdown Curren	I_{SHDN}	V_{IN}=6.0V, V_{EN}=0V		0.1	1	uA
Quiescent Current	I_Q	V_{EN}=5V,I_{OUT}=0A,V_{FB}=V_{REF}*105%		40	70	
Regulated Feedback Voltage	V_{FB}	2.7V＜V_{IN}＜6.0V	0.588	0.6	0.612	V
PFET On Resistance[3)]	R_{DSON_P}	V_{IN}=3.6V,I_{SW}=200mA		260		mΩ
NFET On Resistance[3)]	R_{DSON_N}	V_{IN}=3.6V,I_{SW}=200mA		190		
PFET Leakage Current	I_{LEAK_P}	V_{IN}=6.0V, V_{EN}=0V, V_{SW}=0V			1	uA
NFET Leakage Current	I_{LEAK_N}	V_{IN}=6.0V, V_{EN}=0V, V_{SW}=6V			1	
PFET Current Limit[3)]	I_{LIM_TOP}		1.6	2.0	2.4	A
NFET Current Limit[3)]	I_{LIM_BOT}		1.2	1.5	2	
Switch Frequency[3)]	F_{SW}	I_{OUT}=1A		1.5		MHz
Minimum On Time[3)]	T_{ON_MIN}			100		ns
EN Input Logic High Voltage	V_{EN_H}	V_{EN} rising, FB=0.3V	1.5			V
EN Input Logic Low Voltage	V_{EN_L}	V_{EN} falling, FB=0.3V			0.4	

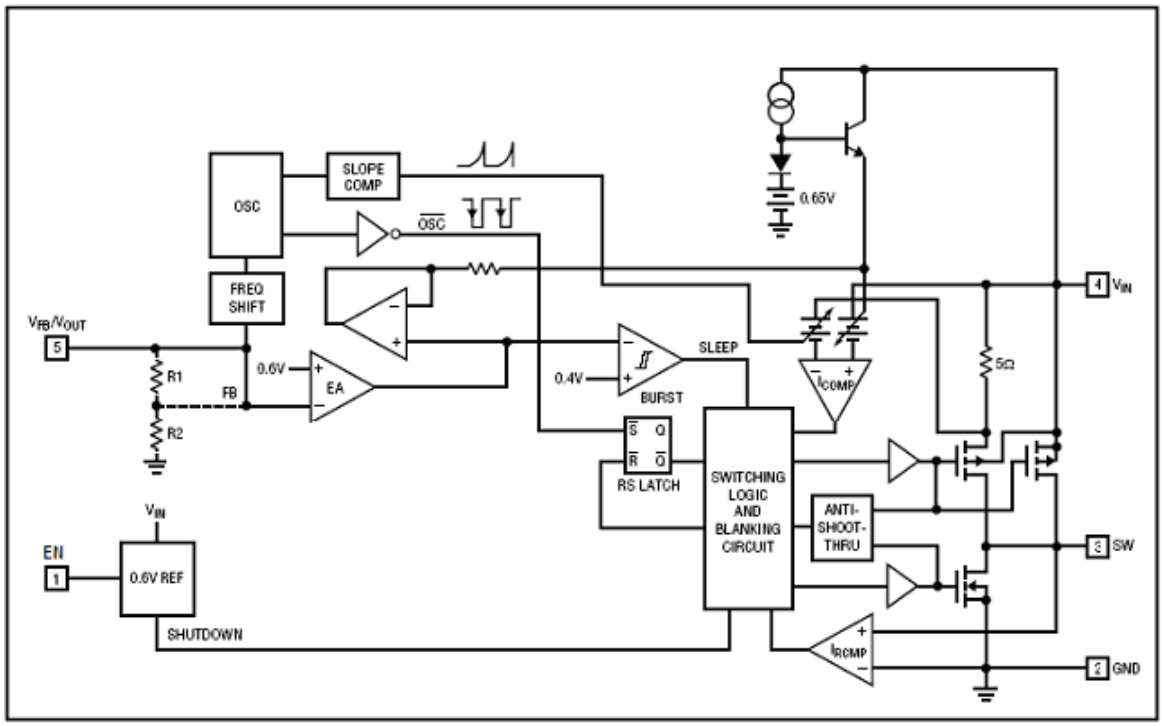
NOTE :

1、Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under recommended operating conditions.

2、The FS1401S includes thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

3、Guaranteed by design

- **Typical Block Diagram**



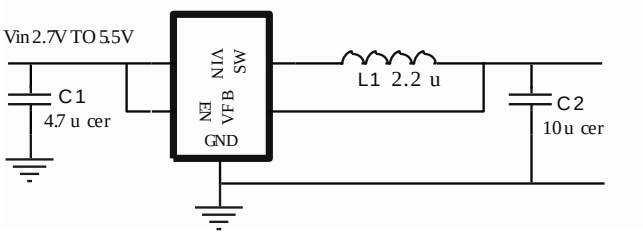
- **Pin Description**

FS1401S -①②③④

DesIgnator	Symbol	Description
①②	Output Detection Voltage	18=1.8V,33=3.3V, AD=ADJ
③④	Package Type:	SK：SOT23-5L

A	Pin Name	Pin Description
①	EN	Enable Control Input. Drive EN to IN or to a logic high for normal operation, drive to GND or a logic low to disable the regulator.
②	GND	Ground.
③	SW	Switching Node Output. Connect this pin to the switching end of the inductor.
④	IN	Power Input. Bypass to GND as close as possible to the IC with a high quality ceramic capacitor.
⑤	FB	Feedback Node. For fixed output voltage options, connects this pin directly to the output. For the Adjustable output version the voltage at this pin is regulated to 0.6V; connect to this pin to the center of the output voltage feedback network.

- **Application Information**



- **Application note:**

1、 Inductor Value (Table 1)

Table 1. Typical Inductor Values

V_{OUT}	0.6V to 0.9V	0.9V to 1.8V	>1.8V
L	1.5uH	2.2uH	2.7uH

2、 C_{IN}=4.7uF(ceramic capacitor).

3、 C_{OUT}=10uF(ceramic capacitor).

4、 Output Voltage Programming

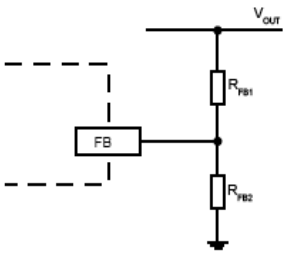


Figure 1. Output Voltage Programming

Figure 1 shows the Feedback network necessary to set the output voltage when the adjustable version is used. Select the proper ratio of the two feedback resistors R_{FB1} and R_{FB2} based on the desired output voltage. Typically choose R_{FB2}≈100KΩ and determine R_{FB1} from the output voltage:

$$R_{FB1}=R_{FB2}(\frac{V_{OUT}}{0.6V}-1)$$

Connect a small capacitor across R_{FB1} for feed forward capacitance at the FB pin:

$$C_{ff}=2\times10^{-5}/R_{FB1}$$

where R_{FB1}=900KΩ use 22pF. When using very low ESR output capacitors, such as ceramic, check for stability while examining load-transient response, and increase the compensation capacitor C_1 if needed.

5、Dropout Operation

As the input supply voltage decreases to a value approaching the output voltage, the duty cycle increases toward the maximum on-time. Further reduction of the supply voltage forces the main switch to remain on for move than one cycle until it reaches 100% duty cycle. Possible occurred larger ripple on the low-dropout operation. Recommended operating voltage V_{IN}≥V_{OUT} + 0.7V

- **PCB layout caution**

1、The power traces, consisting of the GND trace, the SW trace and the Vin trace should be keep short,direct and wide.

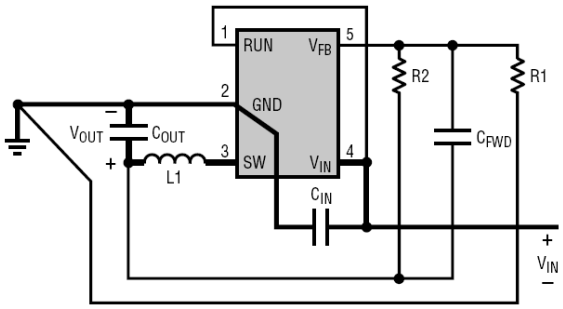
2、V_{FB} should be connected directly to the feedback resistors, The resistive divider R_1/R_2 must connected between the (+) plate of Cout and ground.

3、The (+) plate of C_{IN} should be connected to V_{IN} as closely as possible, because this capacitor provides the AC current to the internal power MOSFETS.

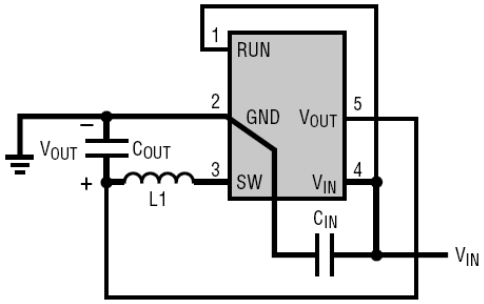
4、Keep the switching node SW away form the sensitive V_{FB} node

5、Keep the (-) plates of C_{IN} and C_{OUT} as close as possible

6、The high current paths

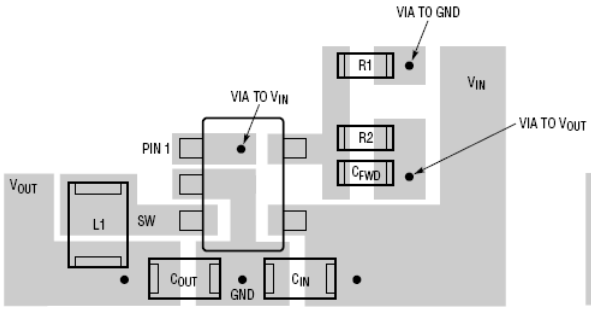


BOLD LINES INDICATE HIGH CURRENT PATHS

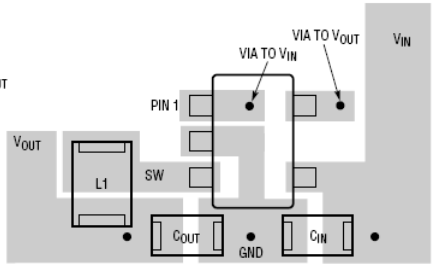


BOLD LINES INDICATE HIGH CURRENT PATHS

7、The recommended PCB layout



The suggested layout for adjustable



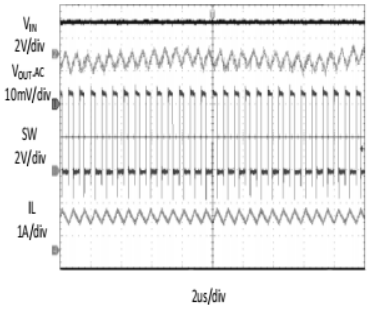
The suggested layout for fixed voltage

Typical Performance Characteristics

VIN =5V, VOUT = 1.8V, L = 1.5μH, C2 = 22μF, TA = +25℃, unless otherwise noted

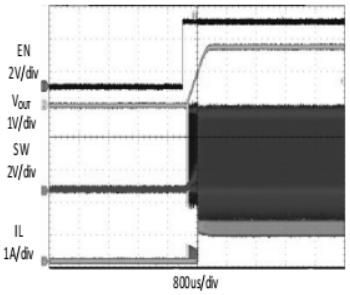
Steady State Test

V_{IN}=5V, V_{OUT}=1.8V
I_{OUT}=1A



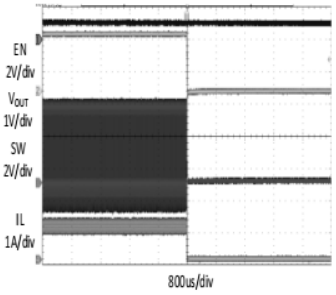
Startup through Enable

V_{IN}=5V, V_{OUT}=1.8V
I_{OUT}=1A(Resistive load)



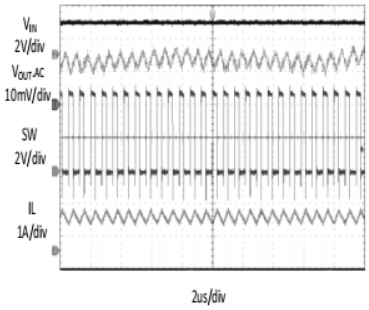
Shutdown through Enable

V_{IN}=5V, V_{OUT}=1.8V
I_{OUT}=1A (Resistive load)



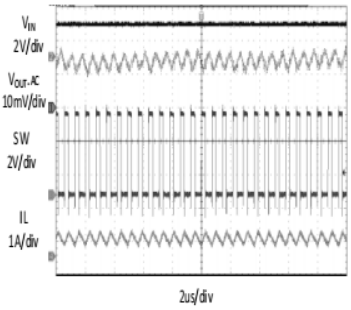
Heavy Load Operation

1A LOAD



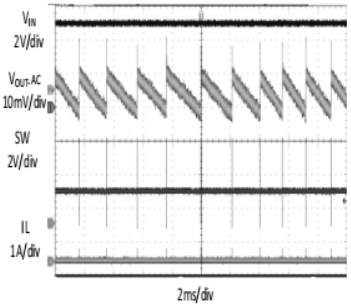
Medium Load Operation

0.5A LOAD



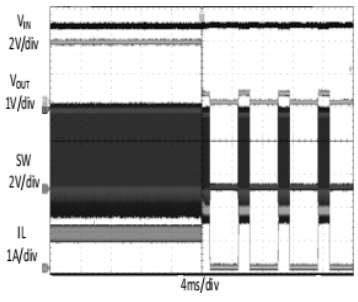
Light Load Operation

0 A LOAD



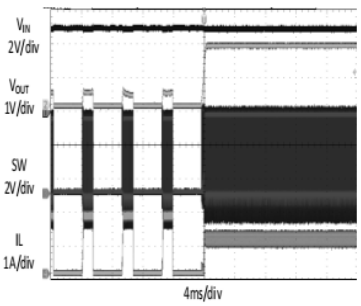
Short Circuit Protection

V_{IN}=5V, V_{OUT}=1.8V
I_{OUT}=1.0A- Short



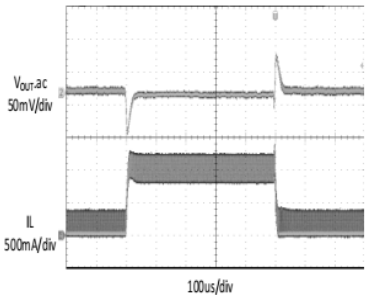
Short Circuit Protection

V_{IN}=5V, V_{OUT}=1.8V
I_{OUT} = Short-1.0A

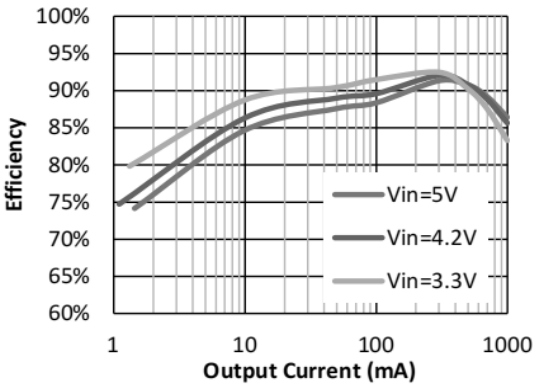


Load Transient

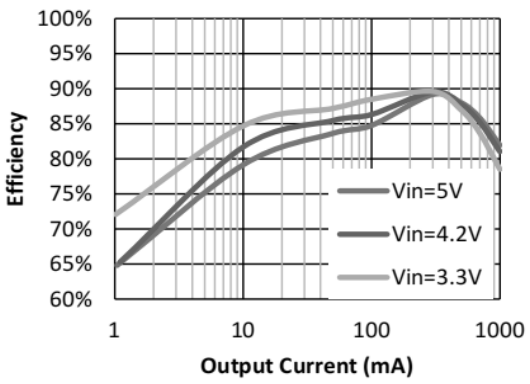
LOAD: 0.1A→ 1.0A →0.1A
2.5A/us, C3=1nF



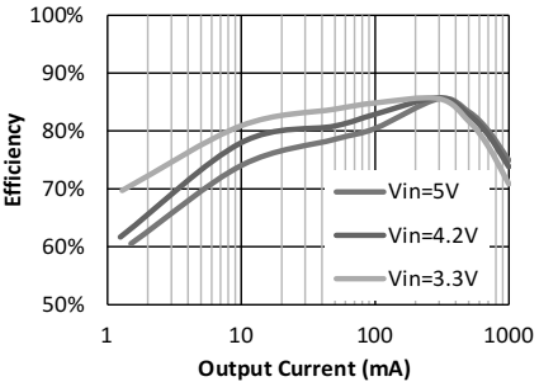
Efficiency @ V_{OUT}=1.8V



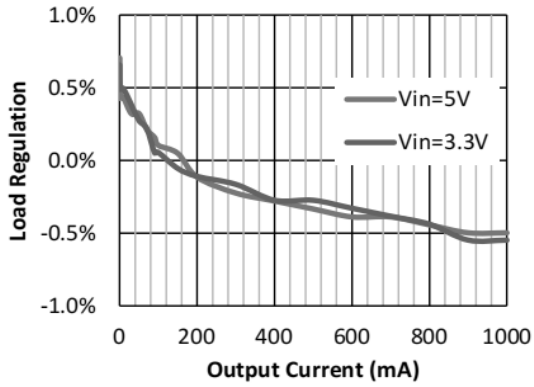
Efficiency @ V_{OUT}=1.2V



Efficiency @ V_{OUT}=0.8V

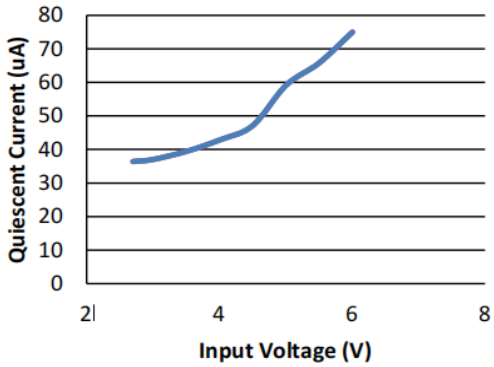


Load regulation @ V_{OUT}=1.8V



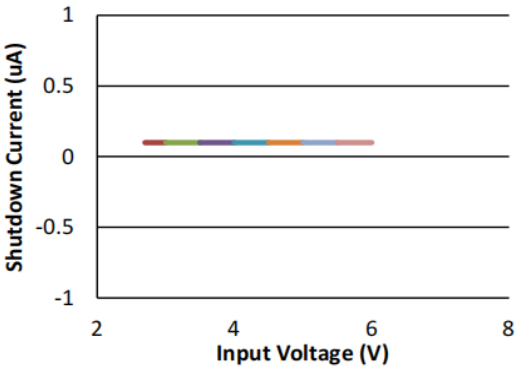
Quiescent Current Vs. Input Voltage

VIN=2.7V ~ 6V, VEN=2.5V, VFB=0.8V



Shutdown Current Vs. Input Voltage

VIN=2.7V ~ 6V, VEN=0V, VFB=0.5V



- **FUNCTIONAL DESCRIPTION**

The FS1401S is a constant on-time control, synchronous, step-down regulator. It regulates input voltages from 2.7V~6.0V down to an output voltage as low as 0.6V, and is capable of supplying up to 1A of load current.

- **Constant On-time Control**

The FS1401S utilizes constant on-time control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal transconductance error amplifier. Output of the internal error amplifier is compared with the switch current measured internally to control the output current limit.

- **PFM Mode**

The FS1401S operates in PFM mode at light load. In PFM mode, switch frequency is continuously controlled in proportion to the load current, i.e. switch frequency decreases when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency increases when load current rises, minimizing output voltage ripples.

- **Shut-Down Mode**

The FS1401S operates in shut-down mode when voltage at EN pin is driven below 0.4V. In shut-down mode, the entire regulator is off and the supply current consumed by the FS1401S drops below 1uA.

- **Power Switches**

P-channel and N-channel MOSFET switches are integrated on the FS1401S to down convert the input voltage to the regulated output voltage.

- **Short Circuit Protection**

When output is shorted to ground, the switching frequency is reduced to prevent the inductor current from increasing beyond PFET current limit. If short circuit condition holds for more than 1024 cycles, both PFET and NFET are forced off and can be enabled again after 8ms. This procedure is repeated as long as short circuit condition is not removed.

- **FB Short Circuit Protection**

When FB is shorted to ground and holds for more 16 cycles, NFET will be turned off after inductor current drops to zero, and then both PFET and NFET are latched off. When short circuit condition is removed, it can be recovery.

- **Hot Plug-in Protection**

When input voltage is greater than hot plug-in protection threshold, typical 6.8V, it will disable FS1401S. When input voltage decrease below 6.4V, it will be enabled again.

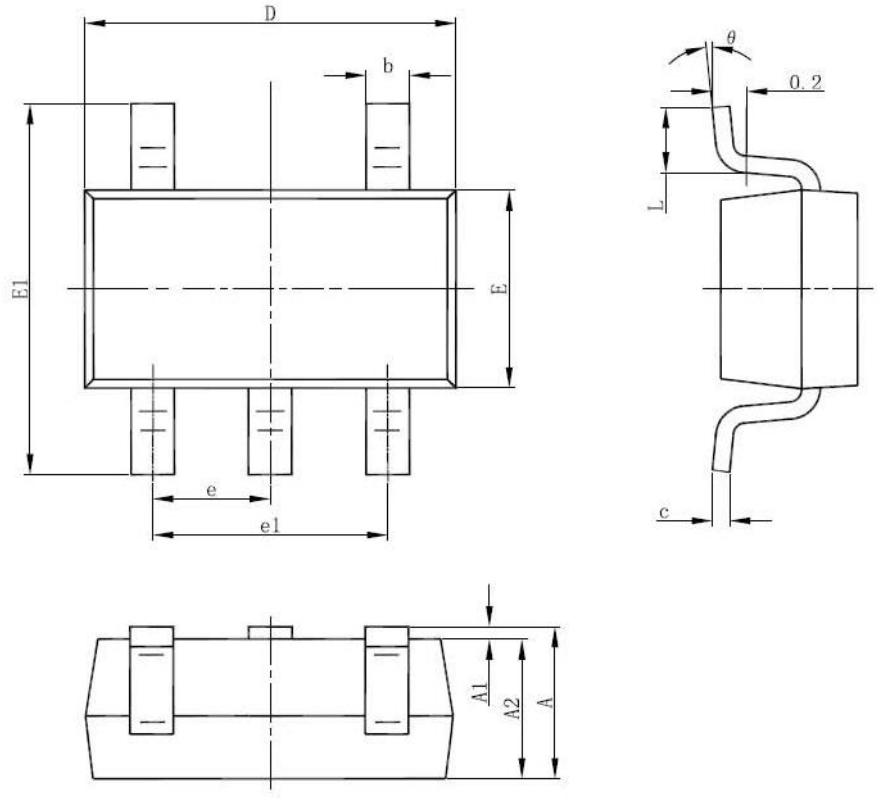
- **Thermal Protection**

When the temperature of the FS1401S rises above 150℃, it is forced into thermal shut-down. Only when core temperature drops below 130° C can the regulator becomes active again.

IMPORTANT NOTICE

- **PACKAGE OUTLINE**

SOT-23-5L PACKAGE OUTLINE DIMENSIONS



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
E	1.500	1.700	0.059	0.067
E1	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°