21V, 6A, 500KHz Synchronous PWM-Buck DC/DC Converter

Description

FR9810 is a high-efficiency synchronous mode step-down DC/DC converter that employs a special process technique to obtain very low RDS(ON) for the internal metal–oxide–semiconductor field-effect transistor (MOSFET), with operation voltage in a wide 4.75V to 21V input voltage range. The output current is over 6A, and the efficiency is over 90%. Controller circuit design by a particular current mode operation provides fast transient response and eases loop stabilization.

This product has a very low standby current less than 1μA in shutdown mode. When the $\overline{\text{SHDN}}$/S pin voltage is less than 0.4V, FR9810 will turn off the switching voltage regulator function and enter the standby mode. Fault protection includes current protect mode over current protection (OCP), voltage protect mode under voltage lockout protection (UVLO), and internal thermal shutdown.

This high-efficiency current mode step-down "**Green Power Converter**" Fitipower offers the standard small-outline integrated chip (SOIC) package with an exposed pad.

Features

- Internal MOSFET RDS(ON) (high side/low side): 120mΩ/20mΩ typ.
- Operation voltage: 4.75V to 21V
- Continuous output current support: 6A
- Feedback voltage: 0.805V
- High efficiency (up to 90%)
- Oscillation frequency (typical): 500 KHz
- Sync to external clock from 300 KHz to 800 KHz
- Internal compensation
- OCP/UVLO protection
- Over Temperature Protection (OTP) with hiccup mode
- < 1μA shutdown current
- Thermal Enhanced SOP-8(Exposed Pad) Package
- RoHS Compliant

Applications

- Networking equipment
- OLPC, Netbooks
- Distributed power systems
- LCD monitors/TVs/STBs
- External HDDs
- Security Systems

Pin Assignments

SP Package (SOP- 8 Exposed pad)

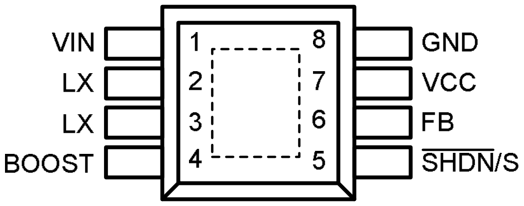
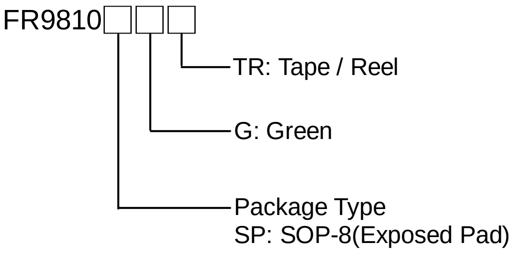


Figure 1. Pin Assignment of FR9810

Ordering Information



Typical Application Circuit

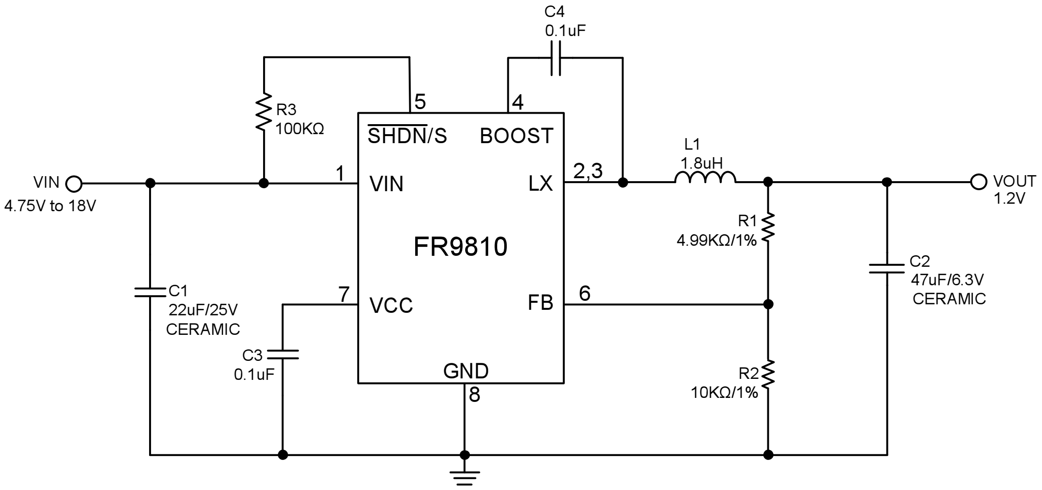


Figure 2. Output 1.2V Application Circuit

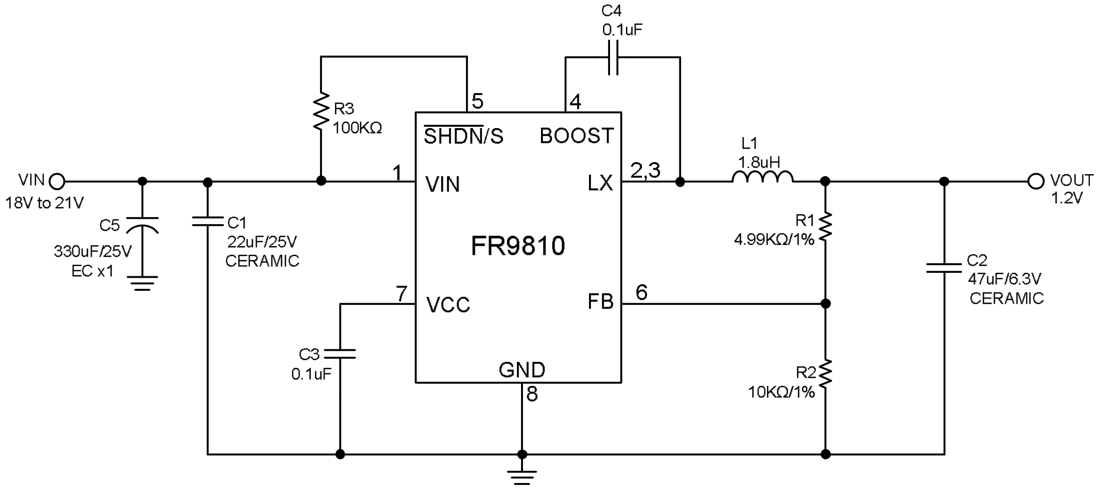


Figure 3. High Input Voltage Application Circuit

Functional Pin Description

I/O	Pin Name	Pin No.	Pin Function
I	FB	6	Voltage Feedback Input Pin. FB and VOUT are connected using a resistive voltage divider. This IC senses feedback voltage via FB and regulates it at 805mV.
I	VIN	1	Power Supply Input Pin. Drive 4.75V to 21V voltage to this pin to power on this chip. A 22µF ceramic bypass capacitor is connected between VIN and GND to eliminate noise.
O	VCC	7	Bias Supply Output Pin. A 0.1µF capacitor must be connected from this pin to GND.
I	$\overline{\text{SHDN}}$/S	5	This pin provides a digital control to turn the converter on or off. For automatic start-up, connect the $\overline{\text{SHDN}}$/S pin to VIN pin with a 100K ohm resistor. An external clock from 300KHz to 800 KHz can be applied to the $\overline{\text{SHDN}}$/S pin to change oscillation frequency.
O	LX	2,3	Power Switching Output Pin. This is the output pin that internal high-side NMOS switches to supply power.
O	BOOST	4	High-Side Gate-Drive Boost Input. A 0.1µF capacitor is connected from this pin to LX. It can boost the gate drive to fully turn on the internal high-side NMOS.
I	GND	8	Ground Pin. This pin is connected to the exposed pad with copper.
I	Exposed Pad		Ground Pin. The exposed pad must be soldered to a large PCB area and connected to GND for maximum power dissipation.

Block Diagram

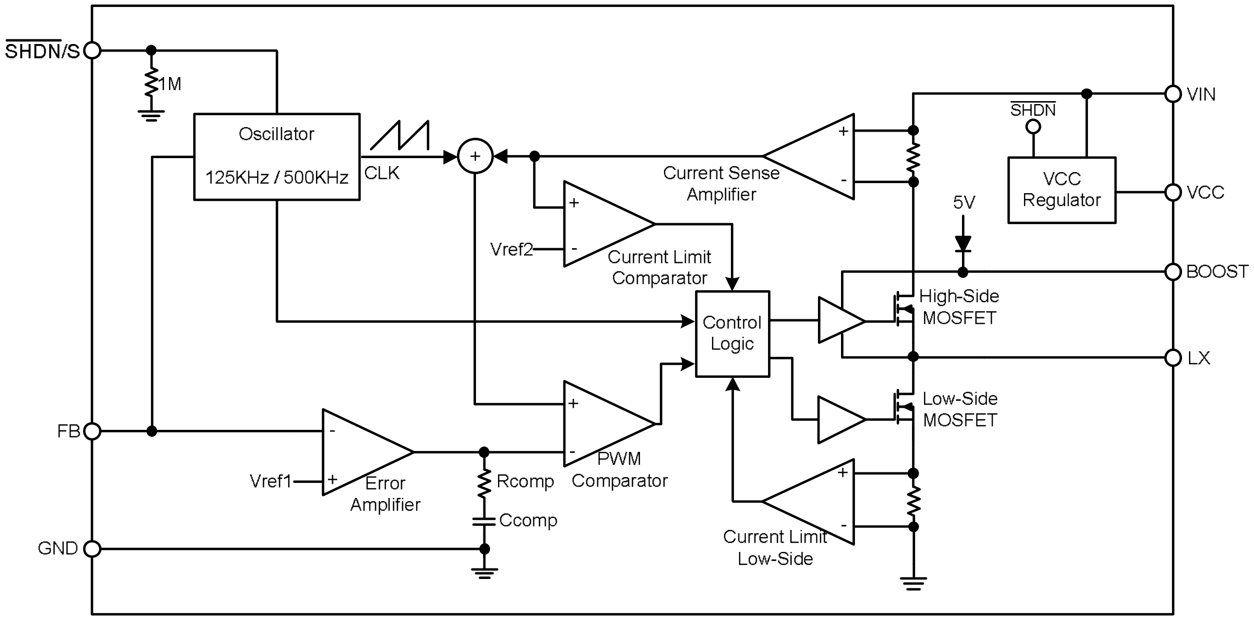


Figure 4. Block Diagram of FR9810

Absolute Maximum Ratings

- Input Supply Voltage V_{IN}-------------------------------- -0.3V to +22V
- LX Voltage V_{LX}-------------------------------- -0.3V to V_{IN} +1V
- Boost Voltage V_{BS} -------------------------------- V_{LX} -0.3V to V_{LX} +6V
- All Other Pins Voltage -------------------------------- -0.3V to +6V
- Maximum Junction Temperature (T_J)-------------------------------- +150℃
- Storage Temperature (T_S)-------------------------------- -65℃ to +150℃
- Lead Temperature (Soldering, 10sec.) -------------------------------- +260℃
- Power Dissipation @T_A=25℃, (P_D)
  - SOP-8 (Exposed Pad)-------------------------------- 1.25W
- Package Thermal Resistance, (θ_{JA}):
  - SOP-8 Exposed Pad-------------------------------- 50°C/W
- Package Thermal Resistance, (θ_{JC}):
  - SOP-8 Exposed Pad-------------------------------- 15°C/W

Note1：Stresses beyond those listed under “Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Input Supply Voltage (V_{IN})-------------------------------- 4.75V to 21V
- Operation Temperature Range-------------------------------- -40℃ to + 85℃

Electrical Characteristics

(V_{IN}=12V, T_A=25℃, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Supply Voltage	V_{IN}		4.75		21	V
VIN Shutdown Supply Current	I_{SD}	$V_{\overline{SHDN}}$ = 0V			1	μA
VIN Quiescent Supply Current	I_{DDQ}	$V_{\overline{SHDN}}$ = 2 V, V_{FB} = 1 V		1.1		mA
Feedback Voltage	V_{FB}	$4.75V \leqq V_{IN} \leqq 21V$	780	805	830	mV
High-Side MOSFET R_{DS}(ON) (Note2)	HSR_{DS}(ON)			120		mΩ
Low-Side MOSFET R_{DS}(ON) (Note2)	LSR_{DS}(ON)			20		mΩ
MOSFET Leakage Current	I_{LX}(Leak)	$V_{\overline{SHDN}}$=0V, V_{LX} = 0V		0	10	μA
High-Side MOSFET Current Limit (Note2)	I_{LIMIT}			8.5		A
Maximum Duty Cycle	D_{MAX}	V_{FB} = 0.7 V		90		%
Oscillation frequency	F_{LX}		350	500	650	KHz
Short-Circuit Oscillation Frequency	F_{LX}(Short)	V_{FB} = 0.3 V		125		KHz
Sync Frequency Range	F_{SYNC}		300		800	KHz
Input UVLO Threshold	VUVLO(Vth)	V_{IN} Rising		4		V
Under Voltage Lockout Threshold Hysteresis	VUVLO(Hys)			200		mV
$\overline{SHDN}$/S Input Low Voltage	$V_{\overline{SHDN}}$ (L)				0.4	V
$\overline{SHDN}$/S Input High Voltage	$V_{\overline{SHDN}}$ (H)		2.0			V
$\overline{SHDN}$/S Input Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = 2 V		2		μA
VCC Regulator	V_{CC}			4.5		V
Soft-Start Time	T_{SS}			600		us
Thermal Shutdown Threshold (Note 2)	T_{SD}			150		℃

Note2：Not production tested.

Function Description

Introduction

FR9810 is a constant-frequency current-mode step-down synchronous DC/DC converter. It regulates input voltage from 4.75V to 21V and can provide 6A of continuous load current.

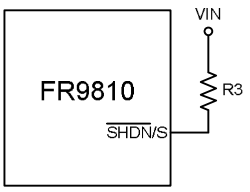
To achieve bias power supply, FR9810 is built on an internal voltage regulator to support the internal circuits. For applications in which VIN is less than 4.5 V, output decreases and a 0.1µF ceramic capacitor is required for decoupling. If VIN is greater than 4.5V, the output of the regulator is in full regulation.

The error amplifier compares the FB voltage with the internal 0.805V reference and outputs a current proportional to the difference between the two.

Internal Soft-Start

The internal soft-start function is used to eliminate the output voltage overshooting during start-up. When the chip permits, the internal reference voltage rises slowly to 0.805V, and the internal COMP signal rises slowly to achieve output voltage that is smooth when ready. The soft-start time is approximately 600us.

$\overline{\text{SHDN}}$/S



The FR9810 $\overline{\text{SHDN}}$/S pin provides digital control to turn on/turn off the regulator. For automatic start-up, tie $\overline{\text{SHDN}}$/S with VIN using a resister, as shown in the figure. The recommended value of R3 is 100KΩ. The FR9810 can be synchronized with an external clock from 300KHz to 800KHz by using the $\overline{\text{SHDN}}$/S pin.

Device Protection:

1. Input Under Voltage Lockout

When the power of FR9810 is on, the internal circuits are held inactive until VIN exceeds the input UVLO threshold voltage. The regulator is disabled when VIN falls below the input UVLO threshold voltage. The hysteretic of the UVLO comparator is 200mV.

2. Over Current Protection

The FR9810 OCP protection function was designed to sense the cycle-by-cycle over current limit signal to prevent device damage due to a short. When the inductor current peak value reaches the current limit threshold, the output voltage starts to drop until the FB voltage is less than 30% of the reference. FR9810 subsequently enters hiccup mode to periodically restart the part and will exit the hiccup mode once the over current condition is lifted.

3. Over Temperature Protection

The FR9810 incorporates an over temperature protection circuit to protect itself from overheating. When the junction temperature exceeds the thermal shutdown threshold temperature, the regulator is shutdown. When the junction temperature is less than the recovery threshold temperature, the chip is re-enabled.

Application Information

Output Voltage Setting

The output voltage V_{OUT} is set using a resistive divider from the output to FB. The FB pin regulated voltage is 0.805V. Thus the output voltage is:

$$V_{OUT} = 0.805 \times \left(1 + \frac{R1}{R2}\right) \ \mathrm{V}$$

Table 1 lists recommended values of R1 and R2 for most used output voltage.

Table 1 Recommended Resistance Values

V_{OUT}	R1 (1%)	R2 (1%)
5V	30.9 kΩ	5.76 kΩ
3.3V	30.9 kΩ	9.76 kΩ
2.5V	4.99 kΩ	2.32 kΩ
1.8 V	4.99 kΩ	3.92 kΩ
1.5 V	4.99 kΩ	5.76 kΩ
1.2 V	4.99 kΩ	10 kΩ
1.05 V	4.99 kΩ	16.5 kΩ

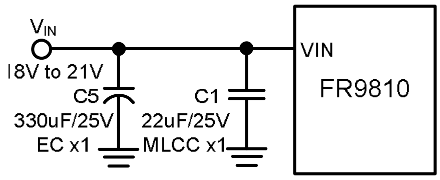
Resistors R1 and R2 should be placed close to the FB pin to prevent stray pickup.

Input Capacitor Selection

The input capacitor is used to control the input voltage ripple and the MOSFETS switching spike voltage. Because the input current to the step-down converter is discontinuous, the input capacitor is required to supply the current to the converter to maintain the DC input voltage. The capacitor voltage rating should be 1.25- to 1.5-fold greater than the maximum input voltage. The input capacitor ripple current RMS value is calculated as:

$$I_{IN\,(RMS)} = I_{OUT} \times \sqrt{D \times (1 - D)}$$

where D is the duty cycle of the power MOSFET.
A low equivalent series resistance (ESR) capacitor is required to keep the noise minimum. Ceramic capacitors are optimal, but tantalum or low ESR electrolytic capacitors will suffice. When using tantalum or electrolytic capacitors, a 0.1μF ceramic capacitor should be placed as close to the IC as possible.



It is recommended that the input EC capacitor be added for applications if the FR9810 will suffer high spike input voltage (ex. hot plug test). It can eliminate the spike voltage induced the IC damage from high input voltage stress (see Note1).

Output Capacitor Selection

The output capacitor is used to maintain the DC output voltage and supply the load transient current. Low ESR capacitors are preferred. Ceramic, tantalum, or low ESR electrolytic capacitors can be used depending on the output ripple requirement. The output ripple voltage ΔV_{OUT} is described as

$$\Delta I = \frac{V_{OUT}}{F_{OSC} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

$$\Delta V_{OUT} = \Delta I \times \left(R_{ESR} + \frac{1}{8 \times F_{OSC} \times C_{OUT}}\right)$$

where ΔI is the peak-to-peak inductor ripple current, F_{OSC} is the switching frequency, L is the inductance value, VIN is the input voltage, V_{OUT} is the output voltage, R_{ESR} is the equivalent series resistance value of the output capacitor, and C_{OUT} is the output capacitor. When using the ceramic capacitors, R_{ESR} can be ignored and the output ripple voltage ΔV_{OUT} is shown as:

$$\Delta V_{OUT} = \frac{\Delta I}{8 \times F_{OSC} \times C_{OUT}}$$

When using tantalum or electrolytic capacitors, typically 90% of the output voltage ripple is contributed by the ESR of output capacitors. the output ripple voltage ΔV_{OUT} can be estimated as:

$$\Delta V_{OUT} = \Delta I \times R_{ESR}$$

Application Information (Continued)

Output Inductor Selection

The output inductor is used to store energy and filter output ripple current. However, there is often a trade-off between maximum energy storage and physical size of the inductor. The first consideration for selecting the output inductor is to make sure that the inductance is large enough to keep the converter in the continuous current mode. This will lower the ripple current and results in lower output ripple voltage. A good rule for determining the inductance is to set the peak-to-peak inductor ripple current ΔI almost equal to 30% of the maximum load current. The minimum inductance can then be calculated with the following equation:

$$\Delta I = 0.3 \times I_{OUT(MAX)}$$

$$L \ge (V_{IN} - V_{OUT}) \times \left(\frac{V_{OUT}}{F_{OSC} \times \Delta I \times V_{IN}} \right)$$

Where V_{IN} is the maximum input voltage.

A 1μH to 10μH inductor with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. Under a light load condition of less than 100mA, larger inductance is recommended for improved efficiency.

PCB Layout Recommendation

Device performance and stability is dramatically affected by the printed circuit board (PCB) layout. It is recommended that the following general guidelines be considered:

1. Place the input capacitors and output capacitors as close to the device as possible. The trace to these capacitors should be as short and wide as possible to minimize parasitic inductance and resistance.
2. Place VIN bypass capacitors close to the VIN pin.
3. Place feedback resistors close to the FB pin.
4. Keep the sensitive signal FB away from the switching signal LX.
5. The exposed pad of the package should be soldered to an equivalent area of metal on the PCB. This area should connect to the GND plane and have multiple via connections to the back of the PCB as well as connections to intermediate PCB layers. The GND plane area that connects to the exposed pad should be maximized to improve thermal performance.
6. Multilayer PCB design is recommended.

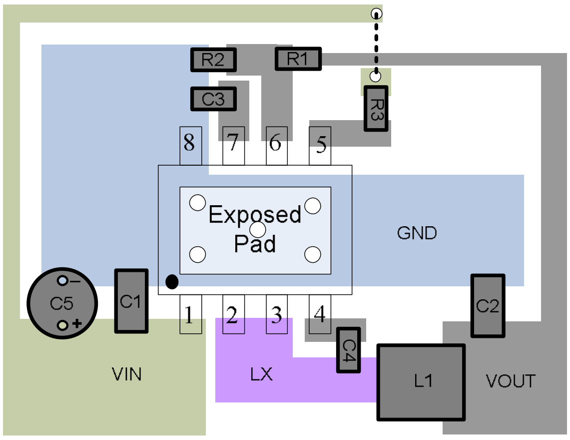
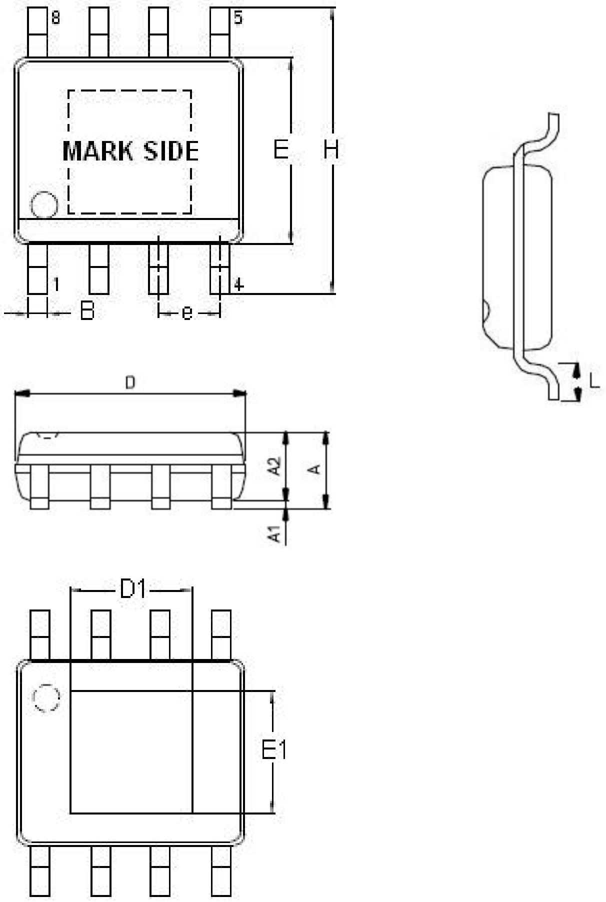


Figure 23. Recommended Layout Diagram

Outline Information

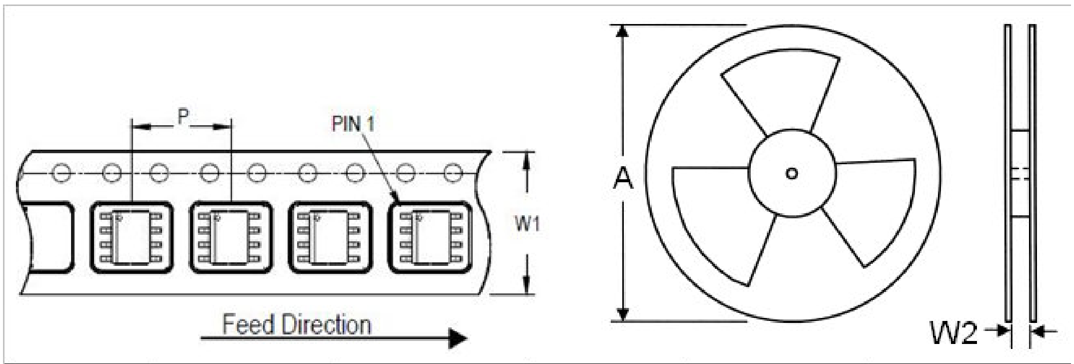
SOP- 8 (Exposed Pad) Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	1.25	1.70
A1	0.00	0.15
A2	1.25	1.55
B	0.31	0.51
D	4.80	5.00
D1	1.82	3.35
E	3.80	4.00
E1	1.82	2.41
e	1.20	1.34
H	5.80	6.20
L	0.40	1.27

Note：Followed From JEDEC MO-012-E.

Carrier dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
12	8	13	330	12.4	400~1000	2,500

Life Support Policy
Fitipower's products are not authorized for use as critical components in life support devices or other medical systems.