1.5MHz, 800mA, High-Efficiency PWM Synchronous Step-Down Converter

Description

The FP6367 is a high efficiency, low-noise, DC-DC step-down pulse width modulated (PWM) converter that goes automatically into PFM mode at light load to improve efficiency. It is ideally suited for systems powered from a 1-cell Li-ion battery or from other power sources such as hand-held devices. The 100% duty cycle feature provides low dropout operation, extending battery life in portable systems. Switch frequency is internally set at 1.5MHz, allowing use of small surface mount inductors and capacitors.

The internal synchronous switch increases efficiency and eliminates the need for an external Schottky diode. Shutdown mode places the device in standby, reducing quiescent supply current to less than 1µA.

The FP6367 is available in small SOT-23-5 package.

Features

- Synchronous Rectification: Approach 95% Efficiency
- 2.5V to 5.5V Input Voltage Range
- The PFM Mode Operation for Improving Efficiency at Light Load
- Real Shutdown Isolated Load from Battery
- Internal Compensation without External Capacitors and Resistors
- No Schottky Diode Required
- Low Dropout Operation: 100% Duty Cycle
- Fixed Frequency Operation at 1.5MHz
- Low Quiescent Current at 35µA
- Low Shutdown Current at 1µA
- RoHS Compliant

Applications

- Cellular Phone
- Handheld Instrument
- Wireless LAN
- MP3 Portable Audio Player
- Battery Operated Device

Pin Assignments

S5 Package (SOT-23-5)

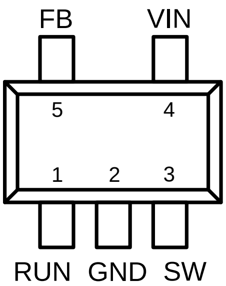
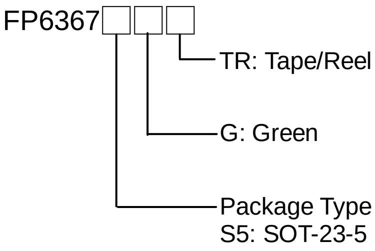


Figure 1. Pin Assignment of FP6367

Ordering Information



SOT-23-5 Marking

Part Number	Product Code
FP6367S5G	**d2=**

Typical Application Circuit

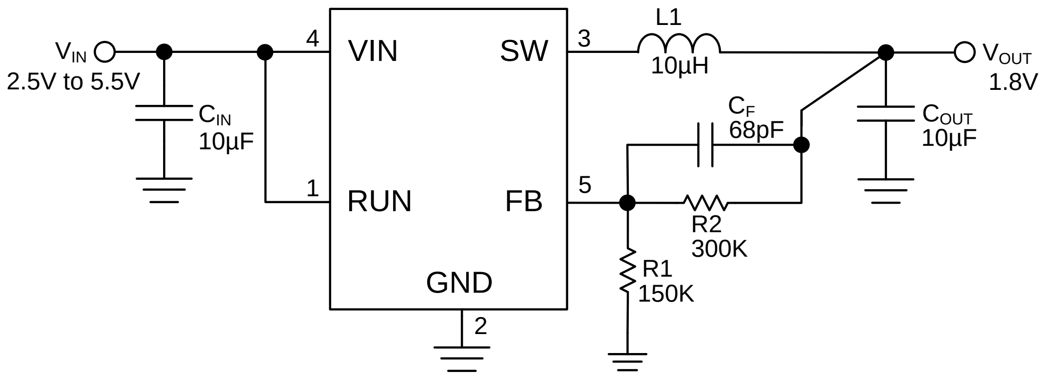


Figure 2. Typical Application Circuit of FP6367

Functional Pin Description

Pin Name	Pin Function
RUN	Enable Pin. Logic high enables the converter, and logic low forces the device into shutdown mode for reducing the supply current to less than 1µA.
GND	Ground.
SW	Inductor connection to the drains of the internal power MOSFETs.
VIN	Supply Voltage Input. Input range from 2.5V to 5.5V. Bypass with a 10µF capacitor.
FB	Feedback Input.

Block Diagram

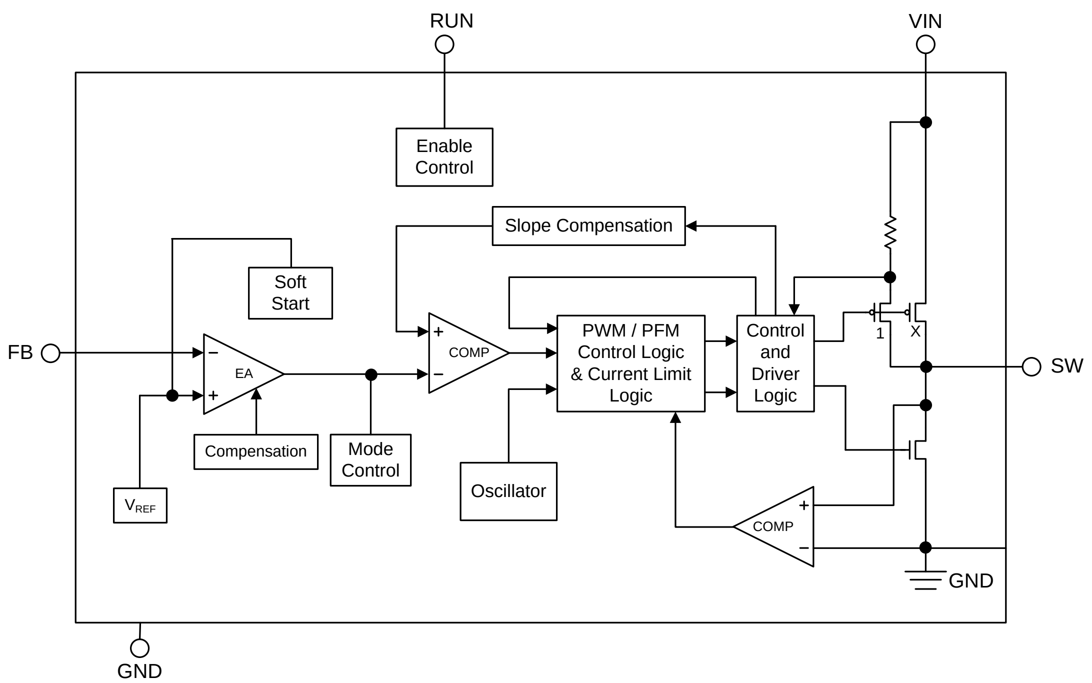


Figure 3. Block Diagram of FP6367

Absolute Maximum Ratings

- VIN to GND -- -0.3V to +6V
- SW to GND -- -0.3V to (Vin+0.3V)
- RUN, FB to GND -- -0.3V to Vin
- Power Dissipation @T_A=25℃, (P_D)
  SOT-23-5 -- +400mW
- Package Thermal Resistance, (θ_{JA})
  SOT-23-5 -- +250°C/W
- Package Thermal Resistance, (θ_{JC})
  SOT-23-5 -- +130°C/W
- Maximum Junction Temperature (T_J) -- +150°C
- Storage Temperature (T_{STG}) -- -65°C to +150°C
- Lead Temperature (Soldering, 10sec.) -- +260°C

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

Recommended Operating Conditions

- Supply Voltage (V_{IN}) -- +2.5V to +5.5V
- Operation Temperature Range (T_{OPR}) --- -40°C to +85°C

Electrical Characteristics

(V_{IN}=3.6V, RUN=V_{IN}, T_A= 25ºC, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Input Voltage	V_{IN}		2.5		5.5	V
Output Voltage Range	V_O		0.8		V_{IN}	V
Supply Current	I_{SUP}	V_{FB}=0.5V or V_{OUT}=90%, I_O=0mA		300	400	µA
		V_{FB}=0.62V or V_{OUT}=103%, I_O=0mA		20	35	
Shutdown Current	I_{SD}	RUN=GND		0.1	1	µA
RUN High-Level Input Voltage	V_{IH}		1.3			V
RUN High-Low Input Voltage	V_{IL}				0.4	V
RUN Input Leakage Current	I_{LKG}	RUN=GND or V_{IN}		0.01	0.1	µA
N-Channel MOSFET On-Resistance (Note2)	$R_{DS(ON)}$	I_{SW} = 100mA		450	500	mΩ
P-Channel MOSFET On-Resistance (Note2)	$R_{DS(ON)}$	I_{SW} = 100mA		450	500	mΩ
Oscillator Frequency	f_S		1200	1500	1800	KHz
P-Channel Current Limit (Note2)	I_{LIM}	V_{FB}=0.5V	0.8	1	1.25	A
Reference Voltage	V_{REF}		0.588	0.6	0.612	V
Line Regulation	ΔV_{LINE}	V_{IN} =V_O+0.5V to 5.5V; I_O = 10mA		0.05		%/V
Load Regulation	ΔV_{LOAD}	I_O = 10mA to 800mA		0.5		%

Note 2：Guarantee by design.

Typical Performance Curves

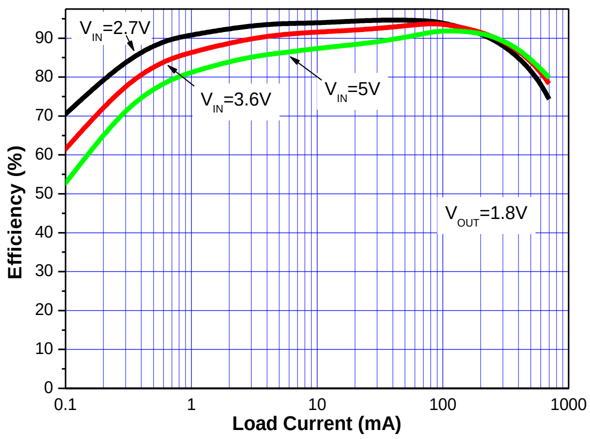


Figure 4. Efficiency vs. Load Current

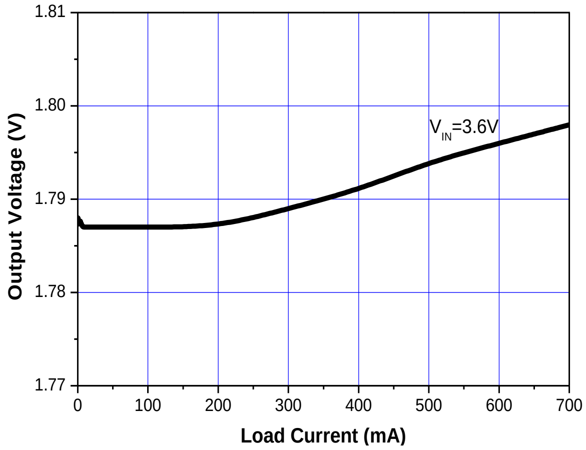


Figure 5. Output Voltage vs. Output Current (V_{IN}=3.6V)

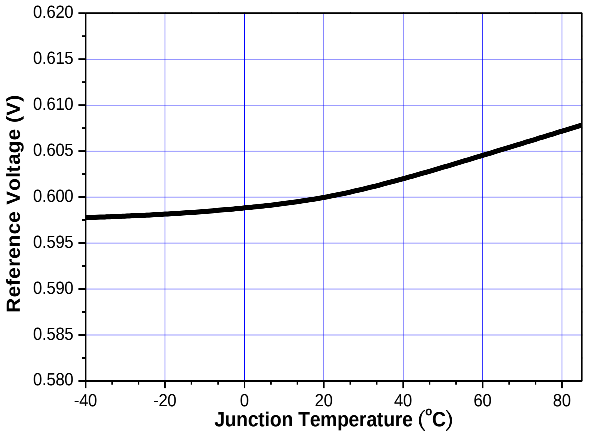


Figure 6. Reference Voltage vs. Junction Temperature

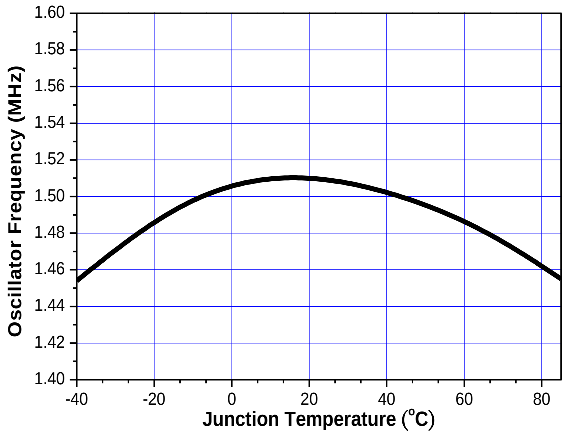


Figure 7. Frequency vs. Junction Temperature

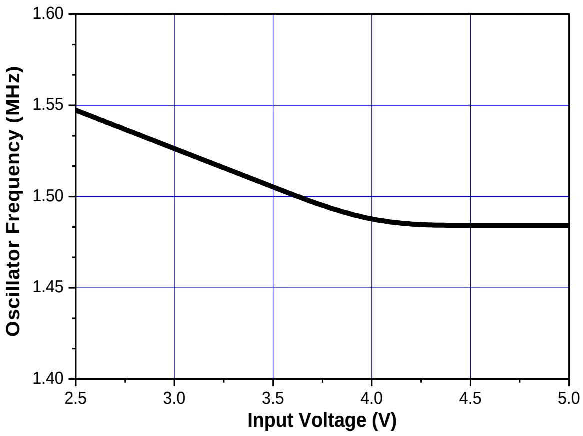


Figure 8. Frequency vs. Input Voltage

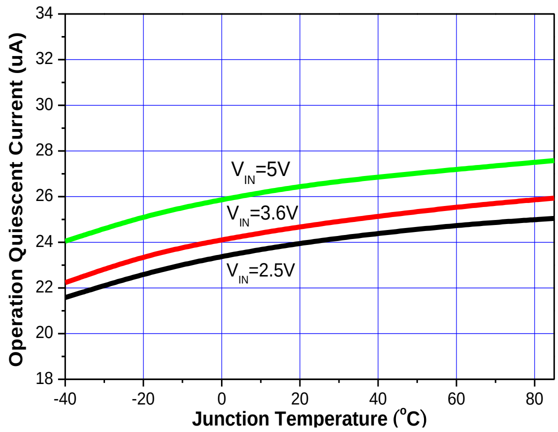


Figure 9. Quiescent Current vs. Junction Temperature

Typical Performance Curves (Continued)

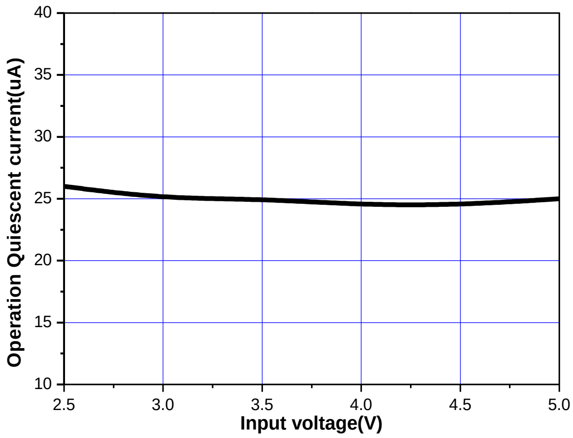
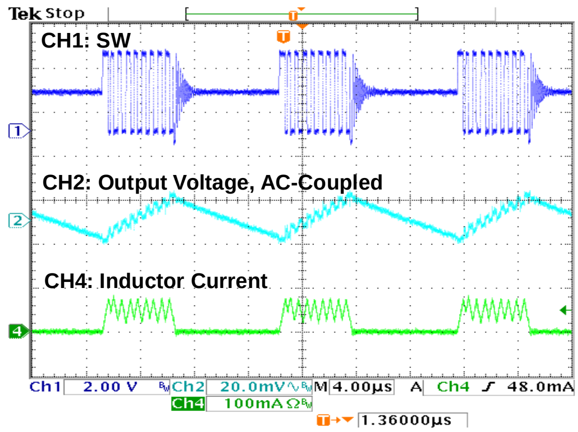
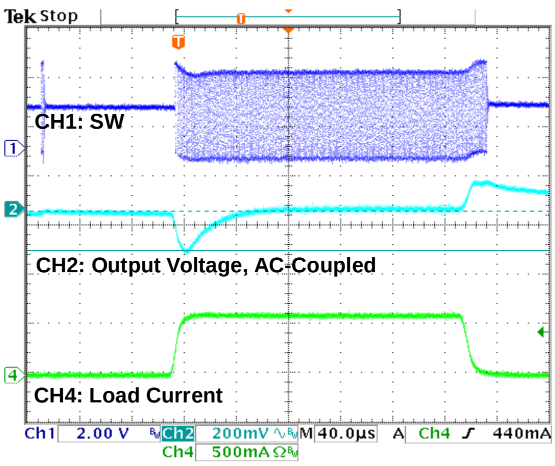


Figure 10. Quiescent Current vs. Input Voltage



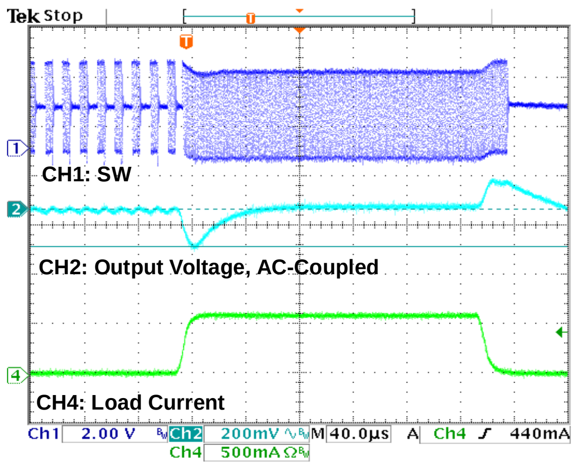
V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF, I_{LOAD}=20mA

Figure 11. Light Load Waveform



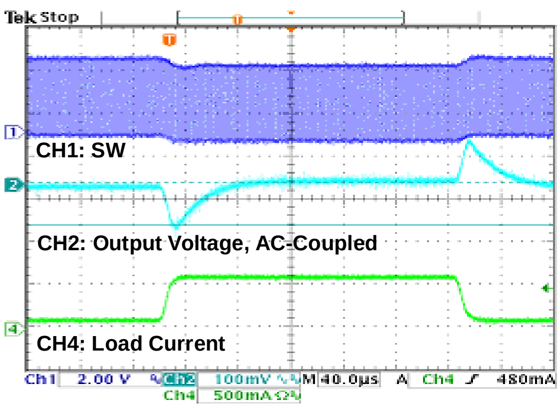
V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF,
I_{LOAD}=1mA to 600mA

Figure 12. Load Transient Response



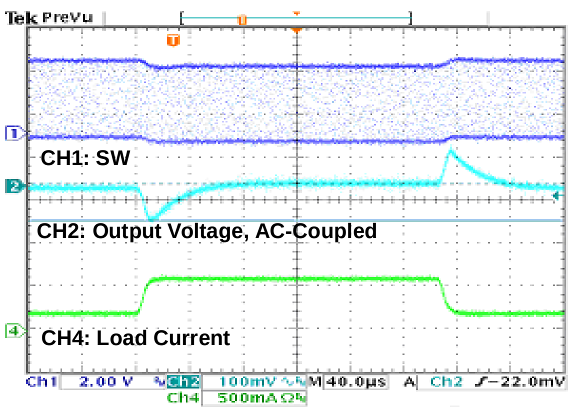
V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF,
I_{LOAD}=20mA to 600mA

Figure 13. Load Transient Response



V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF,
I_{LOAD}=100mA to 600mA

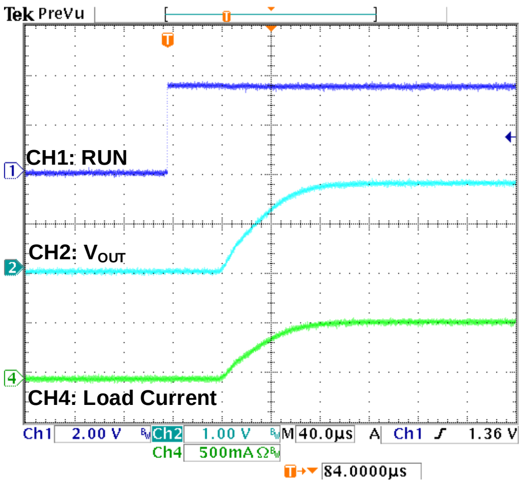
Figure 14. Load Transient Response



V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF,
I_{LOAD}=200mA to 600mA

Figure 15. Load Transient Response

Typical Performance Curves (Continued)



V_{IN}=3.6V, V_{OUT}=1.8V, L=10µH, C_{OUT}=10µF+0.1µF, I_{LOAD}=600mA

Figure 16. Start-up Waveform

Application Information

Inductor Selection

An 8.2μH to 10μH is recommended for general used. The value of inductor depends on the operating frequency. Higher frequency allows smaller inductor and capacitor but increases internal switching loss. Two inductor parameters should be considered, current rating and DCR. The inductor with the lowest DCR is chosen for the highest efficiency. The inductor value can be calculated as:

$$L \geq \frac{V_{OUT}}{f \times \Delta I_L}\left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

ΔI_L: inductor ripple current, which is defined as:

$$\Delta I_L = V_O\left[\left(1-\frac{V_O}{V_I}\right)/(L \times f)\right] \quad \text{(General Setting)}$$
$$\approx 0.1 \times 2 \times I_{O\text{-}MAX}$$

The inductor should be rated for the maximum output current ($I_{O\text{-}MAX}$) plus the inductor ripple current (ΔI_L) to avoid saturation. The maximum inductor current ($I_{L\text{-}MAX}$) is given by:

$$I_{L\text{-}MAX} = I_{O\text{-}MAX} + \frac{\Delta I_L}{2}$$

Capacitor Selection

The small size of ceramic capacitors makes them ideal for FP6367 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 10μF input capacitor and a 10μF output capacitor are sufficient for most FP6367 applications.

When selecting an output capacitor, consider the output ripple voltage and the ripple current. The ESR of capacitor is a major factor to the output ripple. For the best performance, a low ESR output capacitor is required. The ripple voltage is given by:

$$\Delta V_O = \Delta I_L\left(ESR + \frac{1}{8 \times f \times C_O}\right)$$

Output Voltage Programming

The output voltage of FP6367 is set by the resistor divider according to the following formula:

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

R1 is the upper resistor of the voltage divider. For transient response reason, a small feed-forward capacitor (C_F) is required in parallel to the upper feedback resistor, and 68pF is recommended.

Checking Transient Response

The regulator loop response can be checked by looking at the load transient response. Switching regulators take several cycles to respond to a step in load current. When a load step occurs, V_{OUT} immediately shifts by an amount equal to (ΔI_{LOAD} • ESR), where ESR is the effective series resistance of C_{OUT}. ΔI_{LOAD} also begins to charge or discharge C_{OUT}, which generates a feedback error signal. The regulator loop then acts to return V_{OUT} to its steady state value. During this recovery time, V_{OUT} can be monitored for overshoot or ringing that would indicate a stability problem.

The discharged bypass capacitors are effectively put in parallel with C_{OUT}, causing a rapid drop in V_{OUT}. No regulator can deliver enough current to prevent this problem if the load switch resistance is low and driven quickly. The only solution is to limit the rise time of the switch drive so that the load rise time is limited to approximately (25 • CL_{OAD}).

Current Mode PWM Control

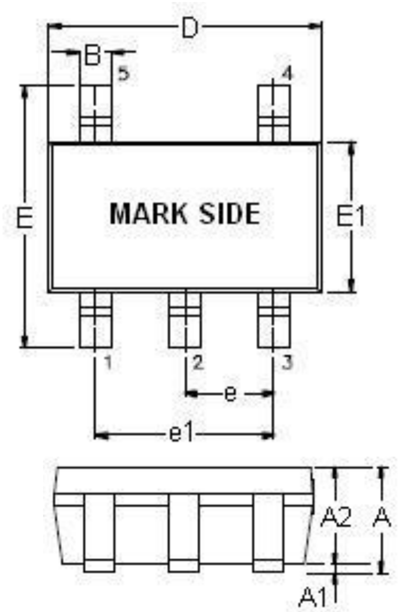
Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for superior load, line response, protection of the internal main switch and synchronous rectifier. The FP6367 switches at a constant frequency (1.5MHz) and regulates the output voltage. During each cycle the PWM comparator modulates the power transferred to the load by changing the inductor peak current based on the feedback error voltage. During normal operation, the main switch is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until next cycle starts.

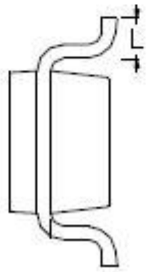
Dropout Operation

The FP6367 allows the main switch to remain on for more than one switching cycle, and increases the duty cycle while the input voltage is dropping close to the output voltage. When the duty cycle reaches 100%, the main switch will be held on continuously to deliver current to the output up to the MOSFET current limit. Then the output voltage will be the input voltage minus the voltage drop across the main switch and the inductor.

Outline Information

SOT-23-5 Package (Unit: mm)

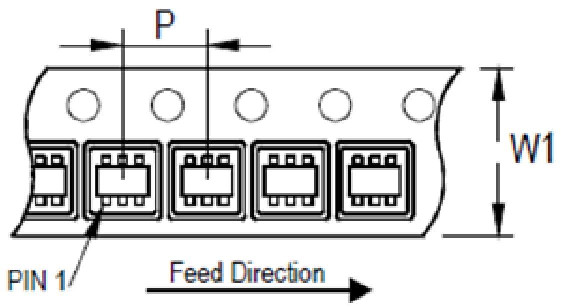


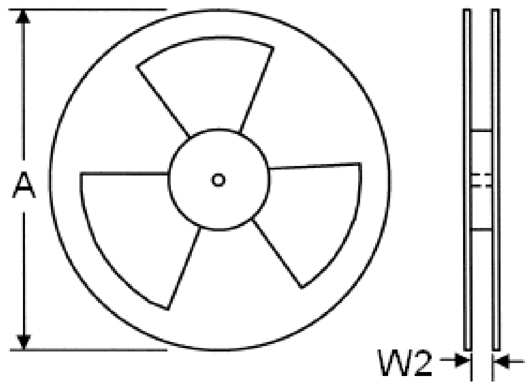


SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
B	0.30	0.50
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.90	1.00
e1	1.80	2.00
L	0.30	0.60

Note：Followed From JEDEC MO-178-C.

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			
8	4	7	180	8.4	300~1000	3,000

Life Support Policy
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