

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 1 μ A.

The FP6367 is available in a 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 35 μ A
- Low Shutdown Current at 1 μ A
- RoHS Compliant

Applications

- Cellular Phones
- Handheld Instruments
- Wireless LAN
- MP3 Portable Audio Players
- Battery Operated Devices

Pin Assignments

S5 Package (SOT-23-5)

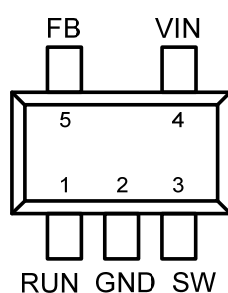
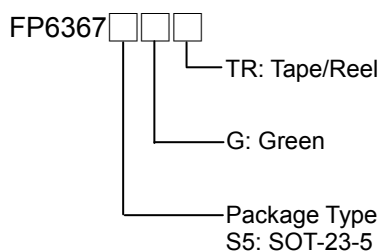


Figure 1. Pin Assignment of FP6367

Ordering Information



SOT-23-5 Marking

Part Number	Product Code
FP6367S5G	d2

Typical Application Circuit

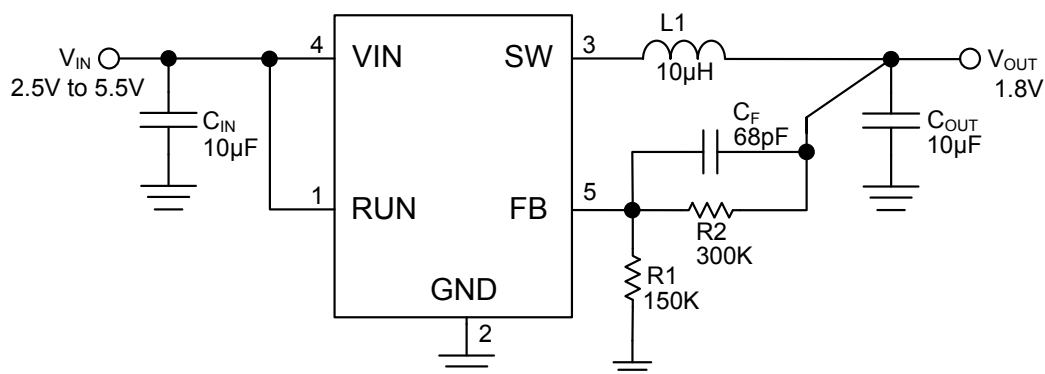


Figure 2. Typical Application Circuit of FP6367

Functional Pin Description

Pin Name	Pin Function
RUN	Enable Pin. A logic high enables the converter, logic low forces the device into shutdown mode 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 10uF Capacitor
FB	Feedback Input.

Block Diagram

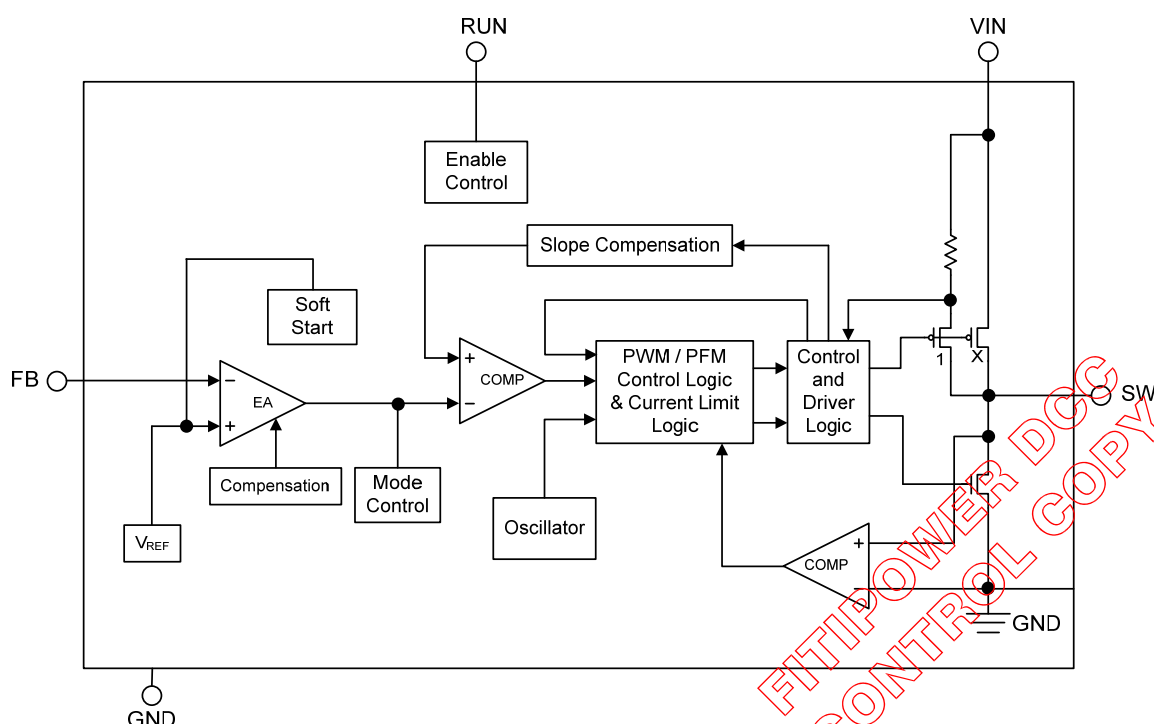


Figure 3. Block Diagram of FP6367

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
- Package Thermal Resistance, SOT-23-5 (θ_{JA})----- + 250°C/W
- Power Dissipation @ $T_A=25^\circ\text{C}$, SOT-23-5 (P_D)----- + 400mW
- 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

($V_{IN}=3.6\text{V}$, $R_{UN}=V_{IN}$, $T_A=25^\circ\text{C}$, 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}	$V_{FB}=0.5\text{V}$ or $V_{OUT}=90\%$, $I_O=0\text{mA}$		300	400	μA
		$V_{FB}=0.62\text{V}$ or $V_{OUT}=103\%$, $I_O=0\text{mA}$		20	35	
Shutdown Current	I_{SD}	$R_{UN}=GND$		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}	$R_{UN}=GND$ or V_{IN}		0.01	0.1	μA
N-Channel MOSFET On-Resistance (Note2)	$R_{DS(ON)}$	$I_{SW}=100\text{mA}$		450	500	m Ω
P-Channel MOSFET On-Resistance (Note2)	$R_{DS(ON)}$	$I_{SW}=100\text{mA}$		450	500	m Ω
Oscillator Frequency	f_S		1200	1500	1800	KHz
P-Channel Current Limit (Note2)	I_{LIM}	$V_{FB}=0.5\text{V}$	0.8	1	1.25	A
Reference Voltage	V_{REF}		0.588	0.6	0.612	V
Line Regulation	ΔV_{LINE}	$V_{IN}=V_O+0.5\text{V}$ to 5.5V ; $I_O=10\text{mA}$		0.05		%/V
Load Regulation	ΔV_{LOAD}	$I_O=10\text{mA}$ to 800mA		0.5		%

Note2: Guarantee by design.

Typical Performance Curves

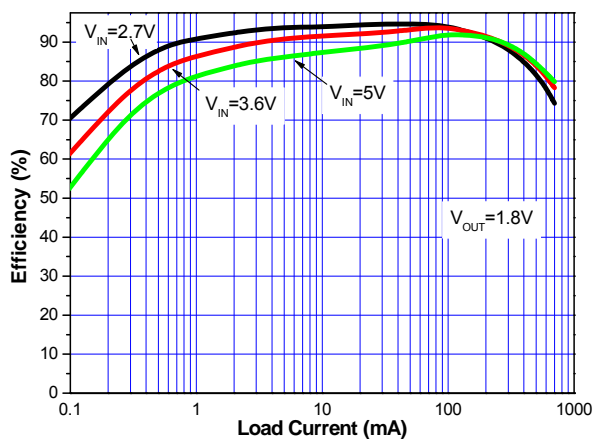


Figure 4. Efficiency vs. Load Current

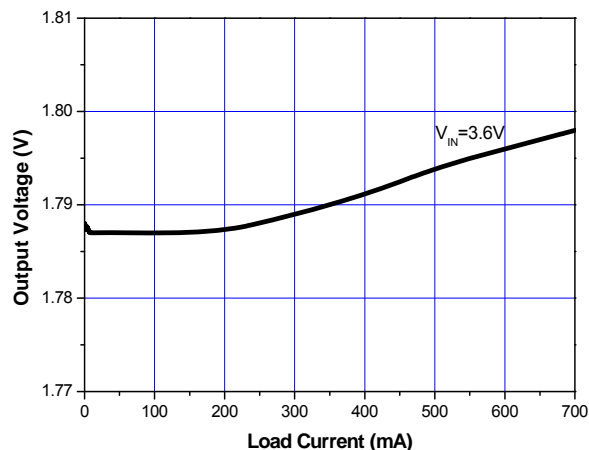


Figure 5. Output Voltage vs. Output Current ($V_{IN}=3.6V$)

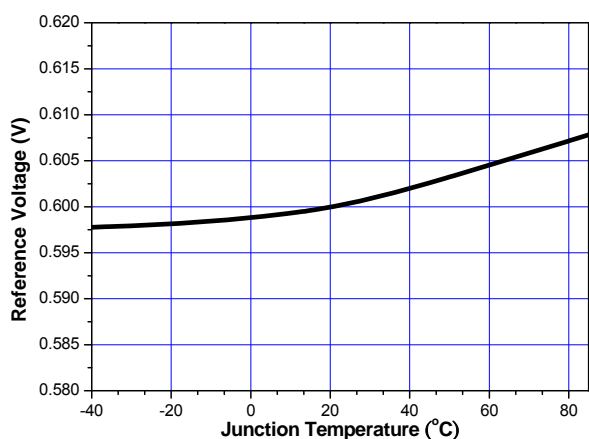


Figure 6. Reference Voltage vs. Junction Temperature

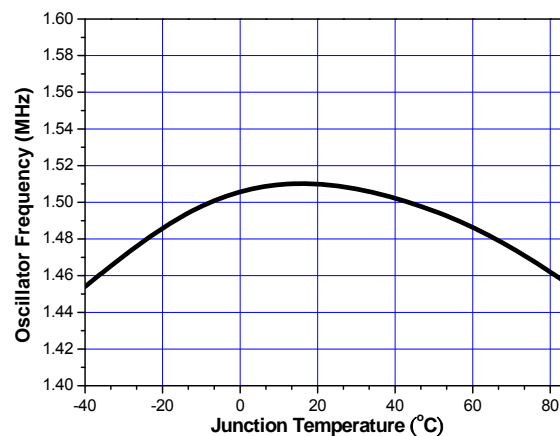


Figure 7. Frequency vs. Junction Temperature

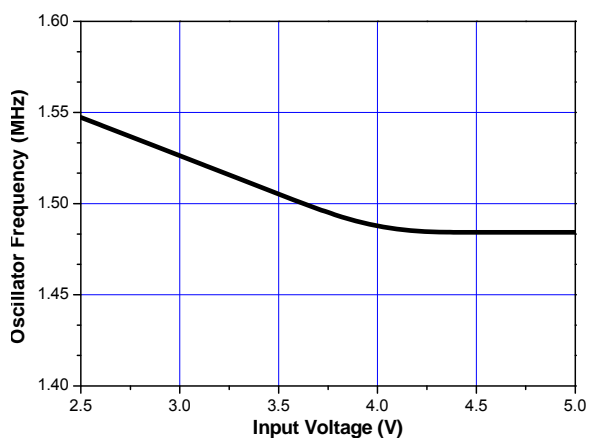


Figure 8. Frequency vs. Input Voltage

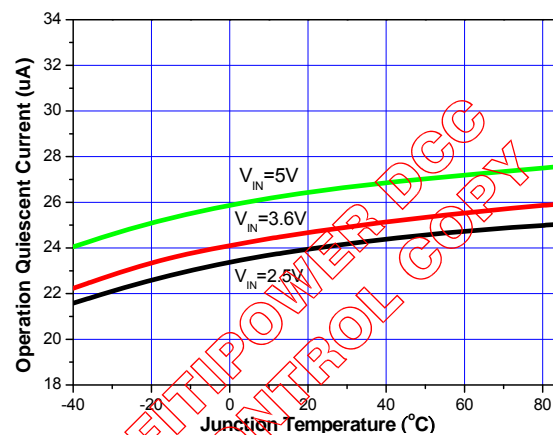


Figure 9. Quiescent Current vs. Junction Temperature

Typical Performance Curves (Continued)

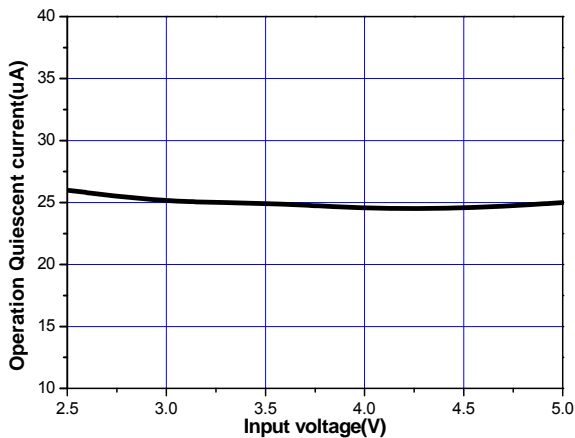
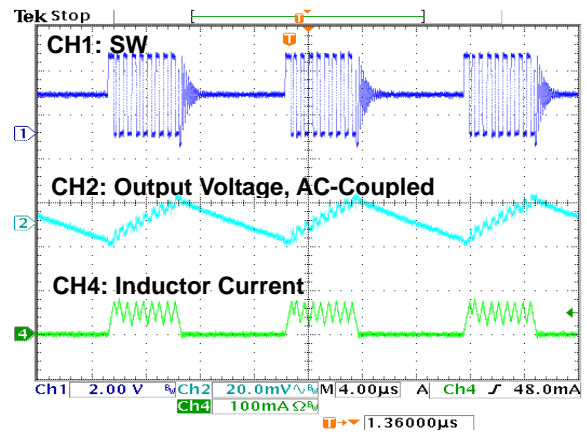
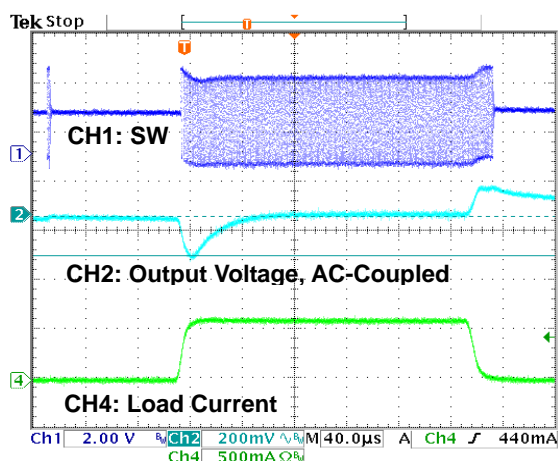


Figure 10. Quiescent Current vs. Input Voltage



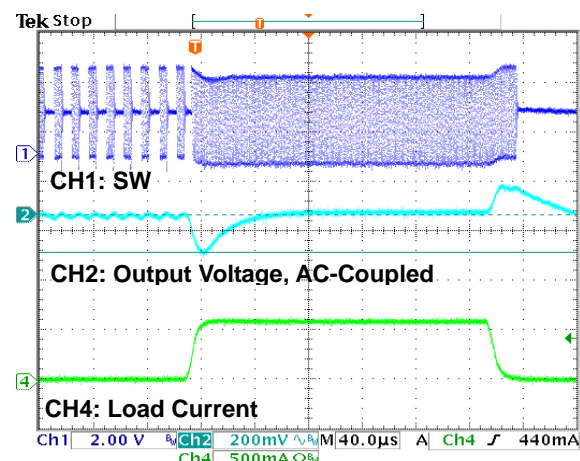
$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$, $I_{LOAD}=20mA$

Figure 11. Light Load Waveform



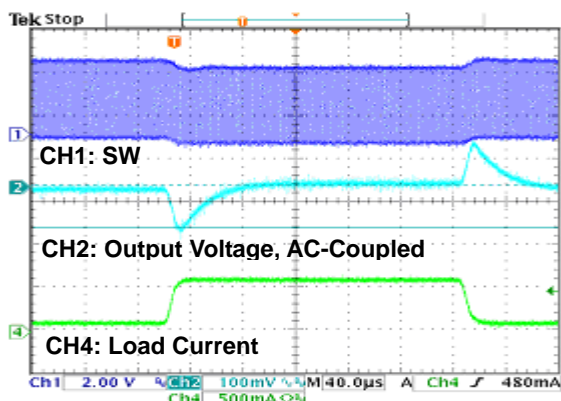
$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$, $I_{LOAD}=1mA$ to 600mA

Figure 12. Load Transient Response



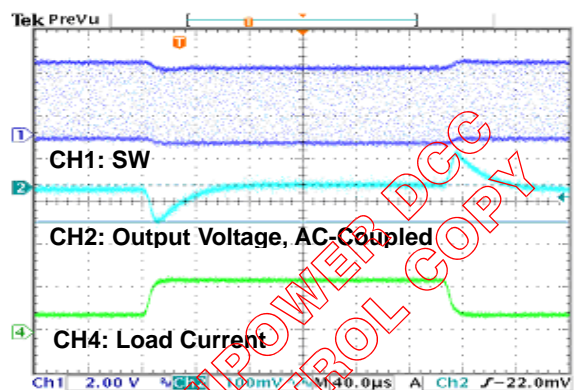
$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$, $I_{LOAD}=20mA$ to 600mA

Figure 13. Load Transient Response



$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$, $I_{LOAD}=100mA$ to 600mA

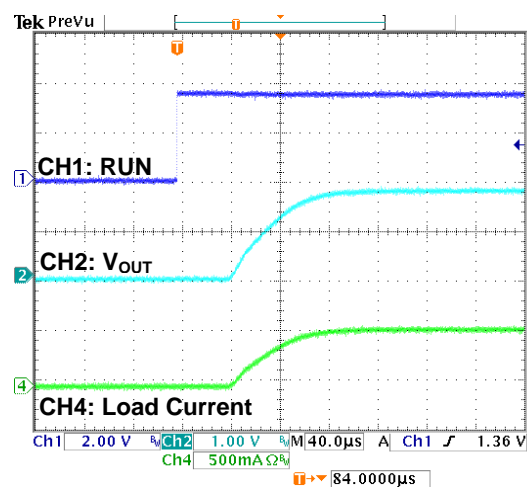
Figure 14. Load Transient Response



$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$, $I_{LOAD}=200mA$ to 600mA

Figure 15. Load Transient Response

Typical Performance Curves (Continued)



$V_{IN}=3.6V$, $V_{OUT}=1.8V$, $L=10\mu H$, $C_{OUT}=10\mu F+0.1\mu F$,
 $I_{LOAD}=600mA$

Figure 16. Start-up Waveform

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Application Information

1. Inductor Selection

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

The inductor value can be calculated as:

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

ΔI_L : inductor ripple current, which defined as:

$$\Delta I_L = V_O \left[\left(1 - \frac{V_O}{V_I}\right) / (L * f) \right] \quad (\text{General Setting})$$

$$\approx 0.1 * 2 * I_{O-MAX}$$

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

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

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 best performance, a low ESR output capacitor is required. The ripple voltage is given by:

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

3. Output Voltage Programming

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

$$V_{OUT} = V_{FB} * (1 + R_2/R_1)$$

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

4. 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 $(\Delta I_{LOAD} * ESR)$, 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 it is 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 $(25 * CL_{OAD})$.

5. Current Mode PWM Control

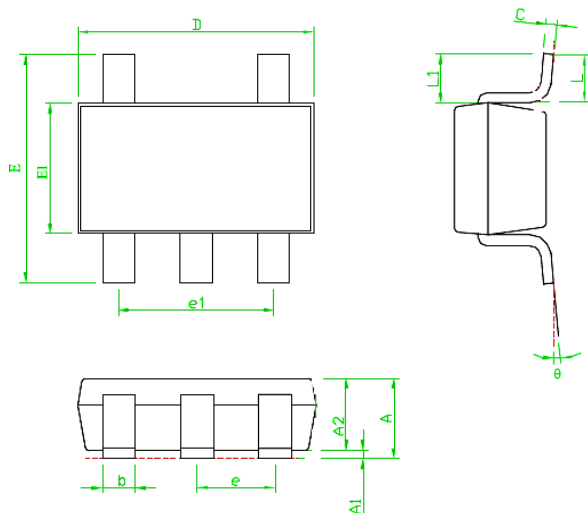
Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for superior load and line response and protection of the internal main switch and synchronous rectifier. The FP6367 switches at a constant frequency (1.5MHz) and regulates the output voltage. During 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 either the next cycle starts.

6. 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 is held on continuously to deliver current to the output up to the MOSFET current limit. The output voltage then is 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
c	0.08	0.22
D	2.70	3.10
E	2.60	3.00
E1	1.40	1.80
e	0.85	1.05
e1	1.80	2.00
L	0.3	0.60
L1	0.50	0.70
θ	0°	8°

Note 1 : Followed From JEDEC MO-178-C.

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