

High-Efficiency, 29V White LED Driver with Dimming Control

Description

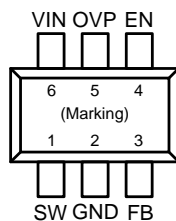
The FP6757 is a step-up DC/DC converter specifically designed for driving WLEDs with a constant current. The FP6757 can drive up to 8 white LEDs in series from a Lithium Ion battery. Series connection of LEDs provides identical LED current for uniform brightness and minimizes the number of traces to the LEDs. The FP6757 uses current mode, fixed frequency of approximately 1.3MHz architecture to regulate the LED current through an external current sense resistor. The low feedback voltage of 195mV can minimize power dissipation.

Other features include current limit protection, thermal shutdown protection, under-voltage lockout (UVLO), and over-voltage function, which can shut off the device if output voltage reaches above 29V.

The FP6757 is available in space saving SOT-23-6 and TDFN-6 (3mm×3mm) packages.

Pin Assignments

S6 Package (SOT-23-6)



DD Package (TDFN-6 (3mm×3mm))

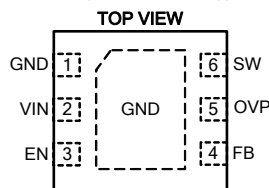


Figure 1. Pin Assignment of FP6757


Features

- Wide Range for PWM Dimming, Ranging from 100Hz to 50kHz
- High Efficiency: 87%
- Drives up to 8 WLEDs
- Fast 1.3MHz Switching Frequency
- Low 195mV Feedback Voltage
- Over Voltage Protection
- Low Profile SOT-23-6 and TDFN-6 (3mm×3mm) Packages
- RoHS Compliant

Applications

- Cellular Phone
- Digital Camera
- LCD Panel Backlight
- GPS Receiver
- PDA, Handheld Computer

Ordering Information

FP6757  Package Type
S6: SOT-23-6
DD: TDFN-6 (3mm×3mm)

SOT-23-6 Marking

| Part Number | Product Code |
|-------------|--------------|
| FP6757S6 | GA5 |

Typical Application Circuit

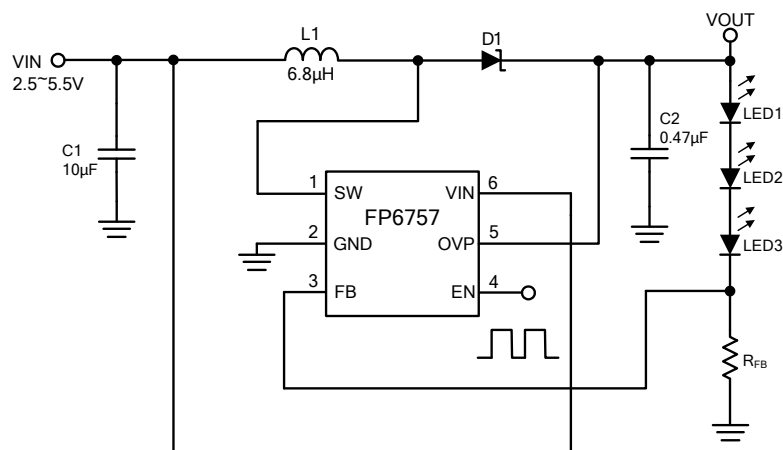


Figure 2. Typical Application Circuit of FP6757 (SOT-23-6 Package)

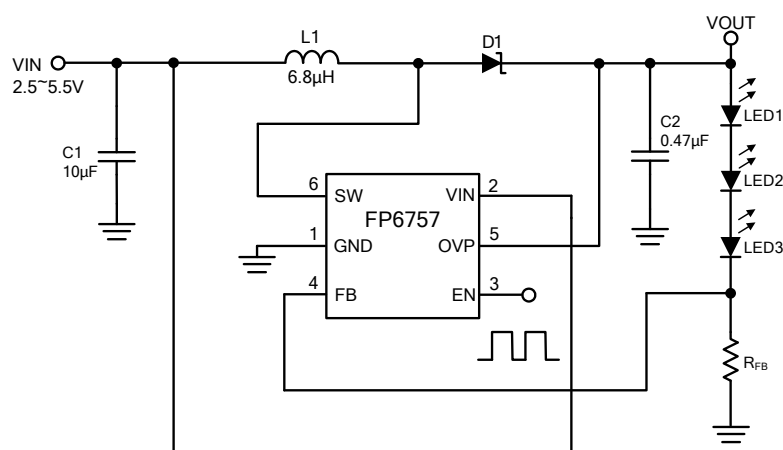


Figure 3. Typical Application Circuit of FP6757 (TDFN-6 Package)

Functional Pin Description

| Pin Name | Pin No. (SOT-23-6) | Pin No. (TDFN-6) | Pin Function |
|----------|-----------------------|---------------------|--|
| SW | 1 | 6 | Switch node pin. Connect inductor/diode here. Minimize trace area at this node to reduce EMI. |
| GND | 2 | 1 | Ground pin. Connect directly to local ground plane. |
| FB | 3 | 4 | Feedback pin. Reference voltage is 195mV. Connect cathode of the lowest LED and resistor here. Calculate resistor value according to the formula: $R_{FB} = V_{FB} / I_{LED}$ |
| EN | 4 | 3 | Enable and dimming control. 1. Enable: Logic high enables the device; logic low forces the device into shutdown mode. 2. Digital dimming control: apply external 100Hz to 50kHz PWM pulse signal with amplitude greater than 1.5V. |
| OVP | 5 | 5 | Over voltage input. OVP measures the output voltage for open circuit protection. Connect OVP to the output at the top of the LED string. |
| VIN | 6 | 2 | Input supply pin. Must be locally bypassed. |

Block Diagram

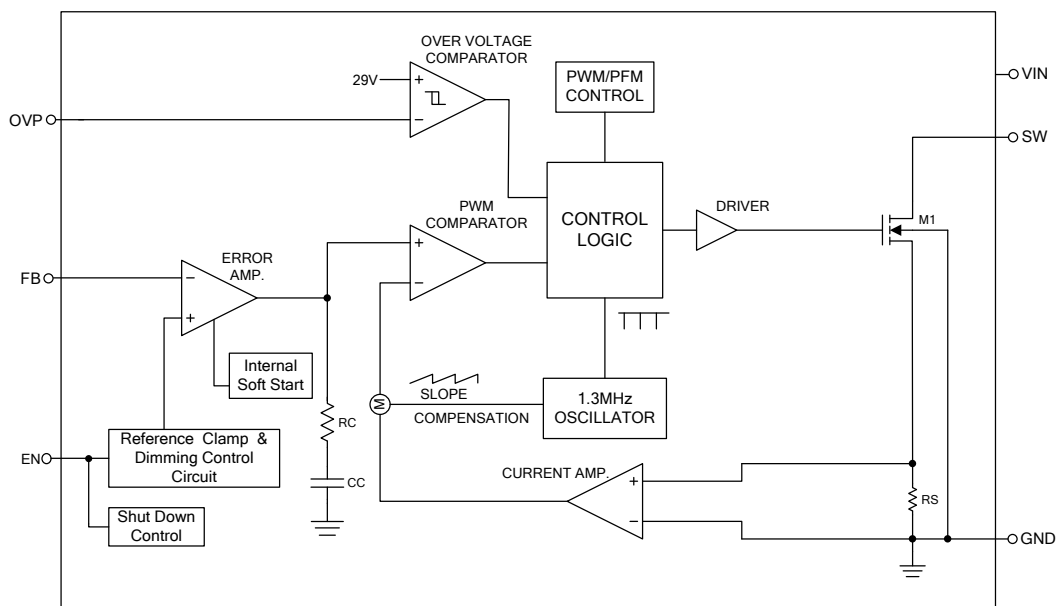


Figure 4. Block Diagram of FP6757

Absolute Maximum Ratings ^(Note 1)

- VIN ----- +6V
- SW Voltage ----- +34V
- FB Voltage ----- +6V
- EN Voltage ----- +6V
- Maximum Junction Temperature (T_J) ----- +150°C
- Power Dissipation @ $T_A=25^{\circ}\text{C}$, (P_D)
 - SOT-23-6 ----- 0.40W
 - TDFN-6 (3mm×3mm) ----- 1.82W
- Package Thermal Resistance, (θ_{JA})
 - SOT-23-6 ----- 250°C/W
 - TDFN-6 (3mm×3mm) ----- 55°C/W
- Storage Temperature Range (T_S) ----- -65°C to +150°C
- Lead Temperature (Soldering, 10 sec.) (T_{LEAD}) ----- +260°C

Note 1: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Input Voltage (V_{IN}) ----- +2.5V to +5.5V
- Operating Temperature Range ----- -40°C to +85°C

Electrical Characteristics

($V_{IN}=V_{EN}=5V$, $T_A=+25^{\circ}C$, unless otherwise noted.)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|--------------------------------------|----------|--------------------------|-----|------|------|-------------|
| Operating Input Voltage | V_{IN} | | 2.5 | | 5.5 | V |
| Operation Current | I_{SD} | $V_{EN}=0V$ | | 4 | 8 | μA |
| | I_Q | $V_{FB}=0.2V$ | | 490 | 610 | μA |
| Switching Frequency | f_{SW} | | 1.0 | 1.3 | 1.5 | MHz |
| Maximum Duty Cycle | Duty | $V_{FB}=0V$ | 90 | | | % |
| Under Voltage Lockout | | | | | | |
| VIN Under Voltage Lockout | UVLO | V_{IN} Rising | | 2.25 | 2.45 | V |
| Under Voltage Lockout Hysteresis | | | | 300 | | mV |
| Open Lamp Shutdown Threshold | V_{OV} | V_{OUT} Rising | 28 | 29 | | V |
| Enable | | | | | | |
| EN OFF Threshold | | V_{EN} Falling | | | 0.3 | V |
| EN ON Threshold | | V_{EN} Rising | 1.4 | | | V |
| Dimming On Time | T_{ON} | PWM=20kHz at $V_{IN}=5V$ | 6 | | | μS |
| Feedback | | | | | | |
| FB Voltage | V_{FB} | $V_{EN}=1.5V$ | 185 | 195 | 205 | mV |
| FB Input Bias Current | I_{FB} | $V_{FB}=0.1V$ | | -300 | | nA |
| Output Switch | | | | | | |
| SW ON-Resistance ^(Note 2) | R_{ON} | | | 0.25 | | Ω |
| SW Current Limit ^(Note 2) | I_{LM} | | | 3 | | A |
| Thermal Shutdown ^(Note 2) | T_{SD} | | | 150 | | $^{\circ}C$ |

Note 2: The specification is guaranteed by design, not production test.

Typical Performance Curves

$V_{IN}=5V$, $C1=10\mu F$, $C2=1\mu F$, $L1=6.8\mu H$, 5S5P WLEDs. $T_A=+25^{\circ}C$, unless otherwise noted.

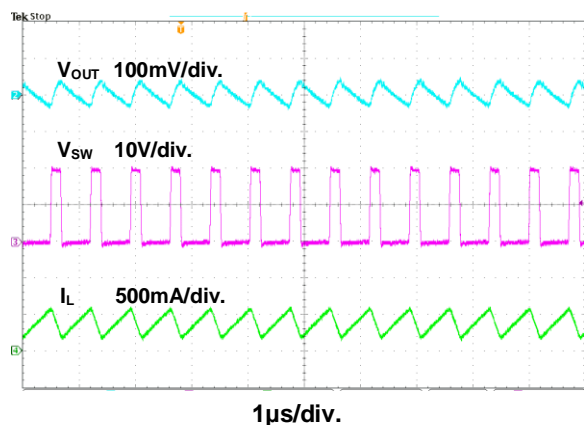


Figure 5. Steady State Waveform

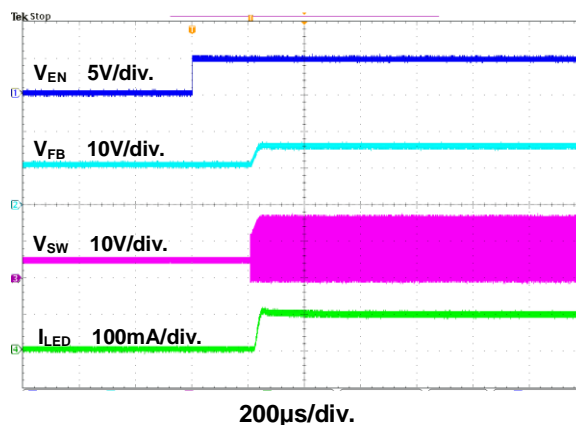


Figure 6. Enable Startup Response Waveform

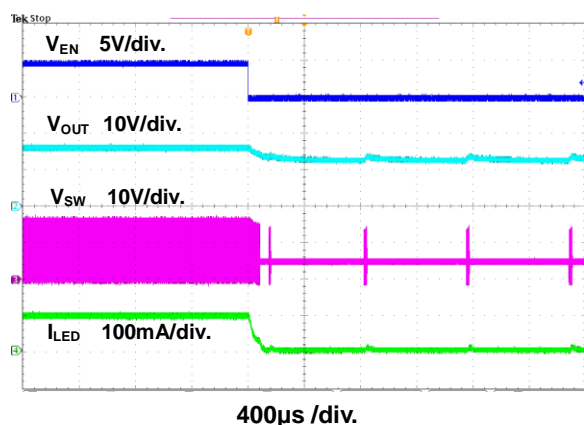


Figure 7. Enable Shutdown Response Waveform

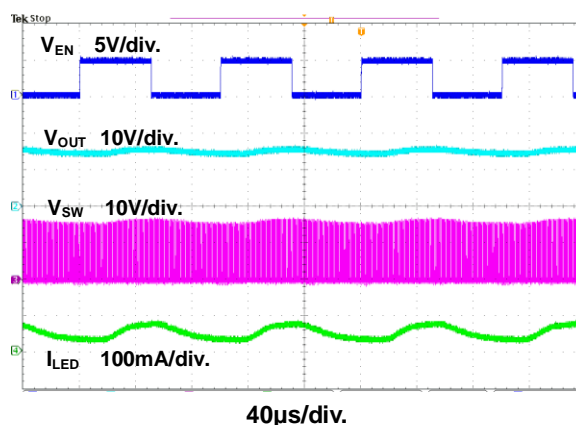


Figure 8. PWM Dimming Response Waveforms at a Frequency of 10kHz

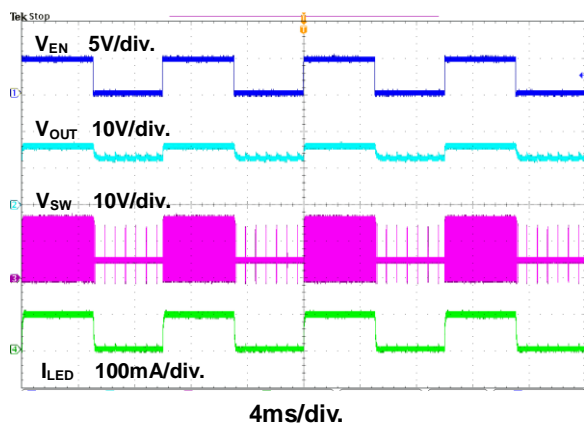


Figure 9. PWM Dimming Response Waveform at a Frequency of 100Hz

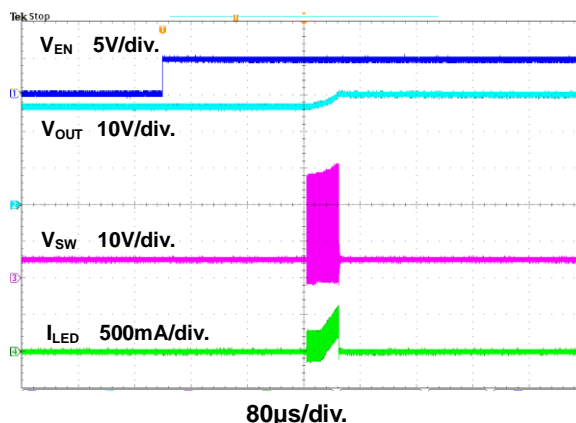


Figure 10. Open Load Protection Waveform

Typical Performance Curves (Continued)

$V_{IN}=5V$, $C1=10\mu F$, $C2=1\mu F$, $L1=6.8\mu H$, 5S5P WLEDs. $T_A=+25^{\circ}C$, unless otherwise noted.

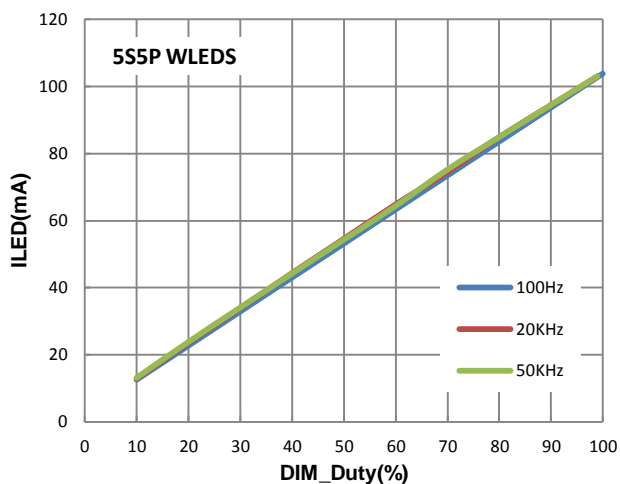


Figure 11. LED Current vs. Duty Cycle

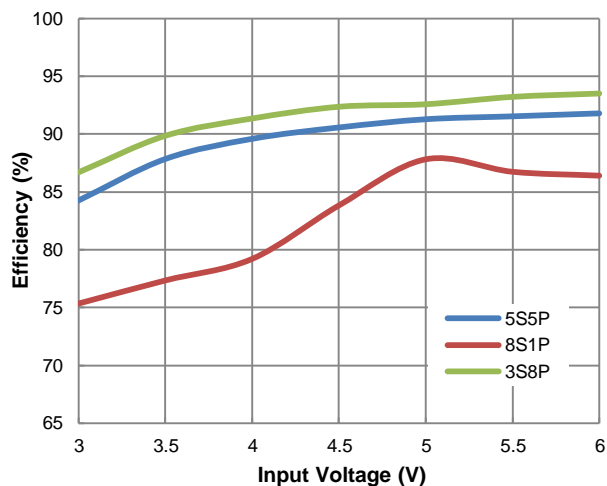


Figure 12. Efficiency vs. Input Voltage.

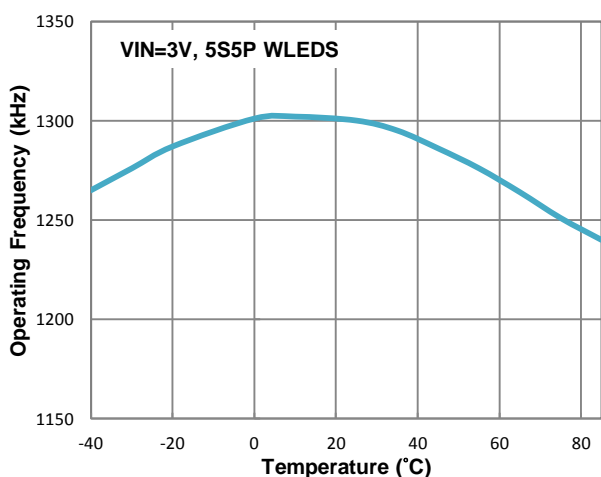


Figure 13. Operating frequency vs. Temperature.

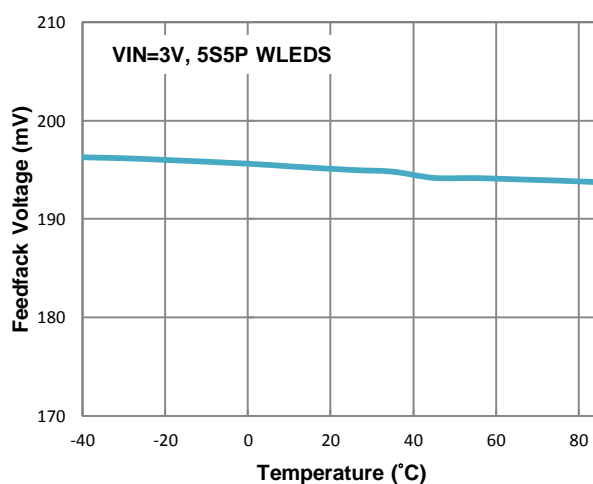


Figure 14. Feedback Voltage vs. Temperature.

Applications Information

Operation

The FP6757 is designed in a current mode, fixed-frequency pulse-width modulation (PWM) step-up converter to drive up to 8 series-connected WLEDs. The FP6757 operates well with a variety of external components. See the following sections to optimize external components for a particular application. The PWM controller that goes automatically into PSM mode at light load.

Inductor Selection

For most applications, a 4.7μH to 15μH is recommended for general use. The inductor parameters, current rating, DCR and physical size, should be considered. The DCR of inductor affects the efficiency of the converter. The inductor with lowest DCR is chosen for highest efficiency. The saturation current rating of inductor must be greater than the switch peak current, typically 3A. These factors affect the efficiency, output load capability, output voltage ripple, and cost.

The inductor selection depends on the switching frequency and current ripple by the following formula:

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

Where f_{SW} is the 1.3MHz switching frequency. ΔI_L is the inductor ripple current.

Capacitor Selection

The ceramic capacitor is ideal for FP6757 application. X5R or X7R types are recommended because they hold their capacitance over wide voltage and temperature ranges than other Y5V or Z5U types. The input capacitor can reduce peak current and noise at power source. The output capacitor is typically selected based on the output voltage ripple requirements. For most applications, a 10μF input capacitors with a 0.47μF output capacitor are sufficient for general use. A higher or lower capacitance may be used depending on the acceptable noise level. When output capacitor larger than 0.47μF and LED may open, also suggested to add a zener diode for enhancing over voltage protection. For detail, can refer to LED open circuit protection (Page 9).

LED Current Setting

The LED current is specified by resistor from the FB pin to ground. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The LED current can be programmed by:

$$I_{LED} = \frac{195mV}{R_{FB}}$$

Over Voltage Protection

The FP6757 has an internal open-lamp protection circuit. In the cases of output open circuit, when the LEDs are disconnected from the circuit or the LEDs fail open circuit, the over-voltage function monitors the output voltage through SW pin to protect the converter against. The LED strings open will cause N-MOS to switch with a maximum duty cycle and come out output over-voltage. This may cause the SW voltage exceed its maximum rating then damage built-in N-MOS. In the state, the OVP protection circuitry will be triggered if output voltage exceeds 29V (typ.). The FP6757 can automatically recovery.

Dimming Control (PWM Signal)

The LED current can be set by modulating the EN pin with a PWM signal.

Changing the LED forward current not only changes the intensity of the LEDs, but also changes the color. Controlling the intensity of the LEDs with a direct PWM signal allows dimming of the LEDs without changing the color.

Dimming the LEDs via a PWM signal essentially involves turning the LED on and off. The LEDs operate at either zero or full current. The amplitude of the PWM signal should be higher than the minimum EN dimming voltage (typically 1.4V). The LED average current increases proportionally with the duty cycle of the PWM signal. The color of the LEDs remains unchanged since the LED current value is either zero or a constant value. The dimming frequency of the PWM signal can up to 50kHz and still retain well linearity. To avoid audio noise, dimming frequency greater than 20kHz is recommended.

Applications Information (Continued)

LED Open Circuit Protection

When the LED is disconnected from the circuit, the feedback voltage will be zero. The FP6757 will then switch at a high duty cycle resulting in a high output voltage, which may cause the SW pin voltage to exceed its 34V. A zener diode can be used at the output to limit the voltage on the SW pin. The zener voltage should be larger than the maximum voltage of the VOUT, and smaller as a value that can keep SW voltage small than 34V. Higher RFBC may cause higher FB voltage when LED open, a maximum 100Ω was suggested for this circuit.

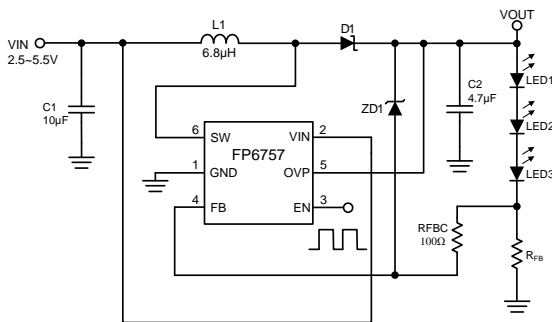


Figure 15. LED Open Circuit Application

Layout Consideration

The proper PCB layout and component placement are critical for all switching regulators. The careful attention should be taken to the high-frequency, high current loops to prevent electromagnetic interference (EMI) problems. Here are some suggestions to the layout of FP6757 design.

- The input capacitor should be located as closed as possible to the VIN and GND pin.
- Minimize the distance of all traces connected to the SW node. The external components, C_{OUT} , L1, and D1 should be placed as close to the device as possible with short and wide route to obtain optimum efficiency.
- Keep the noise-sensitive feedback circuitry away from the switching node. Place feedback resistor as close as possible to FB pin.
- The ground terminal of C_{OUT} must be located as closed as possible to GND pin. Place C_{OUT} next to Schottky diode.

In Backlight application, the system engineers usually place the C_{OUT} close to the LED connector. The far C_{OUT} of the FP6757 may result in variable VFB. Add one more C_{OUT} close to FP6757 is suggestion.

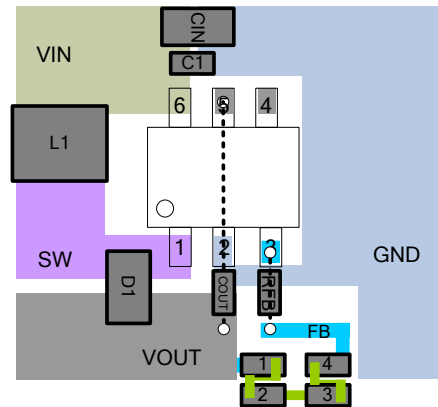
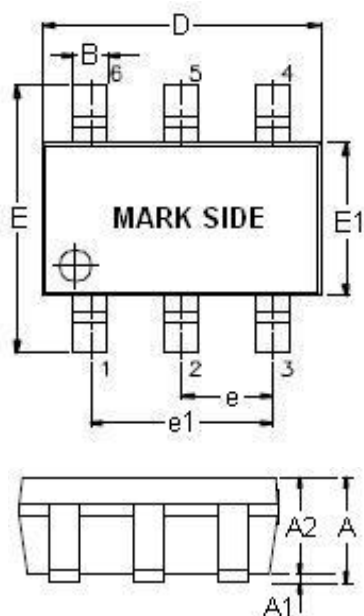


Figure 16. Layout Diagram

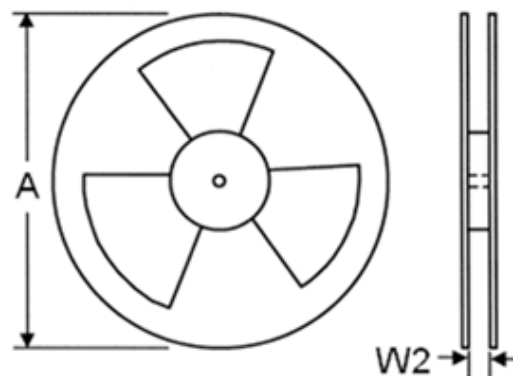
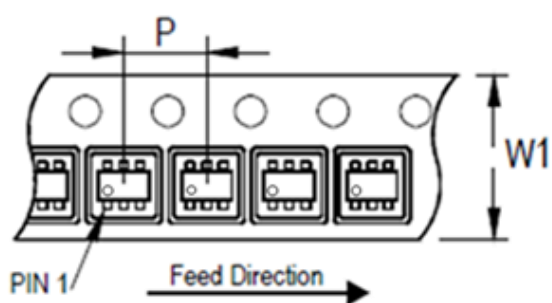
Outline Information

SOT-23-6 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 |

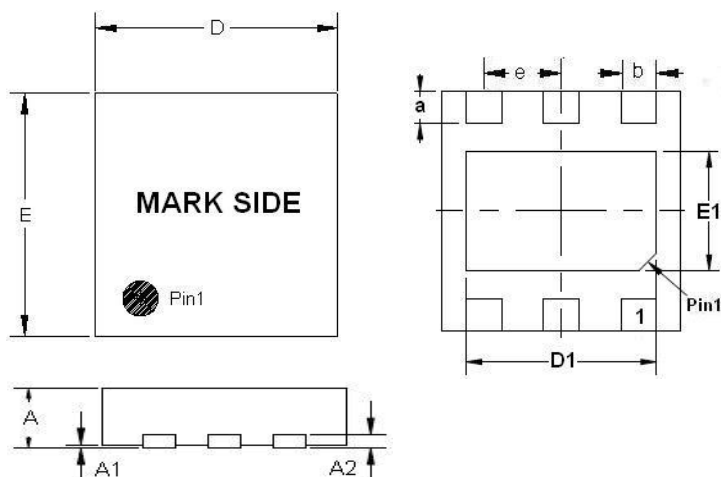
Carrier Dimensions



| 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 |

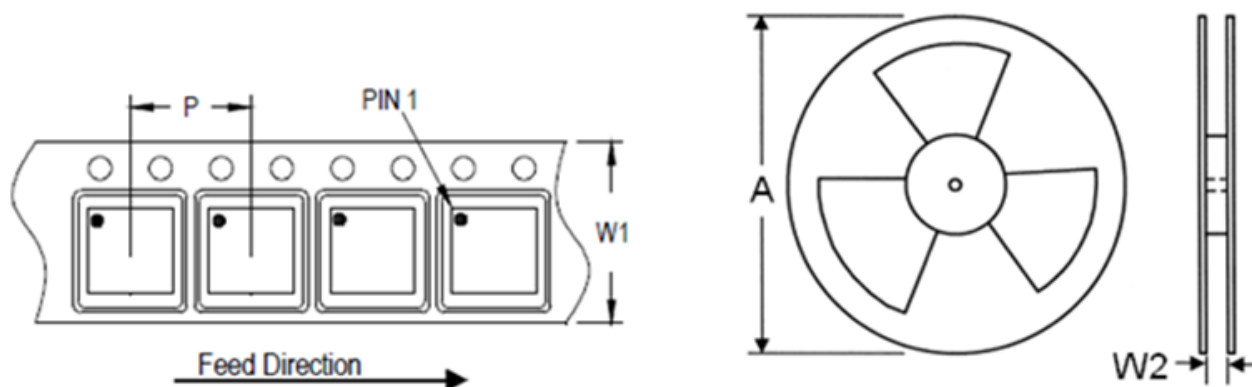
Outline Information (Continued)

TDFN-6 3mm×3mm (pitch 0.95 mm) Package (Unit: mm)



| SYMBOLS UNIT | DIMENSION IN MILLIMETER | |
|-----------------|-------------------------|------|
| | MIN | MAX |
| A | 0.70 | 0.80 |
| A1 | 0.00 | 0.05 |
| A2 | 0.18 | 0.25 |
| D | 2.90 | 3.10 |
| E | 2.90 | 3.10 |
| a | 0.25 | 0.50 |
| b | 0.18 | 0.35 |
| e | 0.90 | 1.00 |
| D1 | 2.25 | 2.35 |
| E1 | 1.45 | 1.55 |

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 | 3,000 |

Life Support Policy

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