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

Description

The FP6755 is a step-up DC/DC converter specifically designed for driving WLEDs with a constant current. The FP6755 can drive up 8 white LEDs in series from a Lithium Lon battery. Series connection of LEDs provides identical LED current for uniform brightness and minimizes the number of traces to the LEDs. The FP6755 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 FP6755 is available in space saving SOT-23-6 & TDFN-6 (2mm×2mm) packages.

Features

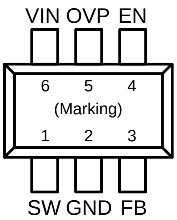
- Wide Range for PWM Dimming, Ranging from 100Hz to 50kHz
- High Efficiency: 87%
- Drives up to 8 WLEDs
- Fast 1.3MHz Switching Frequency
- Low 195mV Feedback Voltage
- Over Voltage Protection
- Low Profile SOT-23-6 and TDFN-6 (2mm×2mm) Packages
- RoHS Compliant

Applications

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

Pin Assignments

S6 Package: SOT-23-6



WD Package: TDFN-6 (2mm×2mm)

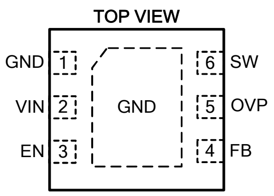
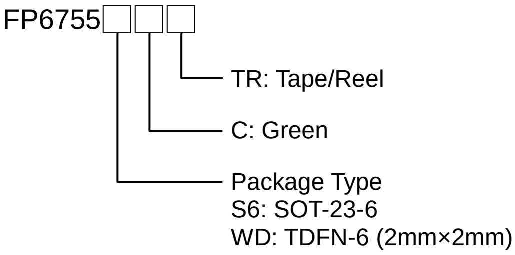


Figure 1. Pin Assignment of FP6755

Ordering Information



SOT-23-6 Marking

Part Number	Product Code
FP6755S6CTR	**FG4**

TDFN-6 (2mmx2mm) Marking

Part Number	Product Code
FP6755WDCTR	**FG6**

Typical Application Circuit

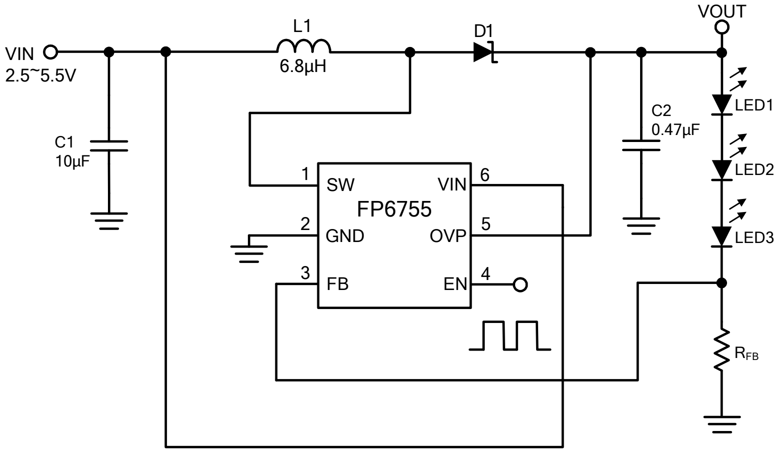


Figure 2. Typical Application Circuit of FP6755 SOT-23-6 Package

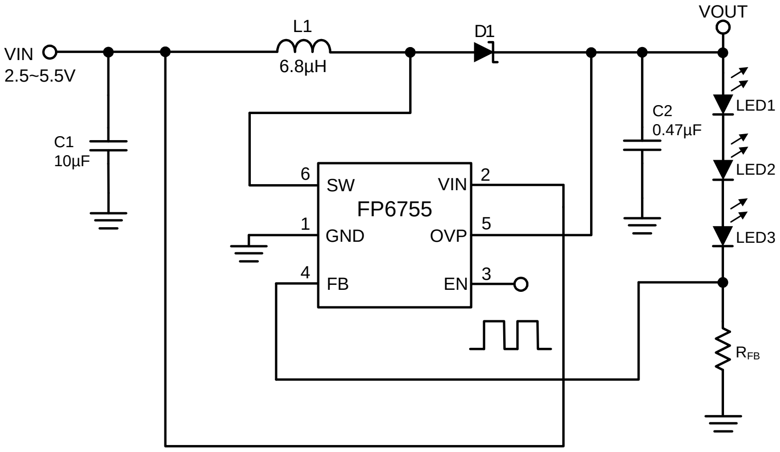


Figure 3. Typical Application Circuit of FP6755 TDFN-6 (2mm×2mm) Package

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

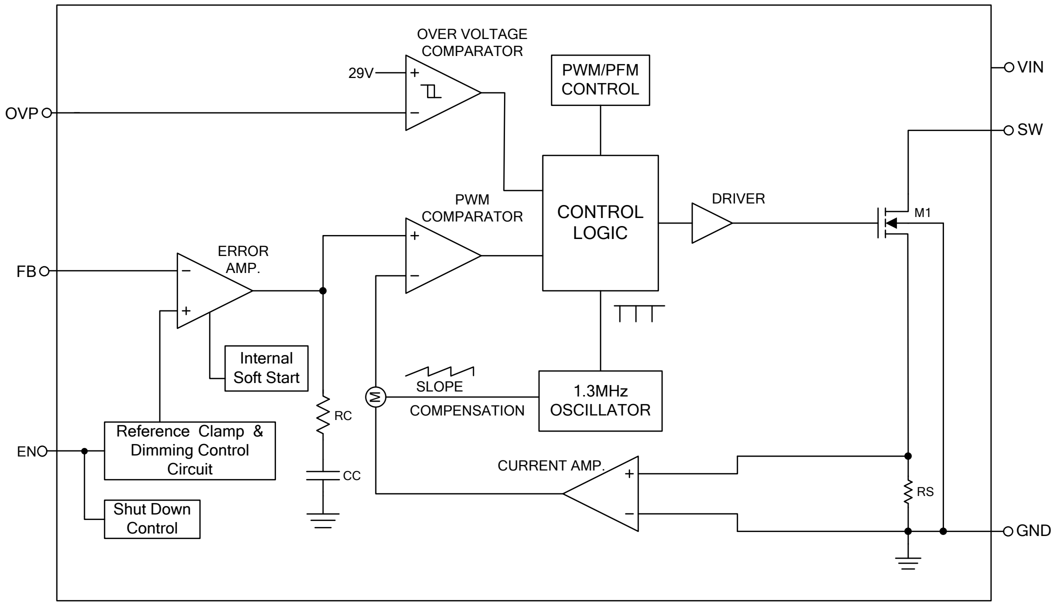


Figure 4. Block Diagram of FP6755

Absolute Maximum Ratings (Note 1)

- VIN -- +6V
- SW Voltage -- +34V
- FB Voltage -- +6V
- EN Voltage -- +6V
- Maximum Junction Temperature (T_J) -- +150ºC
- Power Dissipation @T_A=25℃, (P_D)
  - SOT-23-6 -- 0.40W
  - TDFN-6 (2mm×2mm) -- 0.74W
- Package Thermal Resistance, (θ_{JA})
  - SOT-23-6 -- 250ºC/W
  - TDFN-6 (2mm×2mm) -- 136°C/W
- Package Thermal Resistance, (θ_{JC})
  - SOT-23-6 -- 110ºC/W
  - TDFN-6 (2mm×2mm) -- 56°C/W
- Storage Temperature Range (T_S) -- -65ºC to +150ºC
- Lead Temperature (Soldering, 10 sec.) (T_{LEAD}) -- +260ºC

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 -- -40ºC to +85ºC

Electrical Characteristics

(V_{IN}=V_{EN}=5V, T_A=+25ºC, 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		430	550	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=40kHz at V_{IN}=5V	2			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}			2		A
Thermal Shutdown (Note 2)	T_{SD}			150		°C

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

Typical Performance Curves

V_{IN}=5V, C1=10μF, C2=1μF, L1=6.8μH, 5S5P WLEDs. TA=+25°C, unless otherwise noted.

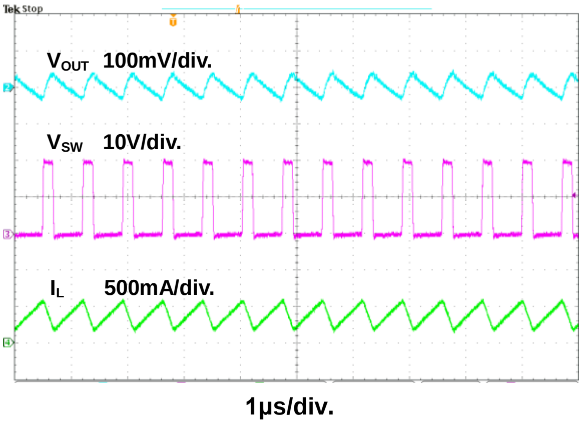


Figure 5. Steady State Waveform

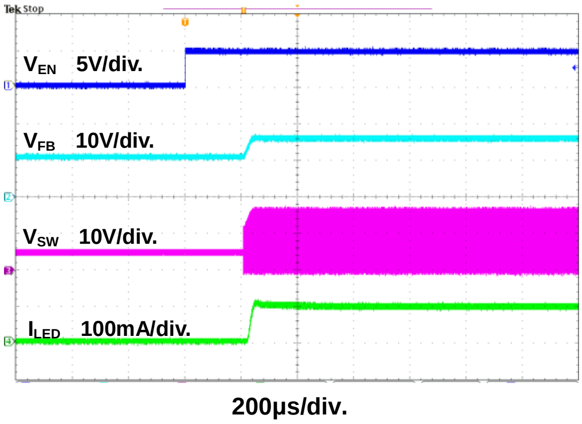


Figure 6. Enable Startup Response Waveform

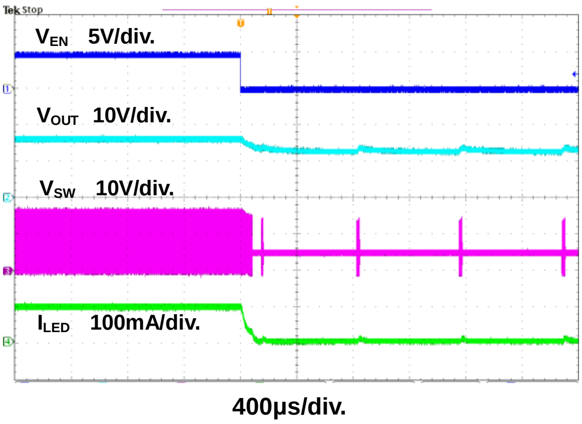


Figure 7. Enable Shutdown Response Waveform

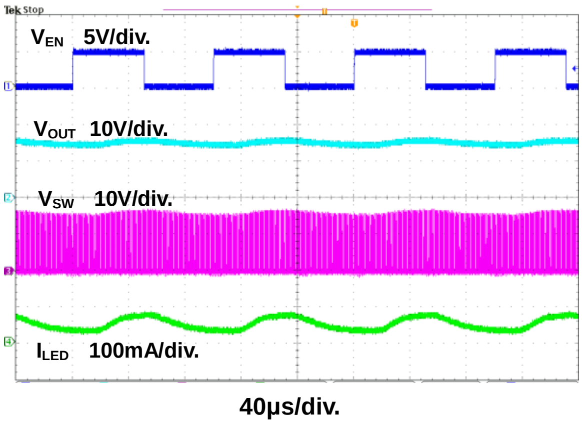


Figure 8. PWM Dimming Response Waveforms at a Frequency of 10kHz

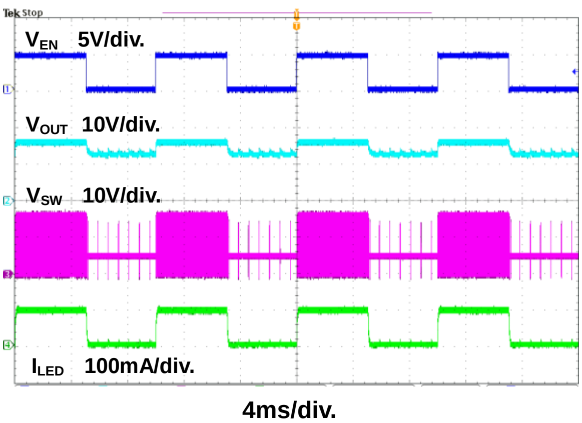


Figure 9. PWM Dimming Response Waveform at a Frequency of 100Hz

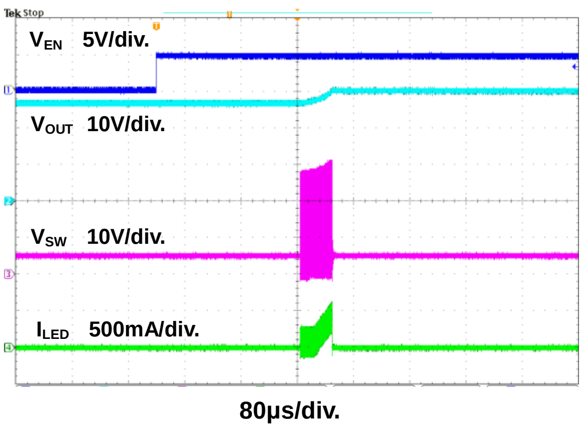


Figure 10. Open Load Protection Waveform

Typical Performance Curves (Continued)

V_{IN}=5V, C1=10μF, C2=1μF, L1=6.8μH, 5S5P WLEDs. TA=+25°C, unless otherwise noted.

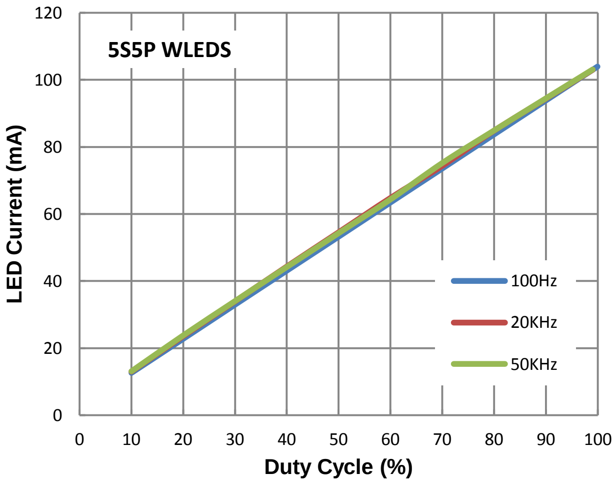


Figure 11. LED Current vs. Duty Cycle

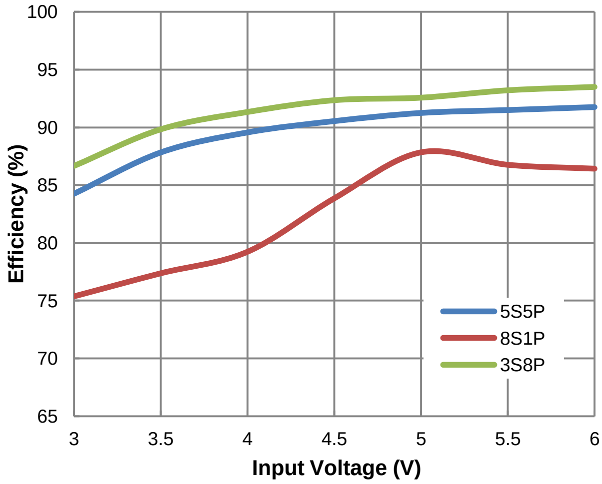


Figure 12. Efficiency vs. Input Voltage

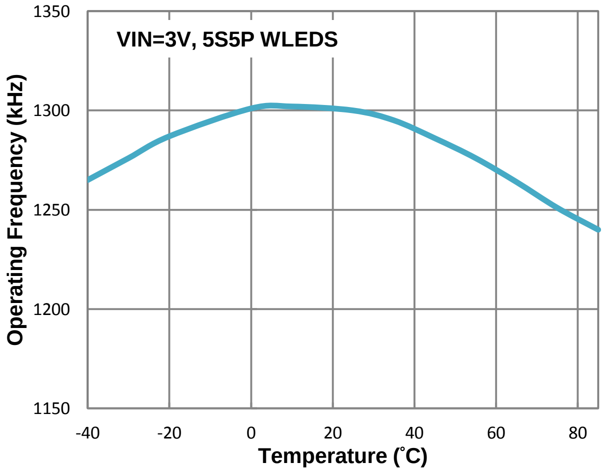


Figure 13. Operating Frequency vs. Temperature

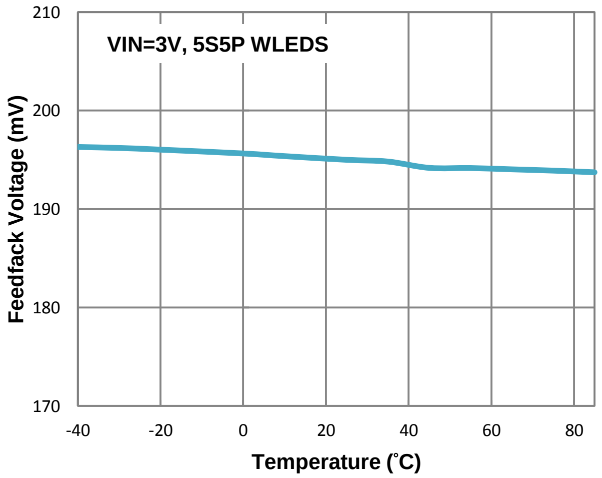


Figure 14. Feedback Voltage vs. Temperature

Applications Information

Operation

The FP6755 is designed in a current mode, fixed-frequency pulse-width modulation (PWM) step-up converter to drive up to 8 series-connected WLEDs. The FP6755 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 used. 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 2A. 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 FP6755 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 reduced 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 used. 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 FP6755 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 FP6755 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 FP6755 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.

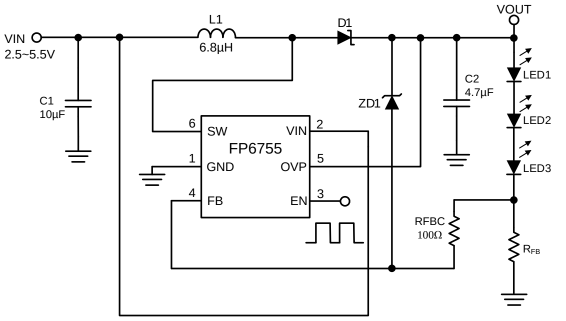


Figure 15. LED Open Circuit Application

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 FP6755 design.

a. The input capacitor should be located as closed as possible to the VIN and GND pin.

b. 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.

c. Keep the noise-sensitive feedback circuitry away from the switching node. Place feedback resistor as close as possible to FB pin.

d. 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 FP6755 may result in variable VFB. Add one more C_{OUT} close to FP6755 is suggestion.

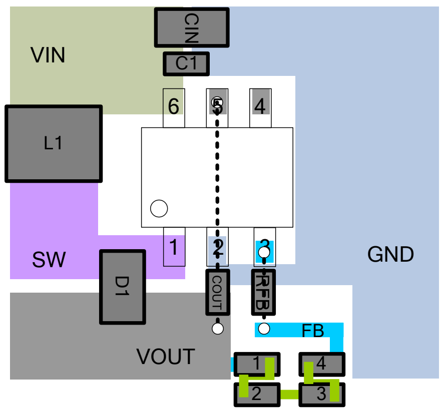
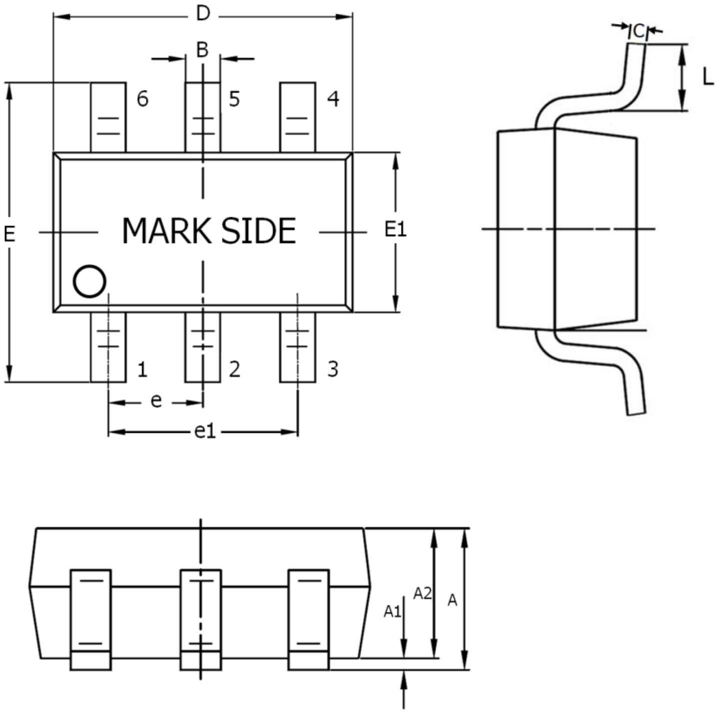


Figure 16. Layout Diagram

Outline Information

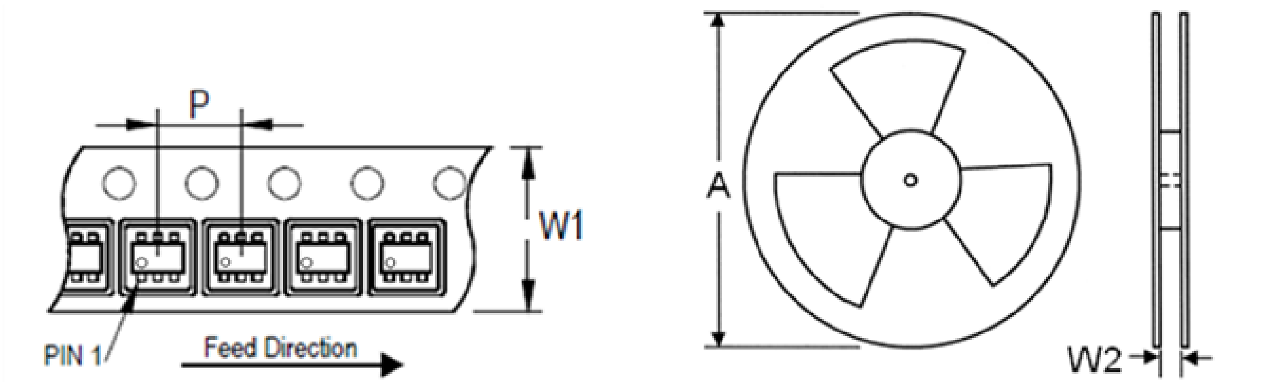
SOT-23-6 Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.90	1.30
A1	0.00	0.15
A2	0.90	1.15
B	0.28	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
C	0.08	0.20
L	0.30	0.60

Note3: Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.3mm.

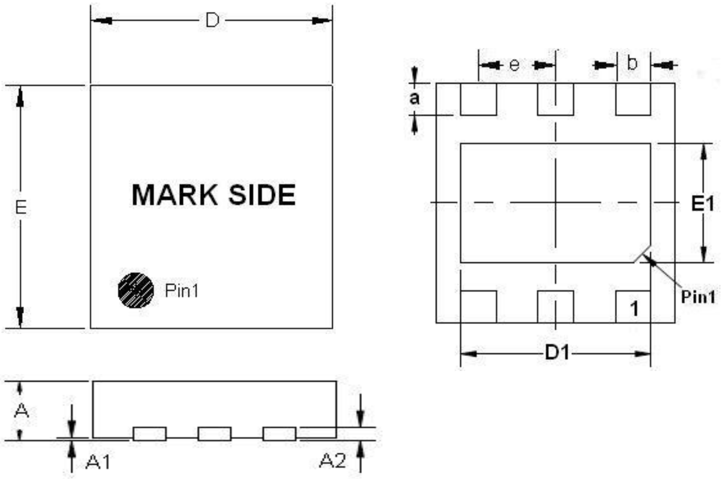
Carrier Dimensions



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

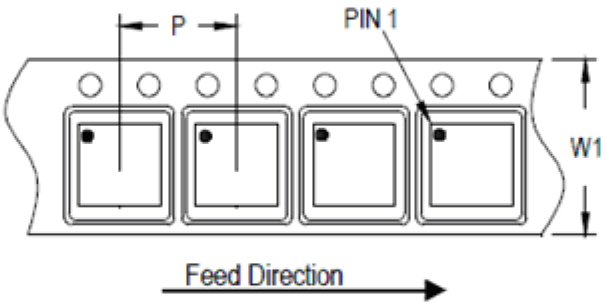
Outline Information (Continued)

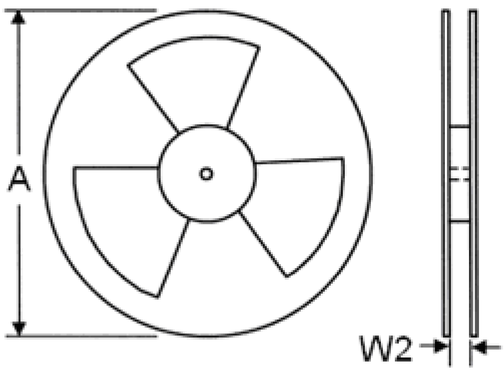
TDFN-6 (2mm×2mm) (pitch 0.65 mm) Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A2	0.19	0.22
D	1.95	2.05
E	1.95	2.05
a	0.20	0.40
b	0.25	0.35
e	0.60	0.70
D1	1.15	1.65
E1	0.55	1.05

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	400~1000	3,000