Diode Embedded Step-up Converter for White LED Driver

Description

The FP6740 is a step-up current mode PWM DC/DC converter with an internal diode and 0.6Ω power N-channel MOSFET. It can support 2 to 4 white LEDs for backlighting and OLED power supply. The device switches at 1MHz fixed frequency, allowing the use of tiny external components.

In shutdown mode, current consumption is reduced to 0.1uA. The FP6740 can convert the input voltage ranged from 2.7V to 5.5V into output voltage up to 16V. Built-in OVP function can prevent the device from being damaged in case of output open circuit. It is available in space-saving TSOT-23-6 and SOT-23-6 packages.

Features

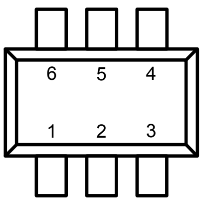
- 85% Efficiency
- Operating Voltage from 2.7V to 5.5V
- 1MHz Switching Frequency
- Built-in diode
- Internal Compensation Network
- 0.1uA Shutdown Current
- Built-in Over Voltage Protection
- TSOT-23-6 and SOT-23-6 Package

Applications

- Cellular Phones
- Digital Cameras
- OLED Power
- Portable instruments

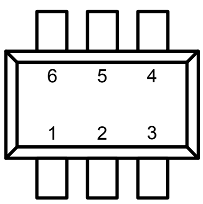
Pin Assignments

S9 Package (TSOT-23-6)



TOP VIEW
1. LX
2. GND
3. FB
4. EN
5. VOUT
6. VIN

S6 Package (SOT-23-6)



TOP VIEW
1. LX
2. GND
3. FB
4. EN
5. VOUT
6. VIN

Figure 1. Pin Assignment of FP6740

Ordering Information

FP6740□□□

- TR: Tape / Reel
  Blank: Tube
- P: Pb Free with Commercial Standard (RoHS Compliant)
- Package Type
  S6: SOT-23-6
  S9: TSOT-23-6

TSOT-23-6 Marking

Part Number	Product Code
FP6740S9P	J0

SOT-23-6 Marking

Part Number	Product Code
FP6740S6P	J5

Absolute Maximum Ratings

- VIN to GND-- -0.3V to +6V
- LX to GND-- -0.3V to +20V
- FB, EN to GND--- -0.3V to +6V
- Power Dissipation @ T_A=70°C,TSOT-23-6 / SOT-23-6 (P_D)--------------------------------------- + 0.22W
- Package Thermal Resistance, TSOT-23-6 / SOT-23-6 (θ_{JA}) ------------------------------------ + 250°C/W
- Junction Temperature--- +150°C
- Storage Temperature Range-- -65°C to +150°C
- Lead Temperature (Soldering, 10sec.) --- 260°C

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

Recommended Operating Conditions

- Supply Voltage, V_{IN}-- 2.7V to 5.5V
- Operation Temperature Range-- -40°C to +85°C

Typical Application Circuit

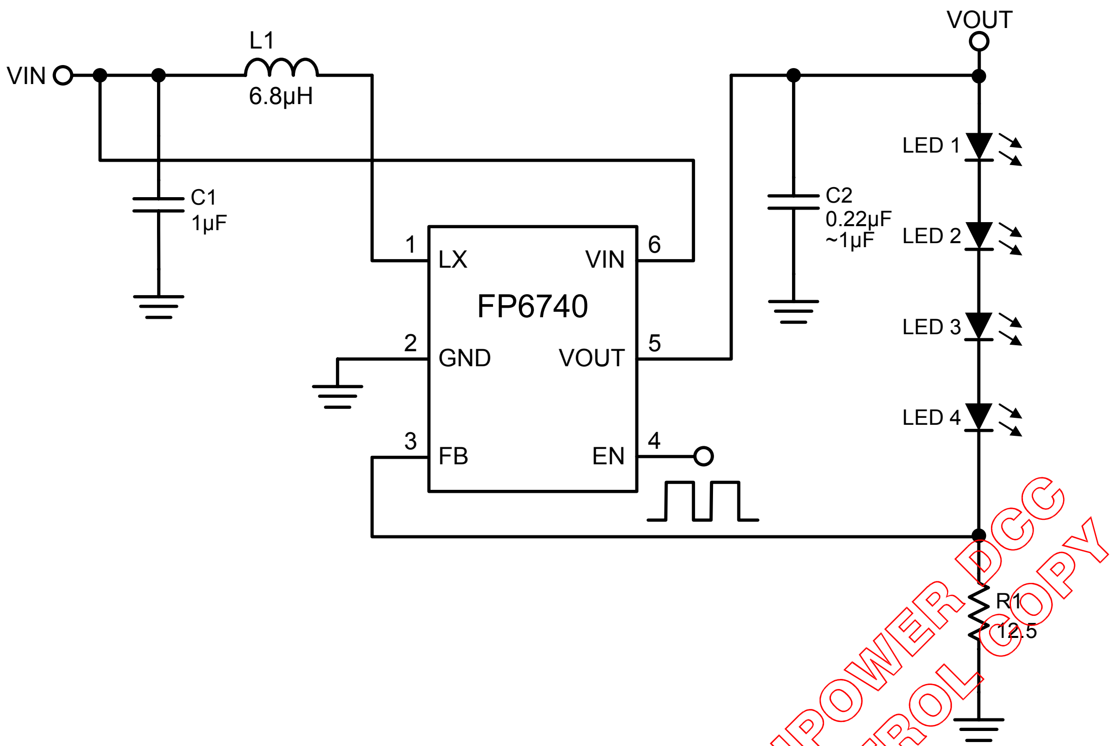


Figure 2. Typical Application Circuit of FP6740

Functional Pin Description

Pin Name	Pin Function
FB	Feedback Pin. Reference Voltage is 0.25V, Connect cathode of the lowest LED and resistor here. Calculate the resistor value according to the formula. $R1=0.25V/I_{LED}$.
EN	Enable Pin. Connect EN low to turn off FP6740. The pin has internal resistor around 300kohm to pull down.
GND	Ground.
LX	Switching Pin. Connect the pin to inductor. Minimize trace area at this node to reduce EMI.
IN	Power Input Pin.
VOUT	Output Voltage Pin. Sensing this pin voltage to avoid LED disconnect.

Block Diagram

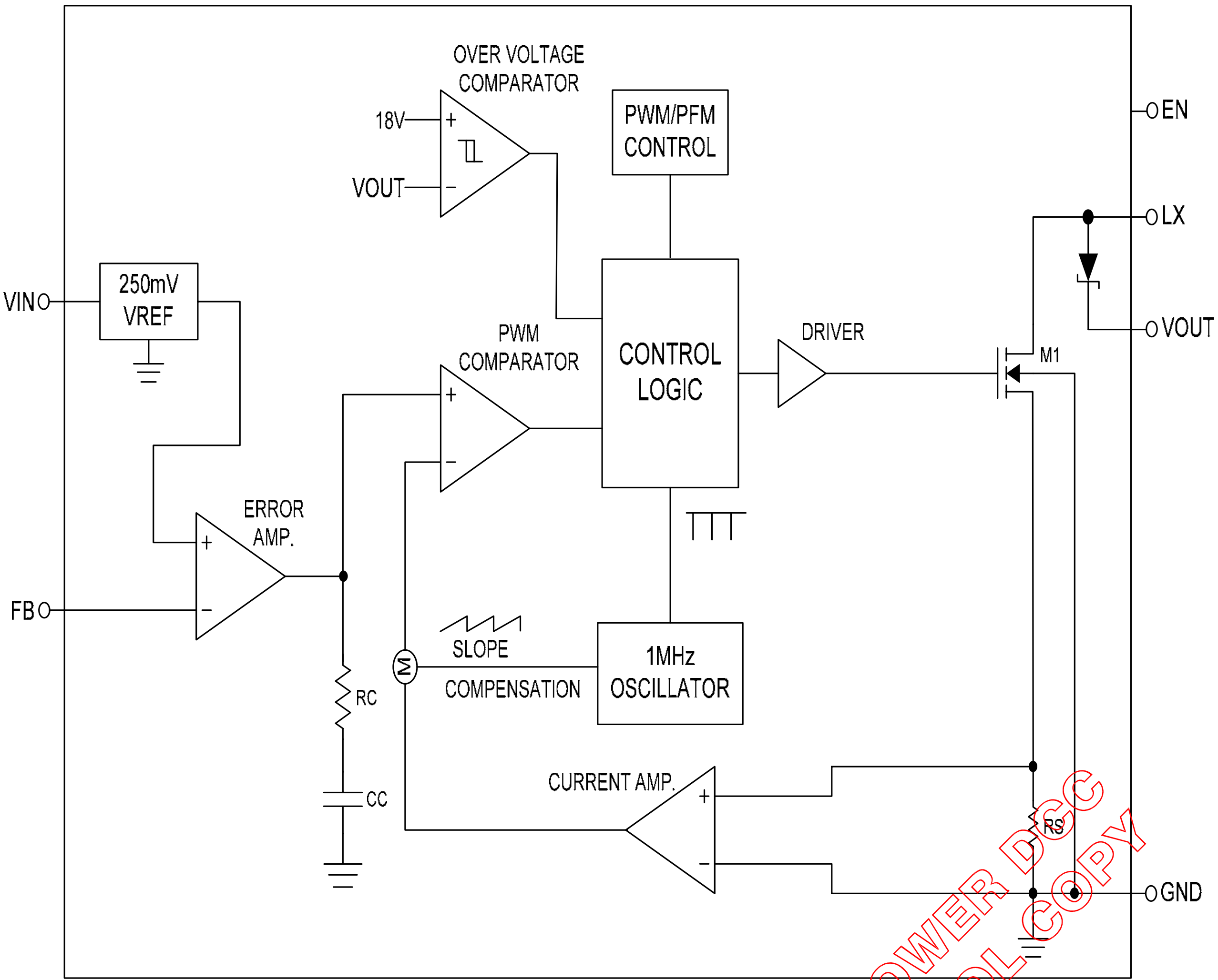


Figure 3. Block Diagram of FP6740

Electrical Characteristics

(V_{IN}=3V, EN=3V, T_A=25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
INPUT						
Operation Voltage Range	V_{IN}		2.7		5.5	V
V_{IN} Under Voltage Lockout	UVLO	V_{IN} rising, typical hysteresis is 100mV	1.8	2.05	2.3	V
Quiescent Current	I_{IN}	V_{FB}=1.3V, not switching		180	360	μA
		V_{FB}=0V, switching		0.4	1	mA
Shutdown Current	I_{SD}	EN=0V		0.1	3	μA
ERROR AMPLIFIER						
Feedback Voltage	V_{FB}		0.237	0.25	0.263	V
FB Input Bias Current	I_{FB}	V_{FB}=0.25V		0.1		uA
Feedback Voltage Line Regulation		3V< V_{IN} <4.3V			3	%
OSCILLATOR						
Frequency	F_{OSC}		0.7	1	1.3	MHz
Maximum Duty Cycle	T_{DUTY}		85	90		%
N-CHANNEL SWITCH						
Current Limit	I_{LIM}	Note1		400		mA
On-Resistance	R_{ON}	I_{LX}= 100mA		0.6		Ω
Diode						
Forward Voltage	V_{FW}	I_{FW}= 100mA		0.8	0.95	V
CONTROL INPUTS						
EN High Level	VIH		1.4			V
EN Low Level	VIL				0.4	V
PROTECTION						
OVP Threshold	V_{OVP}		16	17.5	19	V
OVP Hysteresis				1		V

Note1: The switch current limit is guaranteed by design.

Typical Performance Curves

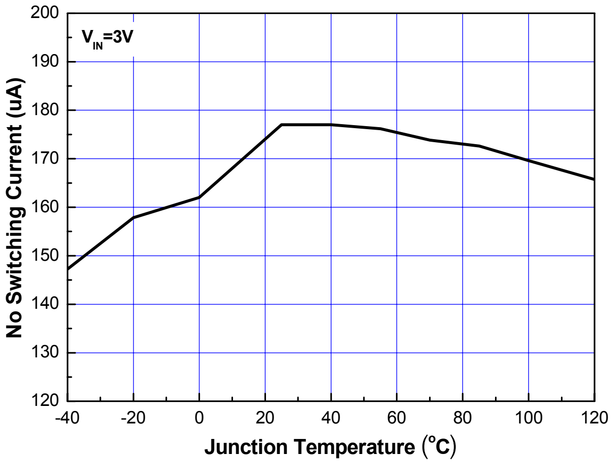


Figure 4. No Switching Current vs. Junction Temperature

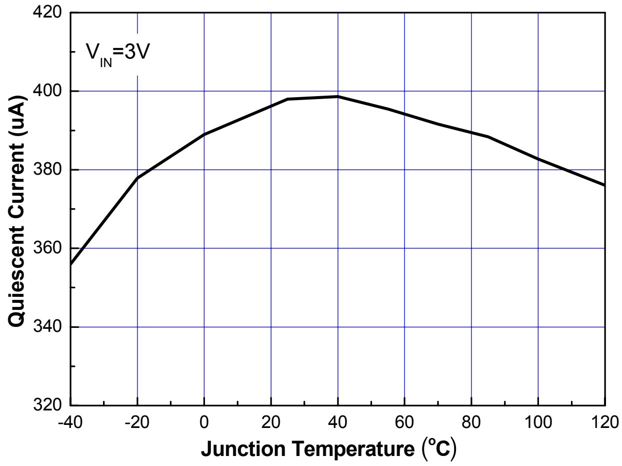


Figure 5. Quiescent Current vs. Junction Temperature

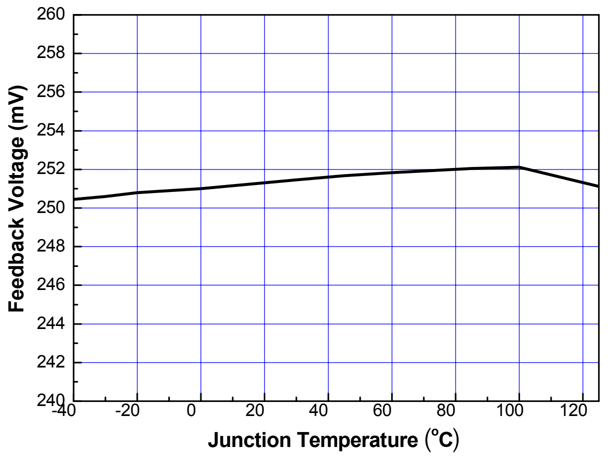


Figure 6. Feedback Voltage vs. Junction Temperature

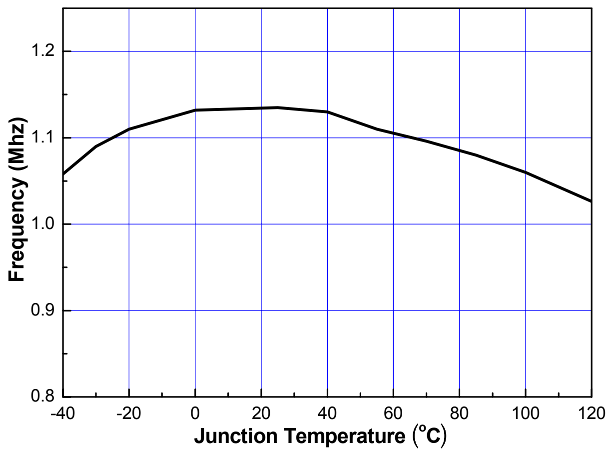


Figure 7. Frequency vs. Junction Temperature

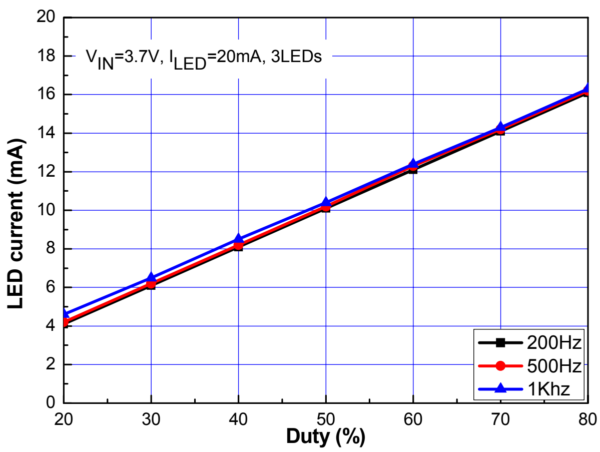


Figure 8. Dimming Control of 3LEDs

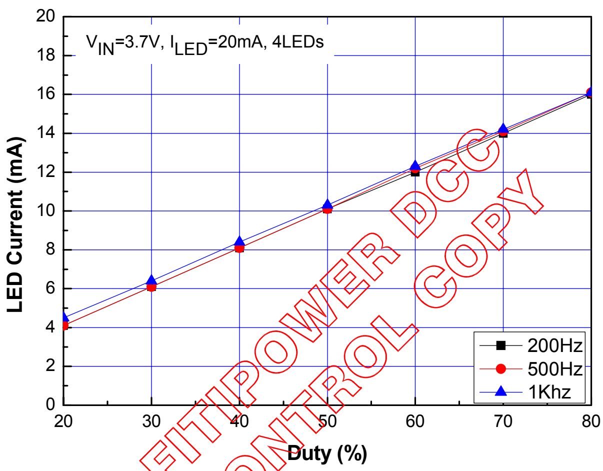


Figure 9. Dimming Control of 4LEDs

Typical Performance Curves (Continued)

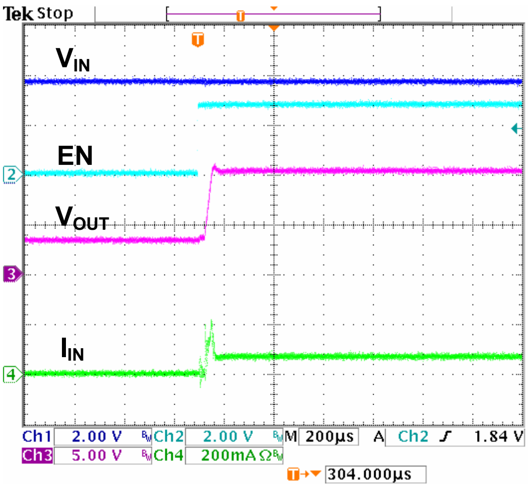


Figure 10. Startup @3 LEDs C_{OUT}=0.22uF

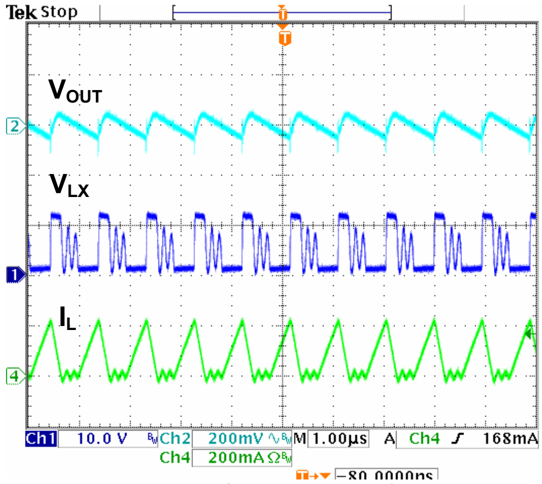


Figure11.Switching waveform
3LEDs,L=6.8uH,C_{OUT}=0.22uF

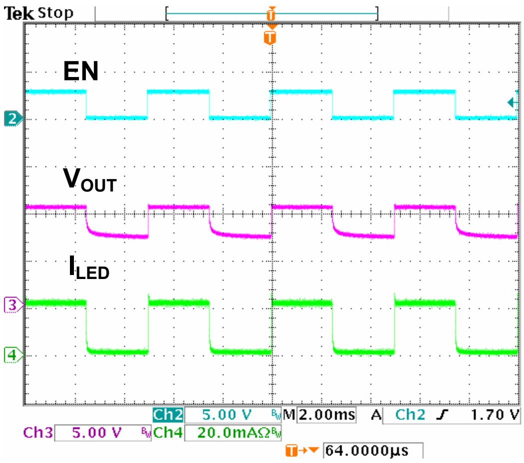


Figure 12. Dimming Operation Frequency=200Hz

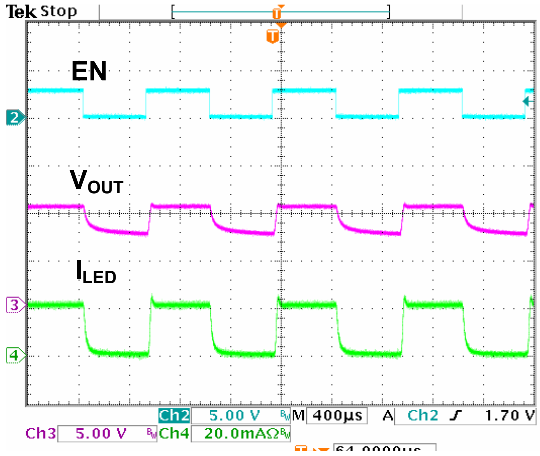


Figure 13. Dimming Operation Frequency=1KHz

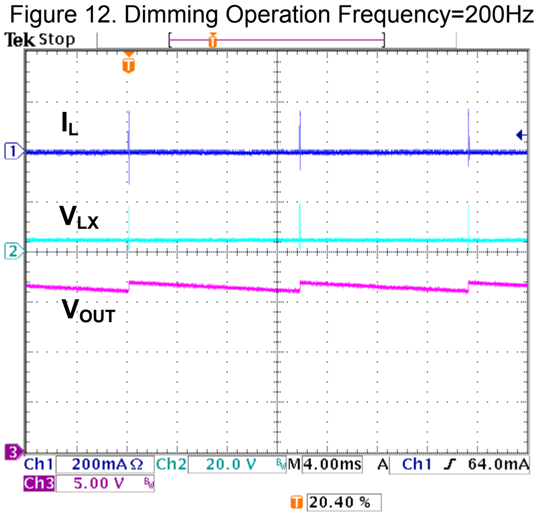


Figure 14. OVP Response waveform

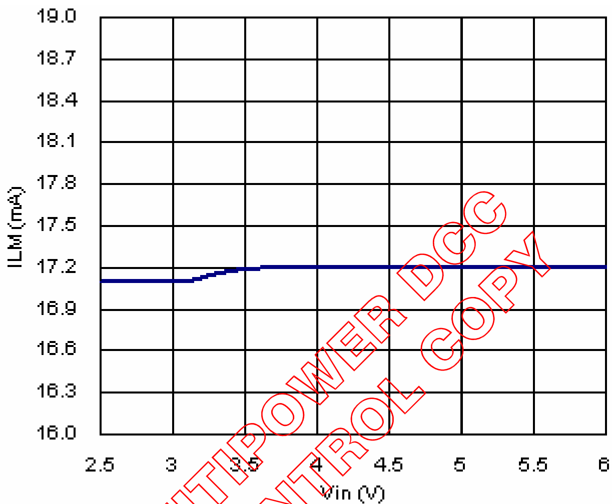


Figure15. OVP vs. Input Voltage

Typical Performance Curves (Continued)

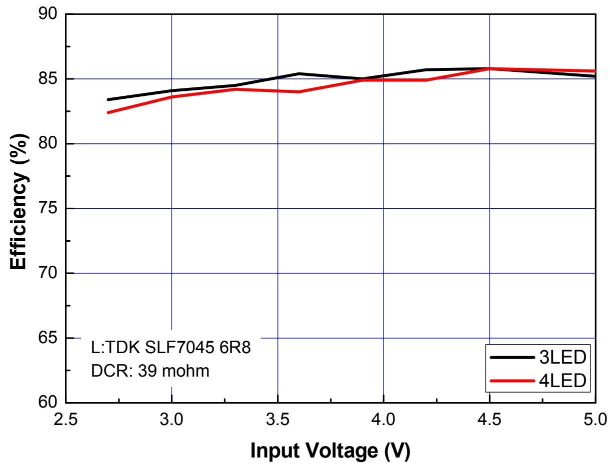


Figure 16. Efficiency vs. Input Voltage

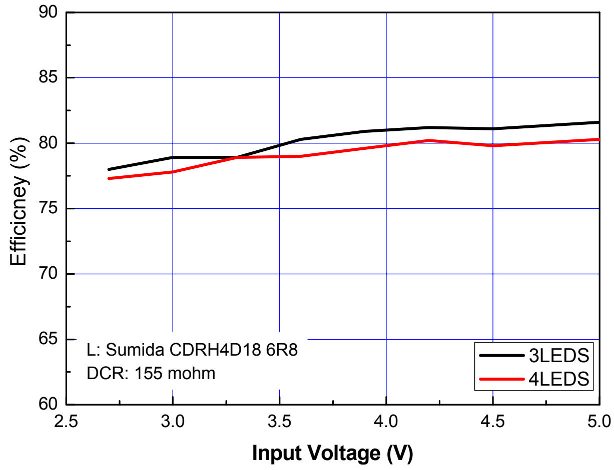


Figure 17. Efficiency vs. Input Voltage

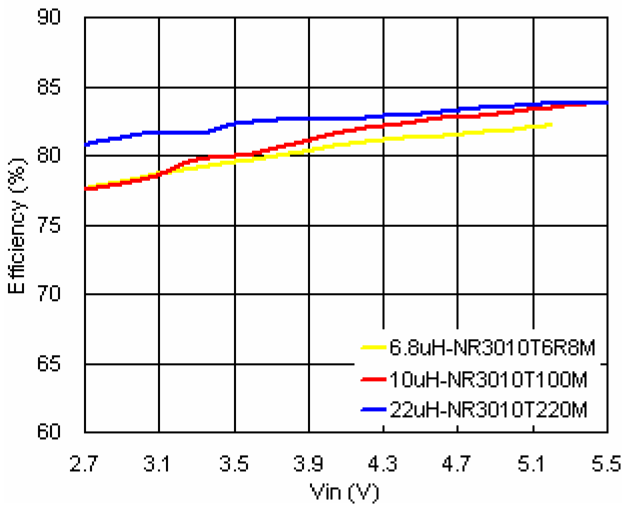


Figure 18. 2LEDs Efficiency vs. Input Voltage

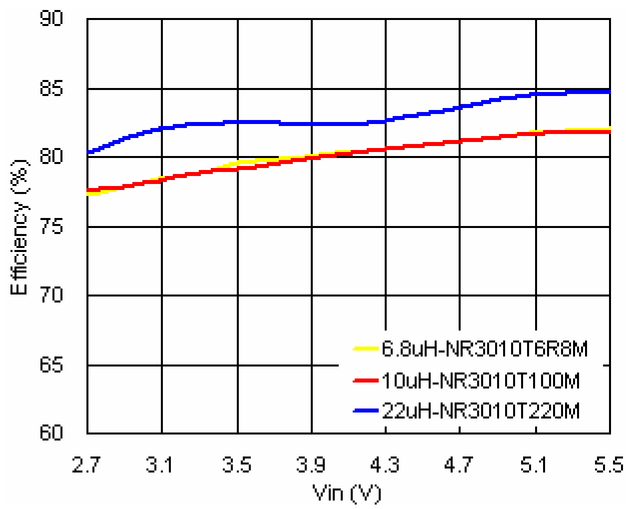


Figure 19. 3LEDs Efficiency vs. Input Voltage

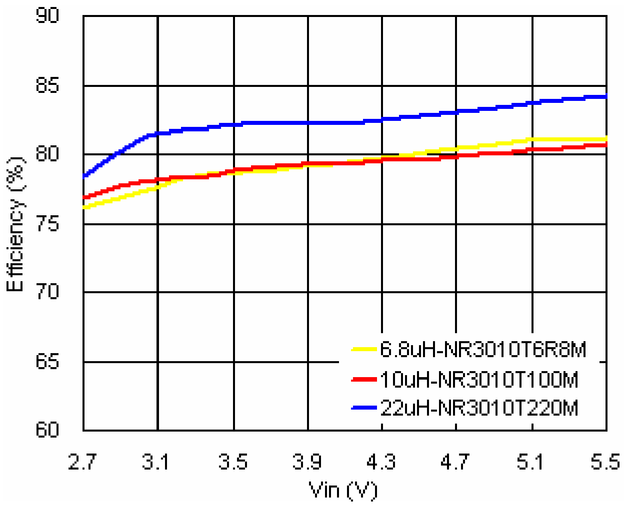


Figure 20. 4LEDs Efficiency vs. Input Voltage

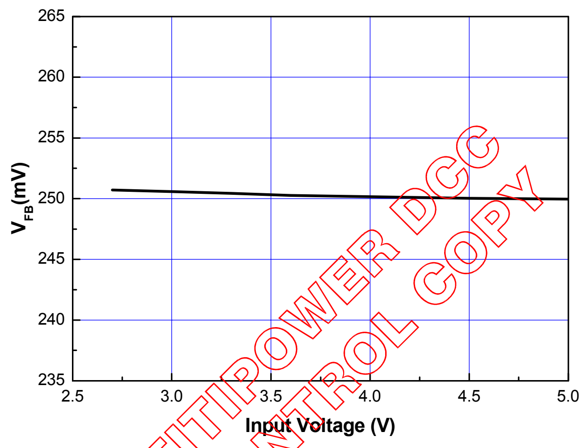


Figure 21. Line Regulation vs. Input Voltage

Applications Information

Operation

The FP6740 is designed in a current mode, fixed-frequency pulse-width modulation (PWM) architecture for fast-transient response and low-noise operation to drive 2 to 4 series-connected LEDs. The FP6740 operates well with a variety of external components. See the following sections to optimize external components for a particular application.

Inductor Selection

For most applications, a 6.8uH 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 0.4A. These factors affect the efficiency, transient response, output load capability, output voltage ripple, and cost.

Capacitor Selection

The ceramic capacitor is ideal for FP6740 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 1uF input capacitors with a 0.22uF output capacitor are sufficient for general used. A higher or lower capacitance may be used depending on the acceptable noise level.

Over Voltage Protection

The FP6740 has an internal open-circuit protection circuit. In the cases of output open circuit, when the LEDs are disconnected from the circuit or the LEDs fail open circuit, OVP is clamped at 17.5V (typ). The FP6740 will then stop switching to minimize input current. The OVP and input current during output open circuit are shown in the Typical Performance Curves. Figure 14 shows the response when the LEDs are disconnected.

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}=250mV / R1

Dimming Control

There are three different types of dimming control circuits. The LED current can be set by modulating the EN pin with a DC voltage, PWM signal or a filtered PWM signal.

(1) Using a DC Voltage

The dimming control using a DC voltage is shown in Figure 22. A VDC ranging from 0V to 3V results in dimming control of LED current from 20mA to 0mA, respectively.

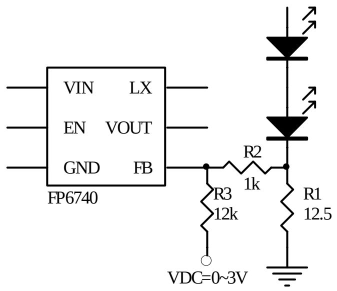


Figure 22. Dimming Control Using a DC Voltage

(2) Using 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 average of LED 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 typical frequency range of the PWM signal is 100Hz to 1kHz.

Applications Information (Continued)

Two way of PWM control dimming, drive EN directly or drive FB pin through a resistor. First, drive EN directly shown as figure 23(a). A 0% duty cycle will turn off the FP6740 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The amplitude of the PWM signal should be higher than the minimum EN voltage. Second, drive FB pin through a resistor shown as figure 23(b). Increase of duty cycle will decrease LED average current. In this application, LED is dimmed by FB pin and turned off completely by EN pin.

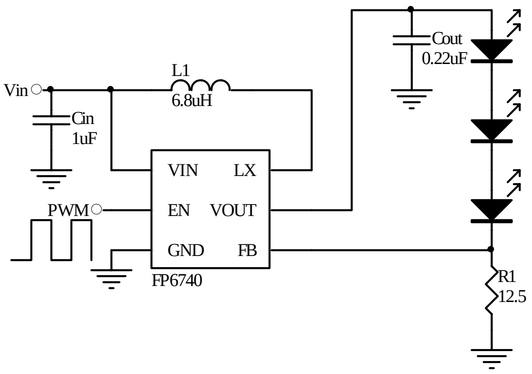


Figure 23(a). Dimming Control Using a PWM Signal

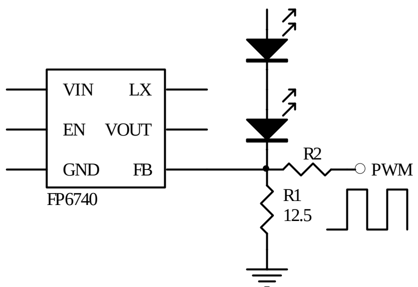


Figure 23(b). Dimming Control Using a PWM Signal

(3) Using a Filtered PWM Signal

A filtered PWM signal can be used to control the brightness of the LED string as an adjustable DC voltage. The PWM signal is filtered by a RC network. The corner frequency of R4, C1 should be much lower than the frequency of the PWM signal. Figure 24 show the two dimming methods of using filtered PWM signal.

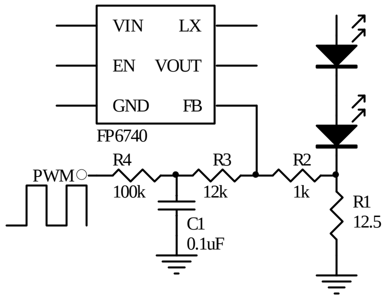


Figure 24. Dimming Control Using a Filtered PWM Signal

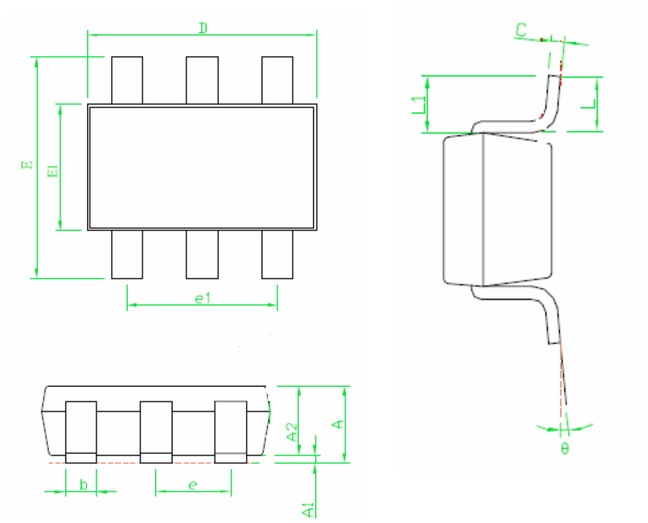
Layout Consideration

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 FP6740 design.

a. The input capacitor should be located as closed as possible to the VIN and PGND pin.
b. Minimize the length and area of LX trace.
c. Keep the noise-sensitive feedback and compensation circuitry away from the switching node. Place feedback resistor as close as FB pin.
d. Place Cout as close as VOUT pin.
e. The through hole of GND pin is recommended as many as possible.

Outline Information

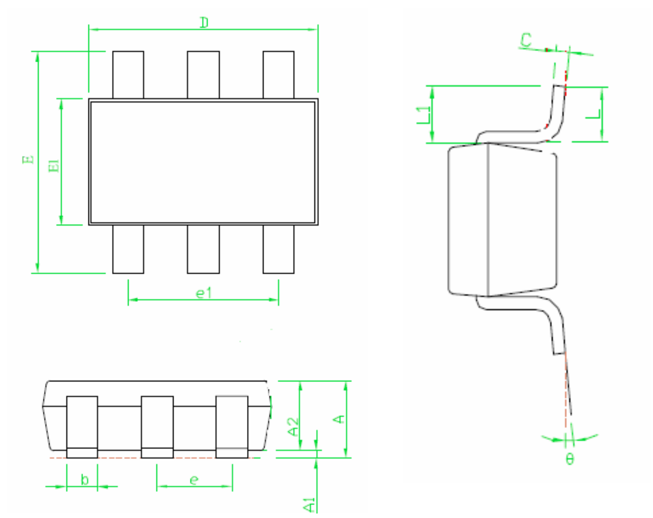
TSOT-23-6 Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER		
	MIN	NOM	MAX
A	---	---	1.10
A1	0.00	---	0.10
A2	0.70	0.90	1.00
b	0.30	---	0.50
c	0.08	---	0.20
D	---	2.90	---
E	---	2.80	---
E1	---	1.60	---
e		0.95	
e1		1.90	
L	0.3	0.45	0.60
L1		0.60	
θ	0°	4°	8°

Note 1:Followed From JEDEC MO-193-C.

SOT-23-6 Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER		
	MIN	NOM	MAX
A	---	---	1.45
A1	0.00	---	0.15
A2	0.90	1.15	1.30
b	0.30	---	0.50
c	0.08	---	0.22
D	---	2.90	---
E	---	2.80	---
E1	---	1.60	---
e		0.95	
e1		1.90	
L	0.3	0.45	0.60
L1		0.60	
θ	0°	4°	8°

Note 1：Followed From JEDEC MO-178-C.

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