Boost DC-DC White LED Driver with 10-Channel Current Match

Description

The FP6741 is a step-up current mode PWM DC/DC converter with 10 channel constant current sources to match LEDs with quite uniform current. It is suitable for 5 to 10 inches TFT LCD backlight white LED driver application.The internal boost converter is built in a 2A, 0.16Ω N-channel MOSFET.

640KHz fixed switching frequency and external compensation pin provide users flexibility in setting the loop dynamic, allowing the use of tiny, low profile inductors and low value, low ESR ceramic output capacitors.

The boost converter provides soft-start feature which is programmable with an external capacitor. In shutdown mode, current consumption is reduced to only 0.1uA. It converts the input voltage ranged from 2.6V to 5.5V into an output voltage up to 12 V.

Besides FP6741 provides 10 channel constant current sources with maximum ±3% current matching. The LED current can be adjusted by an external resistor, which provides users flexibility to control the light intensity of LEDs. In addition, users can precisely adjust LED brightness from 0% to 100% via DIM pin with pulse width modulation.

In order to ensure the system reliability, FP6741 features thermal protection function which could against any combination of overload or ambient temperature that could exceed junction temperature.

FP6741 is available in low-profile, space-saving thermal enhanced 24-pin TSSOP Exposed Pad package.

Features

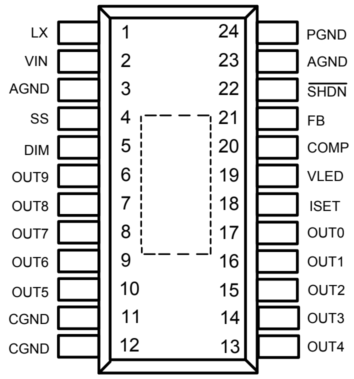
- Operating Voltage from 2.6V to 5.5V
- Output Voltage from Input Voltage to 12V
- 90% Efficiency for Boost Converter
- 2A, 0.16Ω Internal Power MOSFET
- Fixed Switching Frequency at 640KHz
- Programmed Soft Start
- External Compensation Network
- 0.1uA Shutdown Current
- 10 Constant Current Output Channels
- Constant Output Current Invariant to Load Voltage Change
- LED Current Set by an External Resistor.
- Output Current Accuracy : ±3% (max.) between Channels
- Constant Output Current Range : 15 to 25mA per Channel
- LED Brightness Dimming by External PWM Signal.
- Over-Temperature Protection
- RoHS Compliant

Applications

- Portable DVDs
- Car TVs
- GPS Receivers
- PDAs
- Handheld Computers

Pin Assignments

TP Package (TSSOP-24<Exposed Pad>)



Ordering Information

FP6741□□□

- TR: Tape / Reel
  Blank: Tube
- P: Pb Free with Commercial Standard (RoHS Compliant)
- Package Type
  TP: TSSOP-24(Exposed pad)

Typical Application Circuit

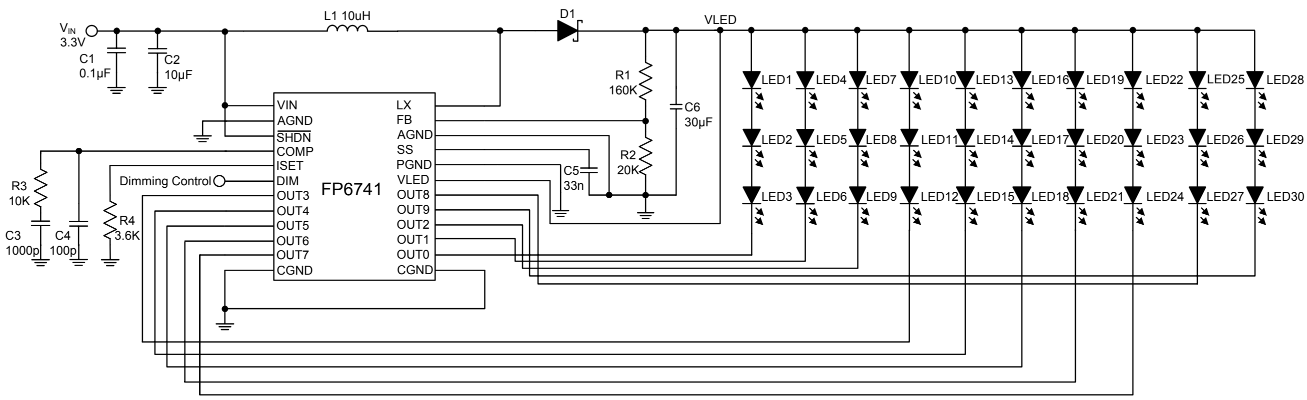


Figure 2. Typical Application Circuit of FP6741

Functional Pin Description

Pin Name	Pin Function
COMP	Compensation pin for error amplifier. Connect a series RC from COMP to ground.
FB	Feedback pin. The typical reference voltage is 1.24V. Set V_{OUT} = 1.24V (1+ R1/R2). See Figure 2.
$\overline{\text{SHDN}}$	Enable pin. Connect $\overline{\text{SHDN}}$ low to turn off FP6741.
AGND	Analog ground.
PGND	Boost converter power ground
LX	Switching pin.
VIN	Power input pin.
SS	Soft-start control pin. Connect a capacitor to this pin. The pin will source 4uA constant current to charge the capacitor. Leaving floating for not using soft-start.
CGND	Constant current sources power ground
VLED	Input power for constant current sources section, which connected to boost converter output
OUT0~OUT9	Constant current output terminals
DIM	Output current enable pin for PWM dimming. When DIM is low, all output channels are turned off. When DIM is high, all output channels are enabled.
ISET	Pin used to connect an external resistor for setting output current for all output channels.

Block Diagram

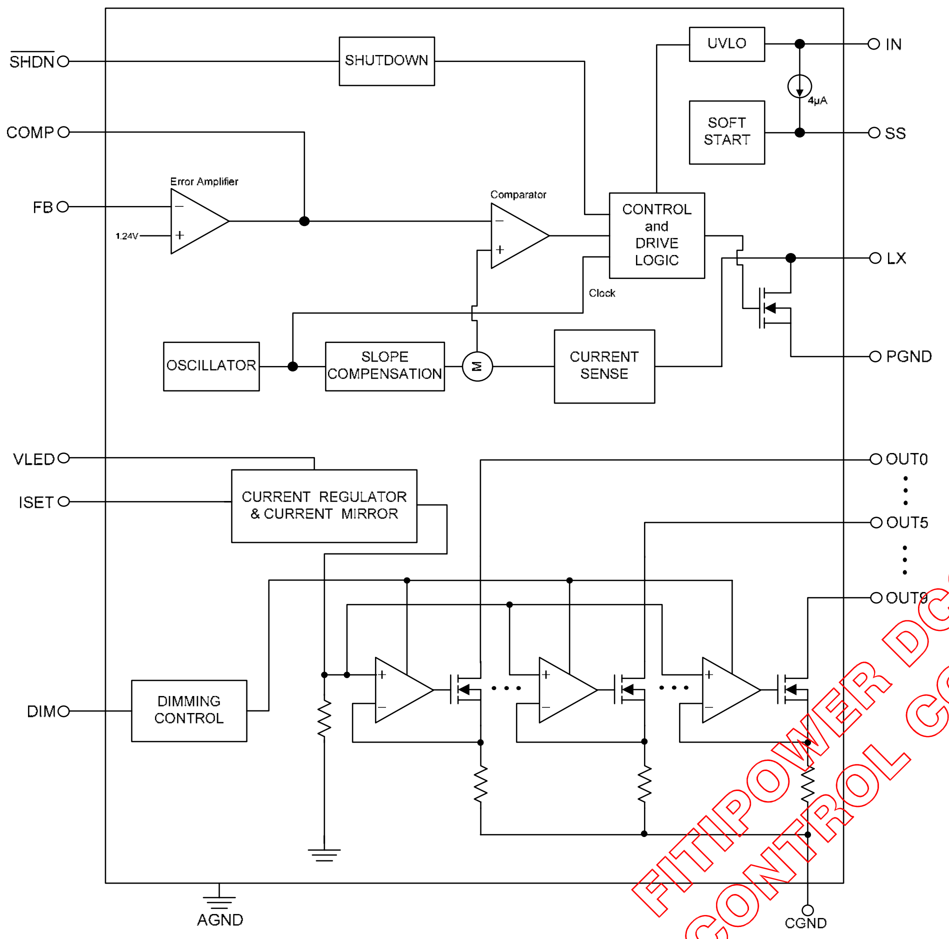


Figure 3. Block Diagram of FP6741

Absolute Maximum Ratings

- VIN to GND-- -0.3V to +6V
- LX to GND--- -0.3V to +14V
- OUT0~OUT9 to GND-- -0.3V to +14V
- SHDN, FB, SS, DIM, ISET, COMP to GND-- -0.3V to +6V
- VLED to GND--- -0.3V to +14V
- Continuous Power Dissipation (T_A=+70°C), TSSOP-24 Exposed Pad------------------------- 1.38W
- Package Thermal Resistance, TSSOP-24 Exposed Pad (θ_{JA}) -------------------------------- 40°C/W
- Junction Temperature--- +150°C
- Storage Temperature Range--- -65°C to +150°C
- ESD Susceptibility (HBM Mode)--- 2KV
- ESD Susceptibility (MM Mode)--- 100V
- 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}-- 3.3V±10%, 5V±10%
- Boost Converter Output Voltage (Max.)-- 12V
- Sustaining Voltage at OUT Pin-- 12V
- Operation Temperature Range--- -40°C to +85°C

Electrical Characteristics

(V_{IN}=3V, $\overline{SHDN}$=3V, T_A=25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
INPUT						
Operation Voltage Range	V_{IN}		2.6		5.5	V
V_{IN} Under Voltage Lockout	V_{UVLO}	V_{IN} rising, typical hysteresis is 100mV	1.9	2.1	2.3	V
Quiescent Current	I_{IN}	V_{FB}=1.3V, not switching		160	350	μA
		V_{FB}=1V, switching		0.8	5	mA
Shutdown Current	I_{VIN}	$\overline{SHDN}$=0V		0.1		μA
ERROR AMPLIFIER						
Feedback Voltage	V_{FB}		1.221	1.24	1.259	V
FB Input Bias Current	I_{FB}	V_{FB}=1.24V			40	nA
Feedback Voltage Load Regulation		0< I_{LED} <full load, transient only		-2		%
Feedback Voltage Line Regulation		2.3V< V_{IN} <5.5V		0.08	0.3	%/V
Trans-Conductance	gm	Δ_I =5μA	70	170	240	μS
Voltage Gain	A_V			700		V/V
OSCILLATOR						
Frequency	F_{OSC}		540	640	740	KHz

Electrical Characteristics (Continued)

(V_{IN}=3V, $\overline{SHDN}$=3V, T_A=25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Maximum Duty Cycle	T_{DUTY}			90		%
N-CHANNEL SWITCH						
Current Limit	I_{LIM}	Note 1		2		A
On-Resistance	R_{ON}	I_{LX}= 200mA		0.16	0.35	Ω
Leakage Current	I_{LXOFF}	V_{LX}=14V		0.1		μA
SOFT-START						
Reset Switching Resistance					100	Ω
Charge Current	I_{SS}	V_{SS}=1.2V	1.5	4	7	μA
SHUTDOWN CONTROL INPUT						
$\overline{SHDN}$ Input High Level	V_{IH}		1.6			V
$\overline{SHDN}$ Input Low Level	V_{IL}				0.4	V
$\overline{SHDN}$ Input Current	$I_{\overline{SHDN}}$			0.1		μA
CONSTANT CURRENT SOURCES						
Supply Voltage	V_{VLED}		6		12	V
Supply Current	I_{VLED}	V_{DMH} ="H", R_{EXT}=3.6KΩ		6		mA
Sustaining Voltage at OUT Pins	V_{OUT}				12	V
Output Leakage Current	I_{OH}	V_{OUT}=14V		0.1		μA
Output Current	I_{OUT}	VDS=0.6V, R_{EXT}=3.6KΩ		20		mA
Current Skew	dI_{OUT}	VDS=0.6V IOL=20mA, R_{EXT}=3.6KΩ		±1	±3	%
Output Current vs. Output Voltage Regulation	$\%/dV_{DS}$	VDS within 1.0V and 3.0V		±0.1		%/V
Output Current vs. Supply Voltage Regulation	$\%/dV_{VLED}$	V_{VLED} within 6V and 16V		±0.1		%/V
DIMMING CONTROL						
Dimming High Level	V_{DMH}		1.6			V
Dimming Low Level	V_{DML}				0.4	V
Dimming Frequency	F_{DIM}				150	KHz
PROTECTION						
Thermal Shutdown	T_{SD}			160		°C
Thermal Shutdown Hysteresis	ΔT_{SD}			25		°C

Note 1: The specification is guaranteed by design, not production tested.

Typical Performance Curves

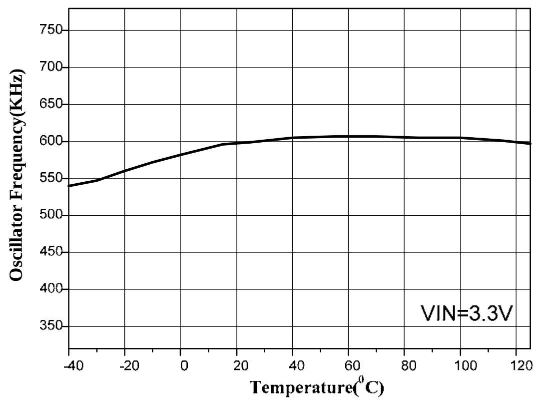


Figure 4. Oscillator Frequency vs. Temperature

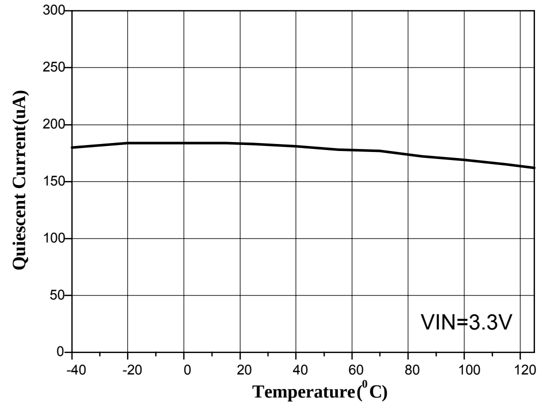


Figure 5. No Switching Current vs. Temperature

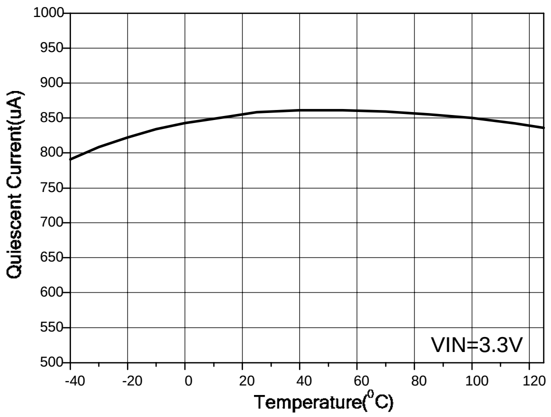


Figure 6. Switching Current vs. Temperature

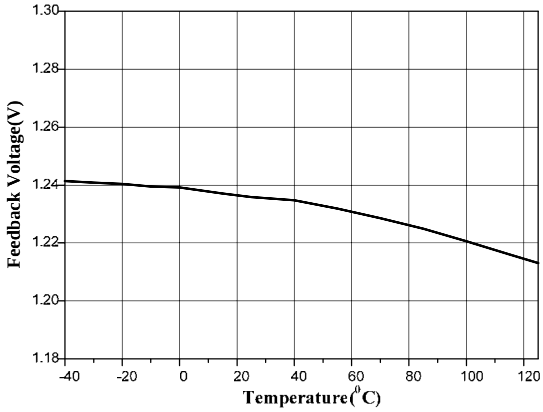


Figure 7. Feedback Voltage vs. Temperature

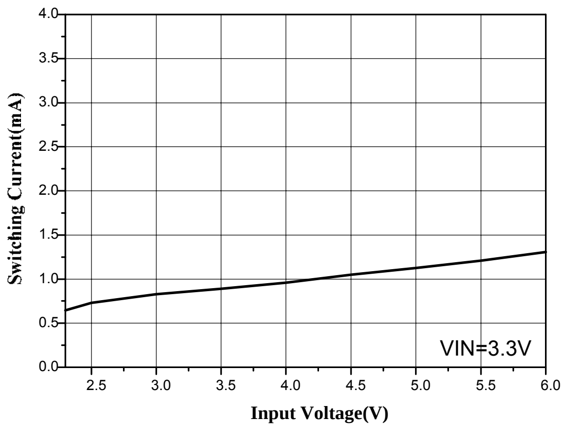


Figure 8. Switching Current vs. Input Voltage

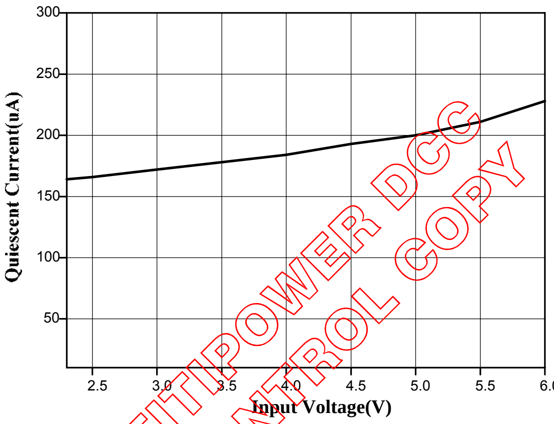


Figure 9. No Switching Current vs. Input Voltage

Typical Performance Curves (Continued)

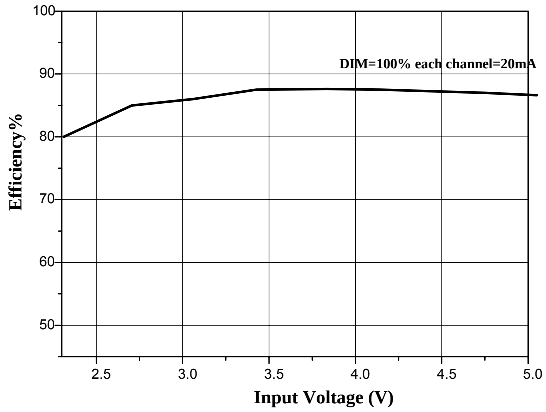


Figure 10. Efficiency vs. Input Voltage

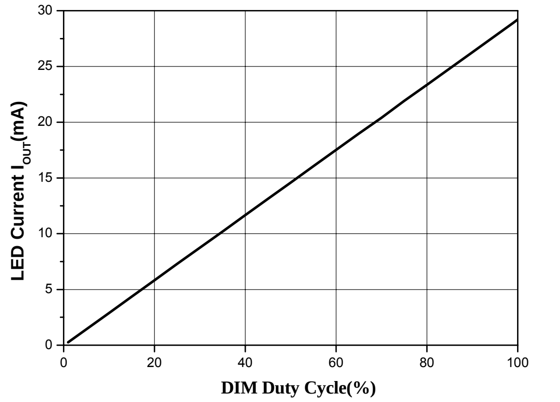


Figure 11. LED Current vs. Dimming Duty Cycle (1KHz)

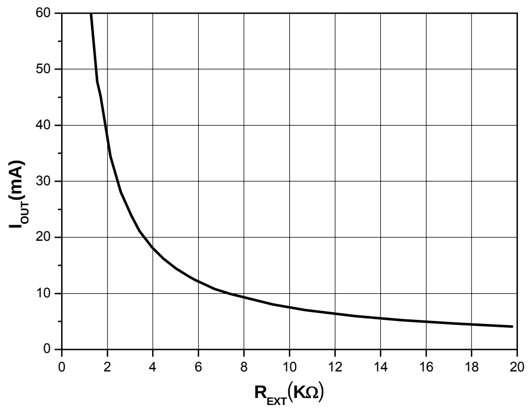
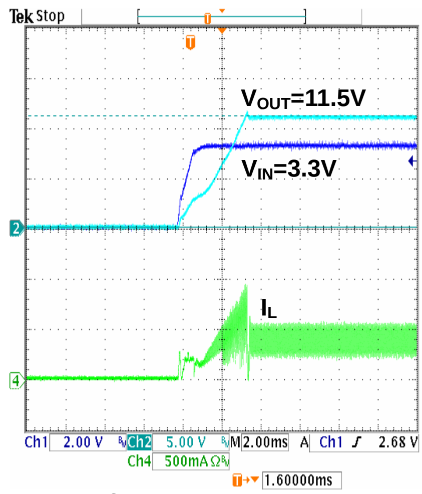
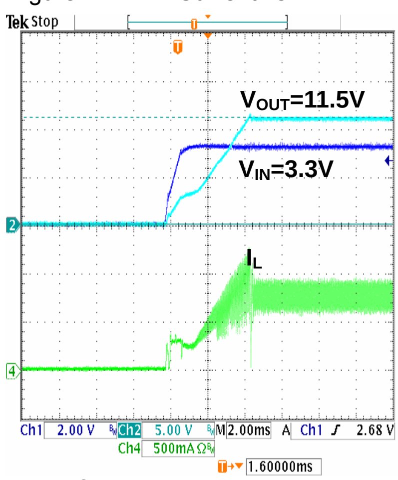


Figure 12. LED Current vs. REXT



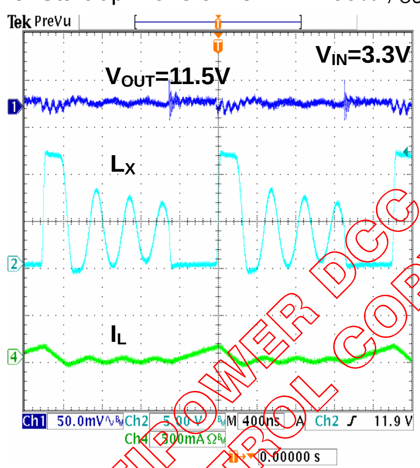
CH1: V_{IN} waveform
CH2: V_{OUT} waveform
CH3: Inductor Current waveform

Figure 13. Start-up Waveforms DIM=100% ,I_{OUT}=10mA



CH1: V_{IN} waveform
CH2: V_{OUT} waveform
CH4: Inductor Current waveform

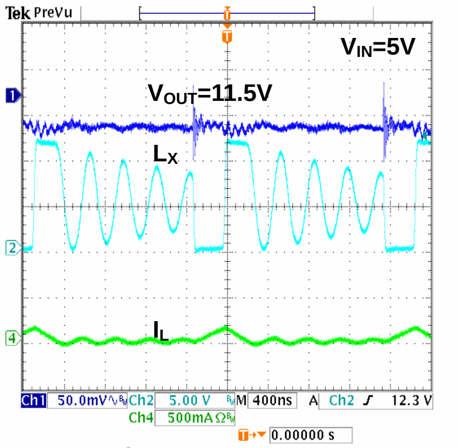
Figure 14. Start-up Waveforms DIM=100% , I_{OUT}=200mA



CH1: V_{OUT} waveform
CH2: LX waveform
CH4: Inductor Current waveform

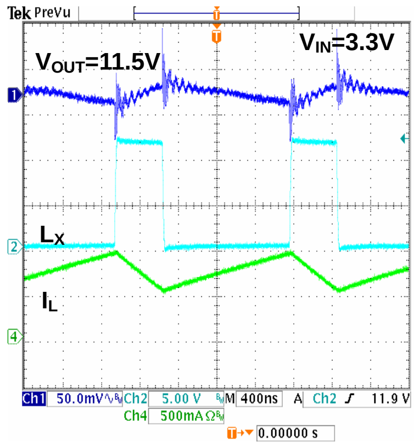
Figure 15. Switching Waveforms DIM=100% ,I_{OUT}=10mA

Typical Performance Curves (Continued)



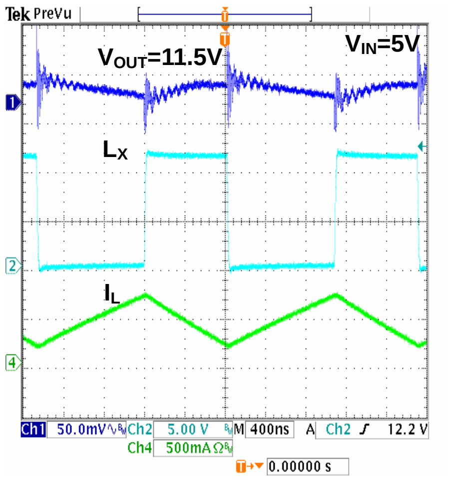
CH1: V_{OUT} waveform
CH2: LX waveform
CH4: Inductor Current waveform

Figure 16. Switching Waveforms DIM=100%,I_{OUT}=10mA



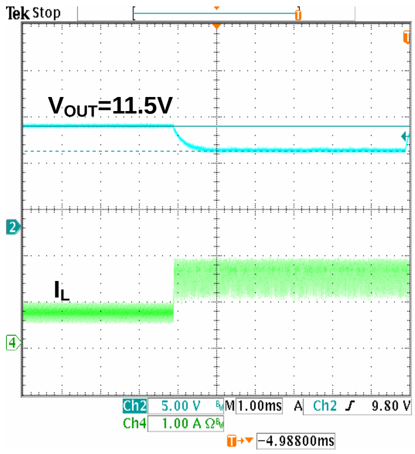
CH1: V_{OUT} waveform
CH2: LX waveform
CH4: Inductor Current waveform

Figure 17. Switching Waveforms DIM=100%,I_{OUT} =200mA



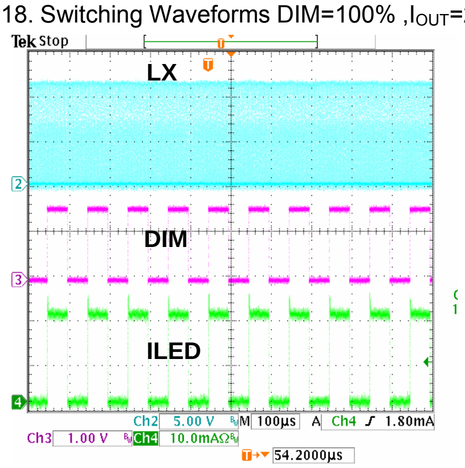
CH1: V_{OUT} waveform
CH2: LX waveform
CH4: Inductor Current waveform

Figure 18. Switching Waveforms DIM=100% ,I_{OUT}=200mA



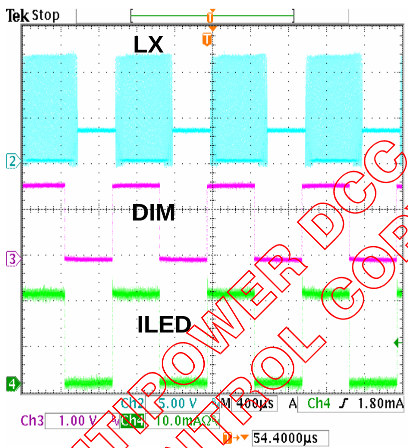
CH2: V_{OUT} waveform
CH4: Inductor Current waveform

Figure 19. OCP Waveforms, I_{OUT}=200mA to 500mA



CH2: LX waveform
CH3: DIM waveform
CH4: LED Current waveform

Figure 20. LED Current Waveforms(DIM=50% at 10KHz)



CH2: LX waveform
CH3: DIM waveform
CH4: LED Current waveform

Figure 21.LED Current Waveforms(DIM=50% at 1KHz)

Application Information

Operation

The FP6741 provides ten LED current sense input to drive up to 30 LEDs (10 strings of 3) to power a backlight. This allows the backlight to remain functioning even a string is damaged. The LED current into OUT will always be actively matched, regardless of which LED string has the highest voltage drop. The constant current circuitry can be left unused when driving fewer strings of LEDs.

Programmable Soft Start

The FP6741 also include programmable soft start function. To avoid inrush current to the load during start up, a soft-start function is implemented to provide reliable load operation. The user can program the soft start time by placing a capacitor to the SS pin. A recommended value for soft start capacitors is 33nF.

LED Current Setting

The LED current is specified by resistor from the ISET pin to ground. The full scale current setting is calculated approximated by the formula

$$I_{LED}(mA) \approx \frac{72}{R_{SET}(k\Omega)}$$

Here are the suggestion values of R_{SET} for different LED current.

I_{LED}	R_{SET}
15mA	4.8kΩ
20mA	3.6kΩ
25mA	2.8kΩ

Table 1

Dimming Control

The FP6741 can receive an external Pulse Width Modulation (PWM) signal for the dimming control function to precisely adjust LED brightness. PWM dimming control is achieved by applying an external PWM signal to DIM pin. Typically, a 0.1kHz to 150kHz PWM signal is used. Varying the PWM duty cycle from 0% to 100% controls the LED brightness. Below curves show the duty cycle vs. LED current at different frequency. The LED current appears approximately linear when PWM frequency under 50kHz. But the audio noise will appear when the PWM frequency is smaller than 20kHz.

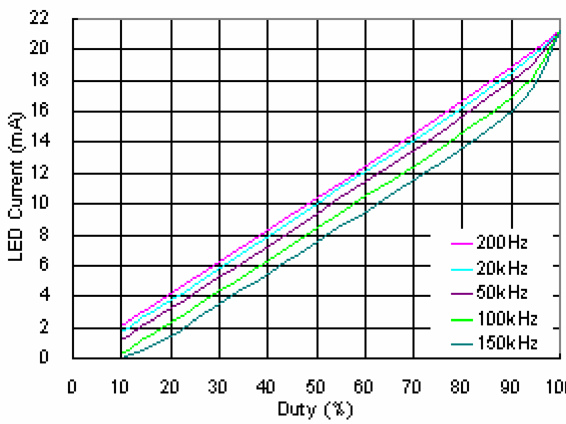


Figure 22. LED current vs. Duty at 3.3Vi

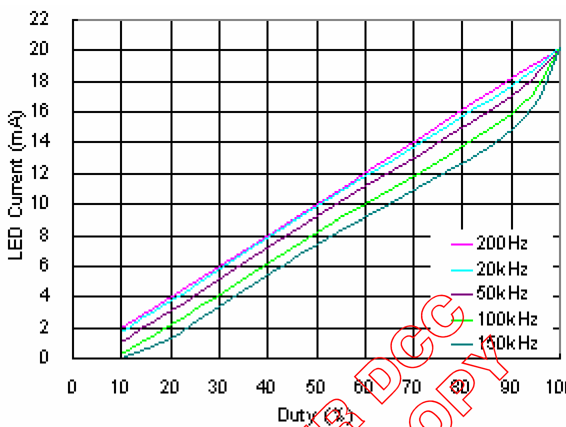


Figure 23. LED current vs. Duty at 5.0Vi

Application Information (Continued)

Inductor Selection

For most applications, a 10uH inductor is sufficient. 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, transient response, output load capability, output voltage ripple, and cost.

Capacitor Selection

The ceramic capacitor is ideal for FP6741 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, 10uF input capacitors with 33uF output capacitor are sufficient for general used. A higher or lower capacitance may be used depending on the acceptable noise level.

Layout Consideration

Figure 24 and 25 show the proper layout for the FP6741 demo-board. The proper PCB layout and component placement are critical for all switch mode power supplies. The noise-sensitive feedback and compensation circuitry are isolated from the high-frequency switching nodes. The careful attention should be taken to the high-frequency, high current loops. There are several power ground pins on the FP6741 and it is important to implement the grounding properly. Here are some suggestions to the layout of FP6741 design.

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

b. For best performance, minimize the LX node and power ground loop are needed (L1→LX→D1→Cout→PGND). The external components, L1, D1, and Cout should be placed as close to the device as possible with short and wide route.

c. Keep feedback resistors, R1 and R2, near FB and GND pin with short wire and should be far away to the noise source, such as switching loop

d. Keep compensation circuitry near COMP pin with short wire and should be far away to the noise source, such as switching loop.

e. The analog ground (AGND and CGND) and the switching ground (PGND) need to be separated, using via connection between them.

f. For the best thermal performance, the exposed pad has to mount in wide copper directly with ground pin. If multilayer PC board is available, place as more vias as possible is the better way to improve heat dissipation.

Board Layout

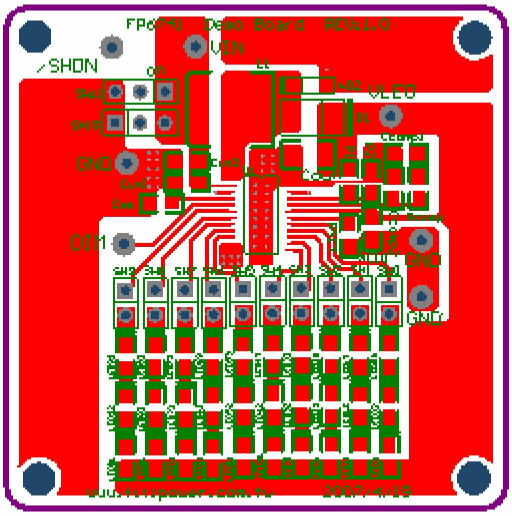


Figure.24 Top layer

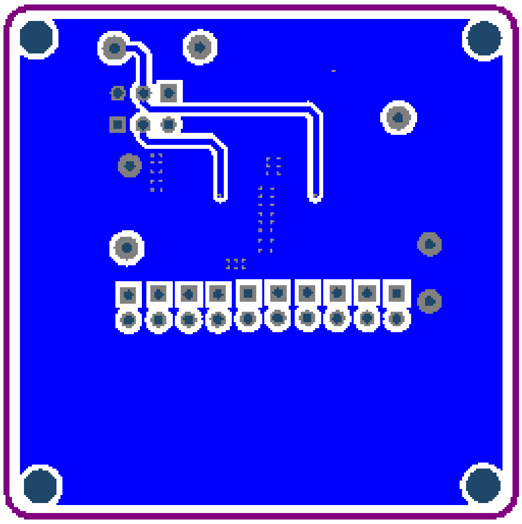
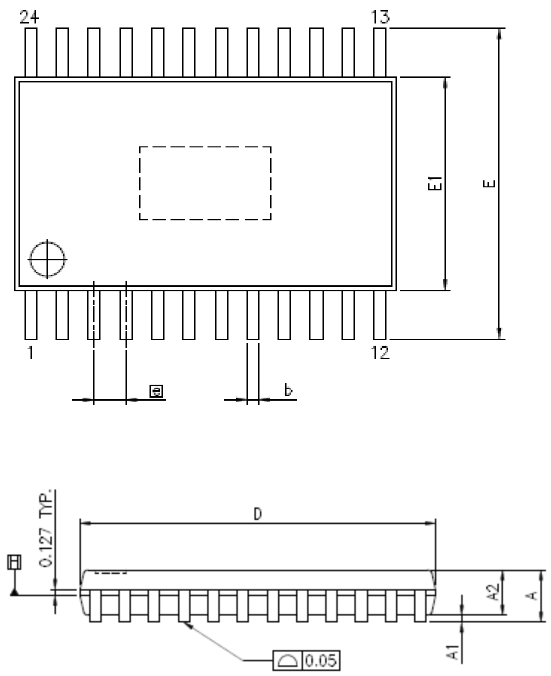


Figure.25 Bottom layer

Outline Information

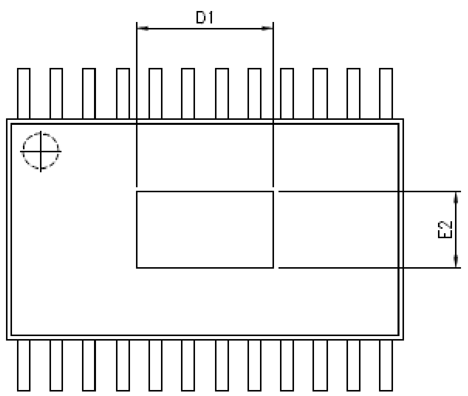
TSSOP-24(Exposed Pad) Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER		
	MIN	NOM	MAX
A	---	---	1.20
A1	0.00	---	0.15
A2	0.80	1.00	1.05
b	0.19	---	0.30
D	7.70	7.80	7.90
E1	4.30	4.40	4.50
E	6.40 BSC		
e	0.65 BSC		
L1	1.00 REF		
L	0.45	0.60	0.75
S	0.20	---	---
θ	0º	---	8º

PAD SIZE	DIMENSION IN MILLIMETER			
	E2		D1	
	MIN	MAX	MIN	MAX
112X18E	2.28	2.85	3.70	5.58

Note 1:Followed From JEDEC MO-153-F.



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