1MHz 2.5A Current-Mode Step-Up DC/DC Converter

Description

The FP6730 is a current-mode, pulse-width modulation, step-up DC/DC converter. The built-in high voltage N-channel MOSFET allows FP6730 for step-up applications with up to 24V output voltage, as well as for Single Ended Primary Inductance Converter (SEPIC).

The high switching frequency (1MHz) allows the use of small external components. The soft-start function is programmable with an external capacitor, which sets the input current ramp rate. Another internal soft-start for SOT-23-5 package.

The FP6730 is available in space-saving SOT-23-5, SOT-23-6 and TDFN-6 (2mm×2mm) packages.

Features

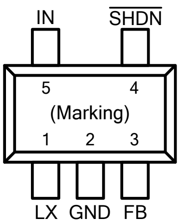
- Fixed Frequency 1MHz Current-Mode PWM Operation
- Adjustable Output Voltage up to 24V
- Automatically Switch to PSM Mode for Improving Efficiency at Light Load
- 3V to 24V Input Range
- Maximum 1μA Shutdown Current
- Programmable Soft-start / Internal Soft-start
- Meet SMD Ceramic Inductor application
- Space-Saving SOT-23-5, SOT-23-6 and TDFN-6 (2mm×2mm) Packages
- RoHS Compliant

Applications

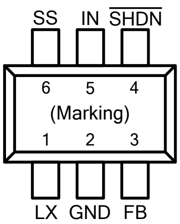
- LCD Displays
- Portable Applications
- Handheld Devices

Pin Assignments

S5 Package: SOT-23-5



S6 Package: SOT-23-6



WD Package: TDFN-6 (2mm×2mm)

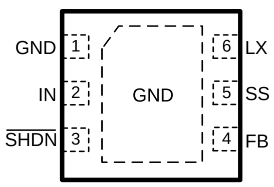
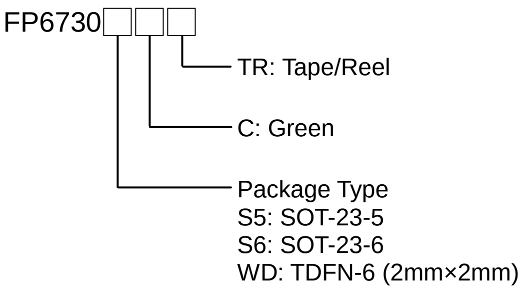


Figure 1. Pin Assignment of FP6730

Ordering Information



SOT-23-5 Marking

Part Number	Product Code
FP6730S5CTR	**FF8**

SOT-23-6 Marking

Part Number	Product Code
FP6730S6CTR	**FC7**

TDFN-6 (2mmx2mm) Marking

Part Number	Product Code
FP6730WDCTR	**FH8**

Typical Application Circuit

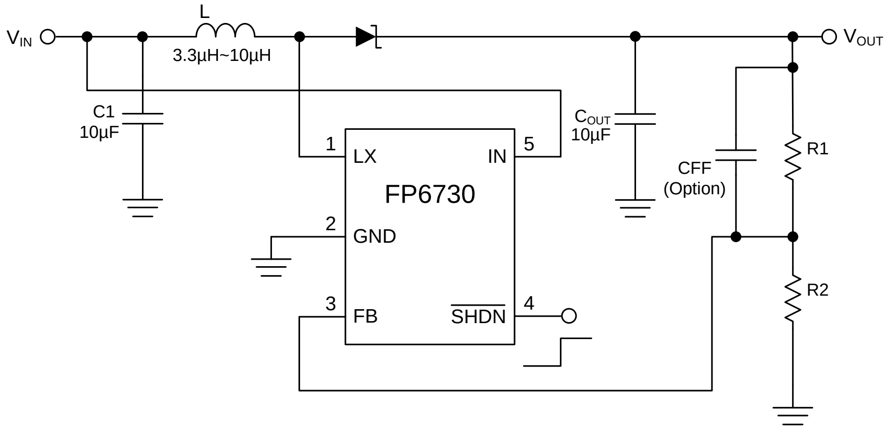


Figure 2. Typical Application Circuit (SOT-23-5 Package)

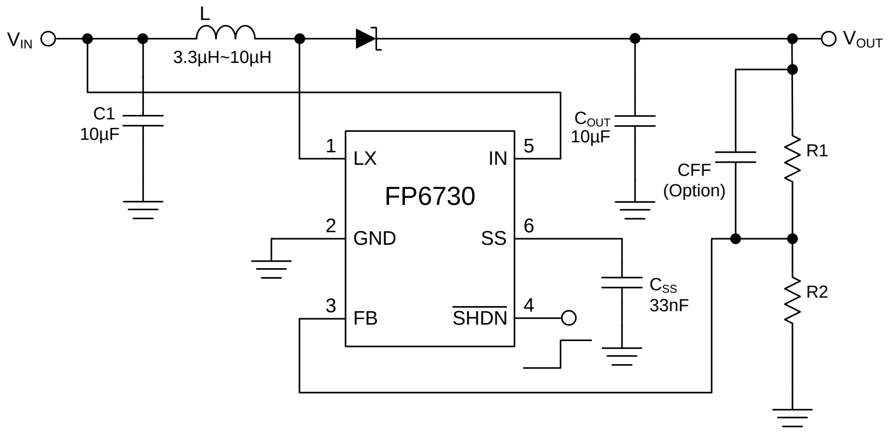


Figure 3. Typical Application Circuit (SOT-23-6 Package)

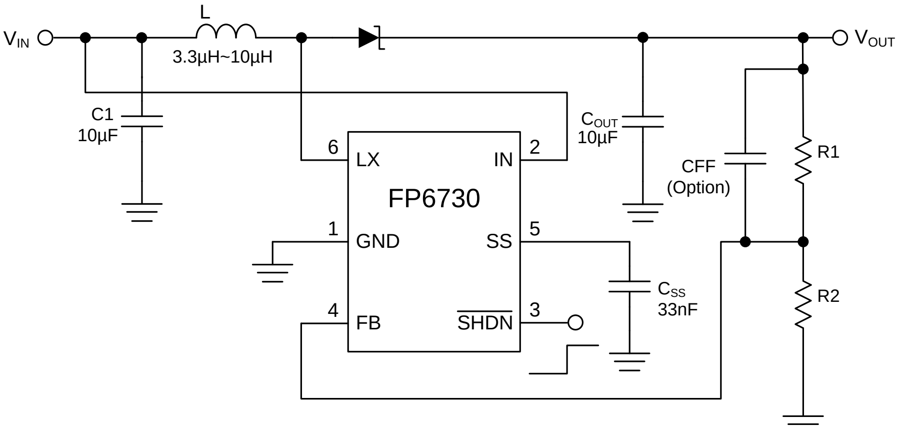


Figure 4. Typical Application Circuit (TDFN-6 Package)

Functional Pin Description

Pin Name	Pin No. (SOT-23-5)	Pin No. (SOT-23-6)	Pin No. (TDFN-6)	Pin Function
LX	1	1	6	Switch node pin. Connect LX to the inductor and output rectifier. Connect components as close to LX as possible.
GND	2	2	1	Ground.
FB	3	3	4	Feedback pin. Connect a resistive voltage-divider from the output to FB to set the output voltage.
$\overline{SHDN}$	4	4	3	Shutdown input. Drive $\overline{SHDN}$ low to turn off the converter. To automatically start the converter, connect $\overline{SHDN}$ to IN. Do not leave $\overline{SHDN}$ unconnected.
IN	5	5	2	Internal bias voltage input. Connect IN to the input voltage source. Bypass IN to GND with a 10μF or greater capacitor as close to IN as possible.
SS	--	6	5	Soft-start input. Connect a soft-start capacitor from SS to GND to soft-start the converter. Leave SS open to inform internal soft-start function.

Block Diagram

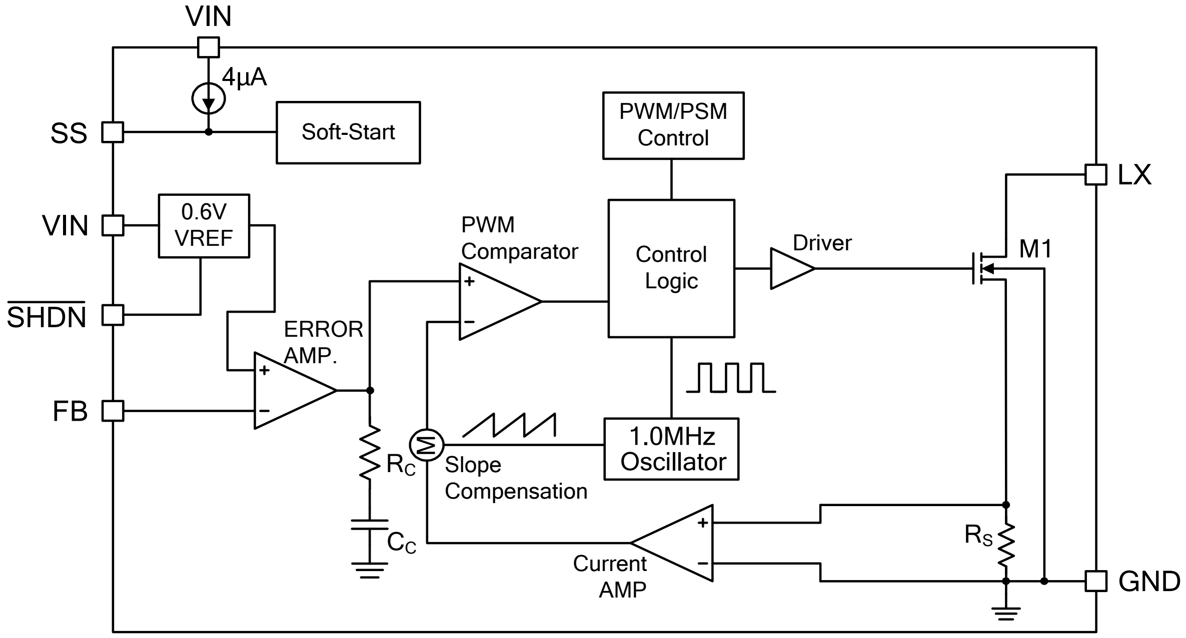


Figure 5. Block Diagram

Absolute Maximum Ratings (Note 1)

- LX , Vin to GND -- +26V
- All Other Pins to GND -- +6V
- LX Voltage V_{LX} (15ns) -- -6V to V_{IN}+6V
- Power Dissipation @T_A=25°C, (P_D)
  - SOT-23-5 -- 0.4W
  - SOT-23-6 -- 0.4W
  - TDFN-6 (2mmx2mm)-- 1.25W
- Package Thermal Resistance, (θ_{JA})
  - SOT-23-5 -- 250°C/W
  - SOT-23-6 -- 250°C/W
  - TDFN-6 (2mmx2mm)-- 80°C/W
- Package Thermal Resistance, (θ_{JC})
  - SOT-23-5 -- 130°C/W
  - SOT-23-6 -- 110°C/W
  - TDFN-6 (2mmx2mm)-- 56°C/W
- Junction Temperature (T_J) --- +150℃
- Storage Temperature Range (T_S) --- -65℃ to +150℃
- Lead Temperature (Soldering, 10 sec.) (T_{LEAD}) -- +260℃

Note1: Stresses beyond those listed under “Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Input Voltage (V_{IN}) -- +3V to +24V
- Operating Junction Temperature Range (T_{OP}) -- -40℃ to +85℃

Electrical Characteristics

(V_{IN}=5V, T_A=25 ºC, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Supply Range	V_{IN}		3		24	V
Output Voltage Adjustable Range	V_{OUT}				24	V
Quiescent Current	I_{IN}	V_{FB}=0.7V, not switching		250	400	μA
		V_{FB}=0.6V, switching		1		mA
Shutdown Supply Current	I_{SD}	$V_{\overline{SHDN}}$=0V		0.1	1	μA
Under Voltage Lockout	V_{UVLO}				2.9	V
Under Voltage Lockout Hysteresis	ΔV_{UVLO}			0.2		V
Thermal Shutdown (Note 2)	T_{SD}			150		°C
Thermal Shutdown Hysteresis				30		°C
Error Amplifier						
Feedback Regulation Set Point	V_{FB}		0.588	0.6	0.612	V
FB Input Bias Current	I_{FB}	V_{FB}=0.6V		21	80	nA
Line Regulation		3V<VIN<24V		0.05	1	%/V
Oscillator						
Frequency	f_{OSC}		800	1000	1200	KHz
Maximum Duty Cycle	DC	FB=GND	90	95		%
Power Switch						
On Resistance	$R_{DS(ON)}$	Guaranteed By Design		0.2		Ω
Switch Current Limit	I_{LIM}			2.5		A
Leakage Current	$I_{LX(OFF)}$	V_{LX}=25V, T_A=+25°C		0.1	1	μA
Soft-start						
Charge Current	I_{SS}		2	4	7	μA
Soft-start time	t_{SS}	SS Pin Voltage=1V, C_{SS}=10nF		2		ms
Internal Soft-start time	t_{SS}	C_{SS}=NC		1		ms
Control Input						
Input Low Voltage	V_{IL}	$V_{\overline{SHDN}}$, V_{IN}=2.5V to 6V			0.3	V
Input High Voltage	V_{IH}	$V_{\overline{SHDN}}$, V_{IN}=2.5V to 6V	1.0			V
$\overline{SHDN}$ Input Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$=5V		0.1	1	μA

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

Typical Performance Curves

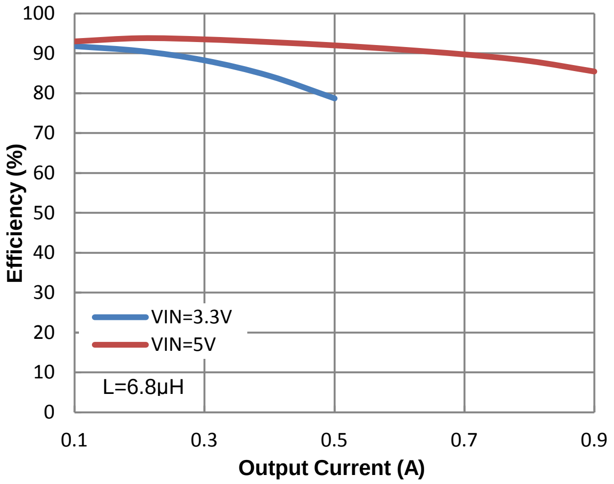


Figure 6. Efficiency vs. Output Current (VOUT=12V)

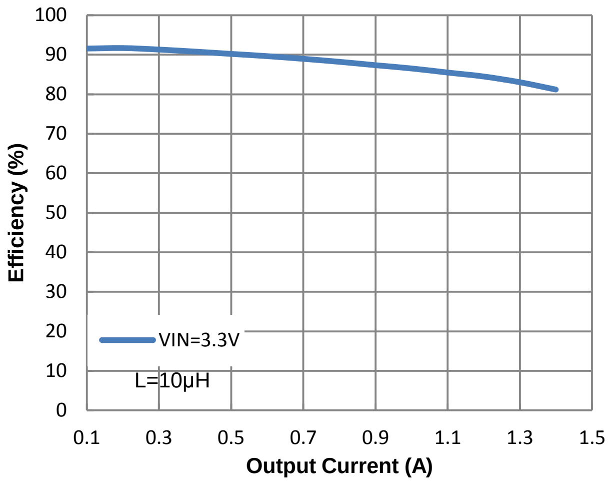


Figure 7. Efficiency vs. Output Current (VOUT=5V)

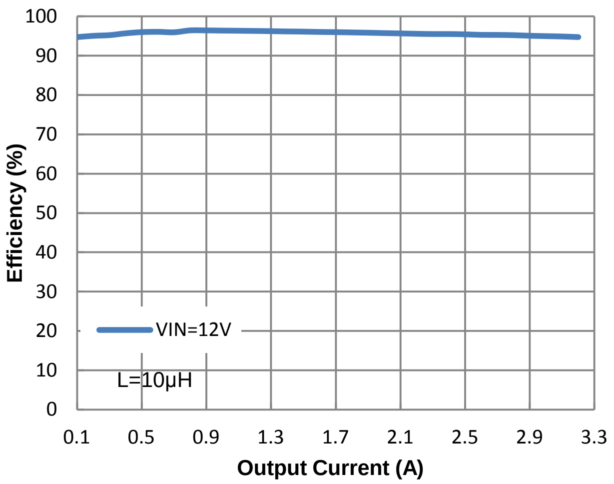


Figure 8. Efficiency vs. Output Current (VOUT=13V)

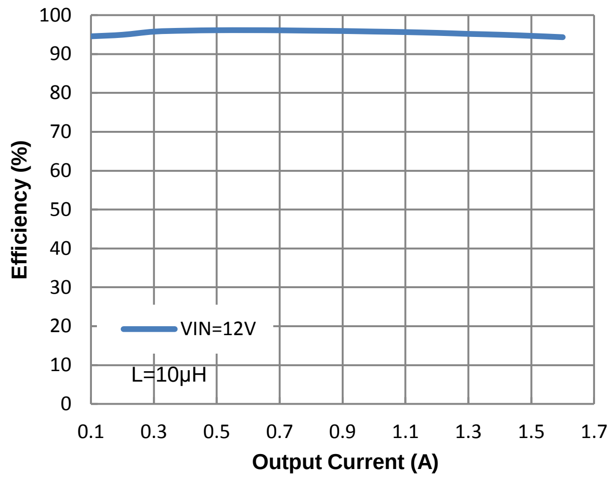


Figure 9. Efficiency vs. Output Current (VOUT=18V)

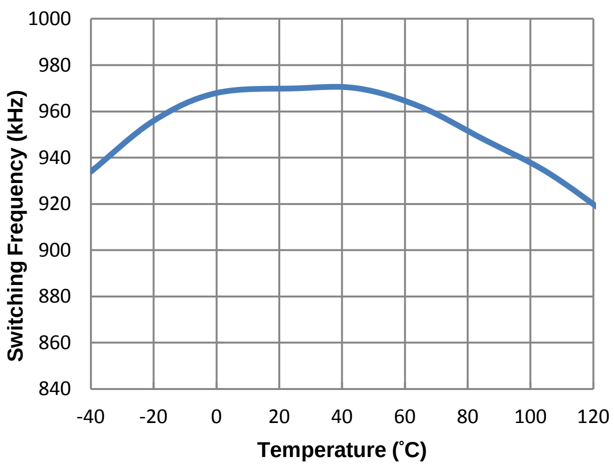


Figure 10. Switching Frequency vs. Temperature

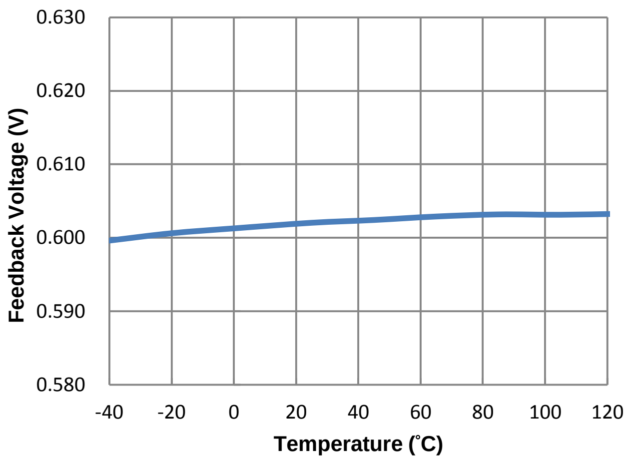
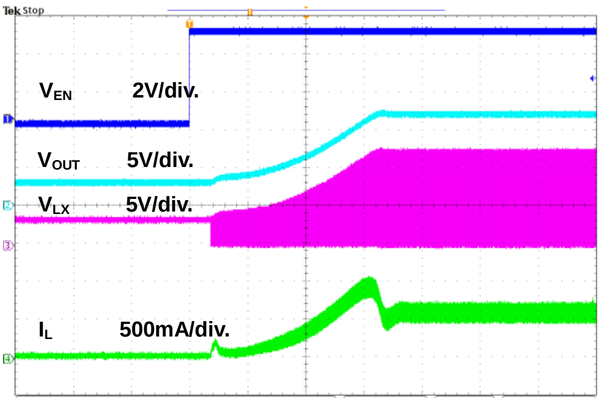


Figure 11. Feedback Voltage vs. Temperature

Typical Performance Curves (Continued)

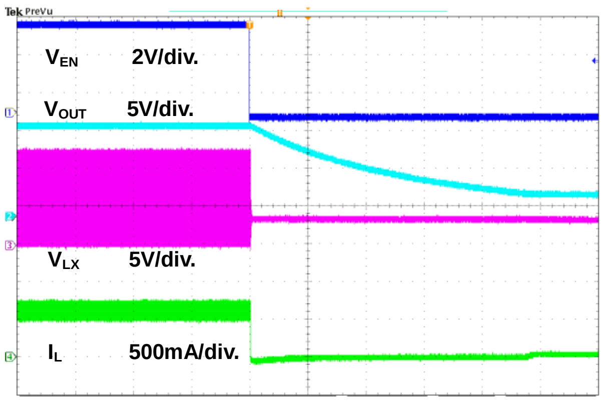
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=140mA



400μs/div.

Figure 12. Power On Through EN Waveform

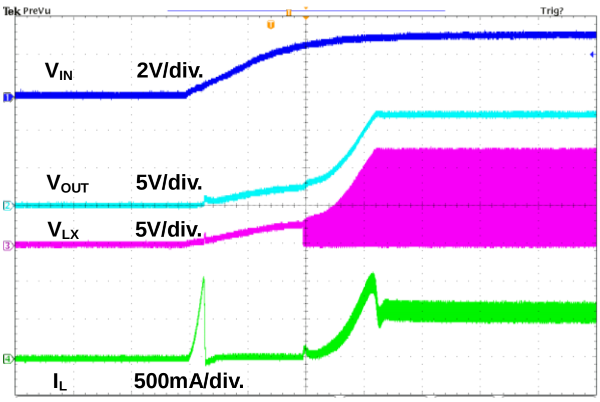
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=140mA



200μs/div.

Figure 13. Power Off Through EN Waveform

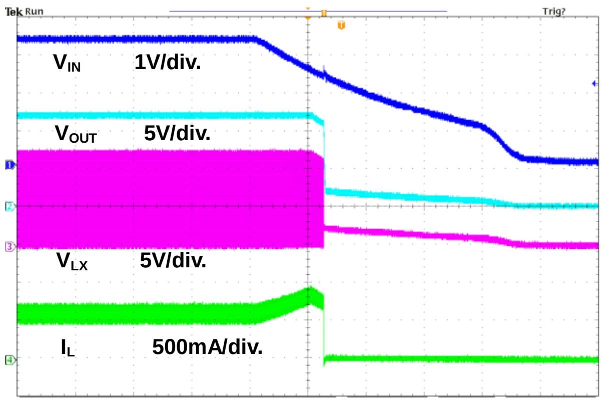
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=140mA



1ms/div.

Figure 14. Power On Through VIN Waveform

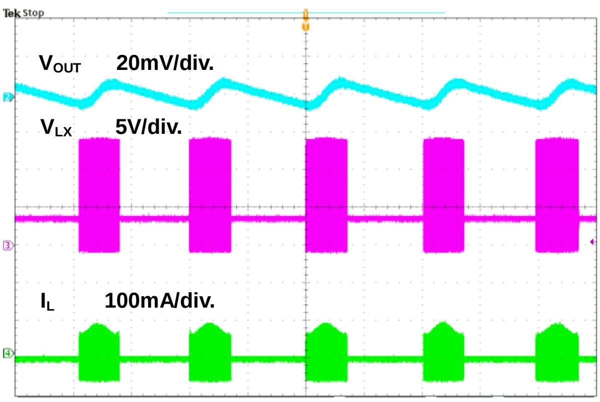
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=140mA



40ms/div.

Figure 15. Power Off Through VIN Waveform

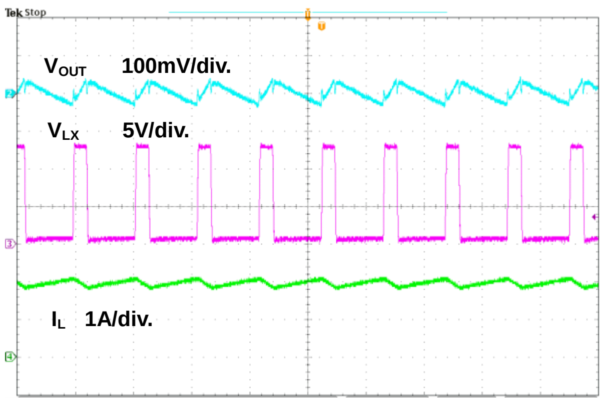
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=0mA



4ms/div.

Figure 16. Switching Waveform

V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=420mA

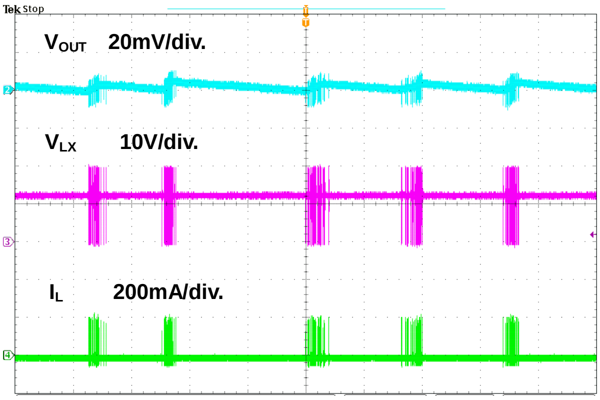


1μs/div.

Figure 17. Switching Waveform

Typical Performance Curves (Continued)

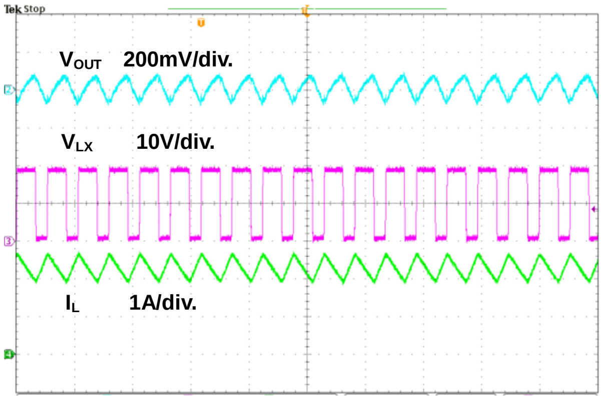
V_{IN}=12V, V_{OUT}=18V, I_{OUT}=0mA



1ms/div

Figure 18. Switching Waveform

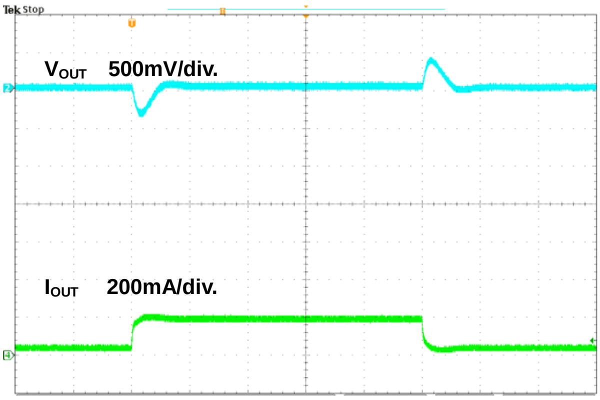
V_{IN}=12V, V_{OUT}=18V, I_{OUT}=1400mA



2μs/div.

Figure 19. Switching Waveform

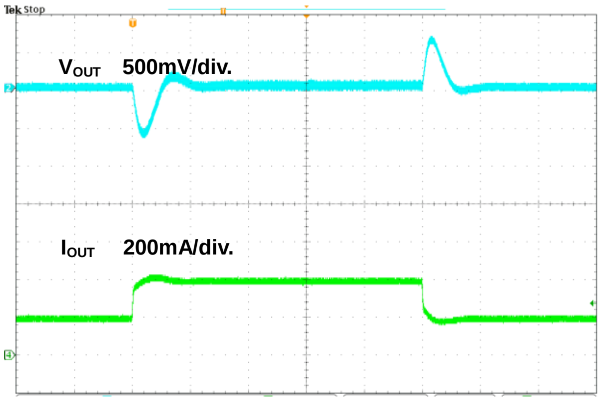
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=50mA→200mA



200μs/div

Figure 20. Load Transient Response

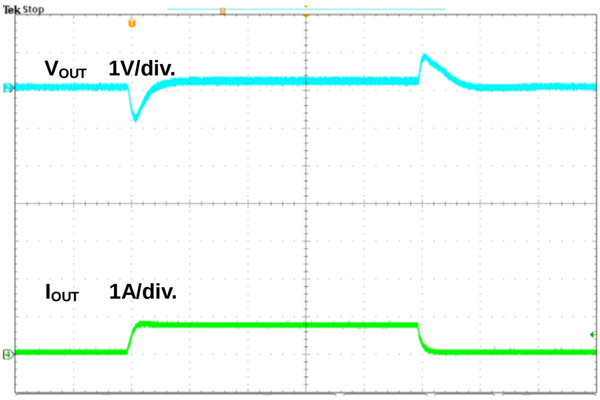
V_{IN}=3.3V, V_{OUT}=12V, I_{OUT}=200mA→400mA



200μs/div.

Figure 21. Load Transient Response

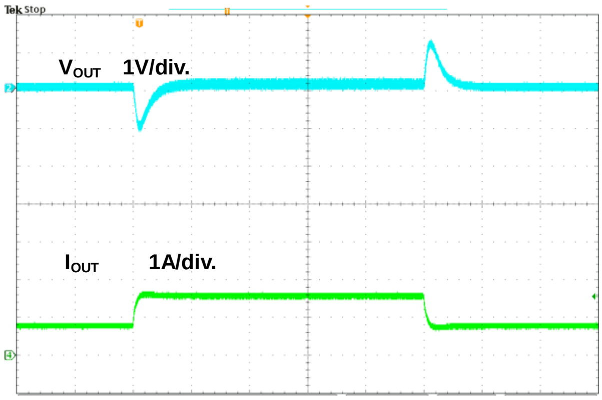
V_{IN}=12V, V_{OUT}=18V, I_{OUT}=100mA→800mA, PSM→PWM



200μs/div

Figure 22. Load Transient Response

V_{IN}=12V, V_{OUT}=18V, I_{OUT}=800mA→1600mA



200μs/div.

Figure 23. Load Transient Response

Application Information

Controller Circuit

The device is based on a current-mode control topology and uses a constant frequency pulse-width modulator to regulate the output voltage. The controller limits the current through the power switch on a pulse by pulse basis. The current sensing circuit is integrated in the device; therefore, no additional components are required. Due to the nature of the boost converter topology used here, the peak switch current is the same as the peak inductor current, which will be limited by the integrated current limiting circuits under normal operating conditions.

PSM Mode

The FP6730 is designed for high efficiency over wide output current range. Even at light load, the efficiency stays high because the switching losses of the converter are minimized by effectively reducing the switching frequency. The controller will enter a power saving mode if certain conditions are met. In this mode, the controller only switches on the transistor if the output voltage trips below a set threshold voltage. It ramps up the output voltage with one or several pulses, and goes again into PSM mode once the output voltage exceeds a set threshold voltage.

Device Enable

The device will be shut down when EN is set to GND. In this mode, the regulator stops switching, all internal control circuitry including the low-battery comparator will be switched off. This also means that the output voltage may drop below the input voltage during shutdown.

The device is put into operation when EN is set high. During start-up of the converter, the duty cycle is limited in order to avoid high peak currents drawn from the battery. The limit is set internally by the current limit circuit.

Adjustable Output Voltage

The accuracy of the output voltage is determined by the accuracy of the internal voltage reference, the controller topology, and the accuracy of the external resistor. The reference voltage has an accuracy of ± 2%. The controller switches between fixed frequency and PSM mode, depending on load current. The tolerance of the resistors in the feedback divider determines the total system accuracy.

Inductor Selection

The inductor recommended from 3.3μF to 10μF for most FP6730 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1MHz and low DCR (copper wire resistance). Recommend inductor equal to below 6.8uH When input voltage equal to 3V and output voltage equal to 5V.

Capacitor Selection

The small size of ceramic capacitors makes them ideal for FP6730 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 FP6730 applications.

Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for FP6730 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (C_T or C_D) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1MHz switching frequency of the FP6730. A Schottky diode rated at 3A is sufficient for most FP6730 applications.

Application Information (Continued)

Open-Circuit Protection

In the cases of output open circuit, when the R1 are disconnected from the circuit, the feedback voltage will be zero. The FP6730 will then switch at a high duty cycle resulting in a high output voltage, which may cause the LX pin voltage to exceed its maximum 24V rating. A zener diode can be used at the output to limit the voltage on the LX pin (Figure 24). The zener voltage should be larger than the maximum voltage of the V_{OUT}. The current rating of the zener should be larger than 0.1mA.

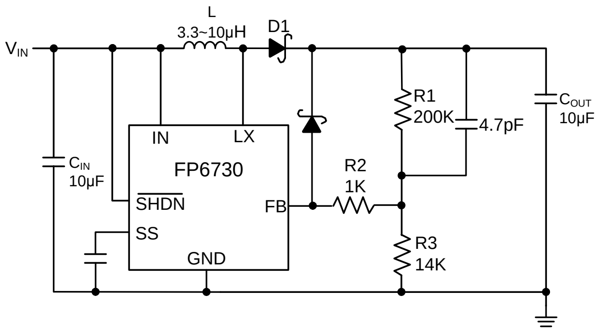


Figure 24. With Open-Circuit Protection

The total ripple is the sum of the ripple caused by the capacitance and the ripple caused by the ESR of the capacitor. It is possible to improve the design by enlarging the capacitor or using smaller capacitors in parallel to reduce the ESR or by using better capacitors with lower ESR, like ceramics. Tradeoffs must be made between performance and costs of the converter circuit.

A 10μF input capacitor is recommended to improve transient behavior of the regulator. A ceramic or tantalum capacitor with a 100nF in parallel placed close to the IC is recommended.

A 10μF output capacitor is recommended to improve transient behavior of the regulator. A ceramic or tantalum capacitor with a 100nF in parallel placed close to the IC is recommended.

Layout Considerations

As for all switching power supplies, the layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems. Therefore, use wide and short traces for the main current path as indicated in bold in Figure 25. The input capacitor, output capacitor should be placed as close to the IC as possible. Use a common ground node as shown in Figure 25 to minimize the effects of ground noise. The feedback divider should be placed as close to the IC as possible.

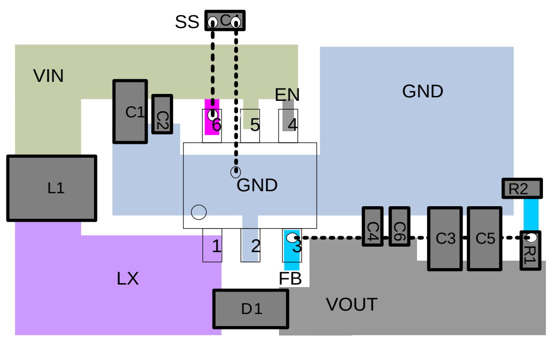
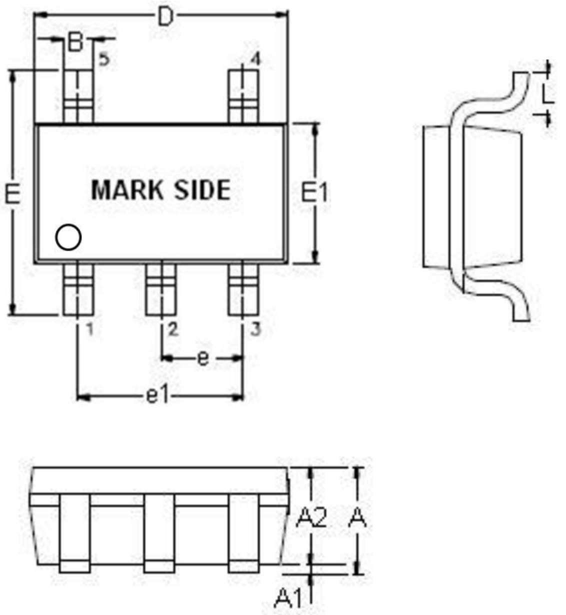


Figure 25. Layout Diagram

Outline Information

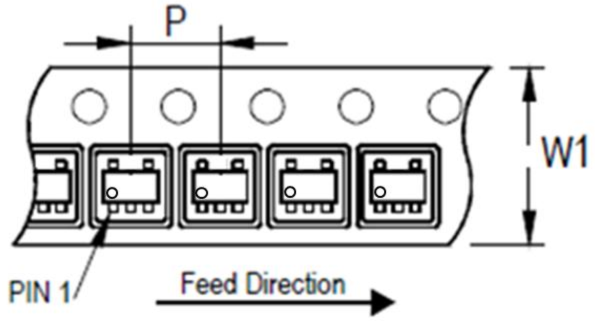
SOT-23-5 Package (Unit: mm)

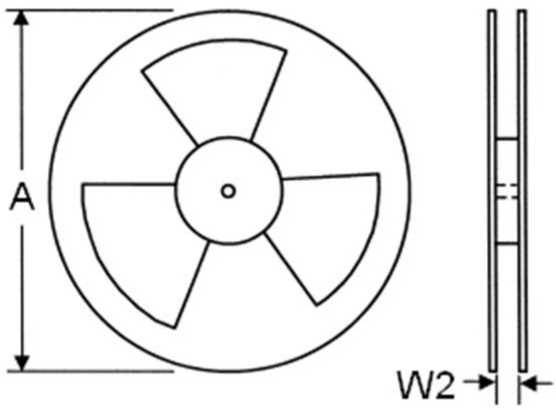


SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
B	0.30	0.50
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.90	1.00
e1	1.80	2.00
L	0.30	0.60

Note: Followed From JEDEC MO-178-C.

Carrier Dimensions

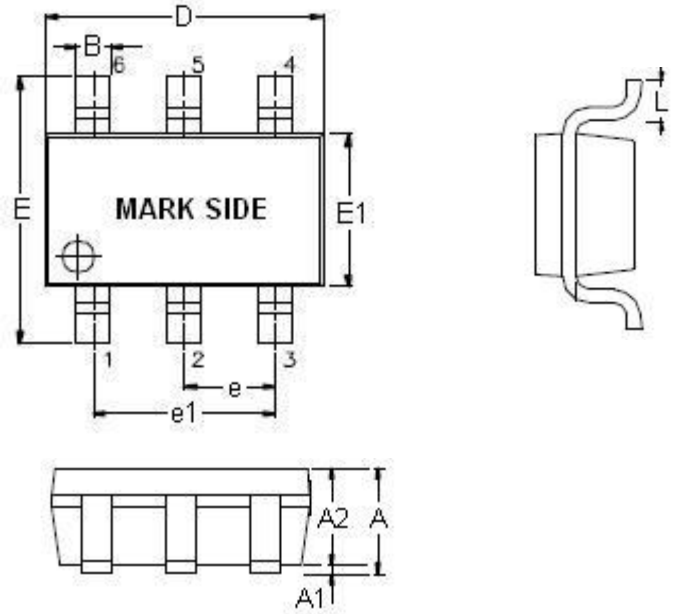




Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
8	4	7	180	8.4	300~1000	3,000

Outline Information (Continued)

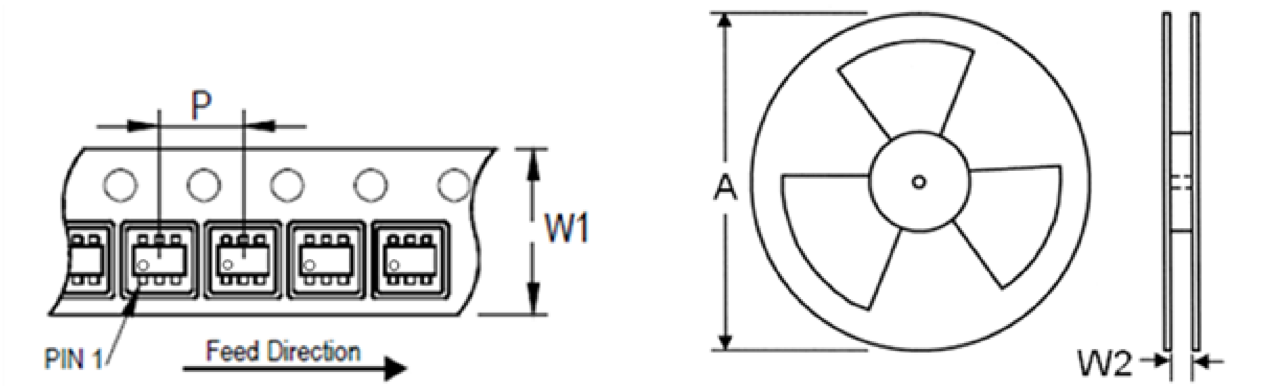
SOT-23-6 Package (Unit: mm)



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

Note: Followed From JEDEC MO-178-C.

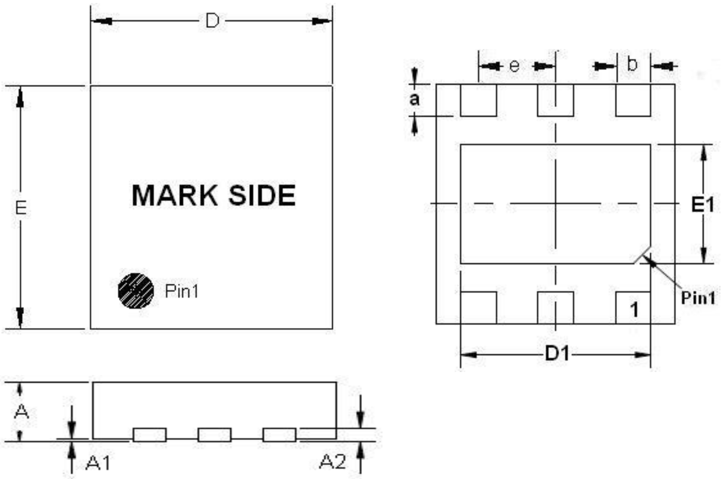
Carrier Dimensions



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

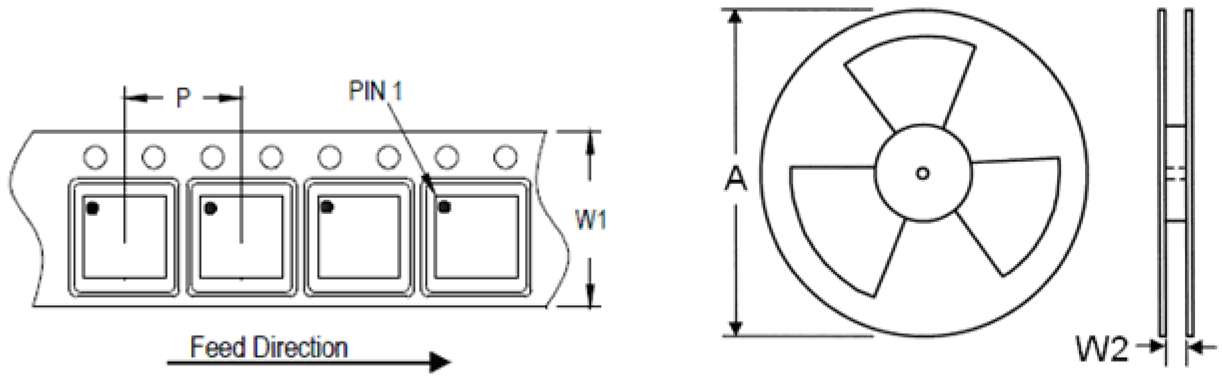
Outline Information (Continued)

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



SYMBOLS	DIMENSION IN MILLIMETER	
UNIT	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