



Features

- Input Voltage Range: 4.5V to 16V
- Output Voltage Range: 0.6V to 12V
- 3A Load Current on Channel
- Up to 95% Efficiency
- 600KHz Switching Frequency
- Short Circuit Protection
- Over-Temperature Protection
- SOT23-6 Package
- RoHS Compliant and Halogen Free
- Pb-Free Package

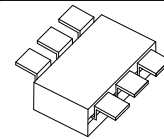
Applications

- Portable Media Players
- Cellular and Smart mobile phone
- PDA/DSC
- GPS Applications

Description


The LP6461 is a synchronous buck converter supporting up to 3A output current. The LP6461 operates over a wide input voltage range from 4.5V to 16V and integrates main switch and synchronous switch with very low RDS(ON) to achieve high efficiency.

The LP6461 integrates two operation modes, PWM control and PFM mode switching control, which allows a high efficiency over the wider range of the load. Other features include over current protection(OCP), over temperature protection(OTP), under-voltage lockout(UVLO) and short circuit protection(SCP).The LP6461 is available in a space saving SOT23-6 package.

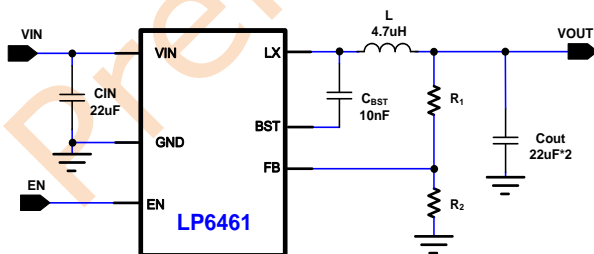


SOT23-6
0.95mm pin pitch

Ordering Information

LP6461 
 F: Green
 Package Type
 B6: SOT23-6

Typical Application Circuit

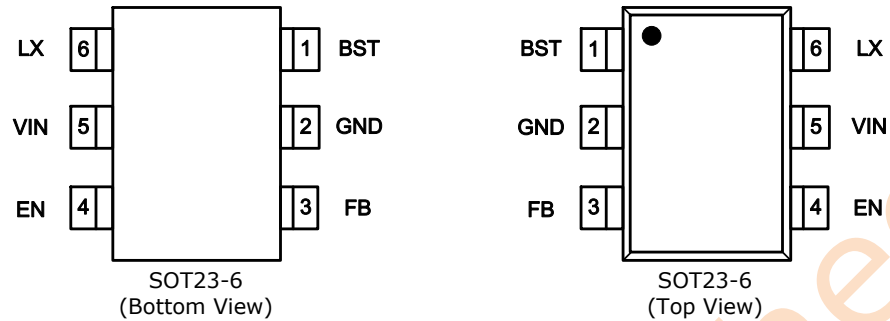


Marking Information

Device	Marking	Package	Shipping
LP6461B6F	LPS A7YWX	SOT23-6	3K/REEL
Marking indication: Y is year code. W is week code. X is series number.			



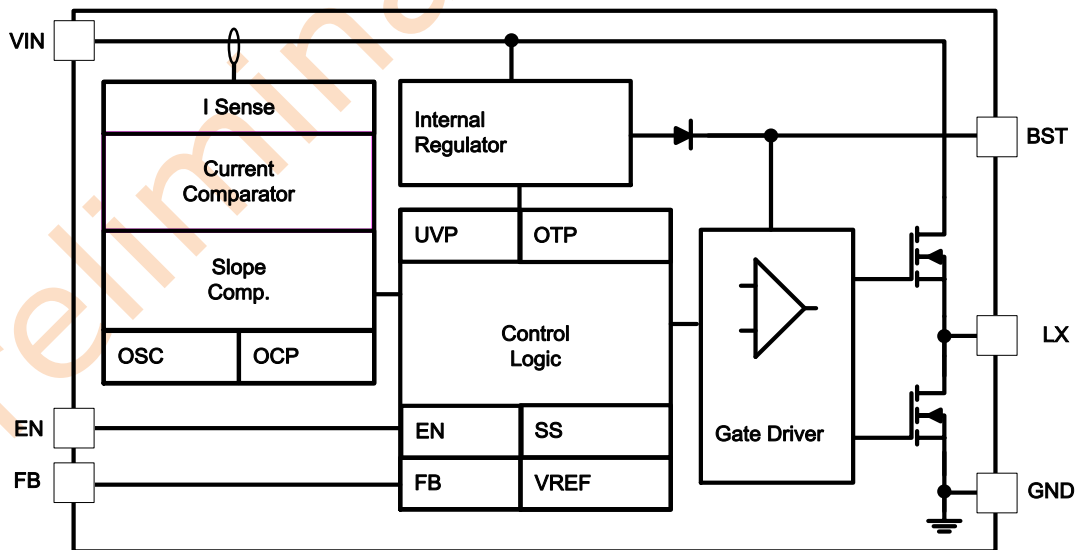
Pin Configuration



Pin Description

Pin NO.	Pin Name	Description
1	BST	High-Side Gate Drive Boost Input. Connect a 0.1uF or greater capacitor from SW to BST to power the high side switch.
2	GND	Ground.
3	FB	Regulator Feedback Input. Connect to an external resistive to set the output current.
4	EN	Chip Enable Control.
5	VIN	Input Supply Pin. Decouple with 20μF ceramic capacitor close to the pin.
6	LX	Switch Mode Connection to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.

Functional Block Diagram





Absolute Maximum Ratings (Note 1)

- VIN to GND ----- -0.3V to 22V
- LX to GND ----- -0.3V to 22V
- BST to LX ----- -0.3V to 6.5V
- EN to GND ----- -0.3V to 18V
- FB to GND ----- -0.3V to 7V
- Maximum Junction Temperature (T_J) ----- 125°C
- Operating Ambient Temperature Range (T_A) ----- -40°C to 85°C
- Maximum Soldering Temperature (At leads, 10 sec) ----- 260°C

*Note 1: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information

- Maximum Power Dissipation (P_D , $T_A \leq 25^\circ\text{C}$) ----- 0.6W
- Thermal Resistance (θ_{JA}) (Note 2) ----- 180°C/W

*Note 2: Measured using 2S2P JEDEC standard PCB with ambient temperature < 25°C



Electrical Characteristics

$V_{IN}=12V$, $V_{EN}=5V$, $T_A=25^{\circ}C$, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Units
General Function						
Input Supply Voltage	V_{IN}		4.5		16	V
Output Voltage Range	V_{OUT}		0.8		12	V
Over Voltage Protection Threshold	$V_{IOVP(VTH)}$			18.3		V
Over Voltage Protection Hysteresis	$V_{IOVP(HYS)}$			1		V
V_{IN} Supply Current	I_Q	$V_{EN}=GND$			10	μA
		$V_{FB}=1V$		0.56		mA
Input UVLO Threshold	$V_{UVLO(VTH)}$	V_{IN} Rising		4	4.3	V
UVLO Threshold Hysteresis	$V_{UVLO(HYS)}$	Falling Hysteresis		400		mV
Soft Start Time	T_{SS}			1.5		ms
Thermal Shutdown Threshold	T_{SD}	Temperature Rising		150		$^{\circ}C$
Thermal Shutdown Hysteresis	ΔT_{SD}			20		$^{\circ}C$
EN Function						
EN Threshold Voltage	V_{IH}	Logic High.			1.2	V
	V_{IL}	Logic Low	0.4			
Enable Input Current	I_{EN}	$V_{EN}=5V$		2		μA
Regulator						
Feedback Voltage	V_{FB}	$16V > V_{IN} > 4.5V$	0.588	0.6	0.612	V
FB Leakage Current	I_{FB}	$V_{FB}=1.0V$			100	nA
Internal Oscillator Frequency	F_{OSC}			600		kHz
Maximum Duty Cycle	D_{MAX}			94		%
High-Side Switch On Resistance	$R_{DS(ON)H}$			85		m Ω
Low-Side Switch On Resistance	$R_{DS(ON)L}$			60		m Ω
Current Limit Protection	I_{Limit}			4.5		A
Output Under Voltage Protection	V_{UVP}			50		%
Hiccup On Timer				1.5		ms
Hiccup Off Timer				65		ms



Function Description

Functional Description

The LP6461 is a high output current monolithic witch-mode step-down DC-DC converter. The device operates at a fixed 600KHz switching frequency, and uses a slope compensated current mode architecture. This step-down DC-DC converter can supply up to 3A output current at input voltage range from 4.5V to 16V. It minimizes external component size and optimizes efficiency at the heavy load range. The integrated slope compensation allows the device to remain stable over a wider range of inductor values so that smaller values (2.2μH to 10μH) with lower DCR can be used to achieve higher efficiency. The device can be programmed with external feedback to any voltage, ranging from 0.6V to 12V. It uses internal MOSFETs to achieve high efficiency and can generate very low output voltages by using an internal reference of 0.6V. At dropout, the converter duty cycle increases to 95% and the output voltage tracks the input voltage minus the low $R_{DS(ON)}$ drop of the P-channel high-side MOSFET and the inductor DCR. The internal error amplifier and compensation provides excellent transient response, load and line regulation.

Enable Chip

The enable pin is active high. When pulled low, the enable input (EN) forces the LP6461 into a low-power, non-switching state. The total input current during shutdown is less than 10μA.

Current Limit and Over-Temperature Protection

For overload conditions, the peak input current is limited to 4.5A(Typ.). To minimize power dissipation and stresses under current limit and short-circuit conditions, switching is terminated after entering current limit condition. The termination lasts for seven consecutive clock cycles after a current limit has been sensed during a series of four consecutive periods of oscillations. Thermal protection completely disables switching when internal dissipation becomes excessive. The junction over-temperature threshold is 150°C with 20°C of hysteresis. Once an over-temperature or over-current fault conditions is removed, the output voltage automatically recovers.

Dropout Operation

When input voltage decreases near the value of the output voltage, the LP6461 allows the main switch to remain on for more than one switching cycle and increases the duty cycle until it reaches 94%. The duty cycle D of a step-down converter is defined as:

$$D = t_{ON} \times f_{OSC} \times 100\% = \frac{V_{OUT}}{V_{IN}} \times 100\%$$

Where T_{ON} is the main switch on time and f_{OSC} is the oscillator frequency.



Typical Characteristics

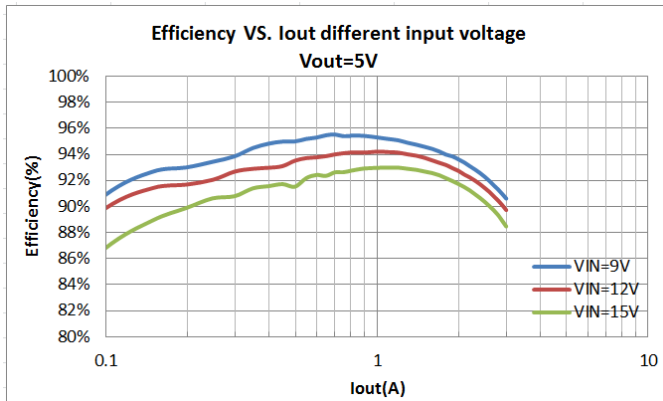


Figure 1. $V_{OUT}=5V$, Efficiency
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)

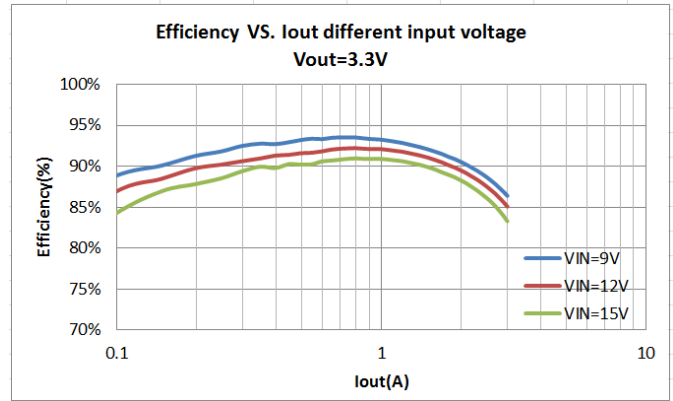


Figure 2. $V_{OUT}=3.3V$, Efficiency
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)

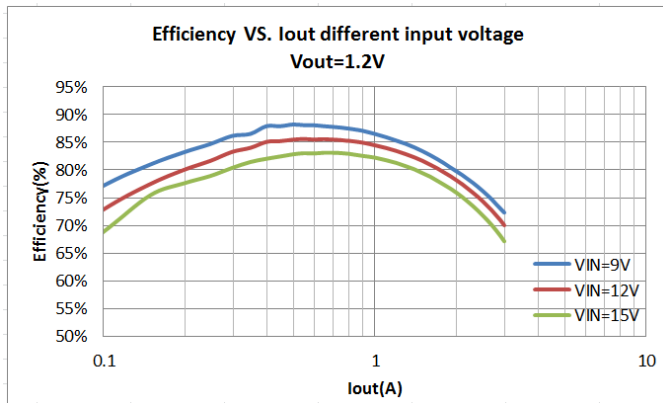


Figure 3. $V_{OUT}=1.2V$, Efficiency
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)

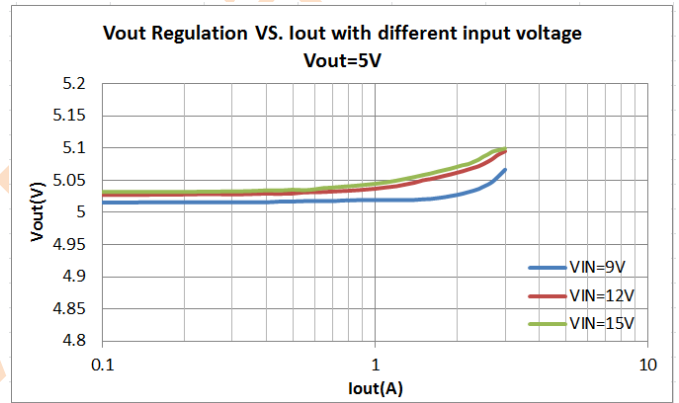


Figure 4. $V_{OUT}=5.0V$, Regulation
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)

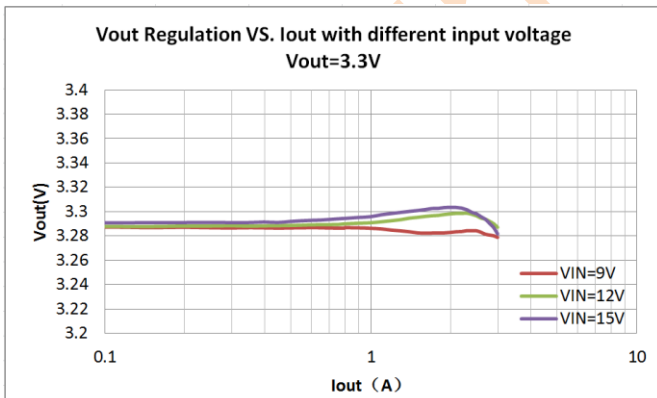


Figure 5. $V_{OUT}=3.3V$, Regulation
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)

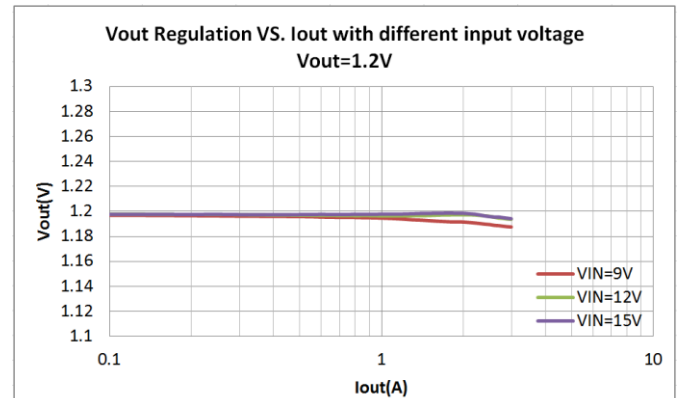


Figure 6. $V_{OUT}=1.2V$, Regulation
($L=4.7\mu H, C_{IN}=22\mu F, C_{OUT}=22\mu F \times 2$)



Application Information

Setting the Output Voltage

The LP6461 can be externally programmed. Feedback resistors R1 and R2 program the output to regulate at a voltage higher than 0.6V. Although a larger value will further reduce quiescent current, it will also increase the impedance of the feedback node, making it more sensitive to external noise and interference. For achieving circuit loop stability, the R1 must be between 10K and 900K. The LP6461, combined with an external feed forward capacitor, delivers enhanced transient response for extreme pulsed load applications. The addition of the feed forward capacitor typically requires a larger output capacitor C2 for stability. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \times \left(1 + \frac{R_1}{R_2}\right)$$

$$R_1 = \left(\frac{V_{OUT}}{0.6V} - 1\right) \times R_2$$

Table1 shows the resistor selection for different output voltage settings

VOUT(V)	R1(KΩ)	R2(KΩ)
1.2	100	100
1.5	150	100
1.8	200	100
2.5	317	100
3.3	450	100
5	733	100

Resistor Selections for Different Output Voltage Settings (Standard 1% Resistors Substituted For Calculated Values).

Inductor Selection

For most designs, the LP6461 operates with inductor values of 2.2μH to 10μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔIL is inductor ripple current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 60% of the maximum load current 3A, or

$$\Delta I_L = 1200mA$$

Manufacturer's specifications list both the inductor DC

current rating, which is a thermal limitation, and the peak current rating, which is determined by the saturation characteristics. The inductor should not show any appreciable saturation under normal load conditions. Some inductors may meet the peak and average current ratings yet result in excessive losses due to a high DCR.

Always consider the losses associated with the DCR and its effect on the total converter efficiency when selecting an inductor. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 20mΩ to 100mΩ range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (3A + 600mA).

Output Capacitor Selection

The function of output capacitance is to store energy to attempt to maintain a constant voltage. The energy is stored in the capacitor's electric field due to the voltage applied. The value of output capacitance is generally selected to limit output voltage ripple to the level required by the specification. Since the ripple current in the output inductor is usually determined by L, VOUT and VIN, the series impedance of the capacitor primarily determines the out-put voltage ripple. The three elements of the capacitor that contribute to its impedance (and output voltage ripple) are equivalent series resistance (ESR), equivalent series inductance (ESL), and capacitance (C). The output voltage droop due to a load transient is dominated by the capacitance of the ceramic output capacitor. During a step increase in load current, the ceramic output capacitor alone supplies the load current until the loop responds. With in three switching cycles, the loop responds and the inductor current increases to match the load current demand. The relationship of the output voltage droop during the three switching cycles to the output capacitance can be estimated by:

$$C_{OUT} = \frac{3 \times \Delta I_{LOAD}}{V_{DROOP} \times f_S}$$

In many practical designs, to get the required ESR, a capacitor with much more capacitance than is needed must be selected. For continuous or discontinuous inductor current mode operation, the ESR of the COUT needed to limit the ripple to ΔVOUT, V peak-to-peak is:

$$ESR \leq \frac{\Delta V_{OUT}}{\Delta I_L}$$

Ripple current flowing through a capacitor's ESR causes power dissipation in the capacitor. This power



dissipation causes a temperature increase internal to the capacitor. Excessive temperature can seriously shorten the expected life of a capacitor. Capacitors have ripple current ratings that are dependent on ambient temperature and should not be exceeded. The output capacitor ripple current is the inductor current, I_L , minus the output current, I_{OUT} .

Thermal Calculations

There are three types of losses associated with the LP6461 step-down converter: switching losses, conduction losses, and quiescent current losses. Conduction losses are associated with the $R_{DS(ON)}$ characteristics of the power output switching devices. Switching losses are dominated by the gate charge of the power output switching devices.

At full load, assuming continuous conduction mode (CCM), a simplified form of the losses is given by:

$$P_{TOTAL} = \frac{I_{OUT}^2 (R_{DS(ON)(HS)} \times V_{OUT} + R_{DS(ON)(LS)} \times (V_{IN} - V_{UTO}))}{V_{IN}} + (t_{SW} \times f \times I_{OUT} + I_Q) \times V_{IN}$$

I_Q is the step-down converter quiescent current. The term t_{sw} is used to estimate the full load step-down converter switching losses.

For the condition where the step-down converter is in dropout at 94% duty cycle, the total device dissipation reduces to:

$$P_{TOTAL} = I_{OUT}^2 \times R_{DS(ON)(HS)} + I_Q \times V_{IN}$$

Since $R_{DS(ON)}$, quiescent current, and switching losses all vary with input voltage, the total losses should be investigated over the complete input voltage range. Given the total losses, the maximum junction temperature can be derived from the θ_{JA} for the SOT23-6 package which is 180°C/W .

$$T_{J(MAX)} = P_{TOTAL} \times \theta_{JA} + T_{AMB}$$

Layout Guidance

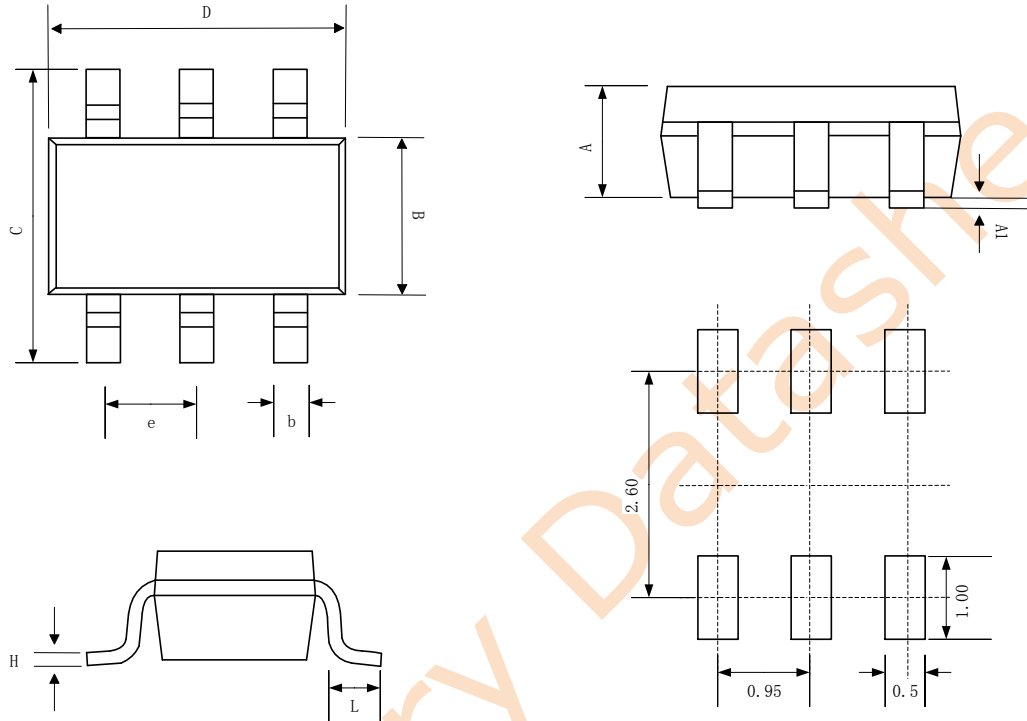
When laying out the PC board, the following layout guideline should be followed to ensure proper operation of the LP6461:

1. The power traces, including the GND trace, the SW trace and the IN trace should be kept short, direct and wide to allow large current flow. The L connection to the SW pins should be as short as possible. Use several VIA pads when routing between layers.
2. The input capacitor (C_{IN}) should connect as closely as possible to V_{IN} (Pin 5) and GND to get good power filtering.
3. Keep the switching node, SW (Pins 6) away from the sensitive FB node.
4. The feedback trace or OUT pin should be separate from any power trace and connect as closely as possible to the load point. Sensing along a high-current load trace will degrade DC load regulation.
5. The output capacitor C_{OUT} and L should be connected as closely as possible. The connection of L to the SW pin should be as short as possible and there should not be any signal lines under the inductor.
6. The resistance of the trace from the load return to PGND should be kept to a minimum. This will help to minimize any error in DC regulation due to differences in the potential of the internal signal ground and the power ground.



Package Dimensions

SOT23-6 Package (Unit: mm)



Recommended Land Pattern

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.889	1.100	1.295
A1	0.000	0.050	0.152
B	1.397	1.600	1.803
b	0.28	0.35	0.559
C	2.591	2.800	3.000
D	2.692	2.920	3.120
e	0.95BSC		
H	0.080	0.152	0.254
L	0.300	0.450	0.610