High Efficiency 6A Synchronous Boost Convertor

General Description

The LP6253 is a Synchronous current mode boost DC-DC converter. Its PWM circuitry with built-in 6A Current power MOSFET makes this converter highly power efficiently. Selectable high switching frequency allows faster loop response and easy filtering with a low noise output. The non-inverting input its error amplifier is connected to an internal 500mV precision reference voltage. Soft-Start time can be programmed with an external capacitor, which sets the input current ramp rate. Current mode control and external compensation network make it easy and flexible to stabilize the system. The converter can be disabled to minimize battery drain. During shutdown, the load is completely disconnected from the battery. A low-EMI mode is implemented to reduce ringing and, in effect, lower radiated electromagnetic energy when the converter enters the discontinuous conduction mode

Ordering Information

LP6253 - □ □ □

F: Pb-Free

Package Type
QV: TDEFN-16

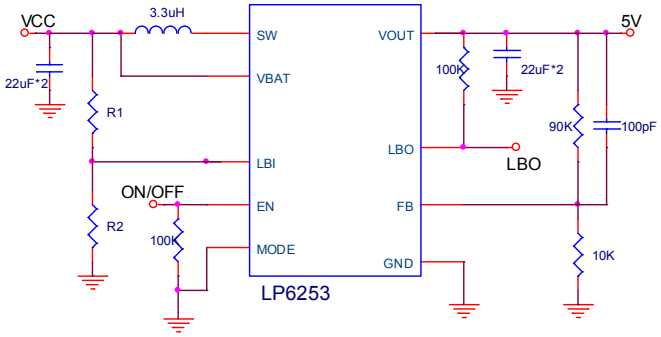
Applications

- Battery products
- Host Products
- Audio power

Features

- Up to 96% efficiency
- Output to Input Disconnect at Shutdown Mode
- Shut-down current:<1uA
- Output voltage Up to 5.5V
- Internal Compensation, Soft-start
- 1.4MHz fixed frequency switching
- High switch on current:6A ,With 2500mA Output Current From 3.5V Input
- Low Battery Comparator
- Available in 4mm×4mm TDFN-16 Package

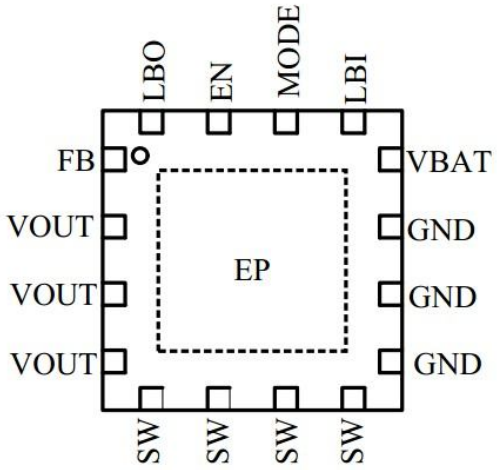
Typical Application Circuit



Marking Information

Please see website:www.lowpowersemi.com.

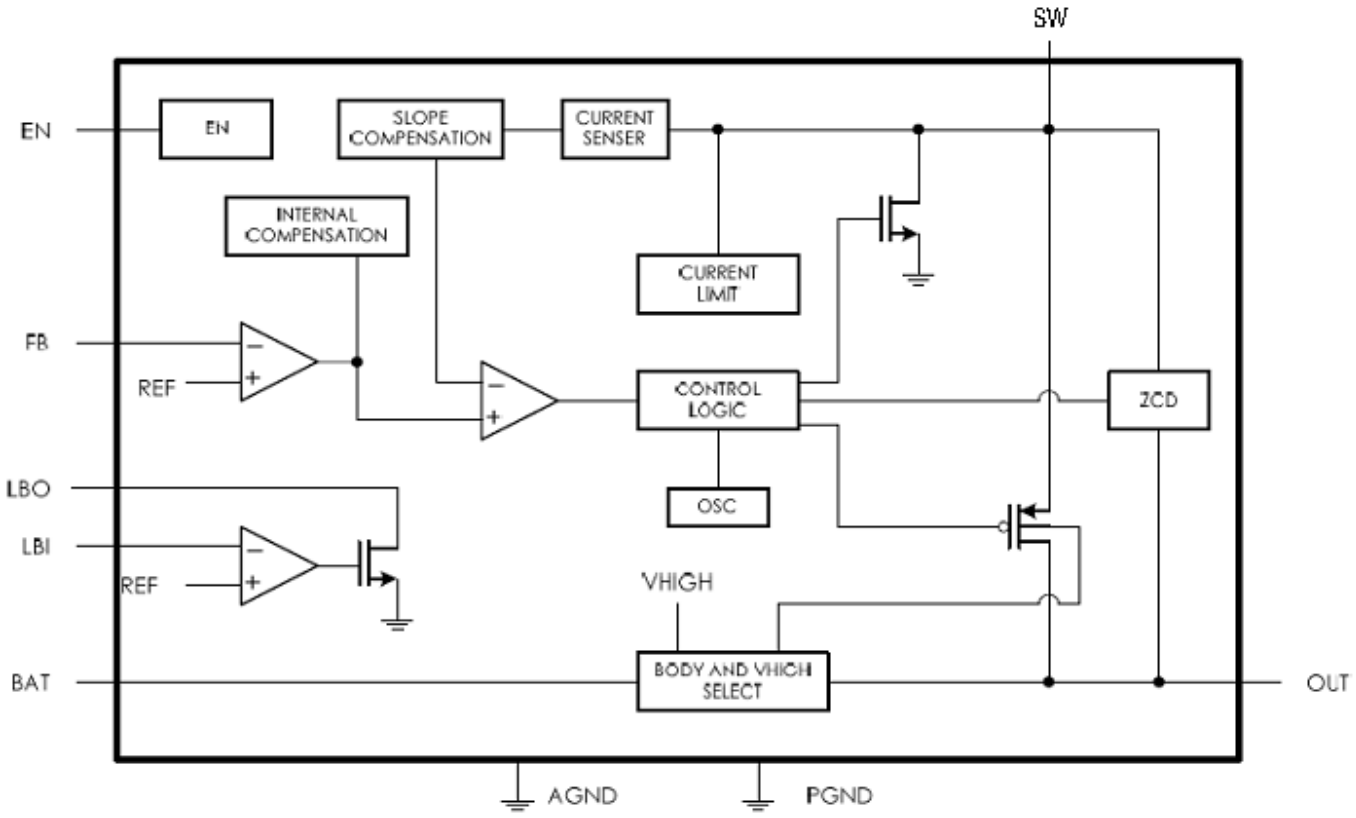
Functional Pin Configurations

Package Type	Pin Configurations
TDFN-16	

Functional Pin Description

PIN	PIN Name	Description
1	FB	Regulation Feedback Input. Connect to an external resistive voltage divider from the output to FB to set the output voltage.
2\3\4	OUT	Voltage output Pin.
5\6\7\8	SW	Boost and rectifying switch input. SW is the drain of the internal low-side N-Channel MOSFET and high-side P-Channel MOSFET. Connect the inductor to SW to Complete the step-up converter.
9\10\11	GND	Ground.
12	VBAT	Battery supply input pin
13	LBI	Battery detector input pin.
14	MODE	Enable/disable power save mode (1/VBAT disabled, 0/GND Enabled)
15	EN	Regulator On/off Control Input. A logic high input(VEN>1.4V) turns on the regulator. A logic low input(VEN<0.4V) puts the LP6250 into low current shutdown mode
16	LBO	Open-drain Low Battery Detector output pin.

Function Block Diagram



Absolute Maximum Ratings

Supply Input Voltage----------6V

Power Dissipation, PD @ TA = 25° C

TDFN----------2W

Package Thermal Resistance

TDFN, θJA ----------45°C/W

Lead Temperature (Soldering, 10 sec.) ----------260°C

Recommended Operating Conditions

Supply Input Voltage----------2.5V to 5.5V

EN Input Voltage ----------0V to 5.5V

Operation Junction Temperature Range ---------- −40°C to 125°C

Operation Ambient TemperatureRange---------- −40°C to 85°C

Electrical Characteristics

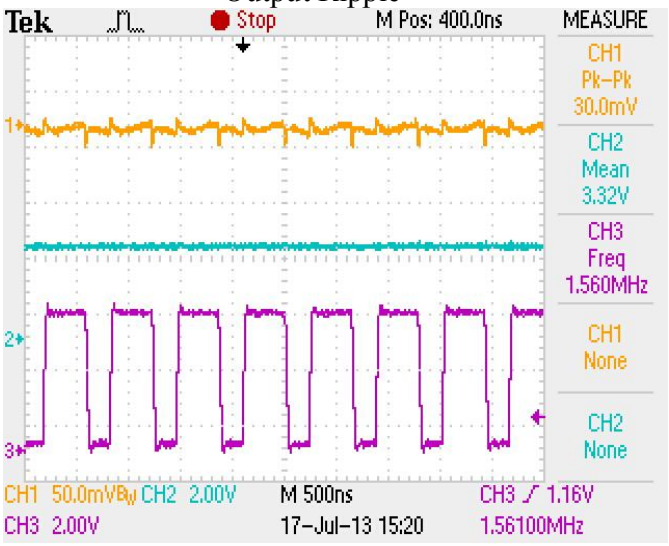
2.5V ≤ V(BAT) ≤ 5.5V, －20° C < T J + 125°C, typical values are at TA = 25°C, with respect to GND (unless otherwise noted)

Parameter	Conditions	LP6253			Units
		Min	Typ	Max	
Supply Voltage		2.5		5.5	V
Output Voltage Range		2.5		5.5	V
Under voltage lockout	VBAT voltage decreasing		1.5		V
Supply Current(Shutdown)	VEN=VOUT=0V,VSW=5V		0.05	1	uA
Supply Current	VFB=1.3V		0.19		mA
Feedback Voltage		490	500	510	mV
Feedback Input Current	VFB=1.2V		50		nA
Switching Frequency		1.2	1.4	1.6	MHz
Switch current limit	Vout= 5 V	5000	5500	6000	mA
Start-up current limit			1200		mA
High-side On Resistance	Vout=5V		55		mΩ
Low-side On Resistance	Vout=5V		55		mΩ
Line regulation				0.6%	
Line regulation				0.6%	
EN Input Low Voltage				0.6	V
EN Input High Voltage		1.2			V
LBI voltage threshold	VLBI voltage decreasing	490	500	510	mV
LBI input hysteresis			10		mV
LBI input current	EN = VBAT or GND		0.01	0.1	uA
LBO output low voltage	VO=3.3V, IOI=100μA		0.04	0.4	V
LBO output low current			100		uA
LBO output leakage current	VLBO = 7 V		0.01	0.1	uA
Overtemperature protection			150		°C
Overtemperature hysteresis			20		°C

Typical Operating Characteristics

(VIN=3.3V Vout=5V L=2.2uH Cin=22uF Cout=22uF)

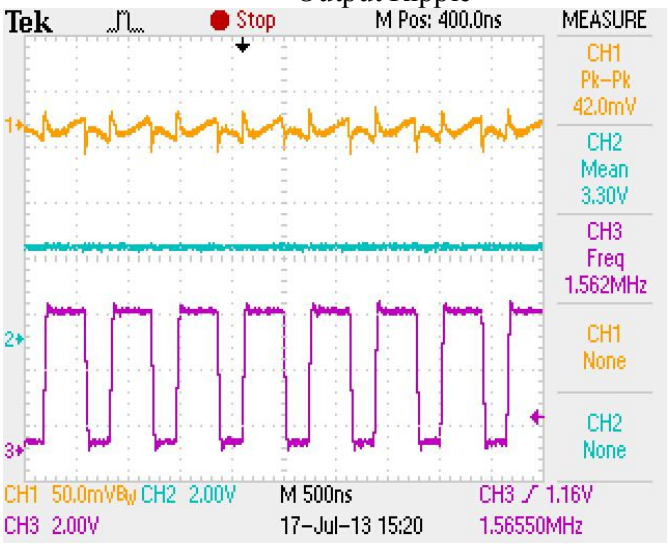
Output Ripple



CH1=Vout CH2=Vin CH3=SW

I_{LOAD} =500mA

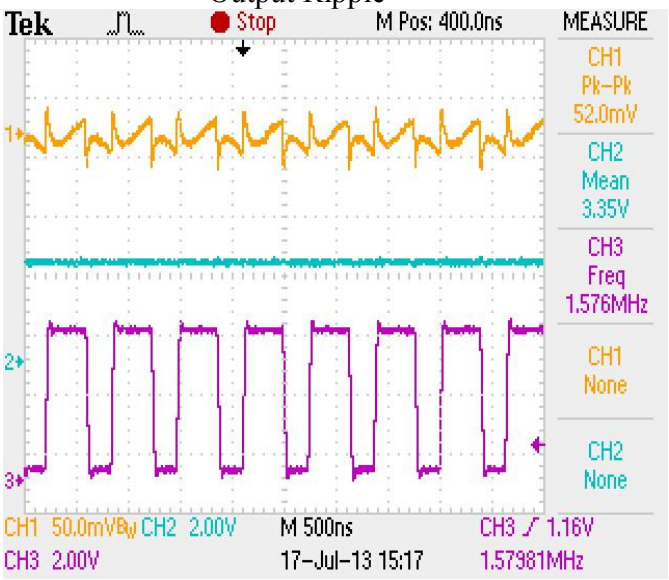
Output Ripple



CH1=Vout CH2=Vin CH3=SW

I_{LOAD} =1000mA

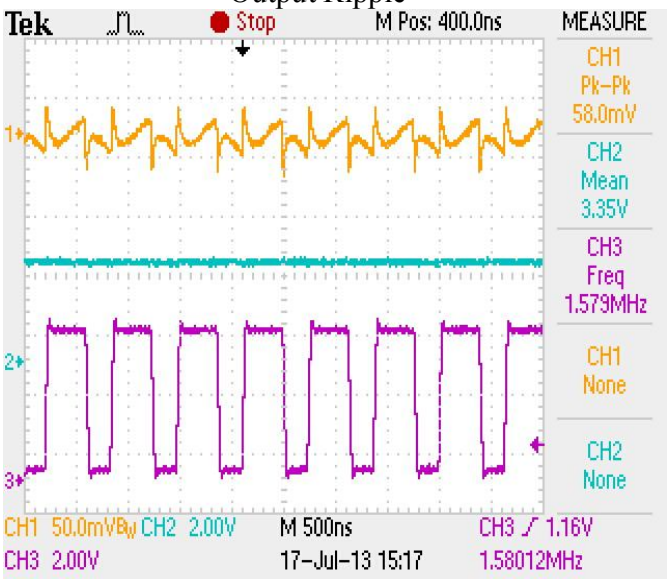
Output Ripple



CH1=Vout CH2=Vin CH3=SW

I_{LOAD} =2000mA

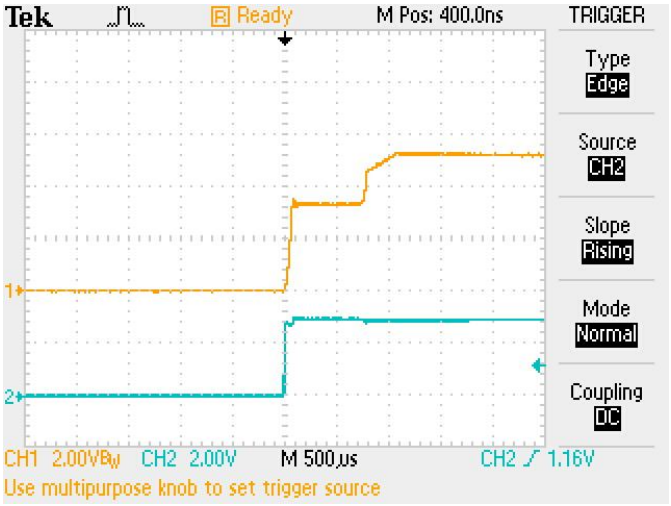
Output Ripple



CH1=Vout CH2=Vin CH3=SW

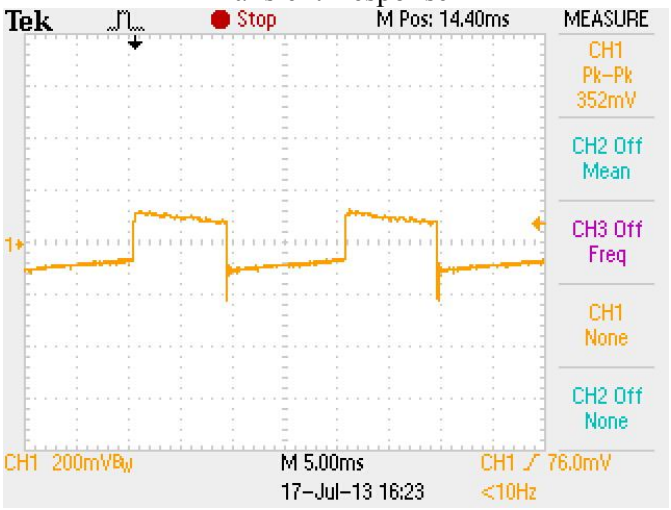
I_{LOAD} =2500mA

Soft Start



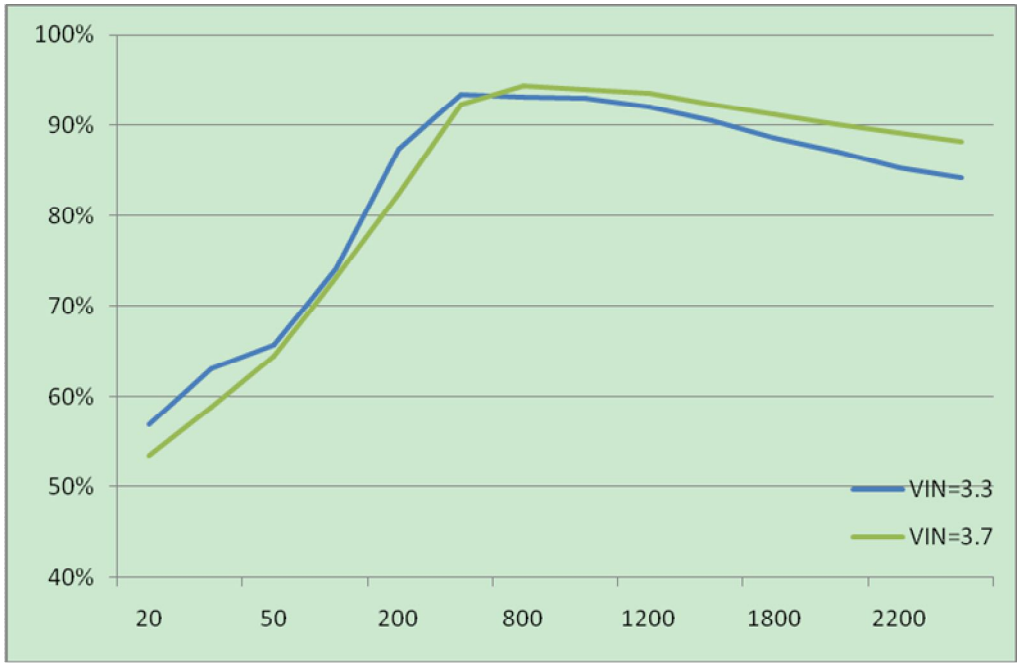
CH1=Vout CH2=EN I_{LOAD}= 10mA

Transient Response



Vin=3.3V Vout=5V I_{LOAD}= 10mA——200mA

Efficiency VS Output Current



Operation Information

The LP6253 uses a synchronous 1.4MHz fixed frequency, current-mode regulation architecture to regulate the output voltage. The LP6253 measures the output voltage through an external resistive voltage divider and compares that to the internal 0.5V reference to generate the error voltage to the inductor current to regulate the output voltage. the use of current-mode regulation improves transient response and control loop stability. The peak current of the NMOS switch is also sensed to limit the maximum current flowing through the switch and the inductor. The typical peak current limit is set to 5.5A. An internal temperature sensor prevents the device from getting overheated in case of excessive power dissipation.

The device integrates an N-channel and a P-channel MOSFET transistor to realize a synchronous rectifier. Because the commonly used discrete Schottky rectifier is replaced with a low RDS(ON) PMOS switch, the power conversion efficiency reaches 94%. To avoid ground shift due to the high currents in the NMOS switch, two separate ground pins are used. The reference for all control functions is the GND pin. The source of the NMOS switch is connected to PGND. Both grounds must be connected on the PCB at only one point close to the GND pin. A special circuit is applied to disconnect the load from the input during shutdown of the converter. In conventional synchronous rectifier circuits, the backgate diode of the high-side PMOS is forward biased in shutdown and allows current flowing from the battery to the output. This device however uses a special circuit which takes the cathode of the backgate diode of the high-side PMOS and disconnects it from the source when the regulator is not enabled (EN = low). The benefit of this feature for the system design engineer is that the battery is not depleted during shutdown of the converter. No additional components have to be added to the design to make sure that the battery is disconnected from the output of the converter.

Device Enable

The device is put into operation when EN is set high. It is put into a shutdown mode when EN is set to GND. In shutdown mode, the regulator stops switching, all internal control circuitry including the low-battery comparator is switched off, and the load is isolated from the input(as described in the Synchronous Rectifier Section). This also means that the output voltage can drop below the input voltage during shutdown. During start-up of the converter, the duty cycle and the peak current are limited in order to avoid high peak currents drawn from the battery.

Undervoltage Lockout

An undervoltage lockout function prevents device start-up if the supply voltage on VBAT is lower than approximately 1.5 V. When in operation and the battery is being discharged, the device automatically enters the shutdown mode if the voltage on VBAT drops below approximately 1.5 V. This undervoltage lockout function is implemented in order to prevent the malfunctioning of the converter.

Softstart

When the device enables the internal start-up cycle starts with the first step, the precharge phase. During precharge, the rectifying switch is turned on until the output capacitor is charged to a value close to the input voltage. The rectifying switch current is limited in that phase. This also limits the output current under short-circuit conditions at the output. After charging the output capacitor to the input voltage the device starts switching. Until the output voltage is reached, the boost switch current limit is set to 40% of its nominal value to avoid high peak currents at the battery during startup. When the output voltage is reached, the regulator takes control and the switch current limit is set back to 100%.

Power Save Mode

The MODE pin can be used to select different operation modes. To enable power save, MODE must be set low. Power save mode is used to improve efficiency at light load. In power save mode the converter only operates when the output voltage trips

below a set threshold voltage. It ramps up the output voltage with one or several pulses and goes again into power save mode once the output voltage exceeds the set threshold voltage. This power save mode can be disabled by setting the MODE to VBAT.

Low Battery Detection ---- LBI/LBO

The LP6253 low-battery detector circuit is typically used to supervise the battery voltage and to generate an error flag when the battery voltage drops below a user-set threshold voltage. The function is active only when the device is enabled. When the device is disabled, the LBO pin is high-impedance. The switching threshold is 500 mV at LBI. During normal operation, LBO stays at high impedance when the voltage, applied at LBI, is above the threshold. It is active low when the voltage at LBI goes below 500 mV

The battery voltage, at which the detection circuit switches, can be programmed with a resistive divider connected to the LBI pin. The resistive divider scales down the battery voltage to a voltage level of 500 mV, which is then compared to the LBI threshold voltage. The LBI pin has a built-in hysteresis of 10mV, If the low-battery detection circuit is not used, the LBI pin should be connected to GND (or to VBAT) and the LBO pin can be left unconnected. Do not let the LBI pin float.

The recommended value for R2 is therefore in the range of 500 kΩ. From that, the value of resistor R1, depending on the desired minimum battery voltage VBAT, can be calculated using:

$$R1=(VBAT/0.5V-1)\times R2$$

Setting the Output Voltage

Set the output voltage by selecting the resistive voltage divider ratio. The voltage divider drops the output voltage to the 0.5V feedback voltage. Use a 10K resistor for R4 of the voltage divider. Determine the high-side resistor R3 by the equation:

$$Vout=(R3/R4+1)\times V_{FB}$$

Low-EMI Switch

The device integrates a circuit that removes the ringing that typically appears on the SW node when the converter enters discontinuous current mode. In this case, the current through the inductor ramps to zero and the rectifying PMOS switch is turned off to prevent a reverse current flowing from the output capacitors back to the battery. Due to the remaining energy that is stored in parasitic components of the semiconductor and the inductor, a ringing on the SW pin is induced. The integrated antiringing switch clamps this voltage to VBAT and therefore dampens ringing.

Pre-Boost Current and Short Circuit Protect

Initially output voltage is lower than battery voltage, and the LP6253 enters pre-boost phase. During pre-boost phase, the internal NMOSFET/PMOSFET is turned off/on and a constant current is provided from battery to output until the output voltage close to the battery voltage. The constant current is limited by internal controller. If the output short to ground, the LP6253 also limits the output current to avoid damage condition.

Inductor Selection

For a better efficiency in high switching frequency converter, the inductor selection has to use a proper core material such as ferrite core to reduce the core loss and choose low ESR wire to reduce copper loss. The most important point is to prevent the core saturated when handling the maximum peak current. Using a shielded inductor can minimize radiated noise in sensitive applications. The maximum peak inductor current is the maximum input current plus the half of inductor ripple current. The calculated peak current has to be smaller than the current limitation in the electrical characteristics. A typical setting of the inductor ripple current is 20% to 40% of the maximum input current. If the selection is 40%, the maximum peak inductor current is

$$I_{PEAK}=I_{IN(MAX)}+\frac{1}{2}I_{RIPPLE}=1.2\times I_{IN(MAX)}$$
$$=1.2\times\left[\frac{I_{OUT(MAX)}\times V_{OUT}}{\eta\times V_{IN(MIN)}}\right]$$

The minimum inductance value is derived from the following equation :

$$L = \frac{\eta \times V_{IN(MIN)}^2 \times [V_{OUT}-V_{IN(MIN)}]}{0.4 \times I_{OUT(MAX)} \times V_{OUT}^2 \times f_{OSC}}$$

Depending on the application, the recommended inductor value is between 2.2μH to 10μH.

Input Capacitor Selection

For better input bypassing, low-ESR ceramic capacitors are recommended for performance. A 10μF input capacitor is sufficient for most applications. A ceramic capacitor or a tantalum capacitor with a 100 nF ceramic capacitor in parallel, placed close to the IC, is recommended .For a lower output power requirement application, this value can be decreased.

Output Capacitor Selection

For lower output voltage ripple, low-ESR ceramic capacitors are recommended. The tantalum capacitors can be used as well, but the ESR is bigger than ceramic capacitor. The output voltage ripple consists of two components: one is the pulsating output ripple current flows through the ESR, and the other is the capacitive ripple caused by charging and discharging. The major parameter necessary to define the output capacitor is the maximum allowed output voltage ripple of the converter. This ripple is determined by two parameters of the capacitor, the capacitance and the ESR. It is possible to calculate the minimum capacitance needed for the defined ripple, supposing that the ESR is zero, by using Equation:

$$V_{RIPPLE} = V_{RIPPLE\_ESR} + V_{RIPPLE\_C}$$

$$\cong I_{PEAK} \times R_{ESR} + \frac{I_{PEAK}}{C_{OUT}}\left(\frac{V_{OUT} - V_{IN}}{V_{OUT} \times f_{OSC}}\right)$$

Layout Guideline

For high frequency switching power supplies, the PCB layout is important step in system application design. In order to let IC achieve good regulation, high efficiency and stability, it is strongly recommended the power components should be placed as close as possible. The set races should be wide and short. The feedback pin and then works of feedback and compensation should keep away from the power loops, and be shielded with a ground trace or plane to prevent noise coupling.

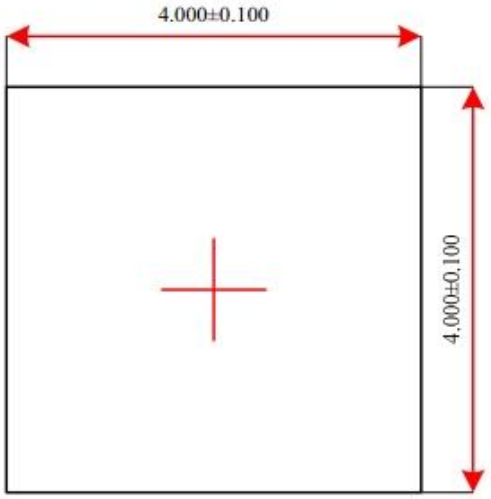
Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power-dissipation limits of a given component. Three basic approaches for enhancing thermal performance are listed below:

Improving the power dissipation capability of the PCB design

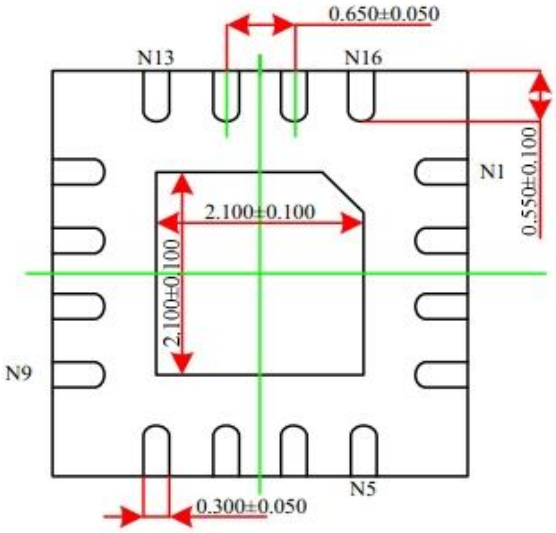
Improving the thermal coupling of the component to the PCB

Introducing airflow in the system

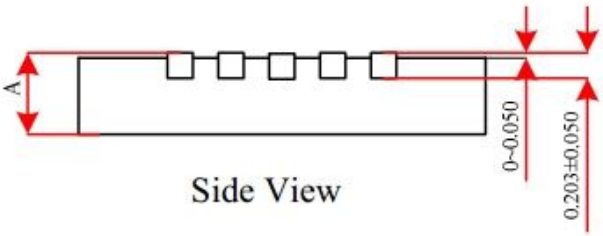
Packaging Information



Top View



Bottom View



Side View

	MIN.	NORM.	MAX.
A	0.700	0.750	0.800
	0.800	0.850	0.900