HM6313

High Efficiency Low Voltage Synchronous Step-up DC/DC Converter

GENERAL DESCRIPTION

The HM6313 is a highly efficient fix frequency synchronous step-up DC/DC converter. Output voltage of the device is adjustable. Power dissipation during operation is only 40μA typical and drops to less than 1μA in shutdown. The 0.85V to 5V input voltage range makes the HM6313 ideally suitable for single cell Li-ion battery, single or dual AA battery voltage step-up applications. Automatic PFM Mode operation increases efficiency at light loads, further extend battery life. Switching frequency is internally set at 1.2MHz, design for use of small value surface mount inductor, input and output capacitors. The internal synchronous switches enhance efficiency. Anti-ringing control circuitry reduces EMI by damping the inductance effect in DCM mode. The HM6313 is available in SOT23-6 package.

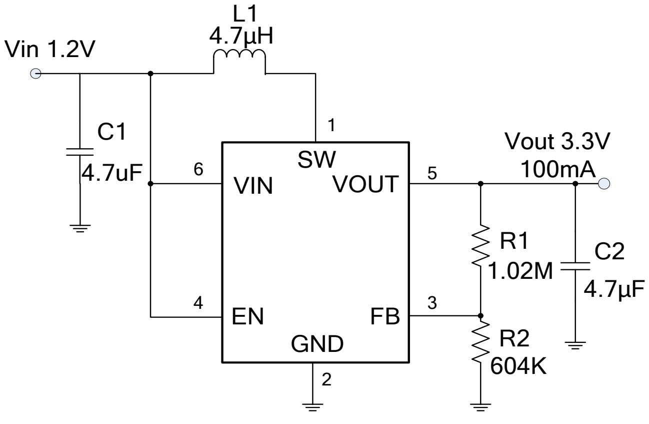
FEATURES

- Input Voltage Operating Range: 0.85V to 5V
- Voltage Output Range: 2.5V to 5.5V
- Efficiency Up to 94%
- 3.3V/100mA Output at 1.0V Input
- 5V/700mA Output at 3.6V Input
- Low Start-up Voltage: 0.85V Typical
- 1.2MHz Constant Frequency Operation
- Internal Synchronous Rectifier
- EMI Reduction Anti-Ring Control Circuitry
- Low Shutdown Current: < 1.0uA
- Over Current Protection
- Over Temperature Protection
- Light Load PFM Mode Operation
- SOT23-6 Package

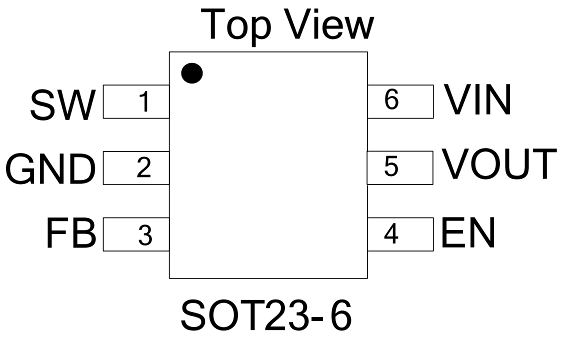
APPLICATIONS

- Li-ion Battery Charger
- USB Audio
- Wireless Mouse
- Digital Still Cameras
- MP3/MP4 Players
- Portable Instruments

TYPICAL APPLICATIONS



PIN ASSIGNMENT



PIN DESCRIPTIONS

PIN NUM	PIN NAME	DESCRIPTIONS
1	SW	Internal Switches Output
2	GND	Chip Ground
3	FB	Regulated Output Feedback
4	EN	Chip Enable, Active High
5	VOUT	Output Voltage
6	VIN	Input Voltage

ORDERING INFORMATION

PACKAGE	TEMPERATURE RANGE	ORDERING PART NUMBER	TRANSPORT MEDIA	MARKING
SOT-23-6	-40 °C~85 °C	HM6313	Tape and Reel 3000units	1311

ABSOLUTE MAXIMUM RATINGS (NOTE1)

SYMBOL	ITEM	RATING	UNIT
V_{IN}	Input Voltage	-0.3~7.0V	V
V_{SW}	SW Pin Switch Voltage	-0.3~7.0V	V
V_{OUT}	Output Voltage	-0.3~7.0V	V
V_{FB}	Feedback Voltage	-0.3~7.0V	V
V_{EN}	Enable Voltage	(GND-0.3V) to (VIN+0.3V)	V
θ_{JA}	Package Thermal Resistance	250	℃/W
T_{OPT}	Operating Temperature Range	-40~85	℃

RECOMMENDED OPERATING RANGE (NOTE2)

SYMBOL	PARAMETER	VALUE
V_{IN}	Input Voltage Range	0.85V-5V

Notes:

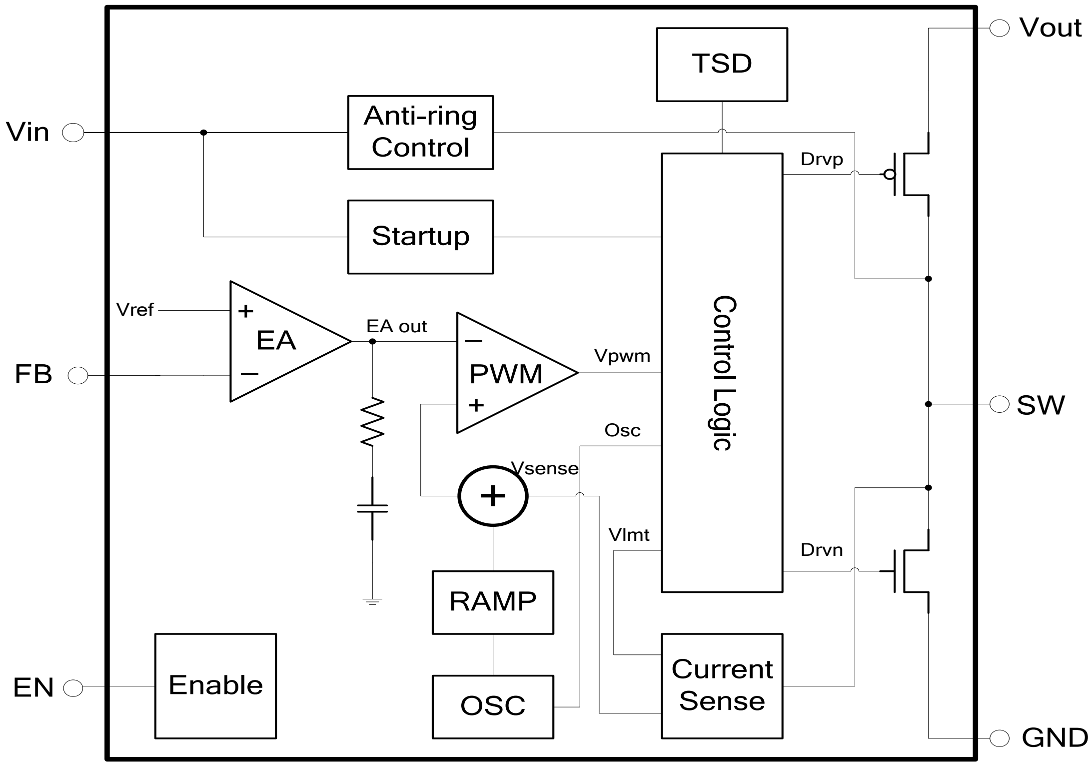
1. Exceeding these ratings may damage the device
2. The device is not guaranteed to function outside of its operating rating

ELECTRICAL CHARACTERISTICS

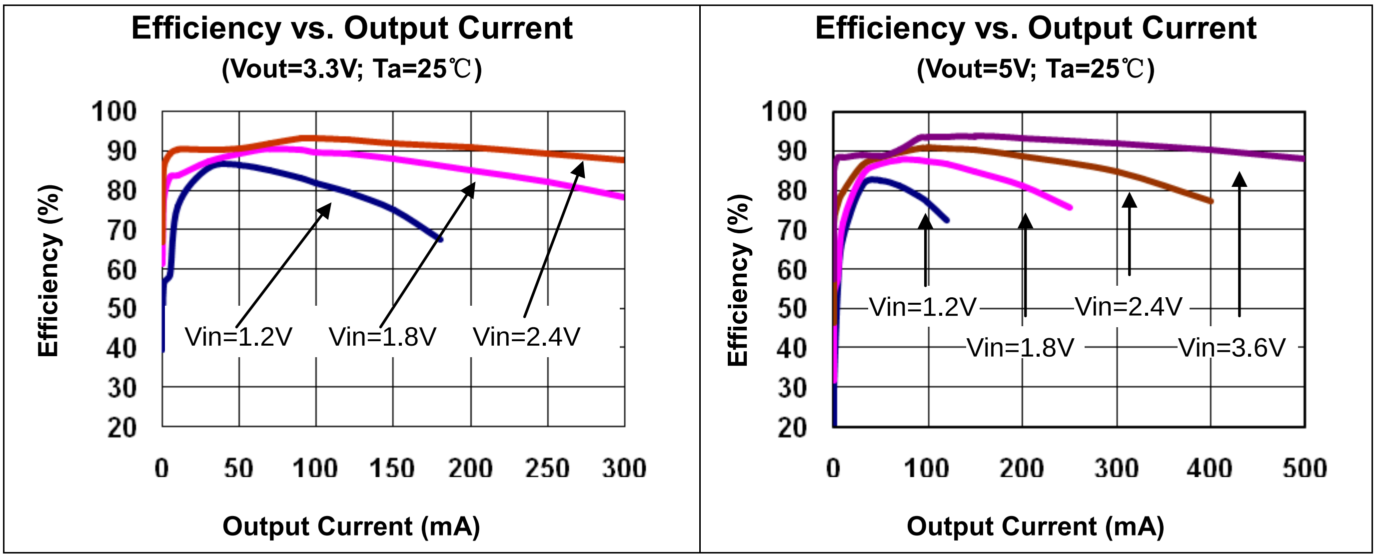
TA = 25°C. V_{IN} = 1.2V. V_{OUT} = 3.3V unless otherwise specified.

Symbol	Description	Conditions	Min	Typ	Max	Unit
V_{IN}	Minimum Startup Voltage	I_{OUT} =1mA	--	0.85	1	V
	Minimum Operational Voltage	V_{EN} =V_{IN}		0.6	0.7	V
V_{OUT}	Output Voltage Range		2.5	--	5.5	V
V_{FB}	Feedback voltage		1.225	1.25	1.275	V
I_Q	**Quiescent Current** (Active)	I_{OUT} =0mA	--	300	500	µA
	Quiescent Current (Switch off)	I_{OUT} =0mA		40		µA
	Quiescent Current (Shutdown)	V_{EN} =0	--	0.01	1	µA
Fosc	Switching Frequency		1	1.2	1.4	MHz
D_{MAX}	Maximum Duty Cycle			90		%
$R_{DS(ON)L}$	NMOS Switch On Resistance	V_{OUT}=3.3V	--	300		mΩ
		V_{OUT}=5.0V		200		mΩ
$R_{DS(ON)H}$	PMOS Switch On Resistance	V_{OUT}=3.3V	--	400		mΩ
		V_{OUT}=5.0V		300		mΩ
I_{LIMIT}	NMOS Peak Current Limit	V_{OUT}=5.0V		1.2		A
$\triangle V_{OUT}$ / V_{OUT} / $\triangle V_{IN}$	Voltage Line Regulation	V_{IN} = 1 ~ 2.5V,	--	0.2		%/V
$\triangle V_{OUT}$ / V_{OUT} / $\triangle I_{OUT}$	Voltage Load Regulation	V_{IN} = 1.2V, I_{OUT} = 10 ~ 100mA	--	0.003		%/mA
T_{SD}	Thermal Shutdown	I_{OUT} = 0		160		℃
	Hysteresis			20		℃

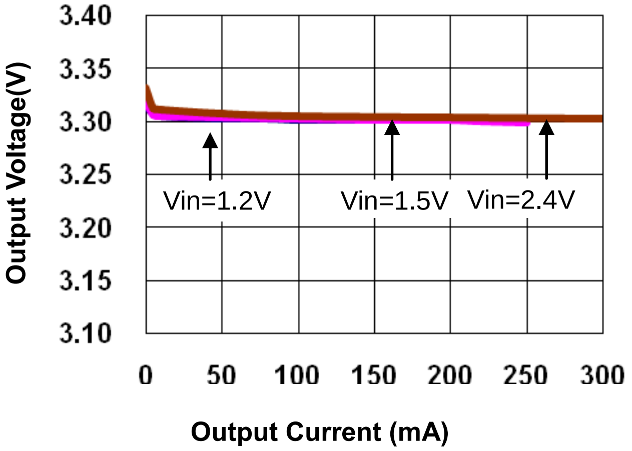
SIMPLIFIED BLOCK DIAGRAM



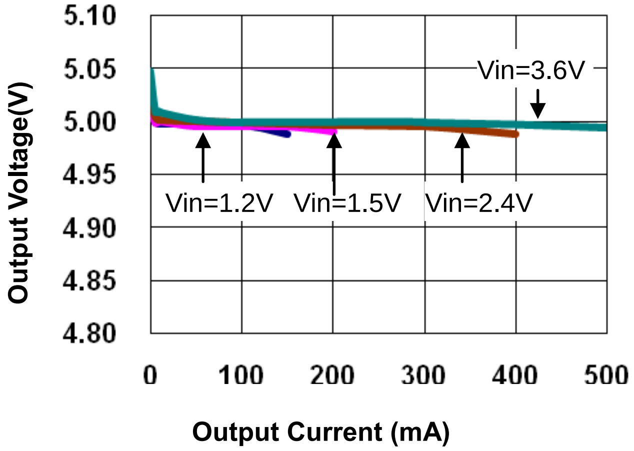
TYPICAL PERFORMANCE CHARACTERISTICS



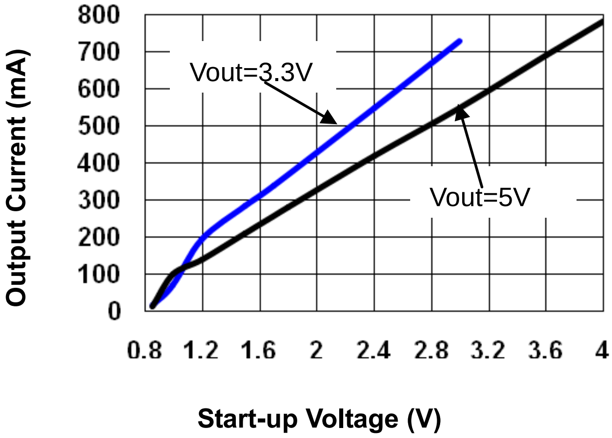
Load Regulation
(Vout=3.3V; Ta=25℃)



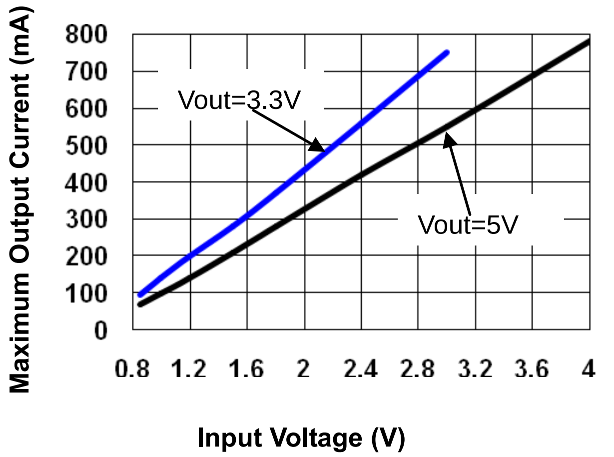
Load Regulation
(Vout=5V; Ta=25℃)



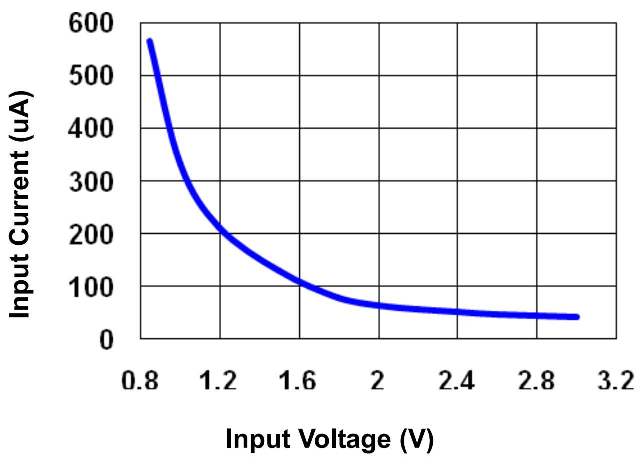
Minimum Start-up Voltage vs. Output Current(L=4.7uH; Ta=25℃)



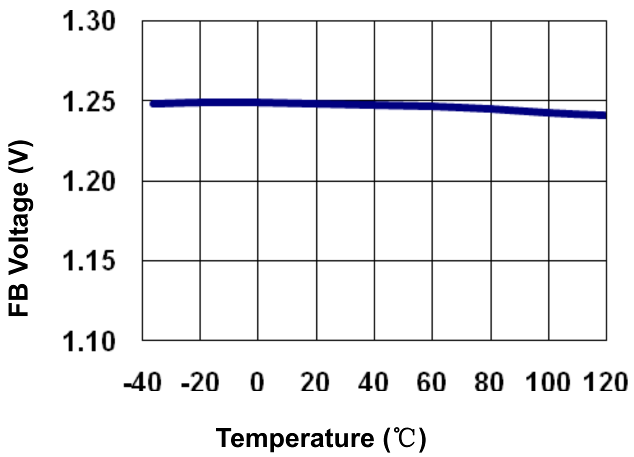
Maximum Output Current vs. Input Voltage
(L=4.7uH; Ta=25℃)



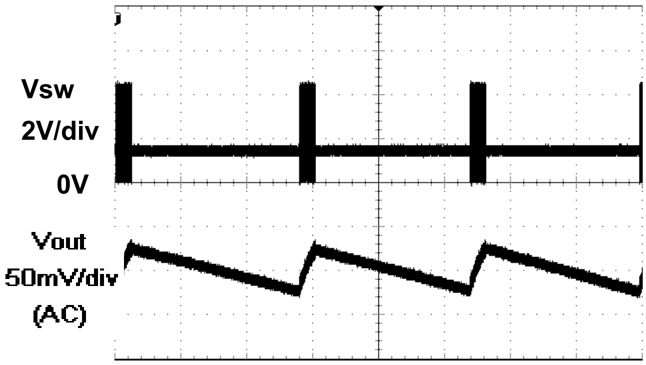
No Load Input Current vs. Input Voltage
(Vout=3.3V; Ta=25℃;No Load)



FB Voltage vs. Temperature
(Vin=1.2V;Vout=3.3V;Load=50mA)

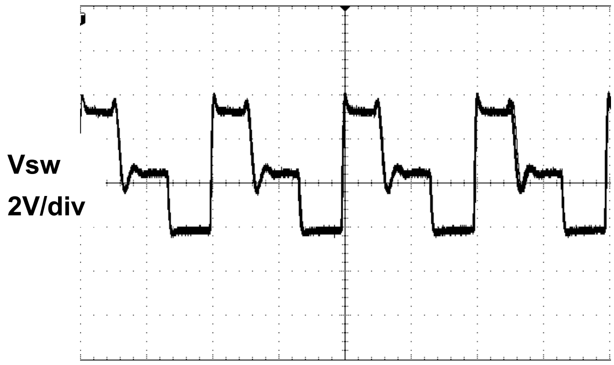


PFM Mode Operation
(Vin=1.3V Vout=3.3V; Iout=1mA)



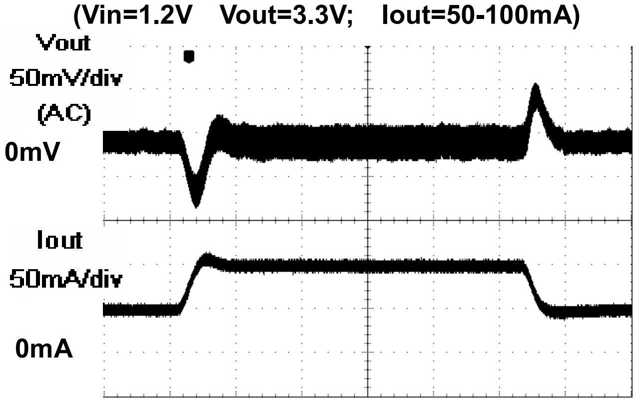
Time (200us/div)

Anti-Ringing Operation at SW
(Vin=2.4V Vout=5V; Iout=20mA)



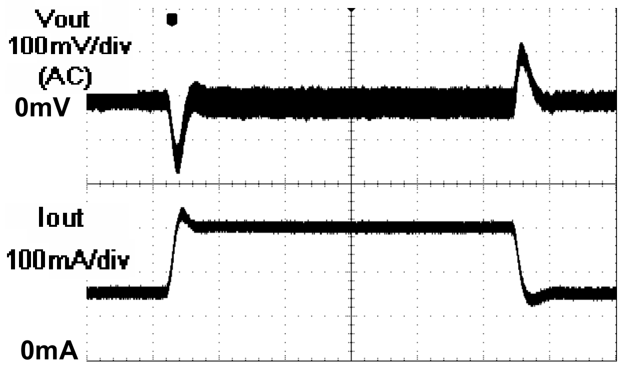
Time (400ns/div)

Load Transient Response
(Vin=1.2V Vout=3.3V; Iout=50-100mA)



Time (200us/div)

Load Transient Response
(Vin=3.6V Vout=5V; Iout=150-300mA)



Time (200us/div)

Functional Description

1) General Description

The HM6313 is a synchronous step-up DC-DC converter. It utilizes internal MOSFET switches to achieve high efficiency over full load current range. It operates at a fixed switching frequency of 1.2MHz, and uses the slope compensated peak current mode pulse width modulation (PWM) architecture. The device can operate with an input voltage below 1V and the minimum start-up voltage is 0.85V.

2) Current Mode Operation

The HM6313 is based on a slope compensated peak current mode PWM control topology. It operates at a fixed frequency of 1.2MHz. At the beginning of each clock cycle, the main switch (NMOS) is turned on and the inductor current starts to ramp. After the maximum duty cycle or the sense current signal equals the error amplifier output, the main switch is turned off and the synchronous switch (PMOS) is turned on. This control topology features cycle-by-cycle current limiting which can prevent the main switch from overstress and the external inductor from saturating.

3) Synchronous Rectification

The HM6313 integrates a synchronous rectifier to improve efficiency as well as to eliminate the need for an external Schottky diode. The synchronous rectifier is used to reduce the loss condition contributed by the forward voltage of an external Schottky diode. The synchronous rectifier is realized by a P-channel MOS (PMOS) with gate control circuitry that incorporates relatively complicated timing concerns.

4) Low voltage Start-up

The HM6313 can start-up with input voltage down to 0.85V. During start-up, the internal low voltage start-up circuitry controls the internal NMOS switch. The HM6313 leaves the start-up mode once output voltage exceeds 2V. An internal comparator monitors the output voltage and place the chip into normal operation once output voltage exceeds 2V. The supply voltage of control circuit is biased by input voltage in start-up mode and biased by output voltage in normal mode. When output voltage exceeds 2V, the HM6313 is independent of input voltage.

5) Pulse Frequency Modulation Operation

At very light load, the HM6313 automatically enters pulse frequency modulation (PFM) Mode to improve efficiency. During this mode, the PFM control will skip some pulses to maintain regulation. If the load increases and output voltage drops, the device will automatically switch back to normal PWM mode and maintain regulation.

6) Anti-Ringing Control

An anti-ringing circuitry is included to remove the high frequency ringing that appears on the SW pin when the inductor current goes to zero. In this case, a ringing on the SW pin is induced due to remaining energy stored in parasitic components of switch and inductor. The anti-ringing circuitry clamps the voltage internally to the preset voltage and therefore dampens this ringing.

APPLICATIONS INFORMATION

1) Output Voltage Setting

Referring to Typical Application Circuit, the output voltage of switching regulator (Vout) is set with following equation:

Vout=(1+R1/R2)*Vfb

2) Feedback Loop Design

Referring to Typical Application Circuit again, the selection of R1 and R2 is a trade-off between quiescent current consumption and interference immunity besides abiding by the above equation.

- Higher R reduces quiescent current (I=1.25V/R2)
- Lower R gives better interference immunity, and is less sensitive to interference, layout parasitic, FB node leakage, and improper probing to FB pin.

Hence for applications without standby or suspend modes lower R1 and R2 values are preferred, while for applications concerning the current consumption in standby or suspend modes, higher values of R1 and R2 are needed. Such high impedance feedback loop is sensitive to any interference, which requires careful PCB layout and avoid any interference, especially to FB pin. To improve the system stability, a proper value capacitor between FB pin and Vout is suggested. An empirical suggestion is around 100pF for MΩ feedback resistors and 10nF～0.1uF for lower R values.

3) Inductor Selection

The high switching frequency of 1.2MHz allows for small surface mount inductor. For most applications, the HM6313 operates with inductor from 2.2uH to 10uH. Use the following steps and equations to select the proper inductor value for a particular application condition:

1, Calculate the Average Input Current：

$$Iin\_avg = \frac{Vout * Iout}{\eta * Vin}$$

2，Calculate the Ripple Input Current：

$$\Delta I = \frac{Vin * (Vout - Vin)}{L * Vout * Fm}$$

3，Make sure the ratios of Ripple Input Current：

$$K = \frac{\Delta I}{Iin\_avg}$$ ，Normally recommend K=0.3~0.5

4，After obtained the ratios of Ripple Input Current ，then:

$$\Delta I = K * Iin\_avg = \frac{Vin * (Vout - Vin)}{L * Vout * Fsw}$$

5，Calculate the required Inductance Value L using the following equation based the above setps：

$$L = \frac{Vin * (Vout - Vin)}{K * \frac{Vout * Iout}{\eta * Vin} * Vout * Fsw}$$

6，Make sure the Peak Input Current $Ipeak$ when the output current is at full load, does not exceed 80% of the Peak Current Limit value of 1.2A.

Peak Input Current calculation equation is as follow：

$$Ipeak = Iin\_avg + \Delta I / 2$$

I_{peak} Peak Input Current
I_{out} Output Current
V_{out} Output Voltage
V_{in} Input Voltage
η Efficiency of converter
F_{sw} Switching Frequency
L Inductance Value
Iin_avg Average Input Current
K Ratios of Input Ripple Current
ΔI Input Ripple Current

4) Input Capacitor

A surface mount of 4.7uF or greater capacitor is suggested for the input capacitor. The input capacitor provides a low impedance loop for edges of the pulsed current drawn by the HM6313. Low ESR/ESL capacitors are ideal for this function. To minimize stray inductance, the capacitor should be placed as close as possible to the IC. This keeps the high frequency content of the input current localized, minimizing EMI and input voltage ripple.

5) Output Capacitor

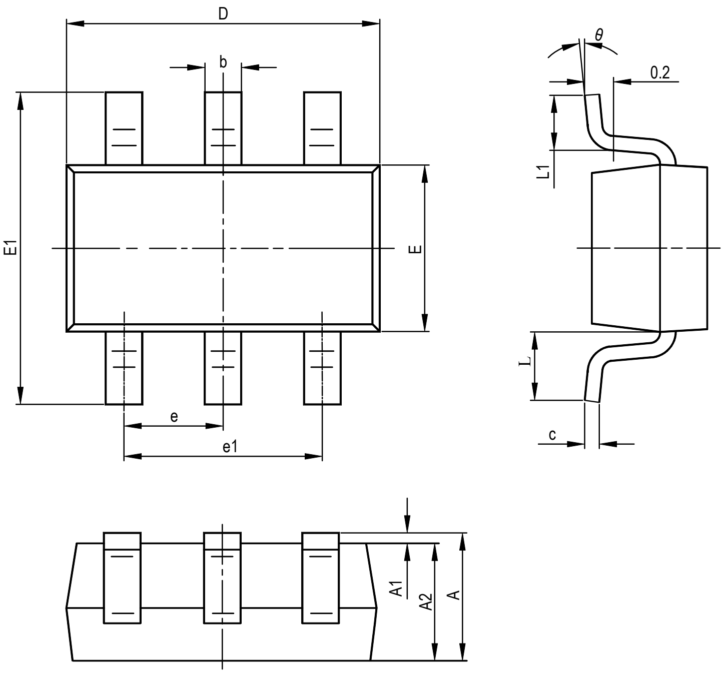
The output capacitor limits the output ripple and provides holdup during large load transitions. A 4.7uF to 10uF capacitor is suggested for the output capacitor. Typically the recommended capacitor range provides sufficient bulk capacitance to stabilize the output voltage during large load transitions and has low ESR/ESL characteristics necessary for low output voltage ripple.

6) PCB Layout Guide

PCB Layout shall follow these guidelines for better system stability:

- Arrange the power components to the appropriate positions and reduce the current loop size consist of SW pin, Vout pin, and the inductor.
- Place input decoupling ceramic capacitor C1 as close to the inductor and Vin pin as possible. Place the output decoupling ceramic capacitor C2 as close to Vout pin as possible. The GND of C1 and C2 need to connect to power GND.
- Place feedback resistor close to FB pin, Reduce the trace connected between FB pin and resistor.

PACKAGE INFORMATION



SOT23-6

SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°