36V, 1.2A Monolithic Step-Down Switching Regulator

1 Features

- 1.2A continuous output current capability
- 4.5V to 36V wide operating input range with 33V input Over Voltage Protection
- Integrated 36V, 250mΩ high side and 36V, 140mΩ low side power MOSFET switches
- Up to 92% efficiency
- Internal Soft-Start limits the inrush current at turn-on
- Internal compensation to save external components
- Input Under-Voltage Lockout
- Input over-voltage protection to protect device from working in high voltage and high current condition
- Output Over-Voltage Protection
- Output short protection with both high side current limit and low side current limit to protect the device in hard short
- Over-Temperature Protection
- Pulse skip mode at light load to improve light load efficiency
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 300KHz Switching Frequency
- Fewest external components and intensive internal protection features
- SOT23-6 Package

2 Applications

- USB car charger
- Portable charging device
- General purpose DC-DC conversion

3 Description

PL8317G is a monolithic 36V, 1.2A step-down switching regulator. PL8317G integrates a 36V 250mΩ high side and a 36V, 140mΩ low side MOSFETs to provide 1.2A continuous load current over a 4.5V to 36V wide operating input voltage with 33V input over voltage protection. Peak current mode control provides fast transient responses and cycle-by-cycle current limiting.

PL8317G has configurable line drop compensation, configurable charging current limit. CC/CV mode control provides a smooth transition between constant current charging and constant voltage charging stages. Built-in soft-start prevents inrush current at power-up.

4 Typical Application Schematic

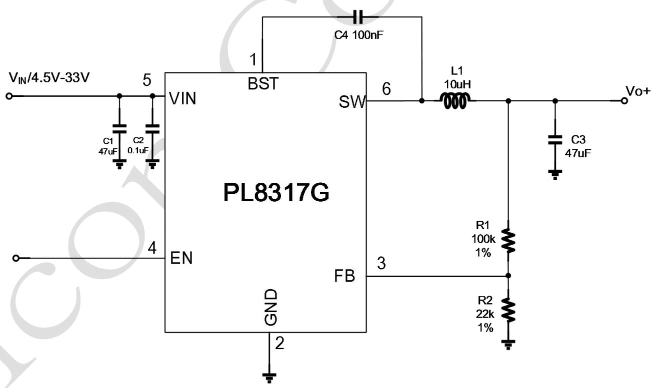


Fig. 1 Schematic

5 Pin Configuration and Functions

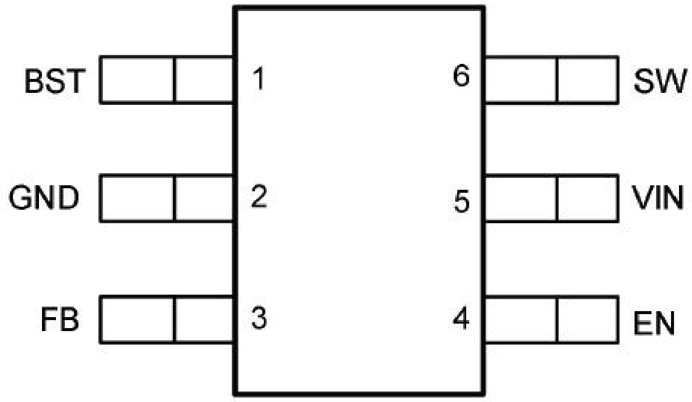


Fig. 2 PL8317G SOT23-6 Package

PL8317G Pin-Functions (SOT23-6 Package)

Pin		Description
Number	**Name**	
1	BST	Boot-Strap pin. Connect a 0.1μF or greater capacitor between SW and BST to power the high side gate driver.
2	GND	Ground
3	FB	Feedback Input. FB senses the output voltage. FB is a sensitive node. Keep FB away from SW and BST pin.
4	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator; low to turn it off. EN pin is pulled to VIN internally by a larger resistor. EN threshold is set to 1.1V without hysteresis.
5	VIN	Power Input. Vin supplies the power to the IC. Supply Vin with a 4.5V to 36V power source. Bypass Vin to GND with a large capacitor and at least another 0.1uF ceramic capacitor to eliminate noise on the input to the IC. Put the capacitors close to Vin and GND pins.
6	SW	Power Switching pin. Connect this pin to the switching node of inductor.

6 Device Marking Information

Part Number	Order Information	Package	Package Qty	Top Marking
PL8317G	**PL8317GISO06**	**SOT23-6**	**3000**	**D8YMD**

PL8317G: Part Number
YMD: Package Date

7 Specifications

7.1 Absolute Maximum Ratings(Note1)

	PARAMETER	MIN	MAX	Unit
Input Voltages	V_{IN} to GND	-0.3	36	V
	V_{EN} to GND	-0.3	6	
	V_{FB} to GND	-0.3	6	
	V_{BST} to V_{SW}	-0.3	6	
	V_{SW} to GND	-1	V_{IN}+ 0.3	

7.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T_{ST}	Storage Temperature Range	-65	150	°C
T_J	Junction Temperature		+160	°C
T_L	Lead Temperature		+260	°C
V_{ESD}	HBM Human body model	2	4	kV
	CDM Charger device model		500	V

7.3 Recommended Operating Conditions (Note 2)

	PARAMETER	MIN	MAX	Unit
Input Voltages	V_{IN} to GND	4.5	30	V
Output Voltages	V_{OUT}	0.5	V_{IN}*D_{max}	V
Output Current	I_{OUT}	0	1.2	A
Temperature	Operating junction temperature range, T_J	-40	+125	°C

7.4 Thermal Information (Note 3)

Symbol	Description	SOT23-6	Unit
θ_{JA}	Junction to ambient thermal resistance	180	°C/W
θ_{JC}	Junction to case thermal resistance	34	

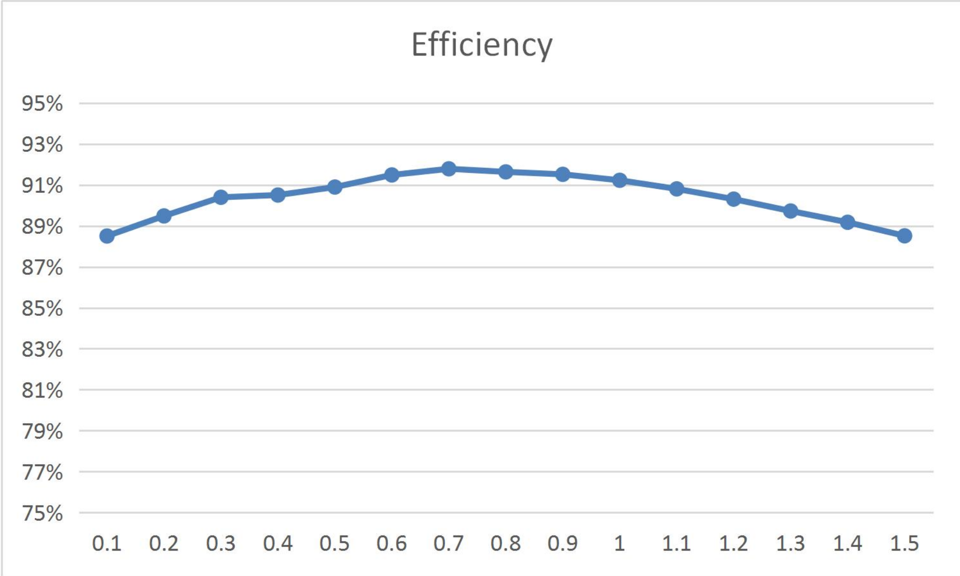
Notes:
1) Exceeding these ratings may damage the device.
2) The device function is not guaranteed outside of the recommended operating conditions.
3) Measured on approximately 1” square of 1 oz copper.

7.5 Electrical Characteristics (Typical at Vin = 12V, T_J=25°C, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
BUCK CONVERTER						
MOSFET						
I_{leak_sw}	High-Side Switch Leakage Current	V_{EN} = 0V, V_{SW}= 0V		0	10	μA
$R_{DS(ON)\_H}$	High-Side Switch On-Resistance	I_{OUT} = 1.2A, V_{OUT} = 3.3V		250		mΩ
$R_{DS(ON)\_L}$	Low-Side Switch On-Resistance	I_{OUT} = 1.2A, V_{OUT} = 3.3V		140		mΩ
SUPPLY VOLTAGE (VIN)						
V_{UVLO_up}	Minimum input voltage for startup				4.4	V
V_{UVLO_down}				4.3		V
V_{UVLO_hys}				0.3		
$I_{Q-NONSW}$	Operating quiescent current	V_{FB} =0.9V		1		mA
CONTROL LOOP						
F_{oscb}	Buck oscillator frequency			300		kHz
D_{max}	Maximum Duty Cycle(Note 4)			98		%
T_{on}	Minimum On Time(Note 4)			100		ns
PROTECTION						
I_{ocl_hs}	Upper Switch Current Limit	Minimum Duty Cycle		3.5		A
I_{ocl_ls}	Lower Switch Current Limit	From Drain to Source		1.2		A
V_{inovp}	Input Over voltage protection			33		V
Th_{sd}	Thermal Shutdown(Note 4)			155		°C
Th_{sdhys}	Thermal Shutdown Hysteresis(Note 4)			15		°C

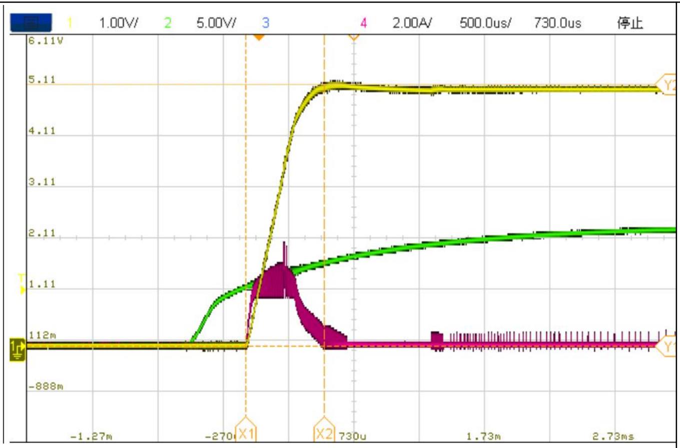
Note:
4) Guaranteed by design, not tested in production.

8 Typical Characteristics



Vin = 12V, Vout = 5V

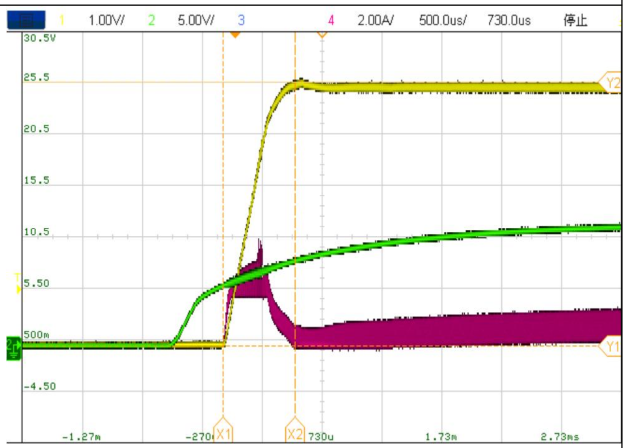
Fig. 3 Efficiency



Vin = 12V, Vo = 5V

Ch1: VOUT Ch2:VIN Ch4:IL

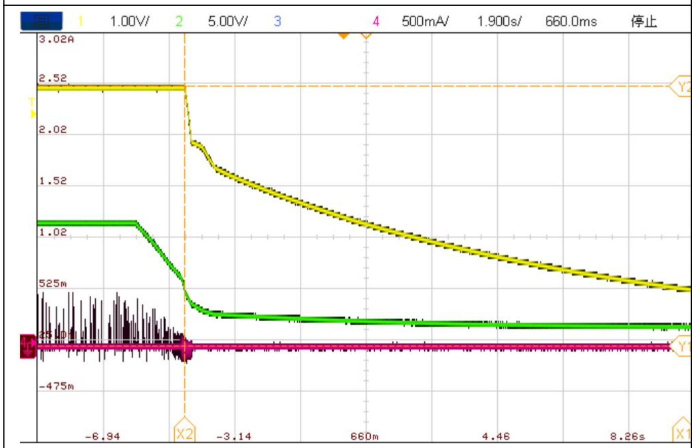
Fig. 4 Startup waveform, Iout = 0A



Vin = 12V, Vo = 5V

Ch1: VOUT Ch2:VIN Ch4:IL

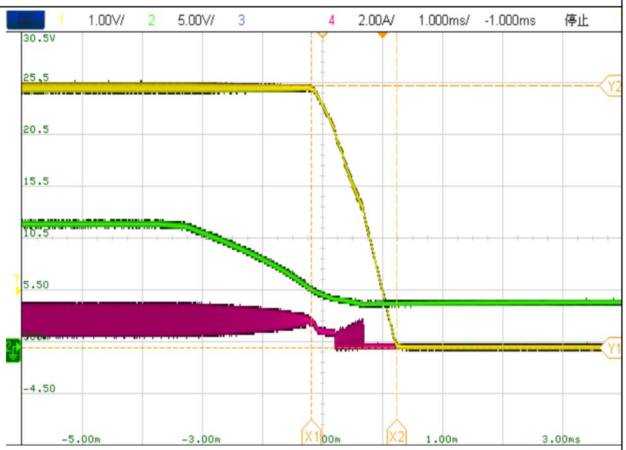
Fig. 5 Startup waveform, Iout = 0.7A



Vin = 12V, Vout = 5V

Ch1: VOUT Ch2:VIN Ch4:IL

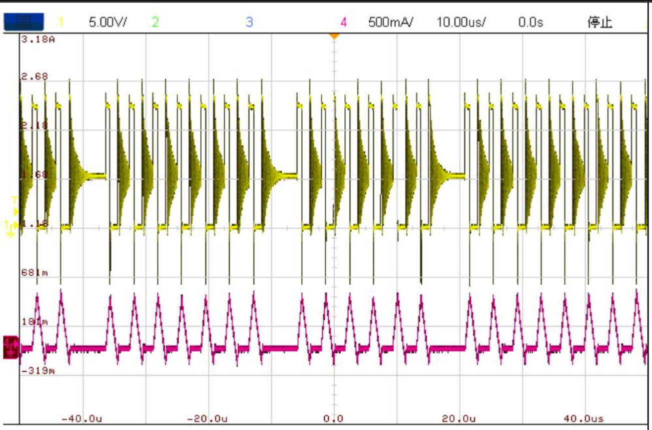
Fig. 6 Shutdown waveform, Iout = 0A



Vin = 12V, Vout = 5V

Ch1: VOUT Ch2:VIN Ch4:IL

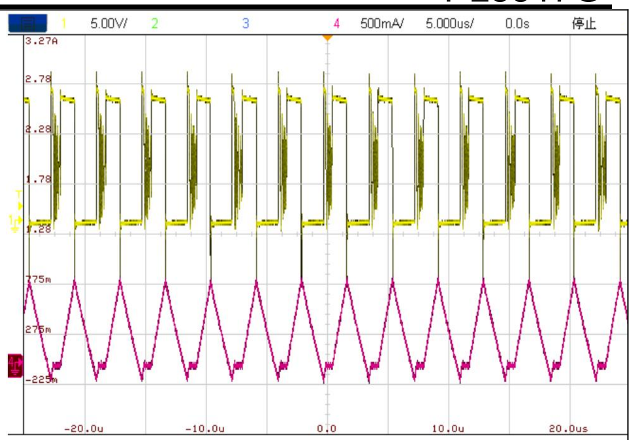
Fig. 7 Shutdown waveform, Iout = 0.7A



Vin = 12V, Vout = 5V

Ch1: SW Ch4:IL

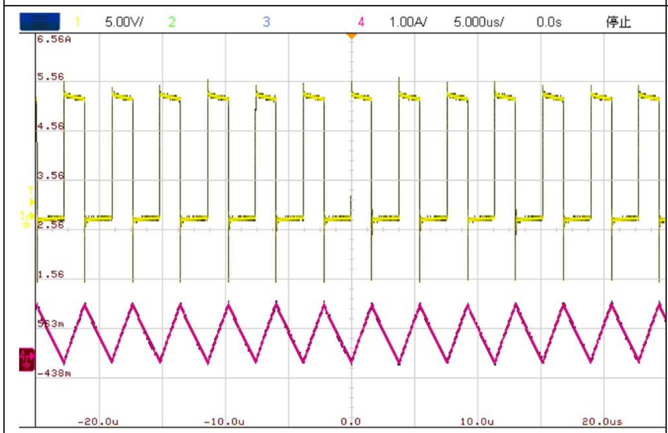
Fig. 8 Steady state waveform, Iout = 0.1A



Vin = 12V, Vout = 5V

Ch1: SW Ch4:IL

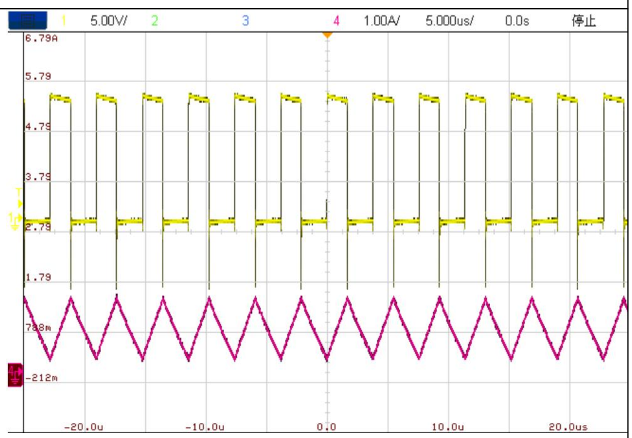
Fig. 9 Steady state waveform, Iout = 0.3A



Vin = 12V, Vout = 5V

Ch1: SW Ch4:IL

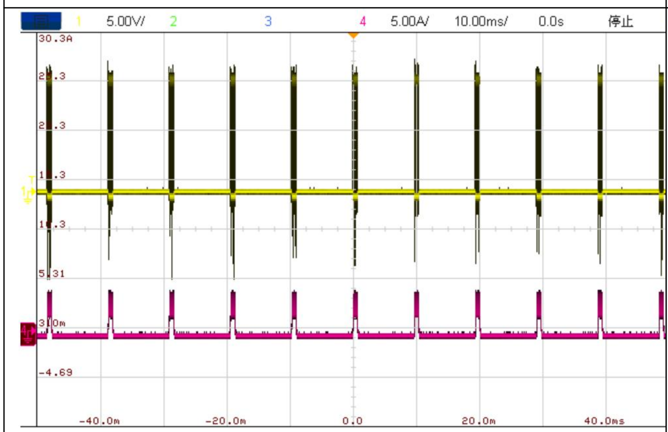
Fig. 10 Steady state waveform, Iout = 0.5A



Vin = 12V, Vout = 5V

Ch1: SW Ch4:IL

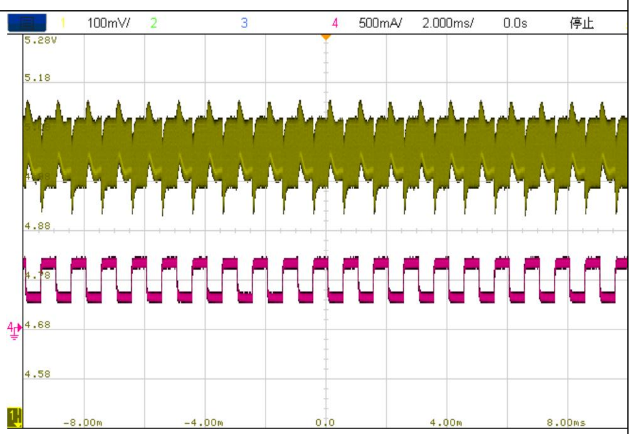
Fig. 11 Steady state waveform, Iout = 0.9A



Vin = 12V, Vout = 5V

Ch1: SW Ch4:IL

Fig. 12 Short circurt waveform



Vin = 12V, Vout = 5V

Ch1: VOUT Ch4:IL

Iout = 0.35A-0.7A,0.25A/uS ,Duty50%

Fig. 13 Load translent,

9 Detailed Description

9.1 Overview

PL8317G is an easy to use synchronous step-down DC-DC converter that operates from 4.5V to 36V supply voltage. It is capable of delivering up to 1.2A continuous load current with high efficiency and thermal performance in a very small solution size.
PL8317G also integrates input over voltage and output over voltage protection. This feature helps customers to design a safe DC-DC converter easily.
The switching frequency is fixed at 300KHz switching frequency to minimize inductor size and improve EMI performance.

9.2 Functional Block Diagram

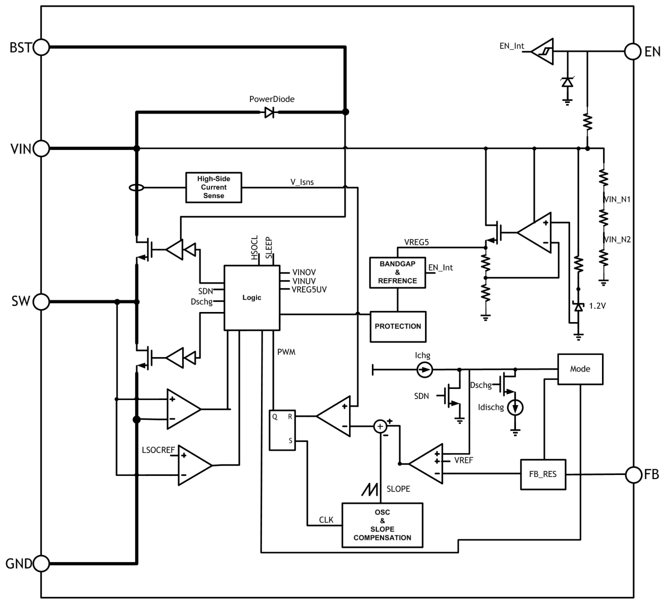


Fig.15 PL8317G Diagram

9.3 Peak Current Mode Control

PL8317G employs a fixed 300KHz frequency peak current mode control. The output voltage is sensed by an external feedback resistor string on FB pin and fed to an internal error amplifier. The output of error amplifier will compare with high side current sense signal by an internal PWM comparator. When the second signal is higher than the first one, the PWM comparator will generate a turn-off signal to turn off high side switch. The output voltage of error amplifier will increase or decrease proportionally with the output load current. PL8317G has a cycle-by-cycle peak current limit feature inside to help maintain load current in a safe region.

9.4 Sleep Operation for Light Load Efficiency

PL8317G has an internal feature to help improving light load efficiency. When output current is low, PL8317G will go into sleep mode.

9.5 Setting Enable Threshold

When the voltage at EN pin exceeds the threshold, PL8317G begins to work. When keeping EN low (below threshold), PL8317G stops working. The quiescent current of PL8317G is very low to maintain a good shut down operation for system.
PL8317G has an internal pull up resistor to make sure IC work when EN pin is float. If an application requires to control EN pin, use open drain or open collector output logic circuit to interface with it.
When system needs a higher VIN UVLO threshold, the EN pin can be configured as shown in Figure 17 below.

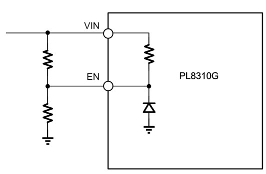


Fig.16 Adjustable VIN Under voltage Lockout

9.6 Slope Compensation

In order to avoid sub-harmonic oscillation at high duty cycle, PL8317G adds a slope compensation ramp to the sensed signal of current flowing through high side switch.

9.7 Error Amplifier

The error amplifier compares the FB voltage against the internal reference (V_{ref}) and outputs a current proportional to the difference between these two signals. This output current charges or discharges the internal compensation network to generate the error amplifier output voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control-loop design.

9.8 Bootstrap Voltage provided by internal LDO

PL8317G has an internal LDO to provide energy consumed by high side switch. At BST pin, PL8317G needs a small ceramic capacitor like 100nF between BST and SW pin to provide gate-drive voltage for high side switch. The bootstrap capacitor is charged when high side is off. In Continuous-Current-Mode, the bootstrap capacitor will be charged when low side is on. The bootstrap capacitor voltage will be maintained at about 5.3V. When IC works under sleep mode, what value the bootstrap capacitor is charged depends on the difference of Vin and output voltage. However, when the voltage on the bootstrap capacitor is below bootstrap voltage refresh threshold, PL8317G will force low side on to charge bootstrap capacitor. Connecting an external diode from the output of regulator to the BST pin will also work and increase the efficiency of the regulator when output is high enough.

9.9 High Side Over-Current Protection

In PL8317G, high-side MOSFET current is sensed. This sensed signal will compare the lower voltage between COMP pin voltage and over current threshold. High-side MOSFET will be turned off when the sensed current reaches the lower voltage. In normal operation, COMP pin voltage will be lower. If the over current threshold is lower, PL8317G enters over current protection mode.

9.10 Thermal Shutdown

The internal thermal-shutdown circuitry forces the device to stop switching if the junction temperature exceeds 155°C typically. When the junction temperature drops below 140°C, IC will start to work again.

10 Application and Implementation

10.1 Inductor selection

An inductor is required to supply constant current to the load while being driven by the switched input voltage. A larger value inductor will result in less current ripple and lower output voltage ripple. However, the larger value inductor will have larger physical size, higher DC resistance, and/or lower saturation current. A good rule to calculate the inductance is to allow the peak-to-peak ripple current in the inductor to be approximately 25% of the maximum load current. At the same time, it is needed to make sure that the peak inductor current is below the inductor saturation current.

The inductance value can be calculated by:

$$L=\frac{V_{OUT}}{f_s\times\Delta I_L}\left(1-\frac{V_{OUT}}{V_{IN}}\right) \quad (1)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum peak current. The peak inductor current can be calculated by:

$$I_{L\_P}=I_{load}+\frac{V_{OUT}}{2\times f_s\times L}\left(1-\frac{V_{OUT}}{V_{IN}}\right) \quad (2)$$

Where I_{load} is the load current.

The choice of inductor material mainly depends on the price vs. size requirements and EMI constraints.

10.2 Input capacitors selection

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the converter. It is recommend to use low ESR capacitors to optimize the performance. Ceramic capacitor is preferred, but tantalum or low-ESR electrolytic capacitors may also meet the requirements. It is better to choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C_{IN}) absorbs the input switching current, a good ripple current rating is required for the capacitor. The RMS current in the input capacitor can be estimated by:

$$I_{CIN}=I_{load}\times\sqrt{\frac{V_{OUT}}{V_{IN}}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)} \quad (3)$$

The worst-case condition occurs at $V_{IN} = 2\times V_{OUT}$, where:

$$I_{CIN}=\frac{I_{load}}{2} \quad (4)$$

For simplification, choose the input capacitor whose RMS current rating is greater than half of the maximum load current.

When electrolytic or tantalum capacitors are used, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When ceramic capacitors are used, make sure that they have enough capacitance to maintain voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta V_{IN}=\frac{I_{load}}{f_s\times C_{IN}}\times\frac{V_{OUT}}{V_{IN}}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right) \quad (5)$$

C_{IN} is the input capacitance.

10.3 Output capacitors selection

The output capacitor (C_{OUT}) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended.

Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT}=\frac{V_{OUT}}{f_s\times L}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)\times\left(R_{ESR}+\frac{1}{8\times f_s\times C_{OUT}}\right) \quad (6)$$

Where L is the inductor value, R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor and C_{OUT} is the output capacitance value. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly determined by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT}=\frac{V_{OUT}}{8\times f_S{}^2\times L\times C_{OUT}}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right) \quad (7)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT}=\frac{V_{OUT}}{f_S\times L}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)\times R_{ESR} \quad (8)$$

The characteristics of the output capacitor also affect the stability of the regulator. PL6320is optimized for a wide range of capacitance and ESR values.

.

11 PCB Layout

11.1 Guideline

PCB layout is a critical portion of good power supply design. The following guidelines will help users design a PCB with the best power conversion efficiency, thermal performance, and minimized EMI.

1. The input bypass capacitor C_1 and C_2 must be placed as close as possible to V_{IN} pin and GND pin. Grounding for both the input and output capacitors should consist of localized top side planes. Make the GND plane as big as possible for best thermal performance.
2. Place current sense resister R3 as close as possible to the chip and stay away from noisy nodes such as SW, BST.
3. Input capacitor, output capacitor, inductor and PL8317G should be placed evenly on the PCB board for the best thermal performance. Separate PL8317G from inductor as much as possible since they are the hottest components on the PCB.

11.2 Example

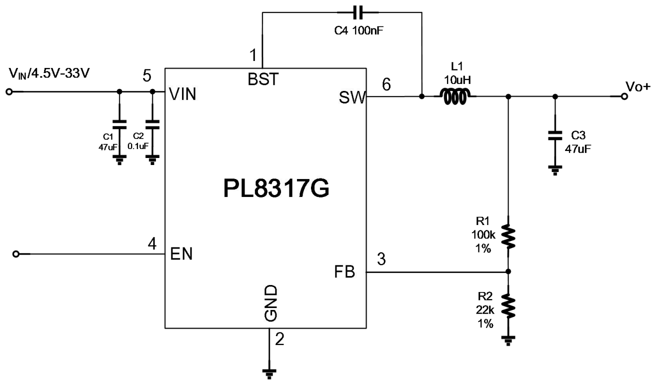
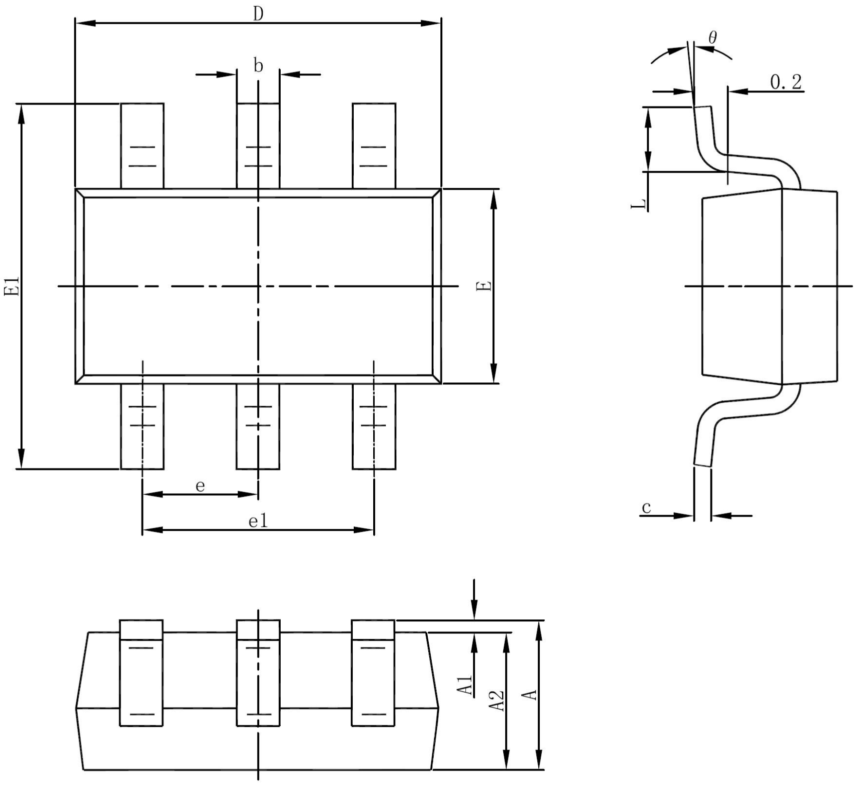


Fig.17 Schematic

SOT-23-6L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In 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	0.500	0.012	0.020
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	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°