APSemi

APS1007

Micropower, High Efficiency, Step-up DC-DC Converter

General Description

The APS1007 is a micropower, high efficiency, and low voltage step-up DC/DC converter intended for use in battery powered wireless applications. With the low start-up input voltage below 1V, the device is suitable for applications with 1 or 2 AA cells, providing up to 300mA output current at 3.3V output. The 35µA low quiescent current, zero shutdown current and high efficiency maintains long battery lifetime. A switching frequency of 450KHz minimizes solution footprint by allowing the use of small inductors and ceramic capacitors. The device is offered in a low profile (1mm) small 6-lead SOT-23 package.

The current mode PWM design is optimized for stable and high efficiency operations over a wide range of load currents. With low resistance internal MOSFET switches, the APS1007 maintains high efficiency over a wide range of load current. In addition to its high efficiency at moderate and heavy loads, the APS1007 includes automatic PFM operation that improves efficiency of the power converter at light loads.

Features

- Low Start-up voltage: 1.0V
- 35µA Quiescent Supply Current in switch-off mode
- <1µA Shutdown Current
- 90% Efficiency
- Excellent load and line regulation characteristics
- 350mΩ Internal MOSFET
- 450KHz Fixed Switching Frequency
- Small 6-Lead SOT-23 package

Applications

- Wireless key board and mouse
- MP3 Player
- PDA
- DSC
- LCD Panel
- RF-Tags
- Portable Equipment

Ordering Information

Part Number	Top Mark	Temp. Range
APS1007ET6	E1XY(NOTE 1)	-40°C to +85°C

Note1: XY is manufacture date code.

Typical Application

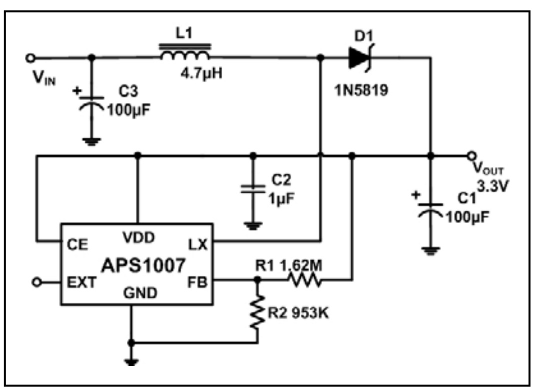


Figure1. Basic Application Circuit for APS1007

Pin Configurations

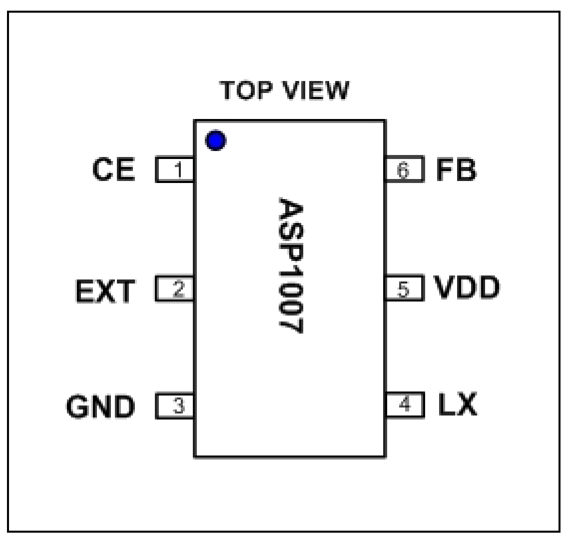


Figure2. Top View of ASP1007

Absolute Maximum Rating (Note 2)

Supply Voltage ....-0.3V to 6V
LX Pin Switch Voltage .... -0.3V to 6V
Other I/O Pin Voltage........ -0.3V to (V_{DD} + 0.3V)
LX Pin Switch Current 2.5A

EXT Pin Driver Current 150mA
Operating Junction Temperature (NOTE 3) ... +125℃
Storage Temperature Range ....-65℃ to +150℃

Note 2: Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

Thermal Resistance (Note 4):

Package	Θ_{JA}	Θ_{JC}
TSOT23-6L	220°C/W	110°C/W

Note 3: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula:

$$T_J = T_A + P_D \times (220°C/W).$$

Note 4: Thermal Resistance is specified with approximately 1 square of 1 oz cooper.

Electrical Characteristics

(V_{IN} = 1.5V, V_{OUT}=3.3V, I_L = 0mA, TA = 25℃, Test Circuit Figure 3,unless otherwise specified)

Parameter	Test Condition	Min	Typ	Max	Units
Start-UP Voltage	I_L = 1mA		0.85	1.05	V
Operating V_{OUT} Range (NOTE 5)	V_{DD} Pin voltage	2		4.2	V
Quiescent current (Shutdown Current)	CE Pin = 0V, V_{IN} = 4.5V		0.01	1	μA
Quiescent current (Switch-off Current)	V_{IN} = 6V		35	50	μA
Quiescent current (Continuous Switching Current)	V_{IN} = CE = 3.3V, V_{FB} =GND		0.4	0.6	mA
Quiescent current (No Load Current)			110		μA
Feedback Reference Voltage	T_A = +25°C	1.195	1.220	1.245	V
	T_A= 0°C ≤ T_A ≤ 85°C	1.190	1.220	1.250	V
	T_A= -40°C ≤ T_A ≤ 85°C	1.183	1.220	1.257	V
Switching Frequency		380	450	520	kHz
Maximum Duty		85	90		%
LX ON Resistance			0.3	1.1	Ω
Current Limit Setting			2		A
EXT ON Resistance to V_{DD}			16		Ω
EXT ON Resistance to GND			18		Ω

Output Voltage	V_{IN}=1.5V, I_L = 100mA T_A= -40°C ≤ T_A ≤ 85°C	3.200	3.300	3.400	V
Output Voltage	V_{IN}=3.0V, I_L = 300mA T_A= -40°C ≤ T_A ≤ 85°C	3.200	3.300	3.400	V
Line Regulation	V_{IN} = 1.0 to 3.0V, I_L = 1mA		0.3		mV/V
Load Regulation	V_{IN} = 1.5V, I_L = 1 to 100mA		0.3		mV/mA
Load Regulation	V_{IN} = 3.0, I_L = 1 to 300mA		0.1		mV/mA
CE Pin Trip Level		0.4	0.8	1.2	V
Temperature Stability for V_{OUT}			110		ppm/℃
Thermal Shutdown			165		℃
Thermal Shutdown Hysteresis			10		℃

NOTE 5: The APS1007 is best suited for application with V_{OUT} = 3.3V.

Test Circuit

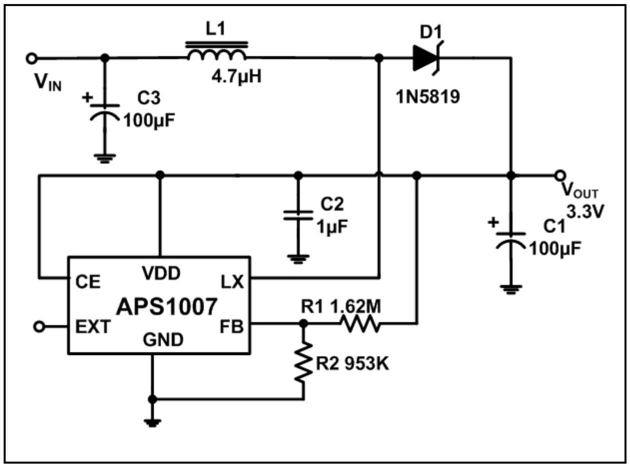


Figure 3. Test Circuit

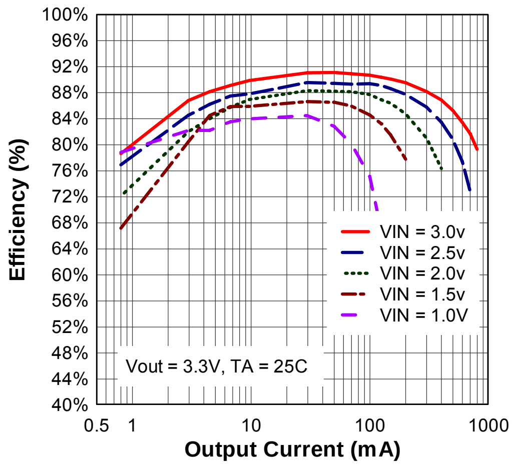
Pin Description

Pin No.	Pin Name	Pin Function
1	CE	Chip enable APS1007 gets into shutdown mode when CE pin set to low
2	EXT	Output pin for driving external NMOS
3	GND	Ground
4	LX	Pin for switching
5	VDD	Input positive power pin
6	FB	Feedback input pin Internal reference voltage for the error amplifier is 1.25V

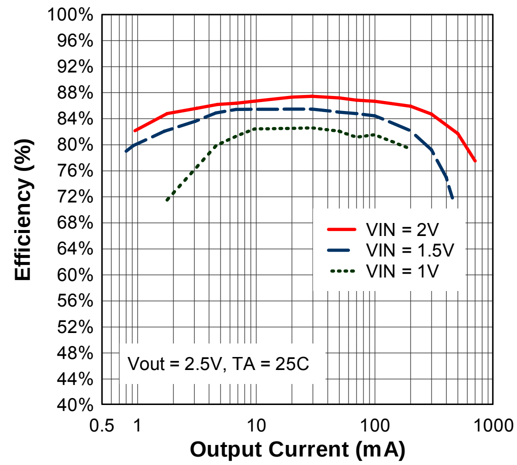
Typical Performance Characteristics

(Test Figure 3 above unless otherwise specified)

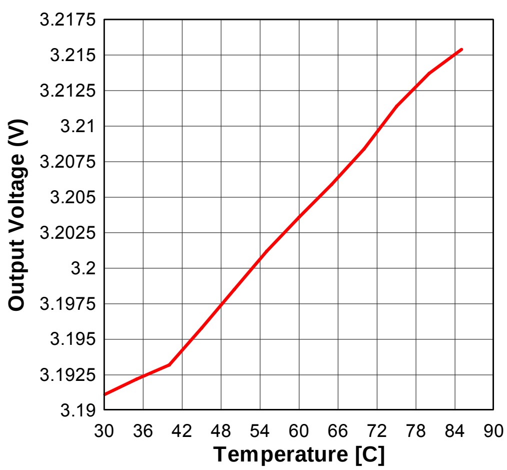
Efficiency vs. Output Current, Vout = 3.3V



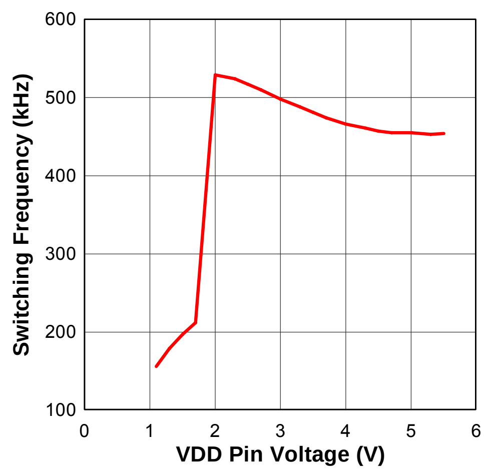
Efficiency vs. Output Current, Vout = 2.5V



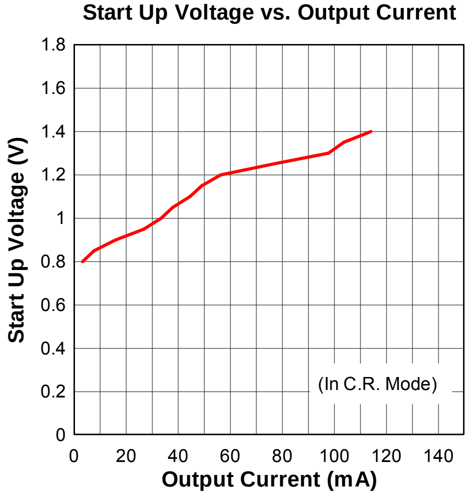
Output Voltage vs. Temperature



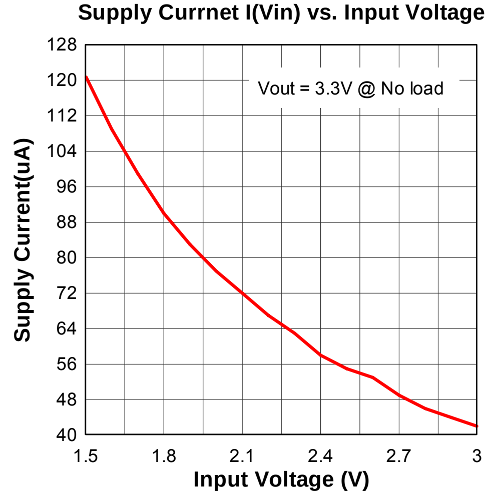
Switching Frequency vs. Pin Voltage



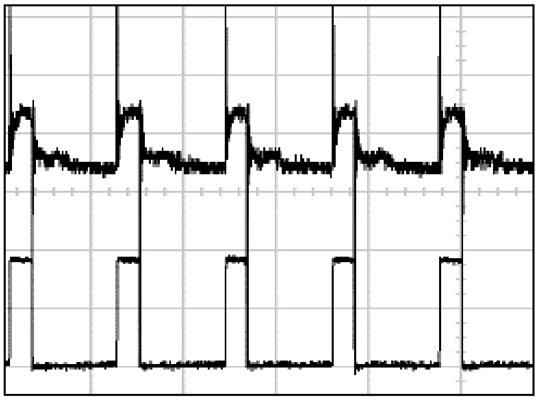
Start Up Voltage vs. Output Current



Supply Currnet I(Vin) vs. Input Voltage

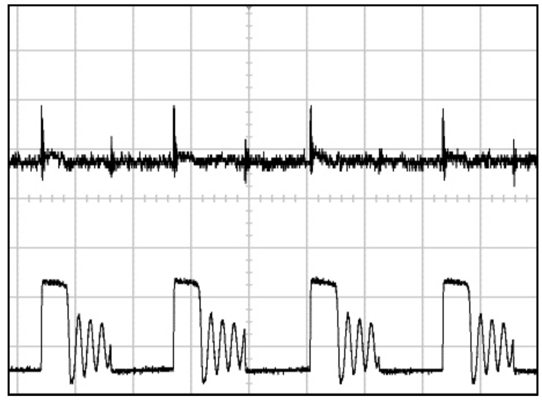


LX Pin Wave Form & Output Ripple



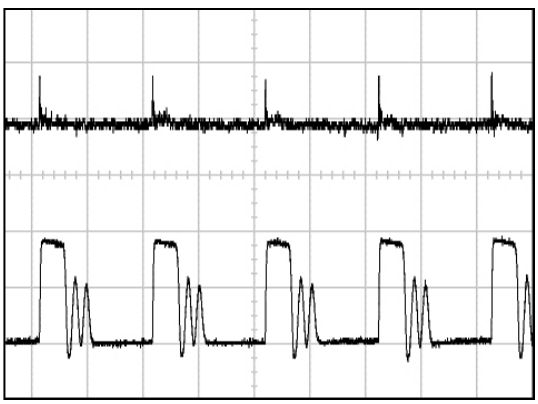
Vin = 1V, Vout = 3.3V @ 100mA

LX Pin Wave Form & Output Ripple



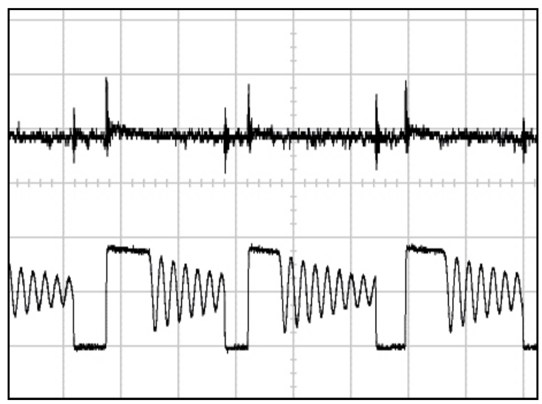
VIN=1V, VOUT=3.3V @10mA

LX Pin Wave Form & Output Ripple



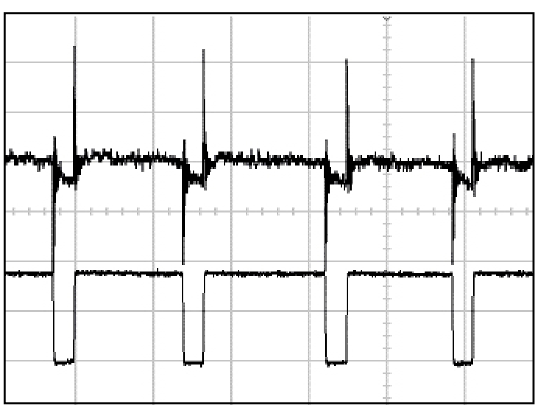
VIN=2V, VOUT = 3.3V @ 200mA

LX Pin Wave Form & Output Ripple



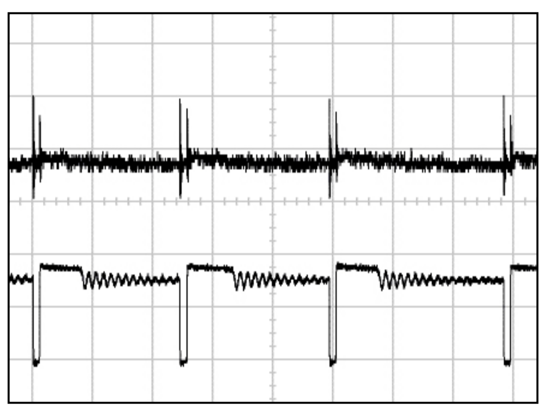
VIN=2V, VOUT3.3V @ 10mA

LX Pin Wave Form & Output Ripple



VIN=3V, VOUT=3.3v @ 200mA

LX Pin Wave Form & Output Ripple



VIN=3V, VOUT=3.3v @ 10mA

Function Block Diagram

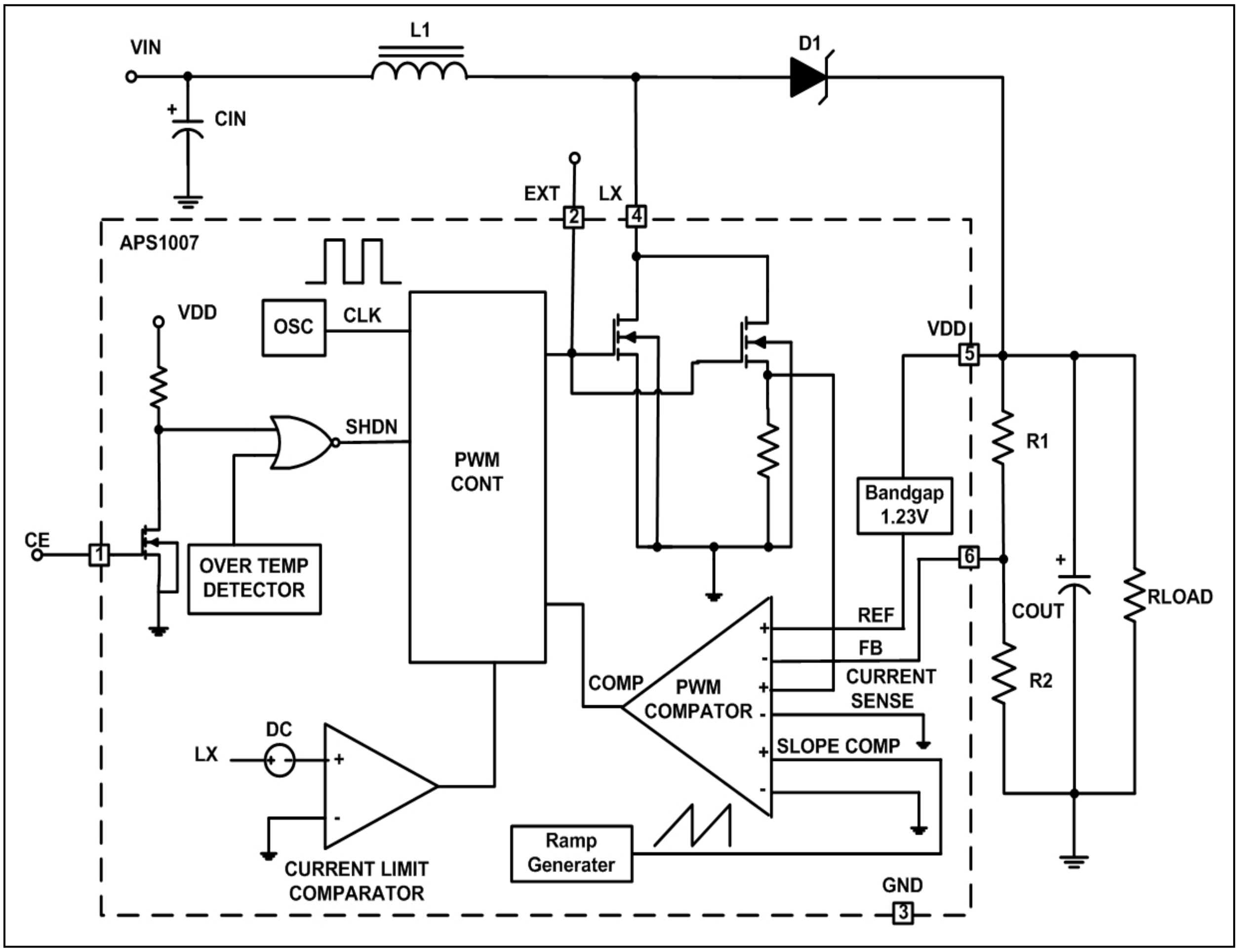


Figure 4. APS1007 Functional Block Diagram

Operation

The APS1007 is a current mode PWM boost converter with a fixed switching frequency at 450KHz. It is able to operate from an input voltage below 1V. With its low R_{DS} (ON) internal MOSFET switch, this device maintains the high efficiency over a wide range of load current.

Low Voltage Start-Up

The APS1007 will start up with a typical VIN voltage at 1V. The low voltage start-up circuitry controls the internal NMOS switch allowing the devices to start up into an output load. Once VOUT exceeds 1.8V, the start-up circuitry is disabled and normal fixed frequency PWM operation is initiated. In this mode, the APS1007 operates independent of VIN. The limiting factor for the application becomes the ability of the battery to supply sufficient energy to the output.

Low Noise Fixed Frequency Operation

Oscillator: The frequency of operation is internally set to 450KHz.

Error Amp: The internal 1.220V reference voltage is compared to the voltage at the FB pin to generate an error signal at the output of the error amplifier. A voltage divider from VOUT to ground programs the output according to the equation:

$$V_{OUT} = 1.220V \cdot [1 + \frac{R_1}{R_2}] \quad \text{(Eq. 1)}$$

Due to device performance limitation, the APS1007 is limited to applications with output voltage less than 4.2V, until the problem is corrected at later date.

PWM MODE: Refer to Figure 4, functional block diagram. The main gain block is a comparator that sums four signals: feedback voltage, reference, current-sensing and slope compensation ramp. This direct-summing method approaches the ideal of cycle-by cycle control of output voltage. Under heavy loads, the controller operates in full PWM mode. Every pulse from the oscillator sets the output latch and turns on the NMOS switch for a period determined by the duty factor and current limit.

PFM Mode Operation: Portable devices frequently spend extended time in low power or standby mode, only switching to high power mode when specific functions are enabled. Maintain high efficiency over a wide range of load current is critical for prolong battery life. In addition to its high efficiency at moderate and heavy loads, the APS1007 includes automatic PFM operation that improves efficiency of the converter at light load. PFM operation is initiated if the output load current falls below an internally programmed threshold. Once initiated, the PFM operation circuitry shuts down most of the device, only keeping alive the circuitry required to monitor the output voltage.

Application Information

COMPONENT SELECTION

Inductor Selection

The APS1007 can utilize small surface mount and chip inductors operating at 450KHz switching frequency. The inductor current ripple is typically set for 20% to 40% of the maximum inductor current. The inductor should have low ESR (series resistance of the windings) to reduce the I^2R power losses, and must be able to handle the peak inductor current without saturating.

Output and Input Capacitor Selection

Low ESR (equivalent series resistance) capacitors should be used to minimize the output voltage ripple. Low ESR input capacitors reduce input switching noise and reduce the peak current drawn from the battery. The input decoupling capacitor should be located as close as possible to the device.

Output Voltage Setting

The output voltage of the switching regulator (VOUT) is determined by (Eq. 1)

Feedback Loop Design

The value selection for R1 and R2 is based on the trade-off between quiescent current consumption and interference immunity.

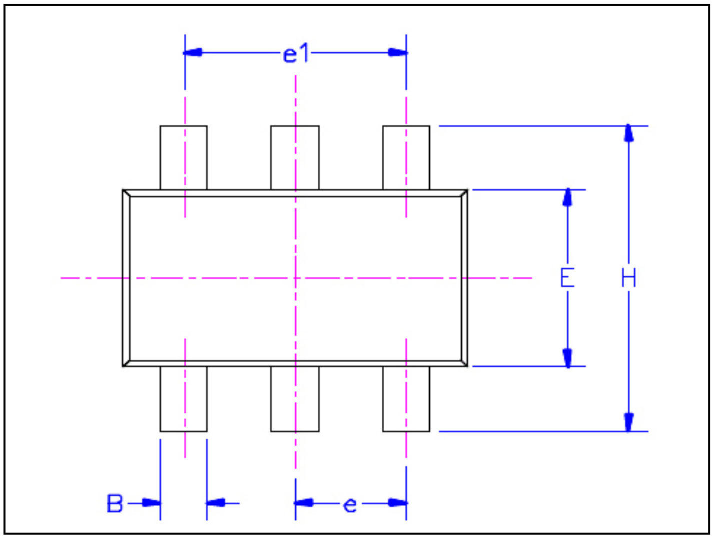
Higher values for R1 and R2 will reduce the quiescent current, while Lower values for R1 and R2 has the advantage of a better noise immunity, and is less sensitive to other interferences. However, a resistor having a value higher than 5MΩ is not recommended. The noise immunity of the feedback loops can be improved by using a proper value of feed forward capacitor in parallel with R1. The value for this capacitor is between 0 to 33pF for feedback resistors of MΩ, and 10nF to 0.1μF for feedback resistors of tens to hundreds KΩ.

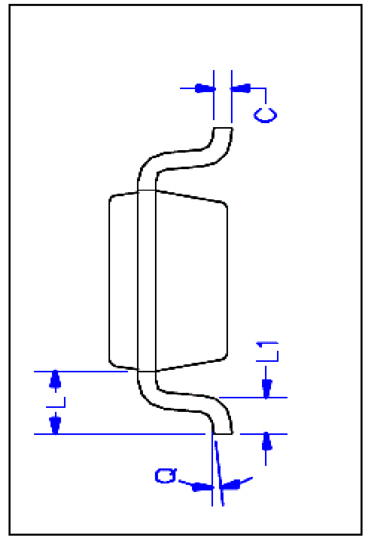
Be aware that such kind of “high impedance feedback Loops” is sensitive to any interference, which require careful layout and avoid any interference.

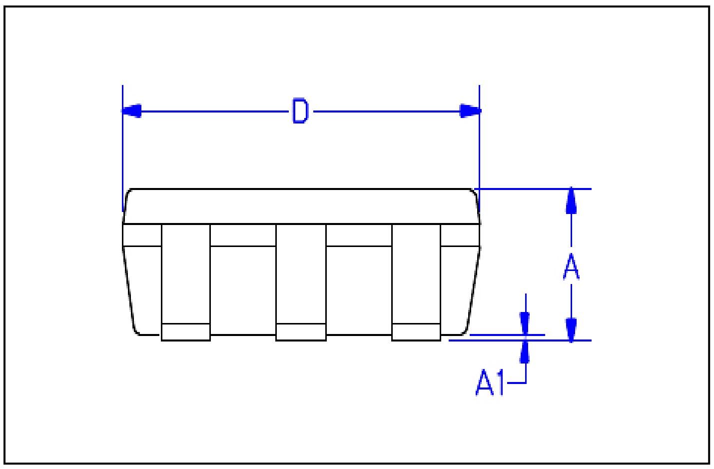
Layout Guide

1. The power traces, which are consisted of GND trace, the LX trace and the VIN trace should be kept short, direct and wide.
2. Keep the switching node, LX, away from the sensitive V_{FB} node.
3. Keep the distance between pin LX and L1 as close as possible, and no more than 3 - 4mm.
4. Keep the distance between capacitor C3 and L1 as close as possible, no more than 3 - 4mm.
5. Connect the (+) plate of C_{IN} to V_{IN} as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
6. Connect pin V_{FB} directly to the feedback resistors. The resistive divider R_1/ R_2 must be connected between the (+) plate of C_{OUT} and ground.
7. Keep the (-) plates of C_{IN} and C_{OUT} as close as possible.

Package Information







Dimension	Min.	Max.
A	0.90	1.10
A1	0.01	0.13
B	0.30	0.50
C	0.09	0.20
D	2.80	3.10
H	2.50	3.10
E	1.50	1.70
e	0.95 REF.	
e1	1.90 REF.	
L1	0.20	0.55
L	0.35	0.80
Q	0º	10º

Note: All dimensions in MM

Figure 6. APS1007 Package Outline Dimensions

IMPORTANT NOTICE

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