PWM Step-Down Controller

❖ GENERAL DESCRIPTION

The AX3302 integrates Pulse-Width-Modulation (PWM) control circuit into a single chip. These devise include a reference voltage source, oscillation circuit, error amplifier and etc.

AX3302 provides low-ripple power, high efficiency, and excellent transient characteristics. The PWM control circuit is able to the duty ratio linearly form 0 up to 100%. An enable function, an over current protect function and short circuit protect function are built inside, and when OCP or SCP happens, the operation frequency will be reduced.

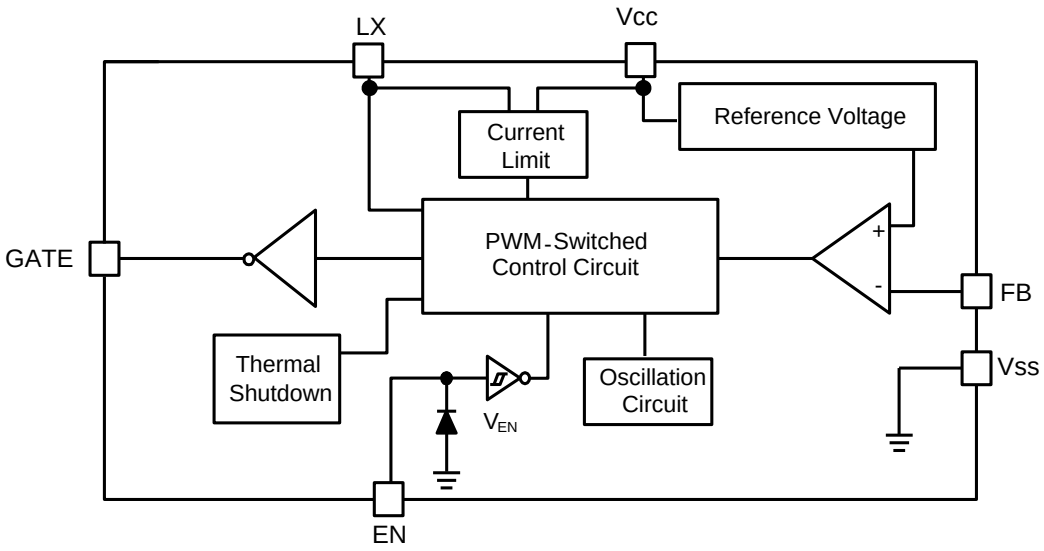
With the addition of an external P-channel Power MOS, a coil, capacitors, and a diode connected externally, these components can function as step-down switching regulators. They serve as ideal power supply units for portable devices when coupled with the SOT-23-6L mini-package, providing such outstanding features as low current consumption. Since this converter can accommodate an input voltage up to 23V, it is also suitable for the operation via an AC adapter.

❖ FEATURES

- Input voltage：3.6V to 23V
- Output voltage：1.222V to V_{CC}
- Duty ratio：0% to 100% PWM control
- Oscillation frequency：380KHz typ.
- Current Limit (CL), Enable function.
- Thermal Shutdown function.
- Short Circuit Protect (SCP).
- External SW P-channel MOS.
- SOT-23-6L Pb-Free package.

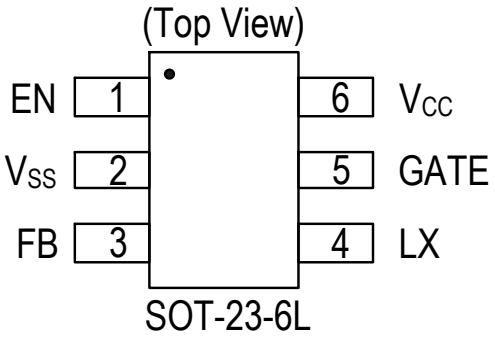
Axelite Confidential Materials, do not copy or distribute without written consent.

❖ BLOCK DIAGRAM



❖ PIN ASSIGNMET

The package of AX3302 is SOT-23-6L; the pin assignment is given by:



Name	Description
EN	Enable input, it is pull-high typically. Drive EN high or floating to turn on the regulator, driver it low to turn it off.
Vcc	IC power supply pin
GATE	Gate drive for external P-channel MOSFET.
LX	LX is the current sense input.
Vss	GND pin
FB	Feedback pin

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
AX3302 X X X Frequency: Blank : 380Khz Package Type: C: SOT-23-6L Packing: Blank : Tube, A : Taping	W5Y WX → ID code:internal WW:01~26 (A~Z) 27~52 (a~z) Year: A=2010 1=2011 AX3302

Axelite Confidential Materials, do not copy or distribute without written consent.

❖ ABSOLUTE MAXIMUM RATINGS (at T_A=25°C)

Characteristics	Symbol	Rating	Unit
VCC Pin Voltage	V_{CC}	V_{SS} - 0.3 to V_{SS} + 25	V
Feedback Pin Voltage	V_{FB}	V_{SS} - 0.3 to V_{CC}	V
ON/OFF Pin Voltage	V_{EN}	V_{SS} - 0.3 to V_{CC} + 0.3	V
Switch Pin Voltage	V_{SW}	V_{SS} - 0.3 to V_{CC} + 0.3	V
Power Dissipation	PD	Internally limited	mW
Storage Temperature Range	T_{ST}	-40 to +150	°C
Operating Junction Temperature Range	T_J	-20 to +125	°C
Operating Supply Voltage	V_{OP}	+3.6 to +23	V
Thermal Resistance from Junction to case	θ_{JC}	180	°C/W
Thermal Resistance from Junction to ambient	θ_{JA}	250	°C/W

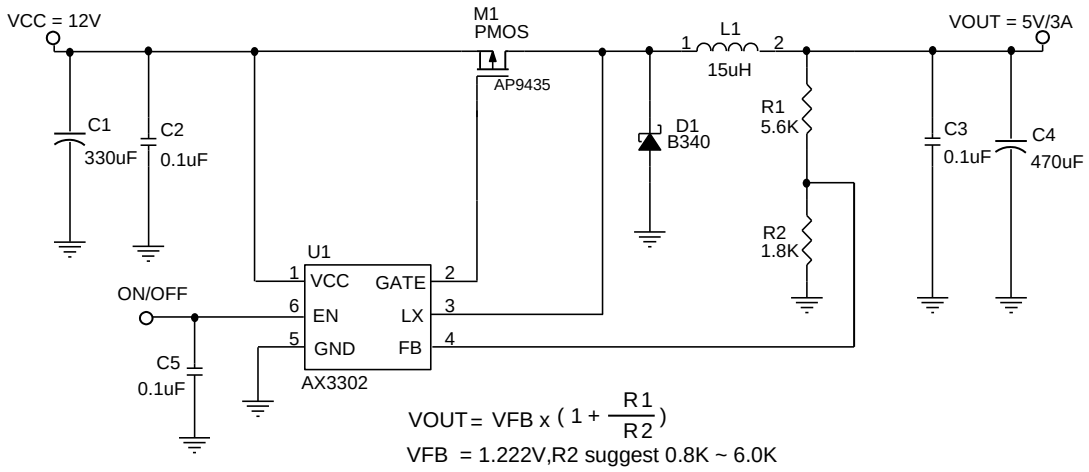
Note: θ_{JA} is measured with the PCB copper area of approximately 1 in^2(Multi-layer).

❖ ELECTRICAL CHARACTERISTICS (V_{CC} = 12V, T_A=25°C, unless otherwise specified)

Characteristics	Symbol	Conditions		Min	Typ	Max	Units
Feedback Voltage	V_{FB}	I_{OUT}=0.2A		1.198	1.222	1.246	V
Quiescent Current	I_{CCQ}	V_{FB}=1.5V force driver off		-	3	5	mA
Feedback Bias Current	I_{FB}	I_{OUT}=0.2A		-	0.1	0.5	uA
Shutdown Supply Current	I_{SD}	V_{EN} =0V		-	23	36	uA
Oscillation Frequency	F_{OSC}	SW pin		330	380	430	KHz
Short Circuit Frequency	F_{OSC1}	V_{FB}=0V		-	80	-	KHz
Maximum Duty	D_{MAX}	V_{FB}=1.0V		100	-	-	%
Minimum Duty	D_{MIN}	V_{FB}=1.5V		-	-	0	%
EN Pin Logic input threshold voltage	V_{SH}	High (regulator ON)		1.5	-	-	V
	V_{SL}	Low (regulator OFF)		-	-	0.7	
EN Pin pull high Current	I_{EN}	V_{EN}=0V		-	20	36	uA
LX Rise Time	T_{LXR}	C_{LX}=1000pF		-	45	-	nS
LX Fall Time	T_{LXF}	C_{LX}=1000pF		-	45	-	
Efficiency	EFFI	V_{OUT} = 5V	I_{OUT} = 2A	-	92	-	%
			I_{OUT} = 3A	-	91	-	
Thermal shutdown Temp	T_{SD}			-	140	-	°C

Axelite Confidential Materials, do not copy or distribute without written consent.

❖ APPLICATION CIRCUIT



❖ FUNCTION DESCRIPTIONS

PWM Control

The AX3302 integrates Pulse-Width-Modulation (PWM) control circuit into a single chip. The pulse width varies in a range from 0 to 100%, according to the load current. The ripple voltage produced by the switching can easily be removed through a filter because the switching frequency remains constant. Therefore, these controllers provide a low-ripple power over broad ranges of input voltage and load current.

RDS (ON) Current Limit Setting

The current limit threshold is setting by PMOS RDS(ON). Choose correct MOSFET is important. Please refer to the formula for setting the current limit value

$$I_{SW(MAX)} = \frac{0.25}{R_{DS(ON)\ (MAX.)}}$$

(Normally, The $I_{SW(MAX)}$ setting more than I_{OUT} 0.5~1.0A).

Example:

PMOS use AM9435GM, the spec maximum $R_{DS(ON)}$ is 50mΩ

$I_{SW(MAX)}$ = 0.25/ 50mΩ (AM9435GM SPEC) = 5A

Axelite Confidential Materials, do not copy or distribute without written consent.

Setting the Output Voltage

Application circuit item shows the basic application circuit with AX3302 adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 1.222V \times \left(1 + \frac{R1}{R2}\right)$$

Table 1 Resistor select for output voltage setting

V_{OUT}	R2	R1
5V	1.8K	5.6K
3.3V	3.3K	5.6K
2.5V	1.2K	1.25K
1.8V	4.7K	2.2K
1.5V	4.7K	1.1K

Inductor Selection

For most designs, 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:

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

Where is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 15% of the maximum output current 3A, ΔI_L=0.45A.

Table 2 Inductor select for output voltage setting (AX3302 at V_{CC}=12V)

V_{OUT}	2.5V	3.3V	5V	3.3V(5A)	5V(5A)
L1 Value	15uH	18uH	22uH	12uH	15uH

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+0.3A).

Axelite Confidential Materials, do not copy or distribute without written consent.

Input Capacitor Selection

This capacitor should be located close to the IC using short leads and the voltage rating should be approximately 1.5 times the maximum input voltage. The RMS current rating requirement for the input capacitor of a buck regulator is approximately 1⁄2 the DC load current. A low ESR input capacitor sized for maximum RMS current must be used. A 330µF low ESR capacitor for most applications is sufficient.

Output Capacitor Selection

The output capacitor is required to filter the output and provide regulator loop stability. The important capacitor parameters are; the 100KHz Equivalent Series Resistance (ESR), the RMS ripples current rating, voltage rating, and capacitance value. For the output capacitor, the ESR value is the most important parameter. The ESR can be calculated from the following formula.

$$V_{RIPPLE} = \Delta I_L \times ESR \quad = 0.4A \text{ x } 110m\Omega = 44mV$$

An aluminum electrolytic capacitor's ESR value is related to the capacitance and its voltage rating. In most case, higher voltage electrolytic capacitors have lower ESR values. Most of the time, capacitors with much higher voltage ratings may be needed to provide the low ESR values required for low output ripple voltage. It is recommended to replace this low ESR capacitor by using a 470µF low ESR values < 110mΩ.

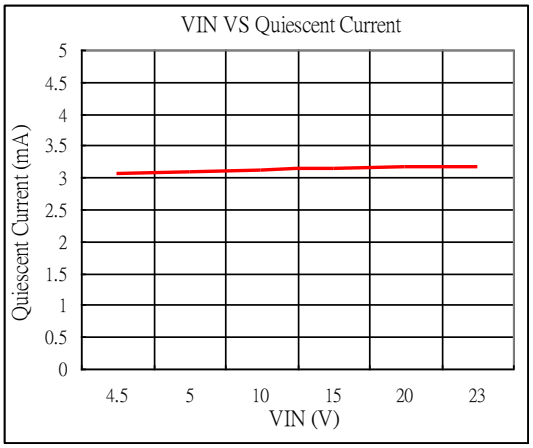
Layout Guidance

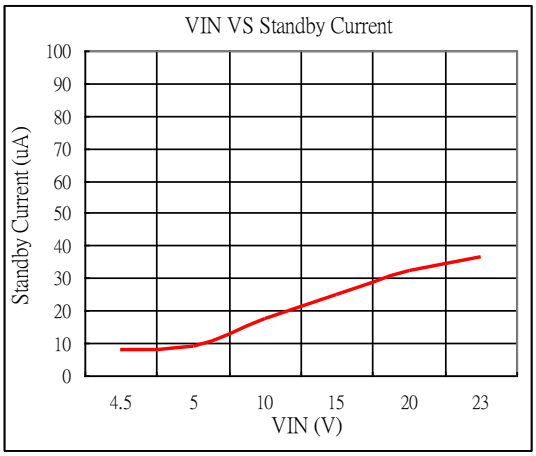
When laying out the PC board, the following suggestions should be taken to ensure proper operation of the AX3302. These items are also illustrated graphically in below.

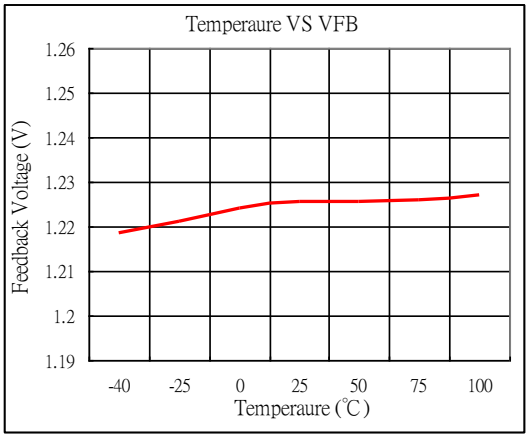
1. The power traces, including the PMOS Drain & Source trace, the Schottky and the C1 trace should be kept short, direct and wide to allow large current flow.
2. Keep the switching node, away from the sensitive FB node.
3. Connect ground side of the C1 and D1 as closely as possible.
4. Do not trace signal line under inductor.

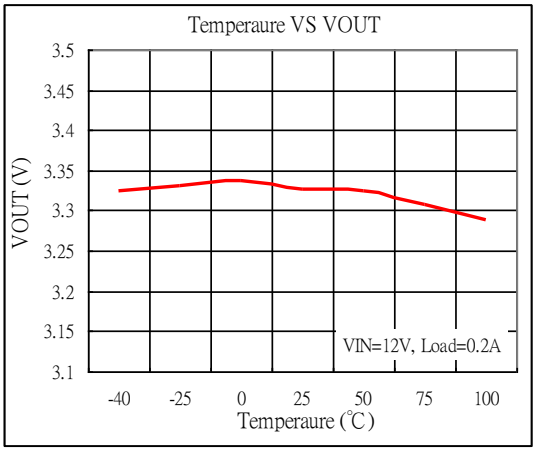
Axelite Confidential Materials, do not copy or distribute without written consent.

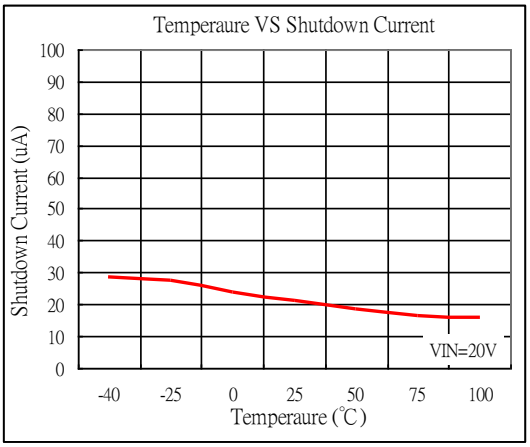
❖ TYPICAL CHARACTERISTICS

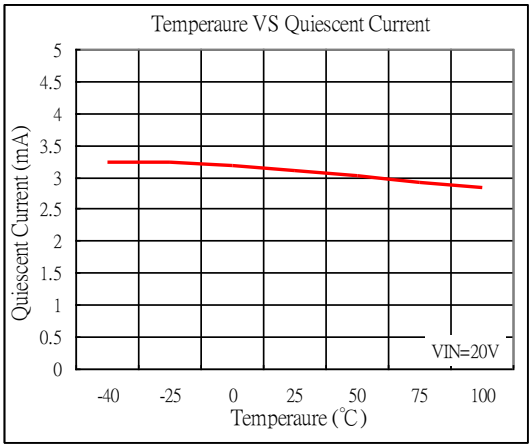






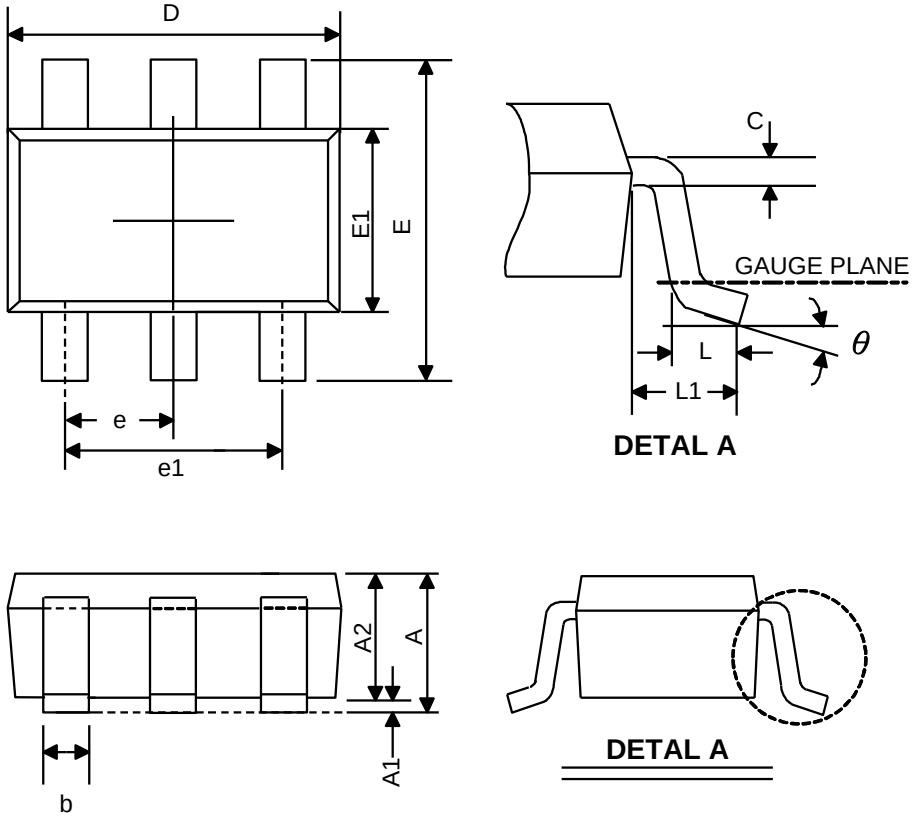






Axelite Confidential Materials, do not copy or distribute without written consent.

❖ PACKAGE OUTLINES



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.45	-	-	0.057
A1	0.00	-	0.15	0	0.003	0.006
A2	0.90	1.10	1.30	0.035	0.043	0.051
b	0.30	0.40	0.50	0.012	0.016	0.020
C	0.08	-	0.22	0.003	0.006	0.009
D	2.70	2.90	3.10	0.106	0.114	0.122
E1	1.40	1.60	1.80	0.055	0.063	0.071
E	2.60	2.80	3.00	0.102	0.110	0.118
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.50	0.60	0.70	0.020	0.024	0.028
e1	1.9 BSC			0.075 BSC		
e	0.95 BSC			0.037 BSC		
θ	0°	4°	8°	0°	4°	8°

JEDEC outline: MO-178 AB

Axelite Confidential Materials, do not copy or distribute without written consent.