

## **Step-up PWM DC/DC Converter**

### **❖ GENERAL DESCRIPTION**

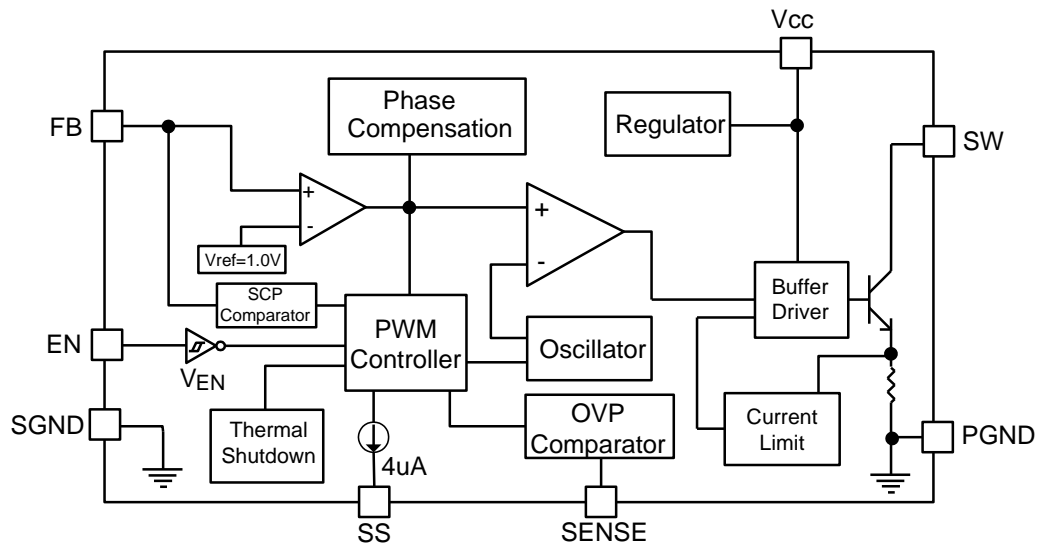
The AX5104 is high efficient step-up DC/DC converter. Large output current is possible having a built in internal transistor, and using an external coil and diode. The converter can be operated at switching frequencies of 800KHz allowing for easy filtering and low noise, the size of the external components can be reduced. Output voltage is programmable with 1.0V of standard voltage supply internal, and using externally connected components, output voltage (FB) can be set up at will.

The AX5104 is external soft-start function that prevents inrush-current and overshooting at startup, soft-start time is be set up by outside capacitance. An enable function, current limit, over voltage protection (OVP) and thermal shutdown functions are built inside.

### **❖ FEATURES**

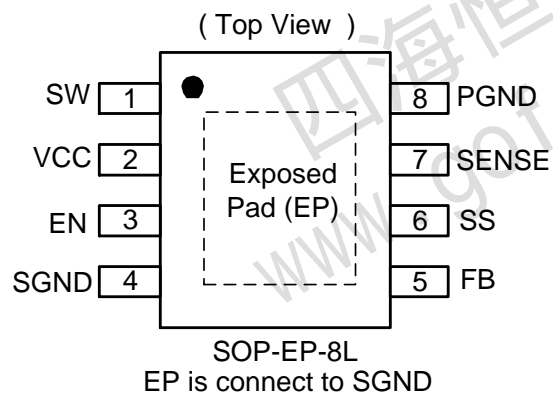
- Input voltage: 4V to 23V
- Output voltage: 4.5V to 25V
- Duty ratio: 0% to 83% PWM control
- Maximum switch current is 1.8A
- Oscillation frequency: 800 KHz (typ.)
- Current limit and thermal shutdown functions
- External soft-start function
- Over voltage protection (OVP)
- Built-in internal Transistor
- SOP-8L with Expose-Pad (EP) Pb-Free Package.

## ❖ BLOCK DIAGRAM



## ❖ PIN ASSIGNMENT

The package of AX5104 is SOP-8L-EP; the pin assignment is given by:



Name	Description
<b>SW</b>	Switch pin. Connect external inductor & diode here.
<b>VCC</b>	IC power supply pin
<b>EN</b>	Power-off pin H : normal operation(Step-up) L : Step-up operation stopped
<b>FB</b>	Feedback pin
<b>SS</b>	Soft-start pin, programming by external capacitance
<b>SENSE</b>	OVP detection pin, The OVP voltage set by outside two resistances.
<b>SGND</b>	Signal ground pin
<b>PGND</b>	Power ground pin

## ❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
<p><b>AX5104 XX X</b></p> <p>Package Type ES: SOP-8L-EP</p> <p>Packing Blank : Tube A : Taping</p>	<p>Logo ← <b>AX</b> 5 1 0 4 → Part number  YY WW X → ID code:internal  → WW: 01~52  → Year: 10=2010  11=2011</p>

## ❖ ABSOLUTE MAXIMUM RATINGS (at $T_A=25^{\circ}\text{C}$ )

Characteristics	Symbol	Rating	Unit
VCC Pin Voltage	$V_{CC}$	GND - 0.3 to GND + 24	V
Feedback Pin Voltage	$V_{FB}$	GND - 0.3 to 6	V
EN Pin Voltage	$V_{EN}$	GND - 0.3 to $V_{CC}$	V
Switch Pin Voltage	$V_{SW}$	GND - 0.3 to 26	V
SS Pin Voltage	$V_{SS}$	GND - 0.3 to 6	V
SENSE Pin Voltage	$V_{SENSE}$	GND - 0.3 to 3	V
Power Dissipation	PD	Internally limited	mW
Storage Temperature Range	$T_{ST}$	-40 to +150	$^{\circ}\text{C}$
Operating Junction Temperature	$T_{OPJ}$	-20 to +125	$^{\circ}\text{C}$
Thermal Resistance from Junction to case	$\theta_{JC}$	15	$^{\circ}\text{C/W}$
Thermal Resistance from Junction to ambient	$\theta_{JA}$	40	$^{\circ}\text{C/W}$

Note :  $\theta_{JA}$  is measured with the PCB copper area of approximately 2 in<sup>2</sup>(Multi-layer) that need connect to exposed pad.

## ❖ ELECTRICAL CHARACTERISTICS

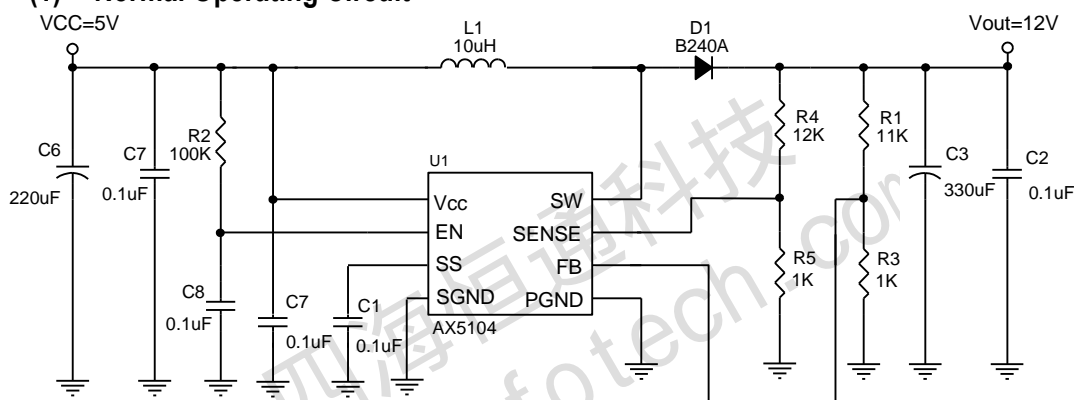
( $V_{IN} = 5\text{V}$ ,  $V_{OUT}=12\text{V}$ ,  $T_A=25^{\circ}\text{C}$ , unless otherwise specified)

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Operating Supply Voltage	$V_{CC}$		4	-	23	V
Output Voltage Range	$V_{OUT}$		4.5	-	25	V
Feedback Voltage	$V_{FB}$	$I_{OUT}=0.1\text{A}$	0.98	1.00	1.02	V
Feedback Bias Current	$I_{FB}$	$I_{OUT}=0.1\text{A}$	-	0.1	0.5	$\mu\text{A}$
Quiescent Current	$I_{CCQ}$	$V_{FB}=1.5\text{V}$ force driver off	-	5	7	mA
Shutdown Supply Current	$I_{SD}$	$V_{EN}=0\text{V}$	-	1	10	$\mu\text{A}$
Switch Current	$I_{SW}$		1.8	-	-	A
Oscillation Frequency	$F_{OSC}$	SW pin	600	800	1000	KHz
Saturation Voltage	$V_{SAT}$	$I_{SW}=1.5\text{A}$	-	1.0	1.2	V
		$I_{SW}=0.6\text{A}$	-	0.8	0.95	
SS charge current	$I_{SS}$		-	4	-	$\mu\text{A}$
EN Pin Logic input threshold voltage	$V_{SH}$	High (regulator ON)	2.0	-	-	V
	$V_{SL}$	Low (regulator OFF)	-	-	0.8	

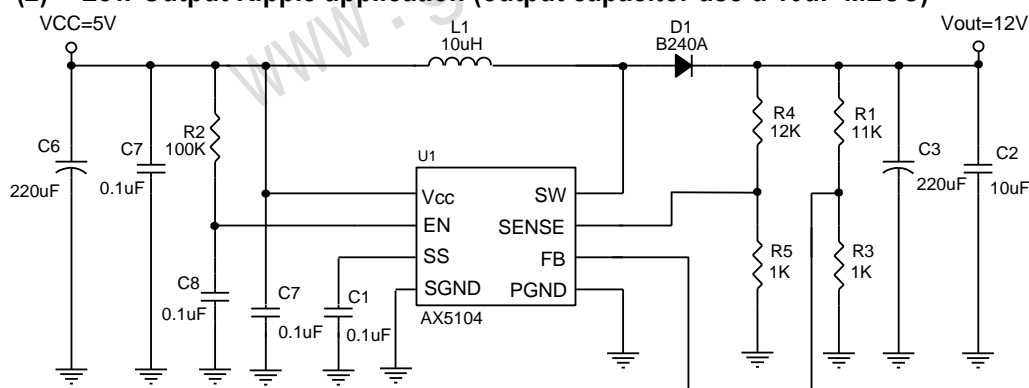
SENSE Voltage	V <sub>SENSE</sub>	If happened, Driver OFF	0.97	1.00	1.03	V
SNESE Pin Bias Current	I <sub>SENSE</sub>	V <sub>SENSE</sub> =1.25V	-	10	100	nA
Efficiency	EFFI	V <sub>CC</sub> = 5V, V <sub>OUT</sub> = 12V I <sub>OUT</sub> = 0.2A	-	83	-	%
		V <sub>CC</sub> = 12V, V <sub>OUT</sub> = 24V I <sub>OUT</sub> = 0.5A	-	90	-	%
Maximum Duty Cycle	DC <sub>MAX</sub>	V <sub>FB</sub> =0V	-	83	-	%
Minimum Duty Cycle	DC <sub>MIN</sub>	V <sub>FB</sub> =1.5V	-	0	-	
Thermal shutdown	T <sub>SD</sub>		-	145	-	°C
Thermal shutdown recovery	T <sub>SDR</sub>		-	30	-	

## ❖ APPLICATION CIRCUIT

### (1) Normal Operating Circuit



### (2) Low Output Ripple application (output capacitor use a 10uF MLCC)



$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R3}\right), V_{FB} = 1.0V, R3 = 1K \sim 3K\Omega$$

## ❖ FUNCTION DESCRIPTIONS

### PWM Control

The AX5104 consists of DC/DC converters that employ a pulse-width modulation (PWM) system. In converters of the AX5104, the pulse width varies in a range from 0 to 83%, 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 converters provide a low-ripple power over broad ranges of input voltage and load current.

### Soft Start

The soft start time is set by outside capacitor (C1). There is 4uA soft start current to charge C1, the real soft-start time is depend on SS voltage from 0.4 to 1V.

### Current Limiting

The current limit threshold is setting by the internal circuit.

### Over Voltage Protection (OVP)

The OVP function is preventing  $V_{OUT}$  overshooting for system unusually working (R1 floating, LED burn-out for LED application.) The OVP voltage is set by output resistance, please refer the following equation:

$$V_{OVP} = V_{SENSE} \times \left( 1 + \frac{R4}{R5} \right), V_{SENSE}=1V, R5 \text{ suggest } 1K \sim 10K\Omega$$

If  $V_{SENSE} > 1V$  and SS voltage is more than 1V, The OVP is happened, the driver is turned off until  $V_{SENSE} < 1V$ . However, the OVP function can keep  $V_{OUT}$  to  $V_{OVP}$  voltage. If the OVP function is not used, please connect the sense pin to ground.

## ❖ APPLICATION INFORMATION

### Setting the Output Voltage

Application circuit item shows the basic application circuit with AX5104 adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 1.0V \times \left(1 + \frac{R1}{R3}\right)$$

Table 1 Resistor select for output voltage setting

V <sub>OUT</sub>	R3	R1
12V	1K	11K
15V	1.3K	18K
18V	1.3K	22K
24V	1.3K	30K

### 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:

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

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 input current 1.8A, ΔI<sub>L</sub>=0.28A.

Table 2 Inductor select for output voltage setting (V<sub>CC</sub>=5V)

V <sub>OUT</sub>	9V	12V	15V	18V
L1 Value	10uH	12uH	15uH	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 (1.8A+0.14A).

## Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used.

The capacitor voltage rating should be at least 1.5 times greater than the input voltage, and often much higher voltage ratings are needed to satisfy.

## Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. A low ESR capacitor sized for maximum RMS current must be used. The low ESR requirements needed for low output ripple voltage.

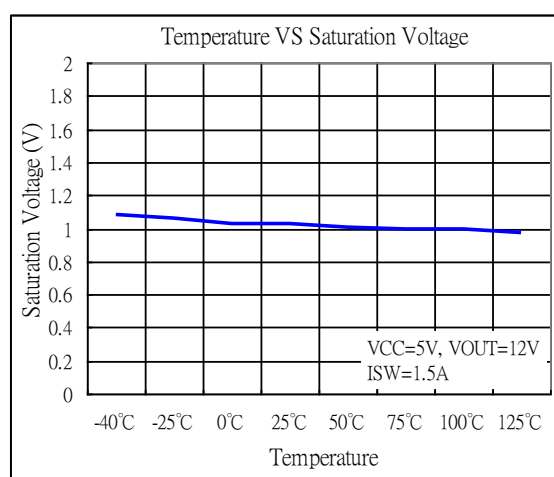
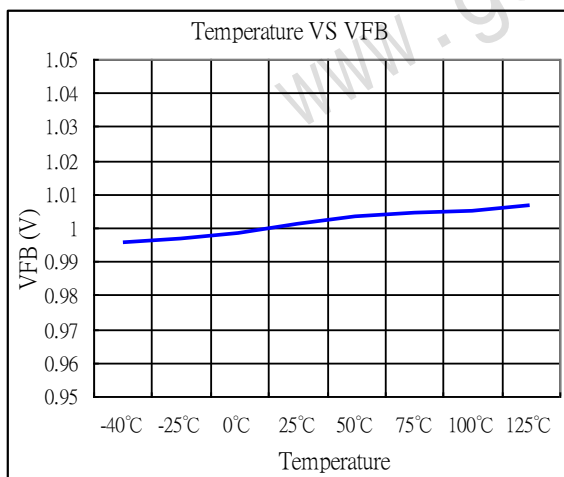
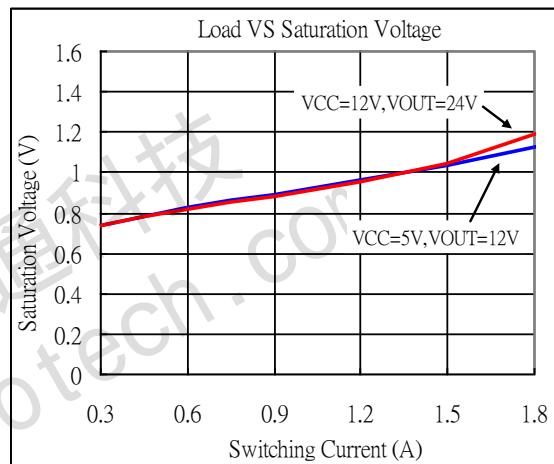
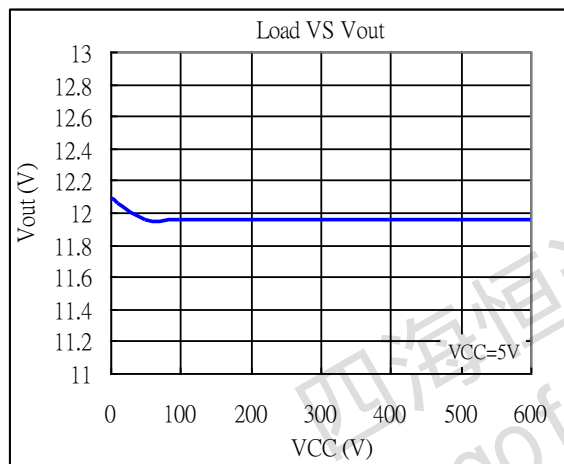
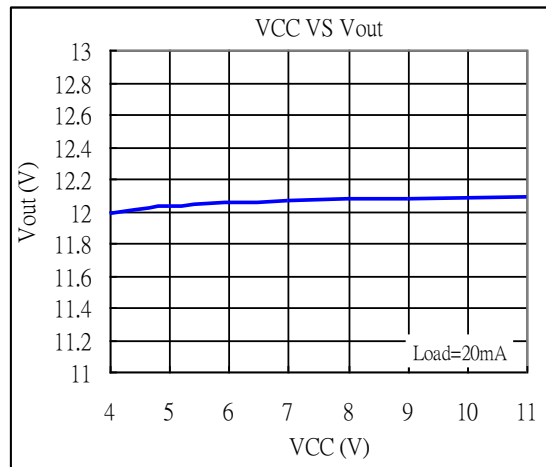
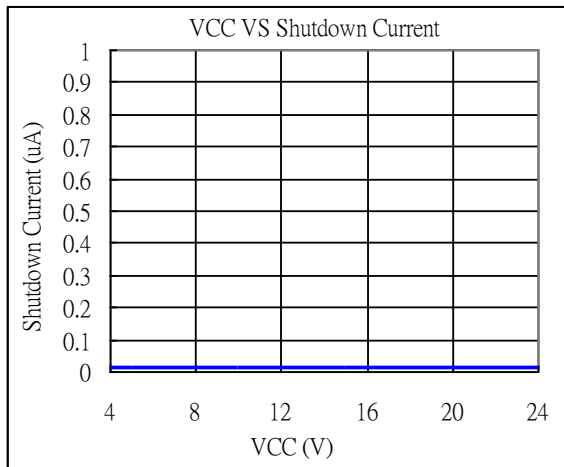
The capacitor voltage rating should be at least 1.5 times greater than the input voltage, and often much higher voltage ratings are needed to satisfy.

## PCB layout guide

If you need low  $T_c$  and  $T_j$  or large PD (Power Dissipation), The Expose-Pad at the SOP-8L package are internally connected to die pad, The PCB layout should allow for maximum possible copper area at the Expose-Pad.

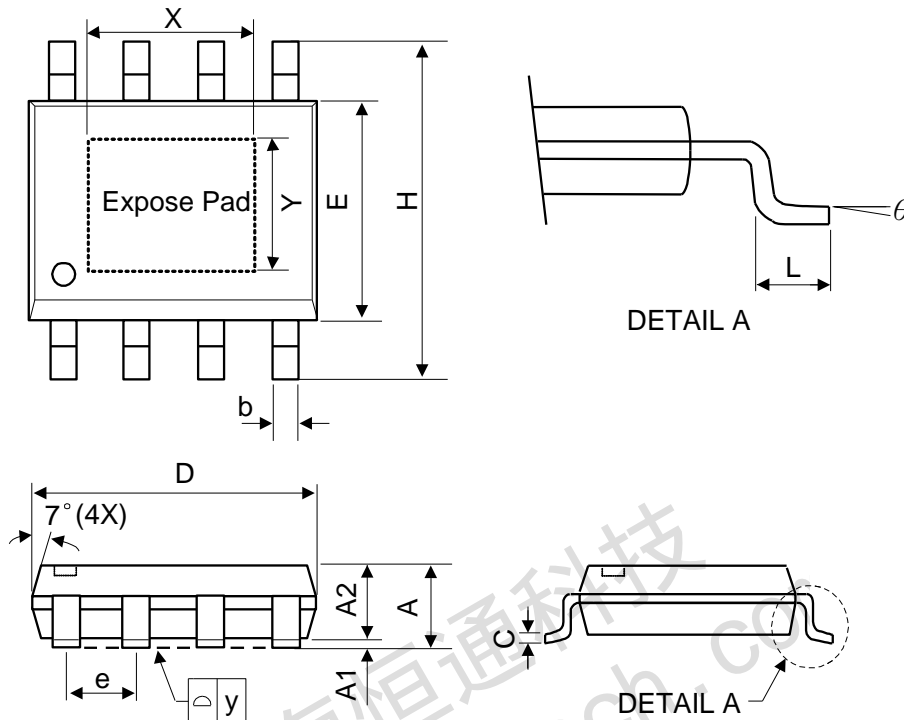
1. The power traces, including the Source trace, the Schottky and the C6 trace should be kept short, direct and wide to allow large current flow.
2. Connect C7 to  $V_{CC}$  pin and signal ground as closely as possible to get good power filter effect.
3. Connect power ground (pin8) to C6's ground as closely as possible.
4. Do not trace signal line under inductor

## ❖ TYPICAL CHARACTERISTICS





# ❖ PACKAGE OUTLINES



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.75	-	-	0.069
A1	0	-	0.15	0	-	0.06
A2	1.25	-	-	0.049	-	-
C	0.1	0.2	0.25	0.0075	0.008	0.01
D	4.7	4.9	5.1	0.185	0.193	0.2
E	3.7	3.9	4.1	0.146	0.154	0.161
H	5.8	6	6.2	0.228	0.236	0.244
L	0.4	-	1.27	0.015	-	0.05
b	0.31	0.41	0.51	0.012	0.016	0.02
e	1.27 BSC			0.050 BSC		
y	-	-	0.1	-	-	0.004
X	-	2.34	-	-	0.092	-
Y	-	2.34	-	-	0.092	-
θ	0°	-	8°	0°	-	8°

Mold flash shall not exceed 0.25mm per side

JEDEC outline: MS-012 BA