

Wide-Input Sensorless CC/CV Step-Down **DC/DC Converter**

❖ GENERAL DESCRIPTION

AX3051 is a wide input voltage, high efficiency ActiveCC step-down DC/DC converter that operates in either CV (Constant Output Voltage) mode or CC (Constant Output Current) mode.

AX3051 consists of step-down switching regulator with PWM control. The device includes a reference voltage source, oscillation circuit, error amplifier, internal PMOS and etc.

AX3051 provides low-ripple power, high efficiency, and excellent transient characteristics. The PWM control circuit is able to the duty ratio linearly forms 0 up to 90%. An over current protection and short circuit protection functions are built outside that it can set by a resistance. An external compensation is easily to system stable; the low ESR output capacitor can be used.

With the addition of an internal N-channel Power MOS, a coil, capacitors, and a diode connected externally, these ICs can function as step-down switching regulators. They serve as ideal power supply units for portable devices when coupled with the SOP-8L and SOP-8L-EP packages, providing such outstanding features as low current consumption. Since this converter can accommodate an input voltage up to 40V, it is also suitable for the operation via an AC adapter.

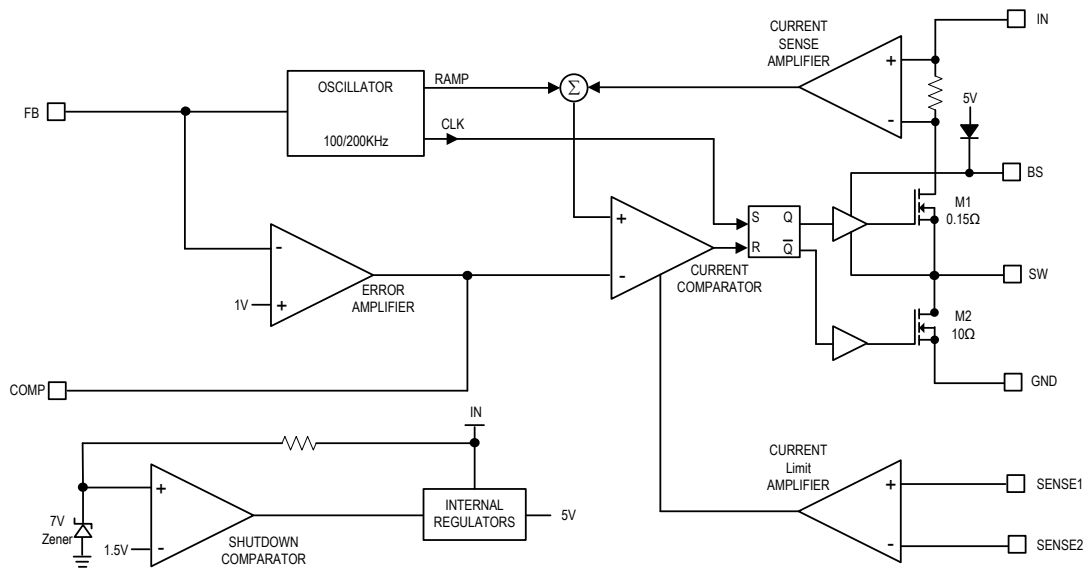
❖ FEATURES

- Input Voltage : 8V to 40V
- Duty ratio : 0% to 90% PWM control
- Oscillation frequency : 100K/200KHz
- Thermal Shutdown function.
- Short Circuit Protect (SCP).
- Built-in internal SW N-channel MOS.
- Current mode non-synchronous PWM converter
- External current limit setting.
- Under Voltage Lockout.
- Over Voltage Protection.
- Line-compensation built in.

❖ FEATURES (CONTINUED)

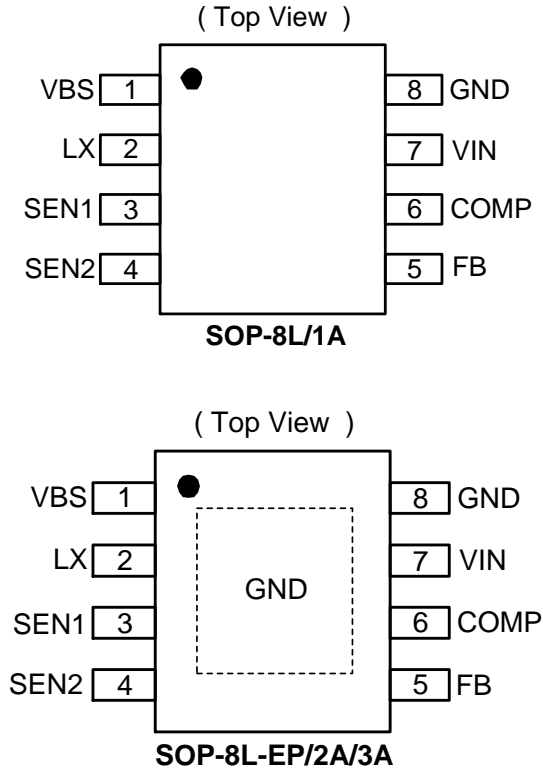
- 100/200KHz Switching Frequency Eases EMI Design
- Advanced Feature Set
 - ◆ Thermal Shutdown
 - ◆ Secondary Cycle-by-Cycle Current Limit
- SOP-8L and SOP-8L-EP Pb-Free packages.

❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The package of AX3051 is SOP-8L; the pin assignment is given by:



Name	Description
BS	Bootstrap Pin. This provides power to the internal high-side MOSFET gate driver. Connect a 10nF capacitor from BS pin to SW pin.
VIN	Power Supply Input. Bypass this pin with a 10 μ F ceramic capacitor to GND, placed as close to the IC as possible.
GND	GND pin
COMP	Error Amplifier Output. This pin is used to compensate the \square inverter.
FB	Output voltage feedback control
SENSE1	Current Sense input1
SENSE2	Current Sense input2
SW	Power Switching Output to External Inductor.

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
<p style="font-size: 24pt; font-weight: bold;">AX3051 XX X</p> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="text-align: center;"> <p style="font-size: 10pt;">Package Type</p> <p>S: SOP-8L</p> <p>ES: SOP-8L-EP</p> </div> <div style="text-align: center;"> <p style="font-size: 10pt;">Packing</p> <p>Blank : Tube</p> <p>A : Taping</p> </div> </div>	<p>Logo ← AX 3 0 5 1 → Part number</p> <p style="margin-left: 40px;">Y Y W W X → ID code: internal</p> <div style="margin-left: 80px;"> <p>WW: 01~52</p> <p>Year: 11=2011</p> <p style="margin-left: 20px;">12=2012</p> </div>

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

Characteristics	Symbol	Rating	Unit
IN to GND		-0.3 to 44	V
SW to GND		-1 to VIN + 1	V
BS to GND		$V_{SW} - 0.3$ to $V_{SW} + 7$	V
FB, SENSE1, SENSE2, COMP LDG to GND		-0.3 to + 6	V
Junction to Ambient Thermal Resistance		105	°C/W
Operating Junction Temperature		-40 to 150	°C
Storage Junction Temperature		-55 to 150	°C
Lead Temperature (Soldering 10 sec.)		300	°C
Thermal Resistance from Junction to case	θ_{JC}	15	°C/W
Thermal Resistance from Junction to ambient	θ_{JA}	40	°C/W

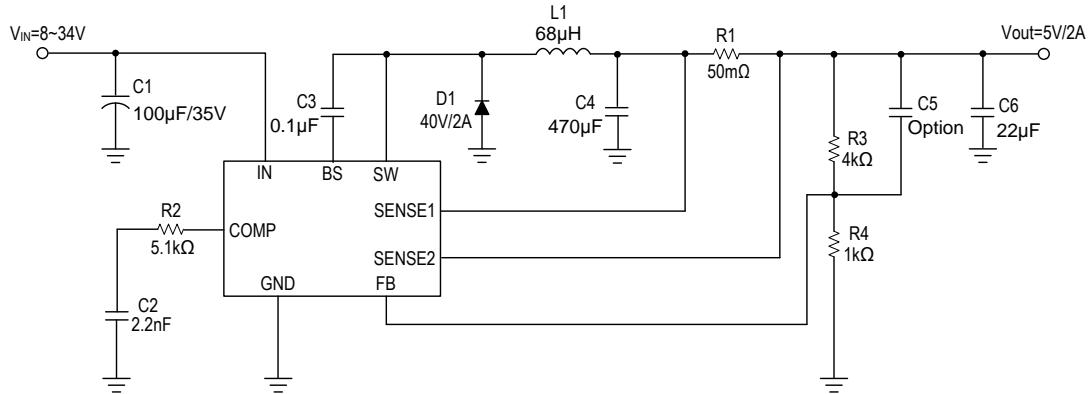
Note : θ_{JA} is measured with the PCB copper are (need connect to Exposed pad) of approximately 1 in²(Multi-layer).

❖ **ELECTRICAL CHARACTERISTICS** ($V_{IN}=12V$, $T_A=25^{\circ}C$, unless otherwise specified)

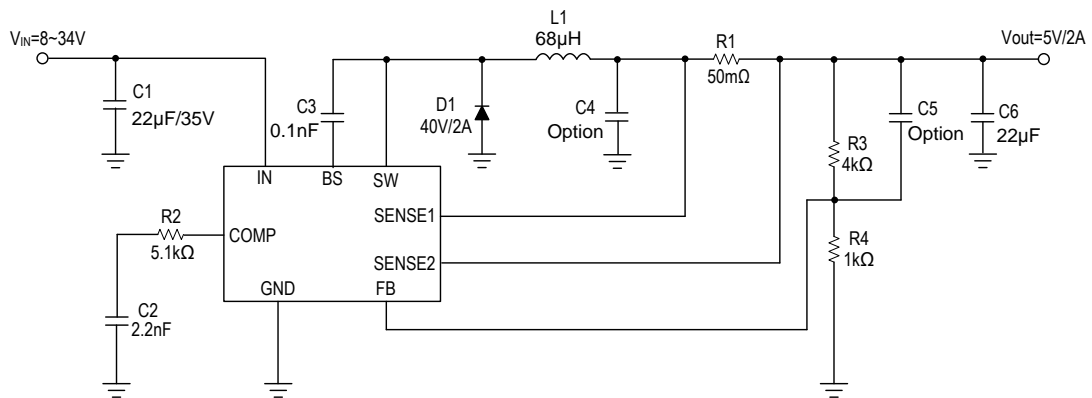
Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage			8	-	40	V
V_{IN} UVLO Turn-On Voltage		Input Voltage Rising	7	7.5	8	V
V_{IN} UVLO Hysteresis		Input Voltage Falling	-	1	-	V
OVP detect voltage	V_{OVP}	Internal define	-	6	-	V
Quiescent Current	I_{CCQ}	$V_{FB} = 1.5V$, force driver off.	-	2	-	mA
Standby Supply Current		$V_0 = 5V$, No Load	-	5	10	mA
Feedback Voltage			0.98	1	1.02	V
High-Side Switch On Resistance	R_{DSON}	$V_{IN}=12V$, $I_{OUT} = 1A$	-	150	200	m Ω
Low-Side Switch On Resistance	R_{DSON}	$V_{IN}=12V$	-	10	-	Ω
Switching Frequency		$I_{OUT}=200mA$	85	100	115	KHz
			170	200	230	KHz
Maximum Duty Cycle			90	93	-	%
Minimum On-Time			-	150	-	ns
Secondary Cycle-by-Cycle Current Limit		Minimum Duty Cycle, no CC	-	3.5	-	A
Sense Voltage	V_{SENSE}	$V_{SENSE1}-V_{SENSE2}$	98	100	102	mV
Thermal shutdown Temp	T_{SD}		-	140	-	$^{\circ}C$
Thermal Shutdown Hysteresis	T_{SH}		-	30	-	$^{\circ}C$

❖ APPLICATION CIRCUIT

(1) AL CAPACITOR



(2) MLCC



❖ FUNCTION DESCRIPTIONS

CV/CC Loop Regulation

As seen in Functional Block Diagram, the AX3051 is a peak current mode pulse width modulation (PWM) converter with CC and CV control. The converter operates as follows:

A switching cycle starts when the rising edge of the Oscillator clock output causes the High-Side Power Switch to turn on. With the SW side of the inductor now connected to Sense1, the inductor current ramps up to store energy in the magnetic field. The inductor current level is measured by the Current Sense Amplifier and added to the Oscillator ramp signal. If the resulting summation is higher than the COMP voltage, the output of the PWM Comparator goes high. When this happens or when Oscillator clock output goes low, the High-Side Power Switch turns off.

At this point, the SW side of the inductor swings to a diode voltage below ground, causing the inductor current to decrease and magnetic energy to be transferred to output. This state continues until the cycle starts again. The High-Side Power Switch is driven by logic using BS as the positive rail. This pin is charged to $V_{SW} + 5V$ when the Low-Side Power Switch turns on. The COMP voltage is the integration of the error between FB input and the internal 1V reference. If FB is lower than the reference voltage, COMP tends to go higher to increase current to the output. Output current will increase until it reaches the CC limit set by the R1 resistor. At this point, the device will transition from regulating output voltage to regulating output current, and the output voltage will drop with increasing load.

The Oscillator normally switches at 200KHz. However, if FB voltage is less than 0.6V, then the switching frequency decreases until it reaches a typical value of 30KHz at $V_{FB} = 0.15V$.

Thermal Shutdown

The AX3051 disables switching when its junction temperature exceeds 140°C and resumes when the temperature has dropped by 30°C.

❖ APPLICATION INFORMATION

Output Voltage Setting

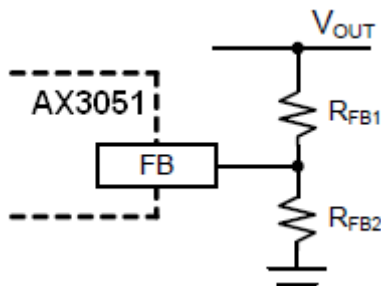


Figure1 Output Voltage Setting

Figure 1 shows the connections for setting the output voltage. Select the proper ratio of the two feedback resistors R_{FB1} and R_{FB2} based on the output voltage. Typically, use R_{FB2} ≈ 10kΩ and determine R_{FB1} from the following equation:

$$R_{FB1} = R_{FB2} \left(\frac{V_{OUT}}{1V} - 1 \right)$$

Inductor Selection

The inductor maintains a continuous current to the output load. This inductor current has a ripple that is dependent on the inductance value:

Higher inductance reduces the peak-to-peak ripple current. The trade off for high inductance value is the increase in inductor core size and series resistance, and the reduction in current handling capability. In general, select an inductance value L based on ripple current requirement:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} f_{SW} I_{OUTMAX} K_{RIPPLE}}$$

where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_{SW} is the switching frequency, I_{OUTMAX} is the maximum output current, and K_{RIPPLE} is the ripple factor. Typically, choose K_{RIPPLE} = 30% to correspond to the peak-to-peak ripple current being 30% of the maximum output current.

With this inductor value, the peak inductor current is I_{OUT} × (1 + K_{RIPPLE}/2). Make sure that this peak inductor current is less than the controller's current limit. Finally, select the inductor core size so that it does not saturate at the peak inductor current.

Table1: Typical Inductor Values

V _{OUT}	1.5V	1.8V	2.5V	3.3V	5V
L	22μH	22μH	33μH	47μH	68μH

Input Capacitor

The input capacitor needs to be carefully selected to maintain sufficiently low ripple at the supply input of the converter. A low ESR capacitor is highly recommended. Since large current flows in and out of this capacitor during switching, its ESR also affects efficiency.

The input capacitance needs to be higher than 10μF. The best choice is the ceramic type, however, low ESR tantalum or electrolytic types may also be used provided that the RMS ripple current rating is higher than 50% of the output current. The input capacitor should be placed close to the IN and G pins of the IC, with the shortest traces possible. In the case of tantalum or electrolytic types, they can be further away if a small parallel 0.1μF ceramic capacitor is placed right next to the IC.

Output Capacitor

The output capacitor also needs to have low ESR to keep low output voltage ripple. The output ripple voltage is:

$$V_{RIPPLE} = I_{OUTMAX} K_{RIPPLE} R_{ESR} + \frac{V_{IN}}{28 \times f_{SW}^2 LC_{OUT}}$$

where I_{OUTMAX} is the maximum output current, K_{RIPPLE} is the ripple factor, R_{ESR} is the ESR of the output capacitor, f_{SW} is the switching frequency, L is the inductor value, and C_{OUT} is the output capacitance. In the case of ceramic output capacitors, R_{ESR} is very small and does not contribute to the ripple. Therefore, a lower capacitance value can be used for ceramic type. In the case of tantalum or electrolytic capacitors, the ripple is dominated by R_{ESR} multiplied by the ripple current. In that case, the output capacitor is chosen to have sufficiently low ESR.

For ceramic output capacitor, typically choose a capacitance of about 22μF. For tantalum or electrolytic capacitors, choose a capacitor with less than 50mΩ ESR.

Rectifier Diode

Use a Schottky diode as the rectifier to conduct current when the High-Side Power Switch is off.

The Schottky diode must have current rating higher than the maximum output current and a reverse voltage rating higher than the maximum input voltage.

Output Cable Resistance Compensation

To compensate for resistive voltage drop across the charger's output cable, the AX3051 integrates a simple, user-programmable cable voltage drop compensation using the impedance at the FB pin. Use the curve in Figure 4 to choose the proper feedback resistance values for cable compensation. RFB1 is the high side resistor of voltage divider.

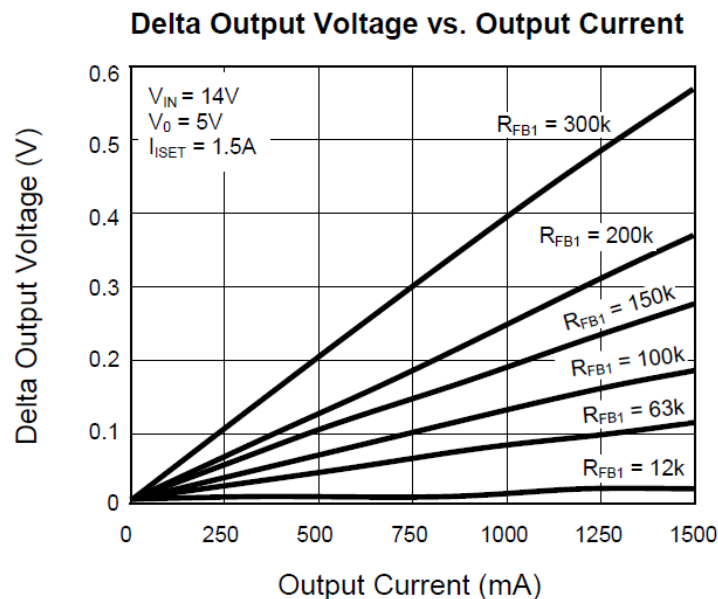
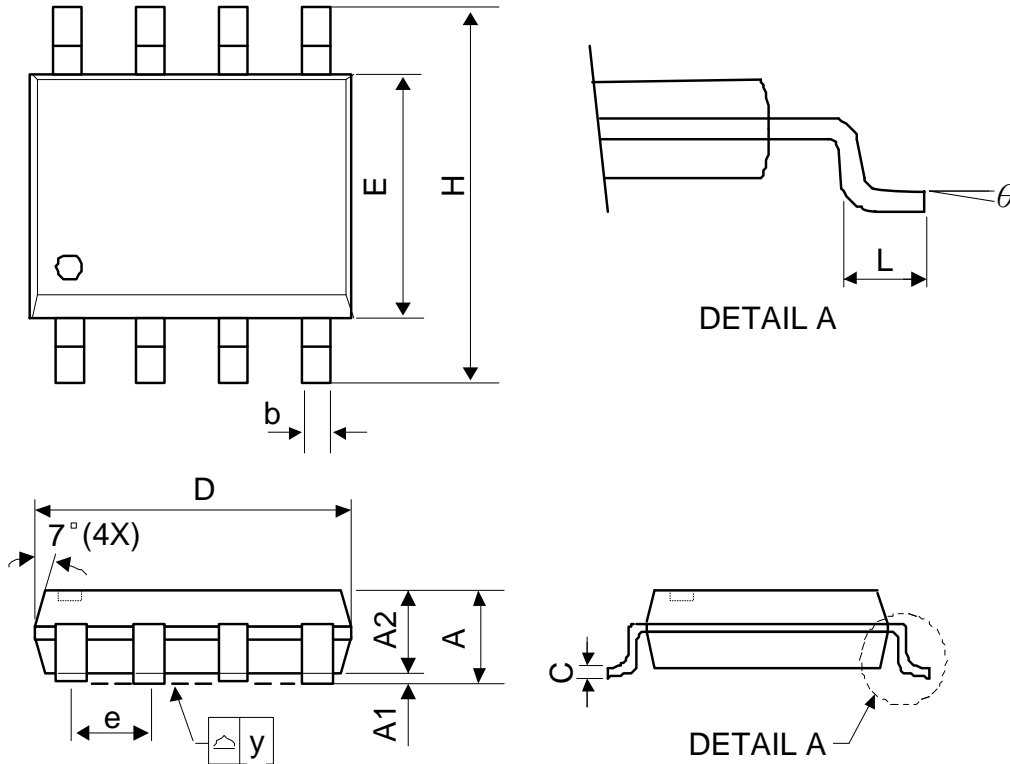


Figure2 Cable Compensation at Various Resistor Divider Values

❖ PACKAGE OUTLINES

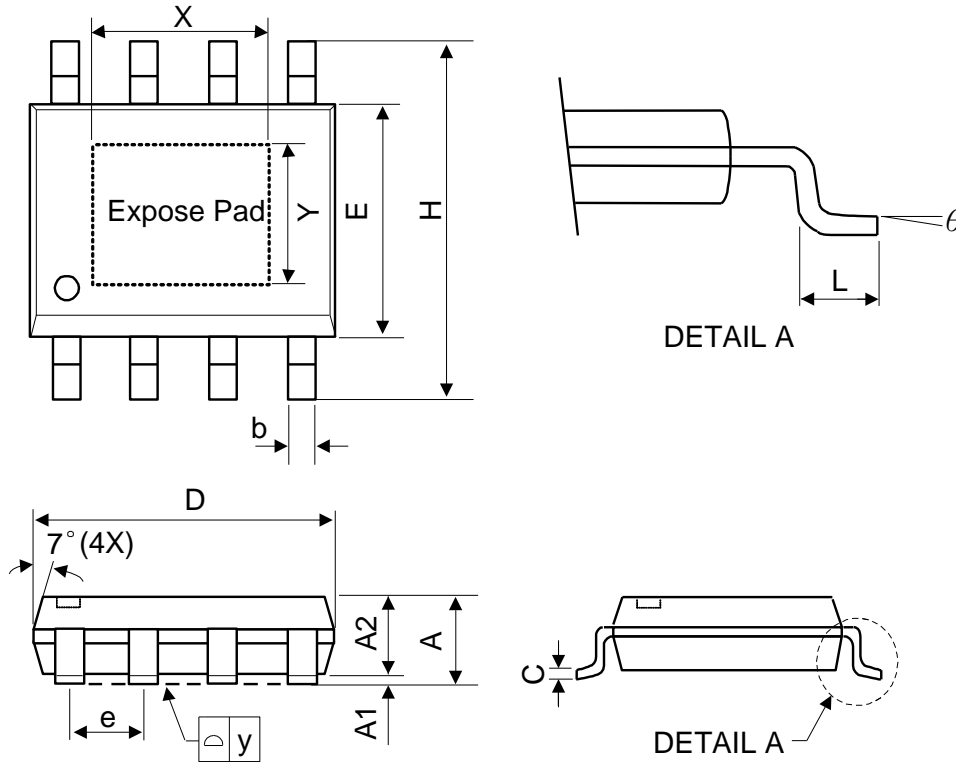
(1) SOP-8L



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.75	-	-	0.069
A1	0.1	-	0.25	0.04	-	0.1
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
θ	0°	-	8°	0°	-	8°

Mold flash shall not exceed 0.25mm per side
JEDEC outline: MS-012 AA

(2) SOP-8L-EP



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