PWM Step-up Controller

❖ GENERAL DESCRIPTION

The AX5301 is high efficient PWM step-up controller. Designed to drive an external N-channel MOSFET, 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 AX5301 can be operated at switching frequencies of 500kHz allowing for easy filtering and low noise, the size of the external components can be reduced.

This controller also contains an error amplifier circuit as well as a soft-start circuit that prevents inrush-current at startup. An enable function and thermal shutdown functions are built inside.

❖ FEATURES

- Input voltage: 3.0V to 24V
- Output voltage: Define by N-channel MOS.
- Duty ratio: 0% to 80% PWM control
- Oscillation frequency: 500KHz (±20%) .
- Enable function
- Soft-Start function
- Thermal Shutdown function
- External SW N-channel MOS.
- MSOP-8L & SOP-8L Pb-Free Package.

❖ Block Diagram
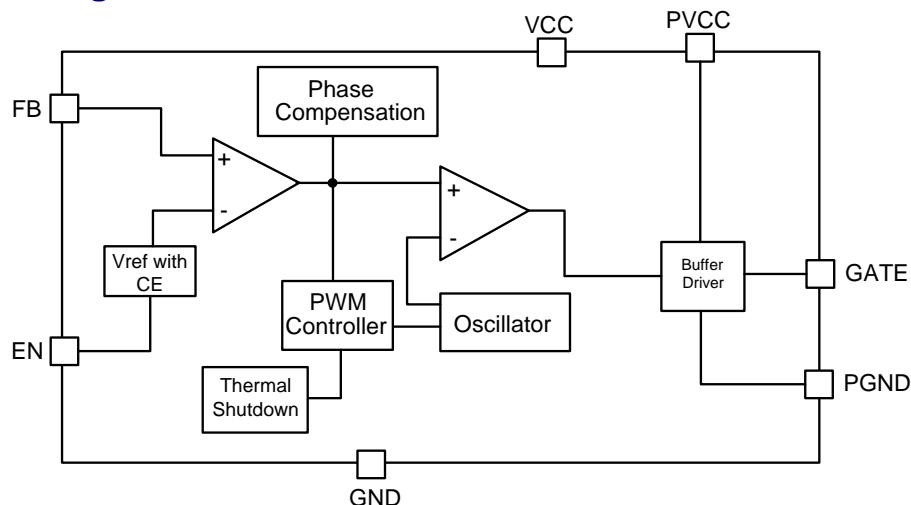
❖ PIN ASSIGNMENT

These packages of AX3301are MSOP-8L & SOP-8L; the pin assignment is given by:

（ Top View ）

MSOP - 8L & SOP - 8L
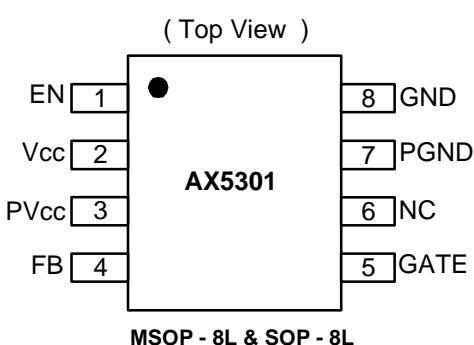
Name	Description
EN	Shutdown Control Input. H：normal operation(Step-down) L：Shutdown mode
FB	Feedback pin
V_{CC}	Signal VCC supply pin
PV_{CC}	Power VCC supply pin
GATE	Gate drive for external N-channel MOSFET.
PGND	Power ground pin
GND	Signal ground pin

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
AX5301 X X Package Type　Packing S: SOP-8L　　Blank : Tube U:MSOP-8L　　A : Taping	Logo ←-- **AX** 5301 → Part number X X X X X → ID code: internal WW: 01~52 Year : 06 = 2006

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❖ Absolute Maximum Ratings (at Ta=25℃)

Characteristics	Symbol	Rating	Unit
PVCC/VCC Pin Voltage	V_{CC}	V_{SS} - 0.3 to V_{SS} + 26	V
Feedback Pin Voltage	V_{FB}	V_{SS} - 0.3 to 12	V
EN Voltage	V_{EN}	V_{SS} - 0.3 to V_{CC}	V
Gate Pin Voltage	V_{GATE}	V_{SS} - 0.3 to V_{CC}	V
Power Dissipation	PD	Internally limited	mW
Storage Temperature Range	T_{ST}	-40 to +150	℃
Operating Temperature Range	T_{OP}	-20 to +125	℃
Operating Supply Voltage	V_{OP}	+3 to +24	V
Thermal Resistance from Junction to case	θ_{JC}	SOP8=40, MSOP8=45	℃/W
Thermal Resistance from Junction to ambient	θ_{JA}	SOP8=120, MSOP8=200	℃/W

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

## ❖ Electrical Characteristics (V_{IN} = 6V, V_{OUT}=12V, Ta=25℃, unless otherwise specified)

Characteristics	Symbol	Conditions		Min	Typ	Max	Units
Feedback Voltage	V_{FB}	I_{OUT}=0.1A		0.975	1.000	1.025	V
Quiescent Current	I_{CCQ}	V_{FB}=1.5V force driver off			4	6	mA
Feedback Bias Current	I_{FB}	I_{OUT}=0.1A		-	0.1	0.5	uA
Shutdown Supply Current	I_{SD}	V_{EN} =0V		-	2	10	uA
Oscillation Frequency	F_{OSC}	SW pin(AX5301)		400	500	600	KHz
EN Pin Logic input threshold voltage	V_{SH}	High (regulator ON)		2.0	-	-	V
	V_{SL}	Low (regulator OFF)		-	-	0.8	
EN Pin Input Current	I_{SH}	V_{EN}=2.5V (ON)		-	20	-	uA
	I_{SL}	V_{EN}=0.3V (OFF)		-	-10	-	uA
Soft-Start Time	T_{SS}			0.3	4	8	ms
LX Rise Time	T_{LXR}	C_{LX}=1000pF		-	80	-	nS
LX Fall Time	T_{LXF}	C_{LX}=1000pF		-	80	-	
Efficiency	EFFI	V_{CC} = 6V, V_{OUT} = 12V	I_{sw} = 2A	-	93	-	%
			I_{sw} = 3A		92		
Maximum Duty Cycle	DC_{MAX}	V_{FB}=0.4V		-	80	-	%
Minimum Duty Cycle	DC_{MIN}	V_{FB}=1.2V		-	0	-	
Thermal shutdown Temp	TSD				135		℃

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❖ Application Circuit

A. Typical circuit

VCC=6V

Vout=+12V/1.4A

L1 15uH

D1 B340A

R4 100K

C3 470uF

C4 0.1uF

C7 0.1uF

U1
1 EN   GND 8
2 Vcc   PGND 7
3 PVcc   NC 6
4 FB   GATE 5

AX5301

Q1 NMOS

R1 22K

R2 2K

C5 470uF X2

C6 1u

B. VCC option

VCC=5~8V

SW1

OPT

Vout=+12V

L1 15uH

D1 B340A

R4 100K

C3 470uF

C4 0.1uF

C7 0.1uF

C7 0.1uF

U1
1 EN   GND 8
2 Vcc   PGND 7
3 PVcc   NC 6
4 FB   GATE 5

AX5301

R1 22K

C1 0p

R2 2K

C5 470uF x2

C6 1u
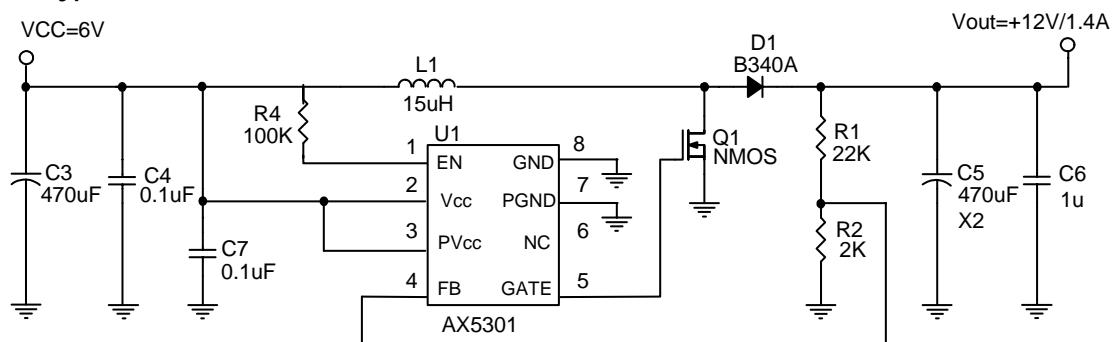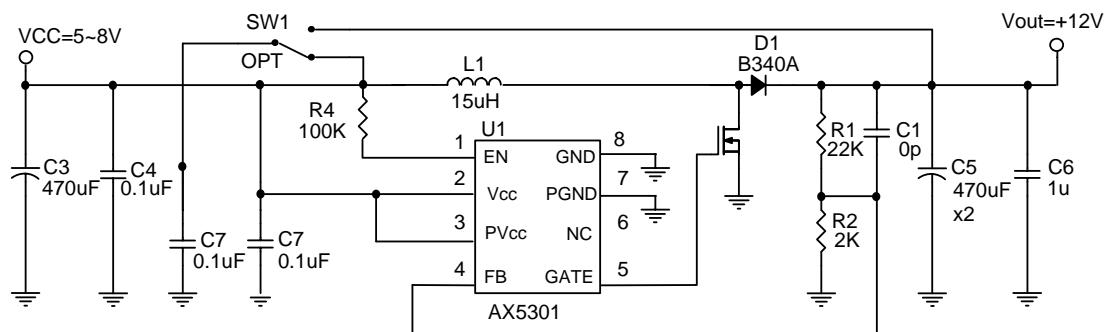
1. $VOUT = VREF \times (1 + \dfrac{R1}{R2})$

   $VREF = 1.0V$; R2 suggest 0.75K ~ 2.5k

2. Current limit = (R5*Iocset)/(Iload*Rdson)

   Iocset = 100uA(TYP).

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❖ **Function Descriptions**

PWM Control

The AX5301 is high efficient PWM step-up controller. In controllers of the AX5301, the pulse width varies in a range from 0 to 90%, 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, AX5301 provide a low-ripple power over broad ranges of input voltage and load current.

Setting the Output Voltage

Application circuit item shows the basic application circuit with AX5301 adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 1.0V \times \left(1 + \frac{R1}{R2}\right)$$

Table 1 Resistor select for output voltage setting

V_{OUT}	R2	R1
12V	1.1K	11K
15V	1.5K	21K
18V	1K	17K
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 3A, ΔI_L=0.45A.

Table 2 Inductor select for output voltage setting (V_{CC}=6V)

V_{OUT}	9V	12V	15V	18V
L1 Value	18uH	22uH	25uH	27uH

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+0.25A).

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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.

The output capacitor need use 470uF*2 at switch current more than 1.5A.

Output Voltage Ripple

Application circuit item shows the basic application circuit with AX5101A. The output voltage ripple (V_{RIPPLE}) very lager at high switch current(I_{SW}=3A, $V_{RIPPLE} \doteqdot$ 0.7V), external π filters can reduce output voltage ripple or add MLCC 22uF at output.

a. π filters
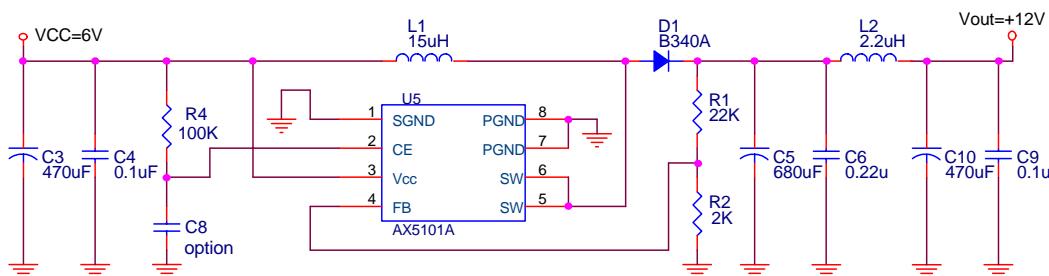
b. C6=22uF(MLCC)
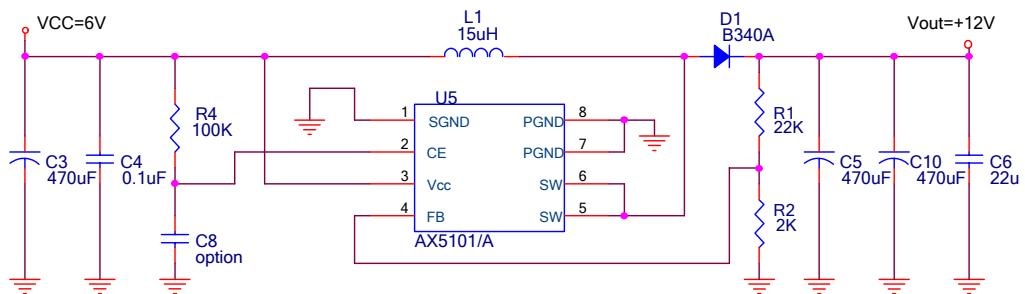
Layout Guidance

When laying out the PC board, the following suggestions should be taken to ensure proper operation of the AX5301. These items are also illustrated graphically in below.

1. The power traces, including the NMOS Drain & Source trace, the inductor and the C3 trace should be kept short, direct and wide to allow large current flow.

2. Connect the C7 to the V_{CC} & SGND pins of the AX5301 as closely as possible to get good power filter effect.

3. Keep the switching node, away from the sensitive FB node.

4. Do not trace signal line under inductor.

❖ Typical Characteristics

**Efficiency**
**(V_{IN}=6V, V_{OUT}=12V/1.4A)**

Efficiency
(V_{IN}=6V, V_{OUT}=18V/1.0A)

Efficiency
(V_{IN}=12V, V_{OUT}=18V/2.0A)

VOUT RIPPLE=710mV
(V_{IN}=6V, I_{IN}=3A, V_{OUT}=12V/1.4A)

(C6=22Uf(MLCC – PAGE 7))
VOUT RIPPLE=102mV
(V_{IN}=6V, I_{IN}=3A, V_{OUT}=12V/1.4A

(external π filters – PAGE 6)
VOUT RIPPLE=17mV
(V_{IN}=6V, I_{IN}=3A, V_{OUT}=12V/1.4A)

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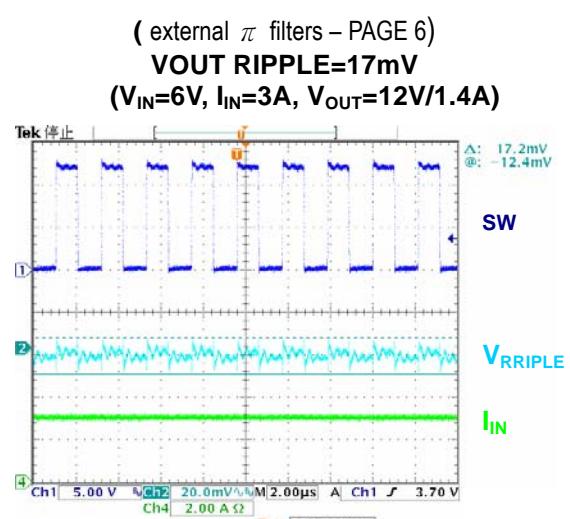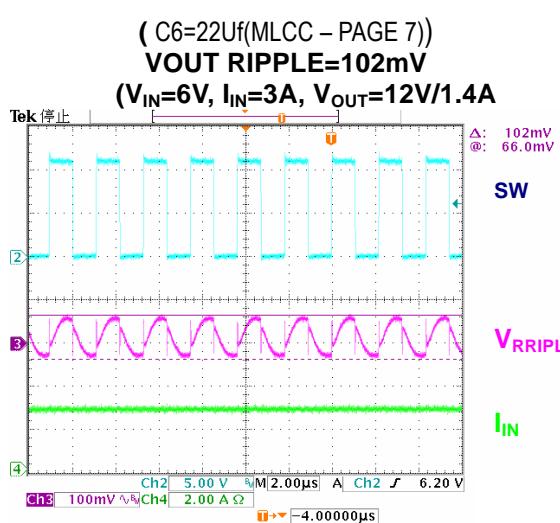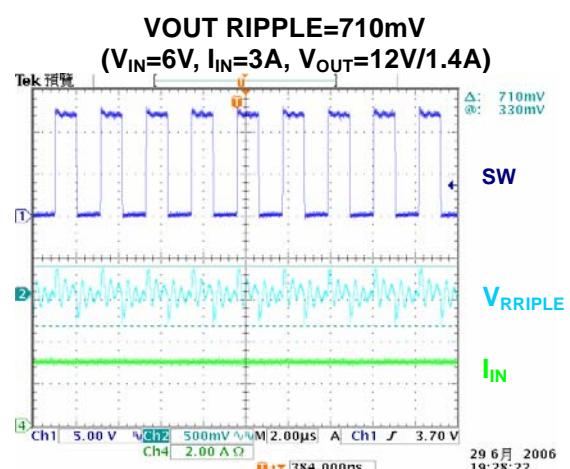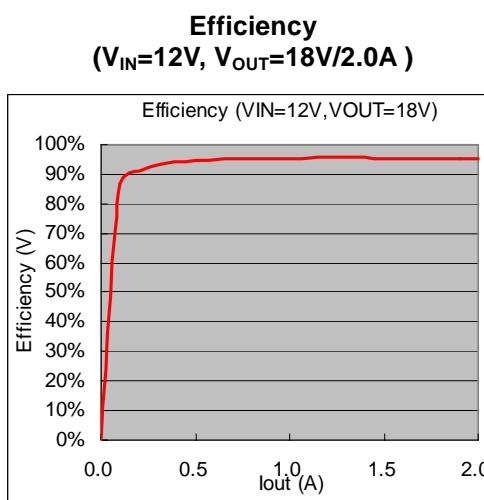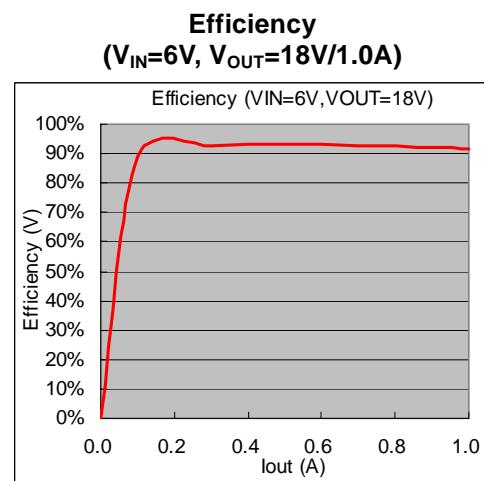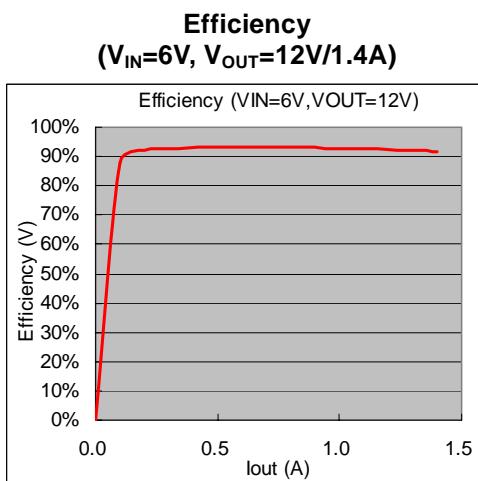
❖ **Package Outlines (SOP-8L)**

DETAIL A

DETAIL A
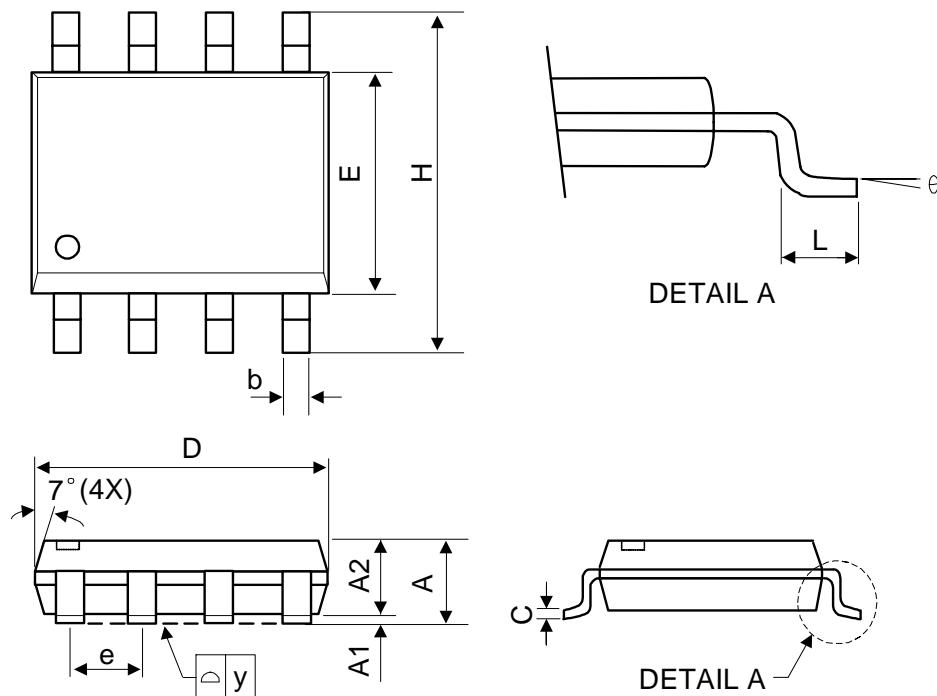
Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	-	0.25	0.040	-	0.100
A2	1.30	1.45	1.50	0.051	0.057	0.059
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	3.80	3.90	4.00	0.150	0.154	0.157
H	5.79	5.99	6.20	0.228	0.236	0.244
L	0.38	0.71	1.27	0.015	0.028	0.050
b	0.33	0.41	0.51	0.013	0.016	0.020
e	1.27 TYP			0.050 TYP		
y	-	-	0.10	-	-	0.004
θ	0º	-	8º	0º	-	8º

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❖ **Package Outlines (MSOP-8L)**
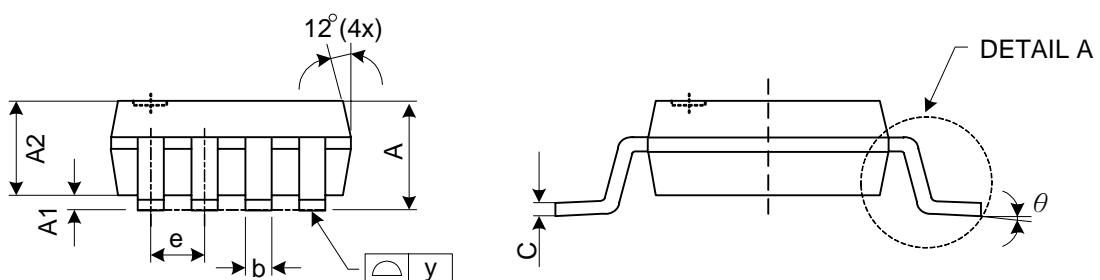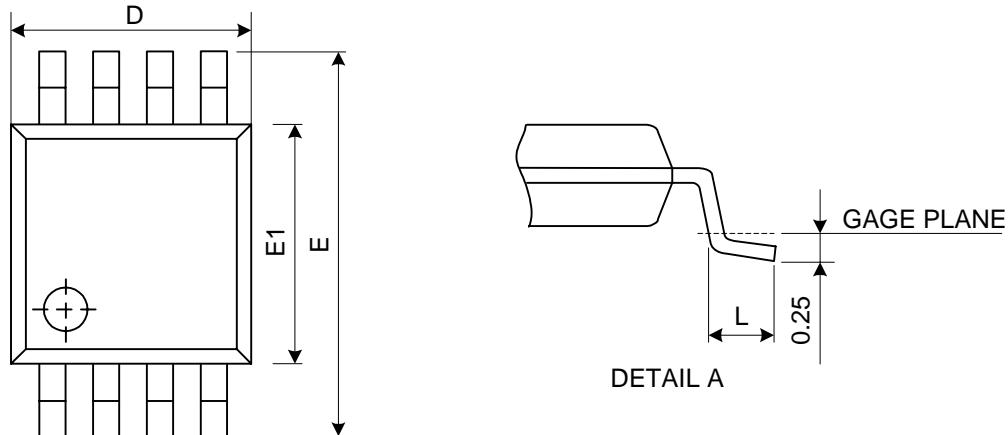
Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.81	0.96	1.12	0.032	0.038	0.044
A1	0.05	-	0.15	0.002	-	0.006
A2	0.76	0.86	0.97	0.030	0.034	0.038
b	0.28	0.30	0.38	0.011	0.012	0.015
C	0.13	0.15	0.23	0.005	0.006	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.80	4.90	5.00	0.189	0.193	0.197
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	-	0.65	-	-	0.0256	-
L	0.40	0.6	0.8	0.016	0.023	0.032
y	-	-	0.076	-	-	0.003
θ	0º	3º	6º	0º	3º	6º

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