PWM BUCK DC/DC CONVERTER

AE1509

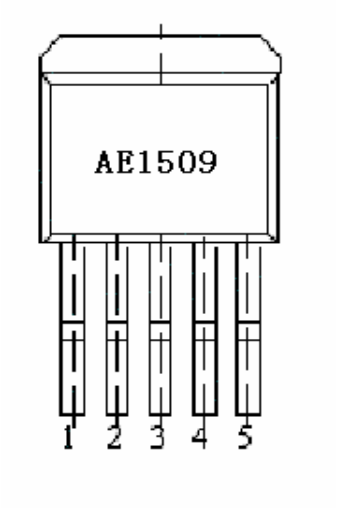
● Features

※ 3.3V, 5V, 12V three fixed output versior and adjustable version
※ Output load current 2A
※ Input voltage range up to 36V
※ Requires only 4 external components
※ 150 kHz fixed frequency internal oscillator
※ TTL shutdown capability
※ Low power standby mode, I_Q typically 80 μA
※ High efficiency
※ Thermal shutdown and current limit protection

● Application

※ Simple high-efficiency step-down (buck) regulator
※ LCD switching regulators

● Pin Configuration



T0-263-5L

● General Description

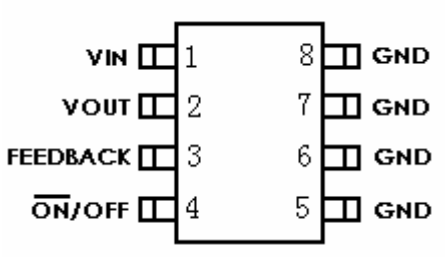
The AE1509 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 2A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V,12V version and adjustable version.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed frequency oscillator.

The AE1509 series operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators.

Other features include a guaranteed ±5% tolerance on output voltage under specified input voltage and output load conditions, and±15% on the oscillator frequency. External shutdown is included, featuring typically 80μA standby current. Selfprotection features include a two stage frequency reducing current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

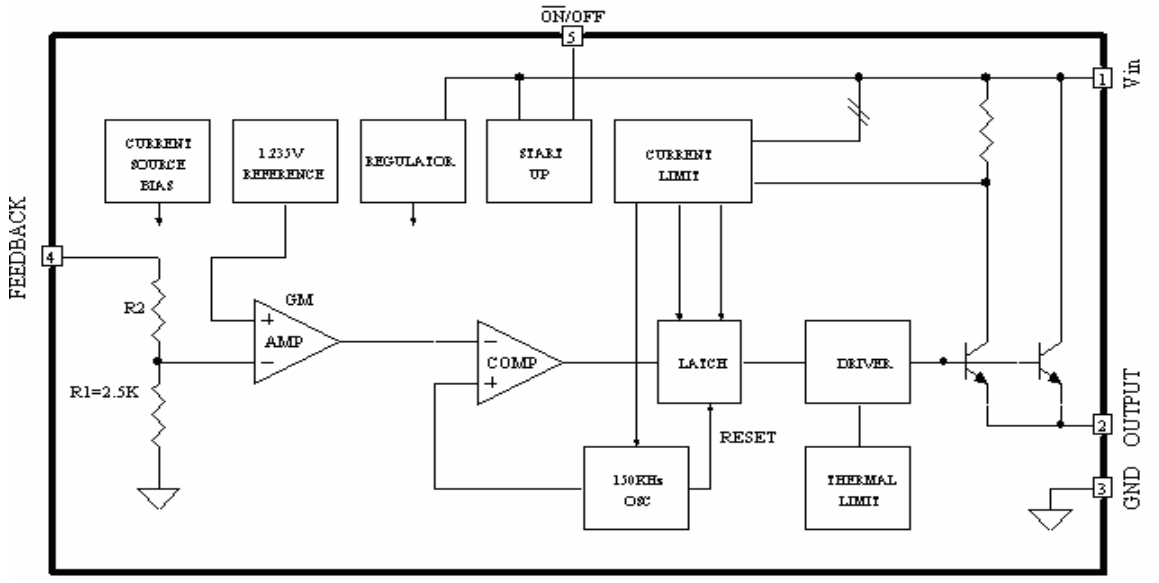
Pin No.	Symbol	Parameter
1	V_{IN}	DC Input
2	V_{OUT}	DC Output
3	GND	GND
4	Feedback	Feedback signal
5	$\overline{ON}$ /OFF	Standby control



SOP-8L

Pin No.	Symbol	Parameter
1	V_{IN}	DC Input
2	V_{OUT}	DC Output
3	Feedback	Feedback signal
4	$\overline{ON}/OFF$	Standby control
5-8	GND	GND

● Block Diagram



● Absolute Maximum Ratings(note1)

Parameter		Rating	Unit
Maximum Supply Voltage		36	V
$\overline{ON}$/OFF Pin Input Voltage		-0.3～25	V
Feedback Pin Voltage		-0.3～25	V
Power Dissipation		Internally limited	--
Storage Temperature Range		-65～150	℃
Conditions	Maximum Junction Temperature	150	℃
	Temperature Range	-40～125	℃
	Supply Voltage	5～36	V

Electrical Characteristics All Output Voltage Versions Electrical Characteristics

(otherwise specified, V_{IN} = 12V,I_{LOAD} = 500 mA)

V_O=3.3V

symbol	Parameter	Conditions		AE1509－XX Min (Note 4)	Typ (Note 3)	Max (Note4)	Units
f_O	Oscillator Frequency	(Note 6)		127	150	173	kHz
V_{SAT}	Saturation Voltage	I_{OUT}=2A(Notes 7, 8)		--	1.15	1.40	V
DC	Max Duty Cycle	$\overline{ON}$ (Note 8)		--	100	--	%
	Min Duty Cycle	OFF (Note 9)		--	0	--	%
I_{CL}	Current Limit	Peak Current (Notes 7, 8)		2.30	2.70	3.05	A
I_L	Output Leakage Current	Output = 0V (Notes 7, 9)		--	--	60	μA
		Output =-1V (Notes 10)		--	5	30	mA
I_Q	Quiescent Current	(Note 9)		--	7.20	12	mA
I_{STBY}	Standby Quiescent Current	$\overline{ON}$/*OFF* pin = 5V (OFF) (Note 10)		--	80	190	μA
θ_{JC}	Thermal Resistance	SOP-8L	Junction to case		15		℃/W
θ_{JA}	Thermal Resistance With copper area of approximately 3 in^2	SOP-8L	Junction to ambient		70		℃/W
θ_{JC}	Thermal Resistance	TO263	Junction to case		2		℃/W
θ_{JA}	Thermal Resistance With copper area of approximately 2.5 in^2	TO263	Junction to ambient		50		℃/W
ON/OFF	**CONTROL**						
	$\overline{ON}$/*OFF* Pin			--	1.4	--	V
V_{IH}	Logic Input	Low (Regulator on)		---	--	0.6	V
V_{IL}	Threshold Voltage	High (Regulator off)		2.0	--	---	V
I_H	$\overline{ON}$/*OFF* Pin Input Current	V_{LOGIC}=2.5V (Regulator OFF)		--	6	15	μA
I_L		V_{LOGIC}=0.5V (Regulator ON)		--	0.02	2	μA

Symbol	Parameter	Conditions	Min (Note 4)	Typ (Note 3)	Max (Note4)	Units

V_{OUT}	Output Voltage	$5V \leq V_{IN} \leq 36V$ $0.2A \leq I_{LOAD} \leq 2A$	3.15	3.30	3.40	V
η	Efficiency	V_{IN}=12V，I_{LOAD}=2A	--	72	--	%
V_O=5V						
V_{OUT}	Output Voltage	$7V \leq V_{IN} \leq 36V$ $0.2A \leq I_{LOAD} \leq 2A$	4.80	5.0	5.15	V
η	Efficiency	V_{IN}=12V，I_{LOAD}=2A	--	80	--	%
V_O=12V						
V_{OUT}	Output Voltage	$15V \leq V_{IN} \leq 36V$ $0.2A \leq I_{LOAD} \leq 2A$	12	11.6	12.35	V
η	Efficiency	V_{IN}=18V，I_{LOAD}=2A		90		%
Vout is adjustable						
V_{FB}	Feedback Voltage	$4.5V \leq V_{IN} \leq 36V$ $0.2A \leq I_{LOAD} \leq 2A$ V_{OUT} programmed for 3V.	1.195	1.230	1.255	V
η	Efficiency	V_{IN}=12V，V_{OUT}=3V， I_{LOAD}=2A	--	71	--	%

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

Note 3: Typical numbers are at 25℃ and represent the most likely norm.

Note4: All limits guaranteed at room temperature (standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note5: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance.

Note6: The switching frequency is reduced when the second stage current limit is activated.

Note7: No diode, inductor and capacitor connected to output pin.

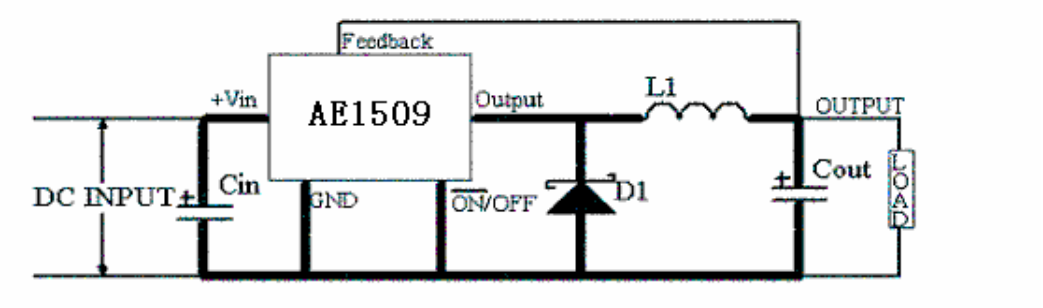
Note8: Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

Note9: Feedback pin removed from output and connected to 12V for the 3.3V, 5V version, and 15v for 12v version to force the output transistor switch OFF.

Note10: V_{IN} = 36V.

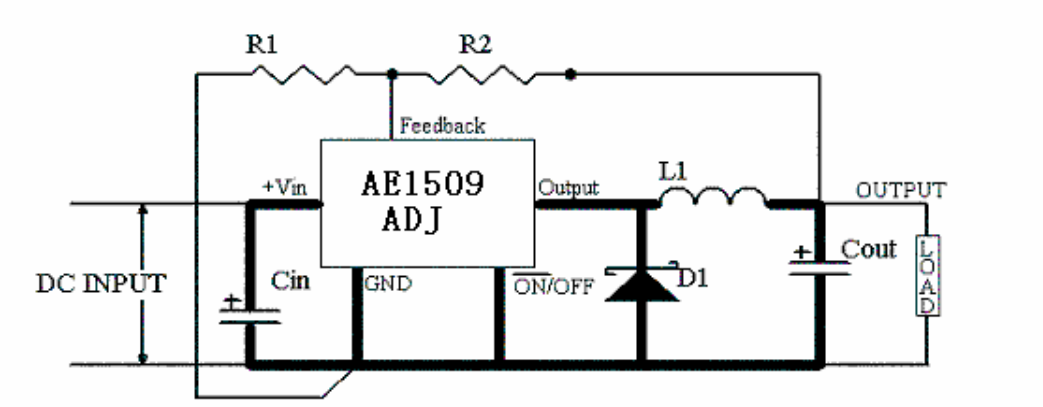
Testing Circuit

Fixed Output Voltage Versions



C_{IN} —470 μF, 50V, Aluminum Electrolytic Nichicon “PL Series”
C_{OUT} —220 μF, 25V Aluminum Electrolytic, Nichicon “PL Series”
D1 —2A, 40V Schottky Rectifier, 1N5822
L1 —68 μH, L38

Adjustable Output Voltage Versions



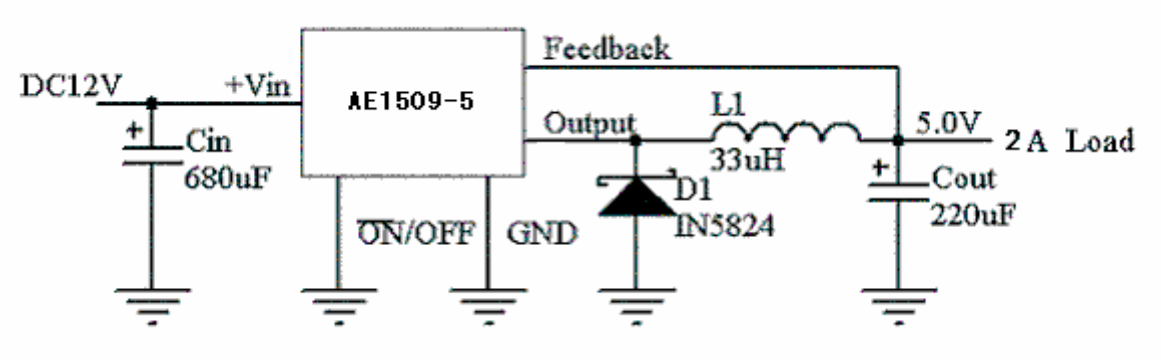
$V_{OUT}=V_{REF}(1+\frac{R_2}{R_1})$ $R_2=R_1(\frac{V_{OUT}}{V_{REF}}-1)$ $V_{REF}=1.23V$

C_{IN} —470μF 50V C_{OUT} —220μF 35V R_1 —1KΩ，1%。
D_1 —5A 40V IN5825 (Schottky Rectifier) L_1 —68μH

Note:

1. Keep Feedback wiring away from inductor flux and heavy line must be kept short and use ground plane construction for best results.
2. For this two package version ,the test circuit and typical application circuit are same.

● Typical Application circuit



● Pin Functions

+V_{IN}

This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

Ground

Circuit ground.

Output

Internal switch. The voltage at this pin switches between (+V_{IN}–V_{SAT}) and approximately–0.5V,with a duty cycle of approximately V_{OUT} / V_{IN}. To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should be kept a minimum.

Feedback

Senses the regulated output voltage to complete the feedback loop.

$\overline{ON}$/OFF

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 150uA. Pulling this pin below a threshold voltage of approximately 1.4V turns the regulator on, and pulling this pin above 1.4V (up to a maximum of 25V) shuts the regulator down. If this shutdown feature is not needed, the $\overline{ON}$/OFF pin can be wired to the ground pin or it can be left open, in either case the regulator will be in the ON condition.

● External Components

INPUT CAPACITOR C_{IN} —A low ESR aluminum or tantalum bypass capacitor is needed between the input pin and ground pin. It must be located near the regulator using short leads. This capacitor prevents large voltage transients from appearing at the input, and provides the instantaneous current needed each time the switch turns on. Selecting an input capacitor requires consulting the manufa- cturers data sheet for maximum allowable RMS ripple current. For a maximum ambient temperature of 40°C, a general guideline would be to select a capacitor with a ripple current rating of approximately 50% of the DC load current. For ambient temperatures up to 70°C, a current rating of 75% of the DC load current would be a good choice for a conservative design. The capacitor voltage rating must be at least 1.25 times greater than the maximum input voltage, and often a much higher voltage capacitor is needed to satisfy the RMS current requirements.

OUTPUT CAPACITOR C_{OUT} —-An output capacitor is required to filter the output and provide regulator loop stability. Low impedance or low ESR Electrolytic or solid tantalum capacitors designed for switching regulator applications must be used. When selecting an output capacitor, the important capacitor parameters are; the 100 kHz Equivalent Series esistance (ESR), the RMS ripple current rating, voltage rating, and capacitance value. For the output capacitor, the ESR value is the most important parameter. The output capacitor requires an ESR value that has an upper and lower limit. For low output ripple voltage, a low ESR value is needed. This value is determined by the maximum allowable output ripple voltage, typically 1% to 2% of the output voltage. But if the selected capacitor's ESR is extremely low, there is a possibility of an unstable feedback loop, resulting in an oscillation at the output.

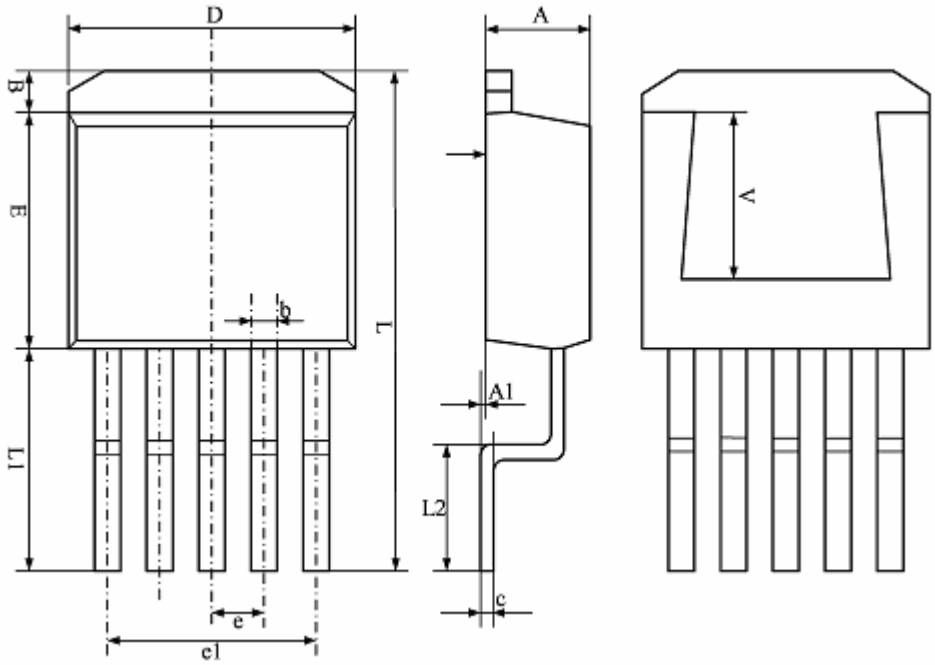
CATCH DIODE D----Buck regulators require a diode to provide a return path for the inductor current when the switch turns off. This must be a fast diode and must be located close to the AE1509 using short leads and short printed circuit traces. Because of their very fast switching speed and low forward voltage drop, Schottky diodes provide the best performance, especially in low output voltage applications (5V and lower). Ultra fast recovery, or High-Efficiency rectifiers are also a good choice, but some types with an abrupt turnoff characteristic may cause instability or EMI problems.

INDUCTOR SELECTION L----All switching regulators have two basic modes of operation; continuous and discontinuous. The difference between the two types relates to the inductor current, whether it is flowing continuously, or if it drops to zero for a period of time in the normal switching cycle. Each mode has distinctively different operating characteristics, which can affect the regulators performance and requirements. Most switcher designs will operate in the discontinuous mode when the load current is low. The AE1509 (or any of the Simple Switcher family) can be sed for both continuous and discontinuous modes of operation. There is a formula for general applications:

$$L=(5\sim10)\frac{V_O}{300I_O}(1-\frac{V_O}{V_{IN}})\text{mH}$$

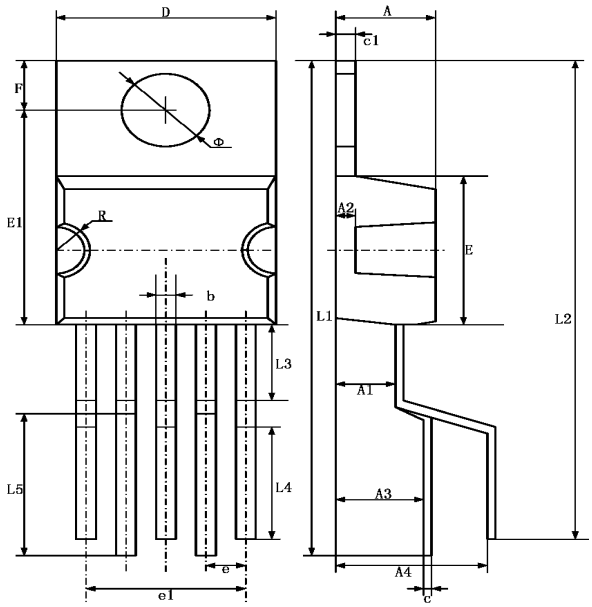
● Package Information

TO-263



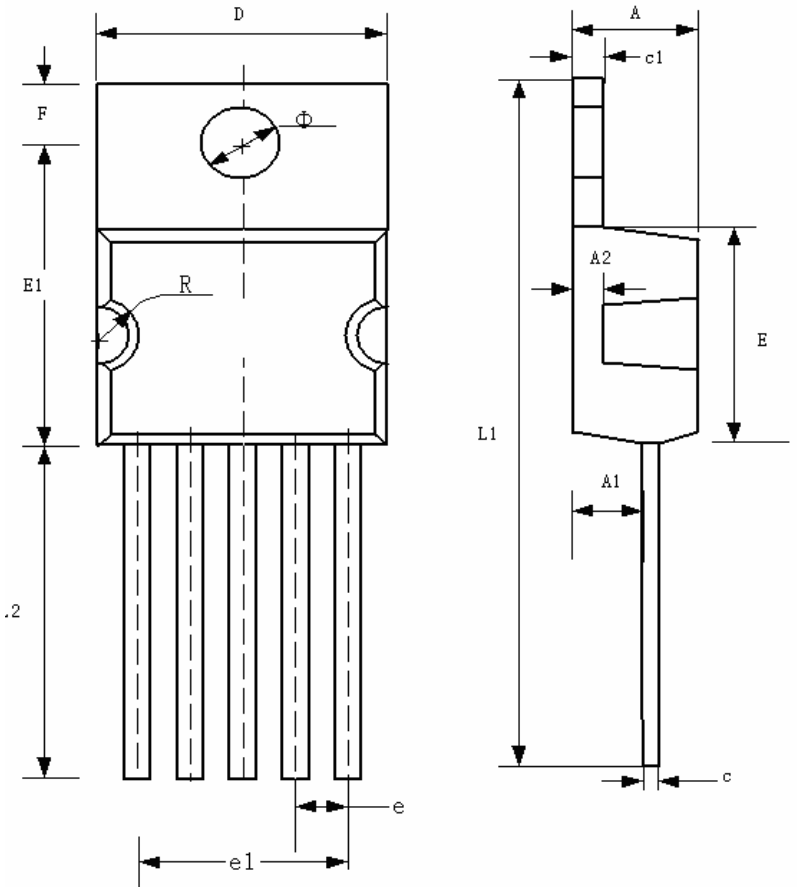
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	0.000	0.150	0.000	0.006
B	1.560	1.760	0.061	0.069
b	0.710	0.910	0.028	0.036
C	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	9.880	10.180	0.389	0.401
E	8.200	8.600	0.323	0.339
e	1.700TYP		0.067TYP	
e1	6.700	6.900	0.264	0.272
L	15.140	15.540	0.596	0.612
L1	5.080	5.480	0.200	0.216
L2	2.340	2.740	0.092	0.108
V	5.600REF		0.220REF	

TO-220(B)



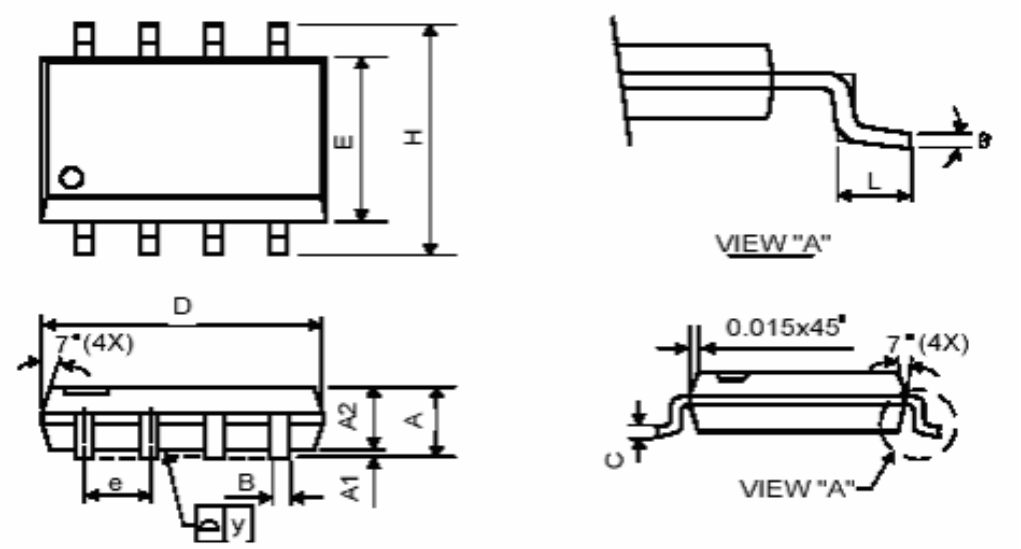
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
A2	1.170	1.370	0.046	0.054
A3	4.250	4.550	0.167	0.179
A4	8.250	8.550	0.325	0.337
b	0.710	0.910	0.028	0.036
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	10.010	10.310	0.394	0.406
E	8.900	9.300	0.350	0.366
E1	12.460	12.860	0.491	0.506
e	1.700TYP		0.220TYP	
e1	6.700	6.900	0.264	0.272
F	2.590	2.890	0.102	0.114
L1	25.100	25.500	0.988	1.004
L2	24.300	24.700	0.957	0.972
L3	3.400	3.600	0.134	0.142
L4	3.800	4.000	0.150	0.157
L5	5.300	5.500	0.209	0.217
R	0.950	1.050	0.037	0.041
Φ	3.790	3.890	0.149	0.153

TO-220(T)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
A2	1.170	1.370	0.046	0.054
b	0.710	0.910	0.028	0.036
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	10.010	10.310	0.394	0.406
E	8.900	9.300	0.350	0.366
E1	12.460	12.860	0.491	0.506
e	1.700TYP		0.220TYP	
e1	6.700	6.900	0.264	0.272
F	2.590	2.890	0.102	0.114
L1	28.700	29.100	1.130	1.146
L2	13.36	13.76	0.526	0.542
R	0.950	1.050	0.037	0.041
Φ	3.790	3.890	0.149	0.153

SOP-8L



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
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	5.05	5.30	0.189	0.199	0.209
E	3.70	3.90	4.10	0.146	0.154	0.161
e	-	1.27	-	-	0.050	-
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
y	-	-	0.10	-	-	0.004
θ	0^{o}	-	8^{o}	0^{o}	-	8^{o}