# SIMPLE SWITCHER POWER CONVERTE

# AE2596

## ● General Description

The AE2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down(buck) switching regulator, capable of driving a 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, and an adjustable output 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 AE2596 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. Available in a standard 5-lead TO-220 package with several different lead bend options, and a 5-lead TO-263 surface mount package.

Other features include a guaranteed±4% 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. Self-protection features include a two stage frequency reducing current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

## ● Features

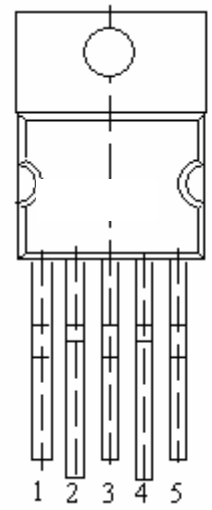
※ 3.3V, 5V, 12V, and adjustable output versions
※ Adjustable version output voltage range,1.2V to 32V
※ TO-220-5L and TO-263-5L packages
※ Output load current 3A
※ Input voltage range up to 40V
※ Requires only 4 external components
※ 150 kHz fixed frequency internal oscillator
※ TTL shutdown capability
※ Low power standby mode, $I_Q$ typically 80 μA
※ High efficiency
※ Thermal shutdown and current limit protection

## ● Application

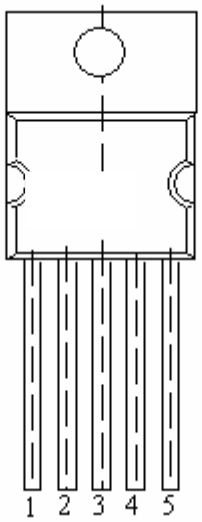
※ Simple high-efficiency step-down (buck) regulator
※ On-card switching regulators
※ Positive to negative converter

## ● Pin Description

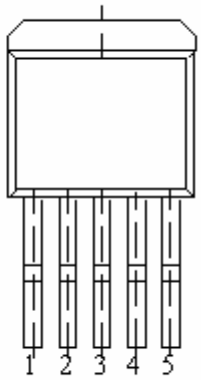
| Pin No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Symbol | VIN | Output | GND | Feedback | $\overline{ON}$/OFF |
| Parameter | DC Input | DC Output | Ground | Feedback signal | Standby control |




5-LeadTO-220(B)

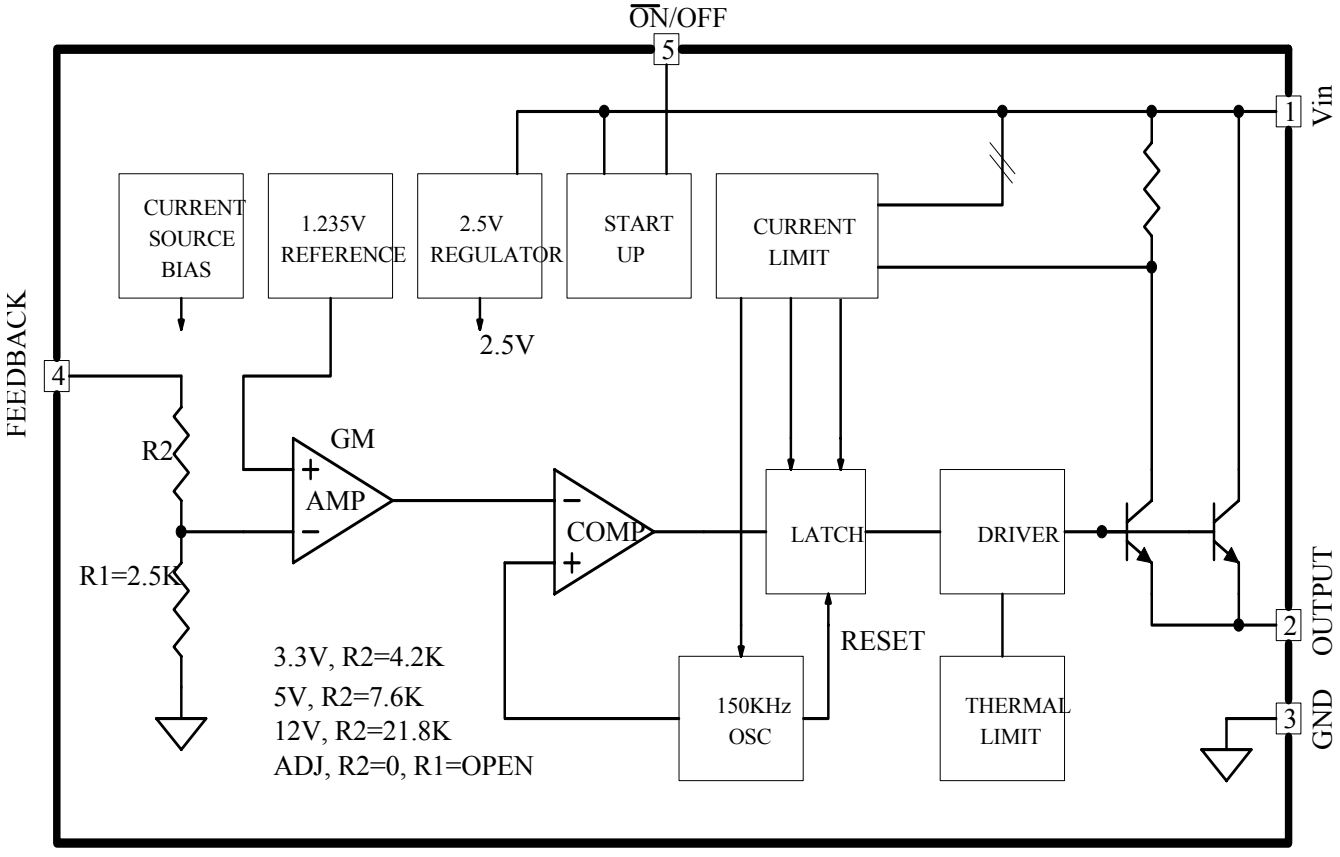



5-Lead TO-220(T)




5-Lead TO-263(S)

## ● Block Diagram



## ● Absolute Maximum Rating

| Parameter | | Rating | Unit |
|---|---|---|---|
| Maximum Supply Voltage | | 40 | 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 | 4.75～36 | V |

## ● Electrical Characteristics

| Symbol | Parameter | Conditions | Min (Note 4) | Typ (Note 3) | Max (Note4 ) | Units |
|---|---|---|---|---|---|---|
| **$V_{OUT}$=3.3V** | | | | | | |
| $V_{OUT}$ | Output Voltage | 5V≤$V_{IN}$≤36V<br>0.2A≤$I_{LOAD}$≤3A | 3.18 | 3.30 | 3.40 | V |
| η | Efficiency | $V_{IN}$=12V，$I_{LOAD}$=3A | -- | 72 | -- | % |
| **$V_{OUT}$=5V** | | | | | | |
| $V_{OUT}$ | Output Voltage | 7V≤$V_{IN}$≤36V<br>0.2A≤$I_{LOAD}$≤3A | 4.80 | 5.0 | 5.20 | V |
| η | Efficiency | $V_{IN}$=12V，$I_{LOAD}$=3A | -- | 79 | -- | % |
| **$V_{OUT}$=12V** | | | | | | |
| $V_{OUT}$ | Output Voltage | 15V≤$V_{IN}$≤36V<br>0.2A≤$I_{LOAD}$≤3A | 11.52 | 12.0 | 12.48 | V |
| η | Efficiency | $V_{IN}$=25V，$I_{LOAD}$=3A | -- | 88 | --- | % |
| **Vout is adjustable** | | | | | | |
| $V_{FB}$ | Feedback Voltage | 4.5V≤$V_{IN}$≤36V<br>0.2A≤$I_{LOAD}$≤3A<br>$V_{OUT}$ programmed for 3V. | 1.195 | 1.230 | 1.255 | V |
| η | Efficiency | $V_{IN}$=12V，<br>$V_{OUT}$=3V，$I_{LOAD}$=3A | -- | 71 | -- | % |

## ● All Output Voltage Versions Electrical Characteristics (otherwise specified, $V_{IN}$ = 12V for the 3.3V, 5V, and Adjustable version and $V_{IN}$ = 24V for the 12V version.$I_{LOAD}$ = 500 mA)

| Symbol | Parameter | Conditions | AE2596－XX | | | Units |
|---|---|---|---|---|---|---|
| | | | Min (Note 4) | Typ (Note 3) | Max (Note) | |
| $I_b$ | Feedback Bias Current | Adjustable Version Only, $V_{FB}$ = 1.3V | -- | 10 | 60 | nA |
| $f_O$ | Oscillator Frequency | (Note 6) | 135 | 150 | 173 | KHz |
| $V_{SAT}$ | VSAT Saturation Voltage | $I_{OUT}$=3A(Notes 7, 8) | -- | 1.36 | 1.60 | V |
| DC | Max Duty Cycle | ON (Note 8) | -- | 100 | -- | % |
| | Min Duty Cycle | OFF(Note 9) | -- | 0 | -- | % |
| $I_{CL}$ | Current Limit | Peak Current (Notes 7, 8) | 4.0 | 4.80 | 5.50 | A |
| $I_{SC}$ | Output Short Current | $R_{LOAD}$=0 | 5.20 | 5.50 | 6.40 | A |
| $I_L$ | Output Leakage Current | Output = 0V (Notes 7, 9) | -- | -- | 60 | μA |
| | | Output =-1V (Notes 10) | -- | 4 | 30 | mA |
| $I_Q$ | Quiescent Current | (Note 9) | -- | 7.60 | 12 | mA |
| $I_{STBY}$ | Standby Quiescent Current | $\overline{ON}$/*OFF* pin = 5V (OFF) (Note 10) | -- | 80 | 180 | μA |
| $\theta_{JC}$ | Thermal Resistance | TO-220 or TO-263 | -- | 2 | -- | °C/W |
| $\theta_{JA}$ | | TO-220 | -- | 50 | -- | °C/W |
| $\theta_{JA}$ | | TO-263 | -- | 50 | -- | °C/W |
| $\theta_{JA}$ | | TO-263 | -- | 30 | -- | °C/W |
| $\theta_{JA}$ | | TO-263 | -- | 20 | -- | °C/W |
| **ON/OFF** | **CONTROL** | | | | | |
| | $\overline{ON}$/*OFF* Pin Logic Input | | -- | 1.3 | -- | V |
| $V_{IH}$ | Threshold Voltage | Low (Regulator on) | 2.0 | -- | -- | V |
| $V_{IL}$ | | High(Regulator off) | -- | -- | 0.8 | V |
| $I_H$ | $\overline{ON}$/*OFF* Pin Input Current | $V_{LOGIC}$=2.5V (Regulator OFF) | -- | 4 | 15 | μA |
| $I_L$ | | $V_{LOGIC}$=0.5V (Regulator ON) | -- | 0.02 | 2 | μA |

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°C and represent the most likely norm.

Note4: All limits guaranteed at room temperature (standard type face) and at t emperature 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, and voltage programming resistors can affect switching regulator system performance.

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

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

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

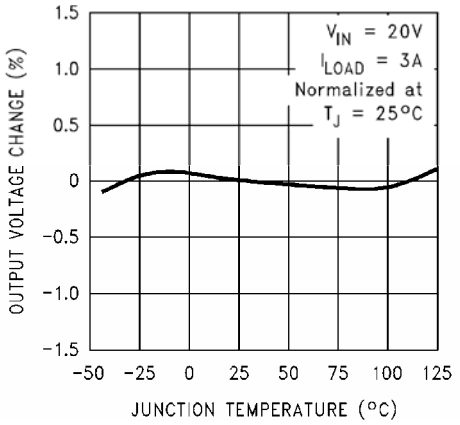
Note9: Feedback pin removed from output and connected to 12V for the 3.3V, 5V, and the ADJ. version, and 15V for the 12V version, to force the output transistor switch OFF.

Note10: $V_{IN}$ = 36V.

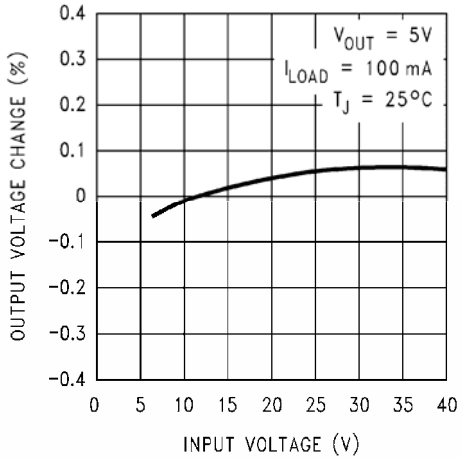
Note11: Junction to ambient thermal resistance (no external heat sink) for the TO-220 package mounted vertically, with the leads soldered to a printed circuit board with (1 oz.)copper area of approximately 1 $in^2$.

## ● Typical Performance Characteristics

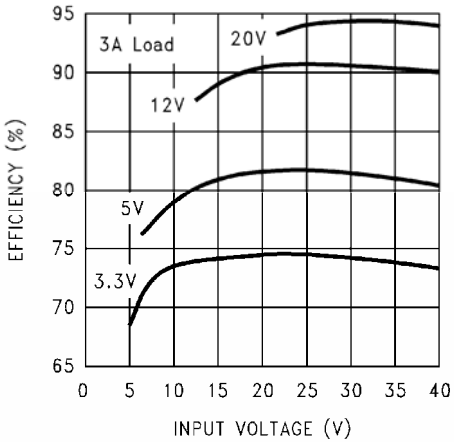
**Normalized Output Voltage**



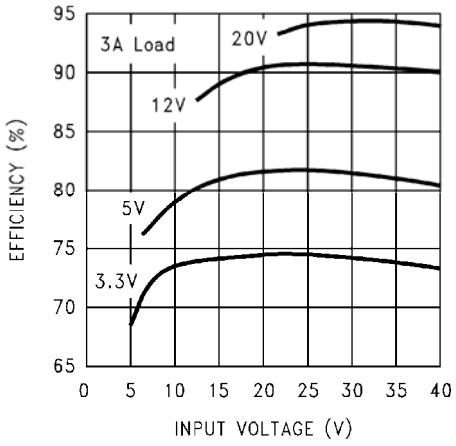

**Line Regulation**




**Efficiency**

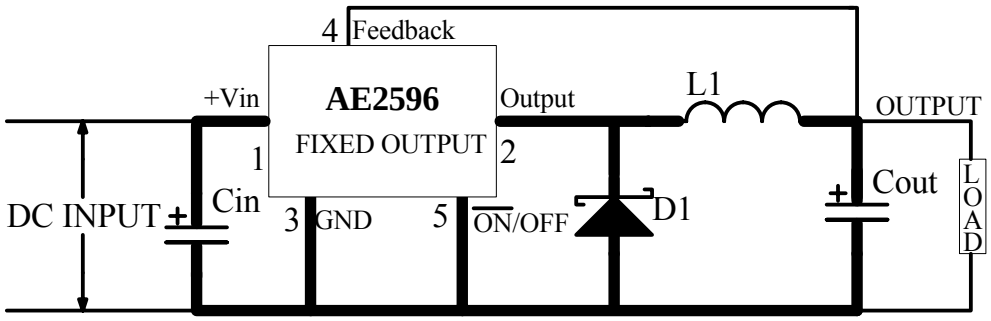



**Efficiency**



## ● Testing Circuit

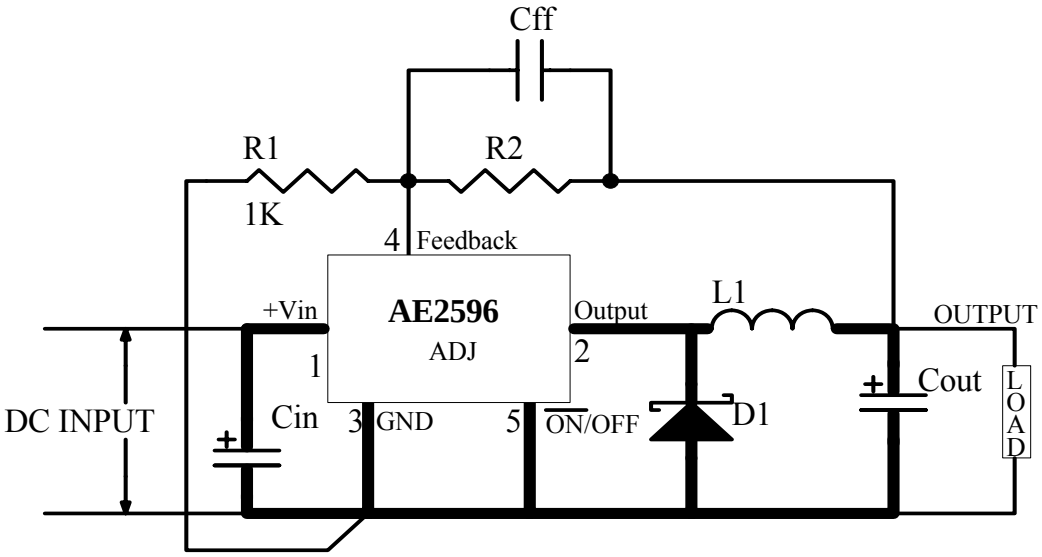
Fixed Output Voltage Versions




$C_{IN}$ —470 μF, 50V, Aluminum Electrolytic Nichicon “PL Series”
$C_{OUT}$ —220 μF, 25V Aluminum Electrolytic, Nichicon “PL Series”
D1 —5A, 40V Schottky Rectifier, 1N5825
L1 —68 μH, L38

**Note**: Keep Feedback wiring away from inductor flux and heavy line must be kept short and use ground plane construction or best results.

Adjustable Output Voltage Versions

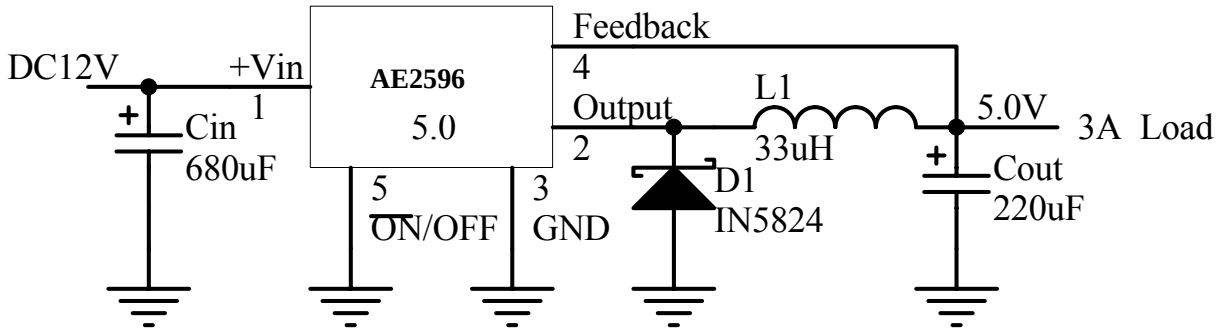



where VREF = 1.23V, $V_{OUT}=V_{REF}(1+\frac{R_2}{R_1})$ $R_2=R_1(\frac{V_{OUT}}{V_{REF}}-1)$

Select R1 to be approximately 1 k , use a 1% resistor for best stability.
$C_{IN}$ —470 μF, 50V, Aluminum Electrolytic Nichicon “PL Series”
$C_{OUT}$ —220 μF, 35V Aluminum Electrolytic, Nichicon “PL Series”
D1 —5A, 40V Schottky Rectifier, 1N5825
L1 —68 μH, L38

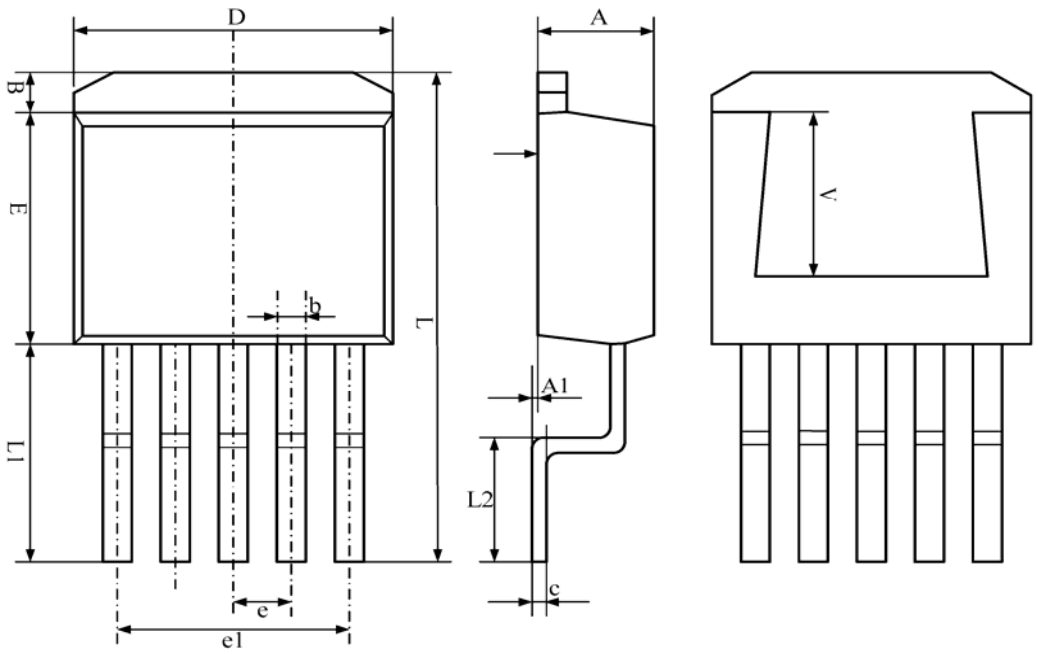
R1 —1 k , 1%
CFF —See Application Information Section
**Note**: Keep Feedback wiring away from inductor flux and heavy line must be kept short and use ground plane construction or best results.

- Typical Application circuit



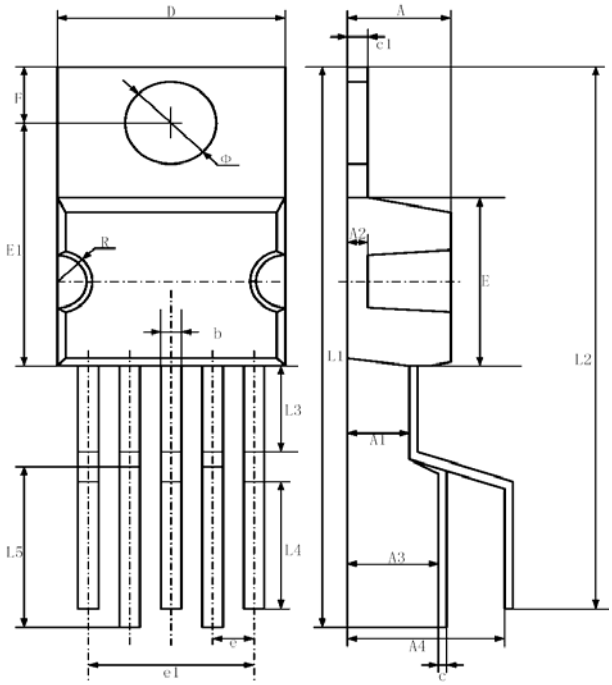
## ● Package Information

**TO-263**



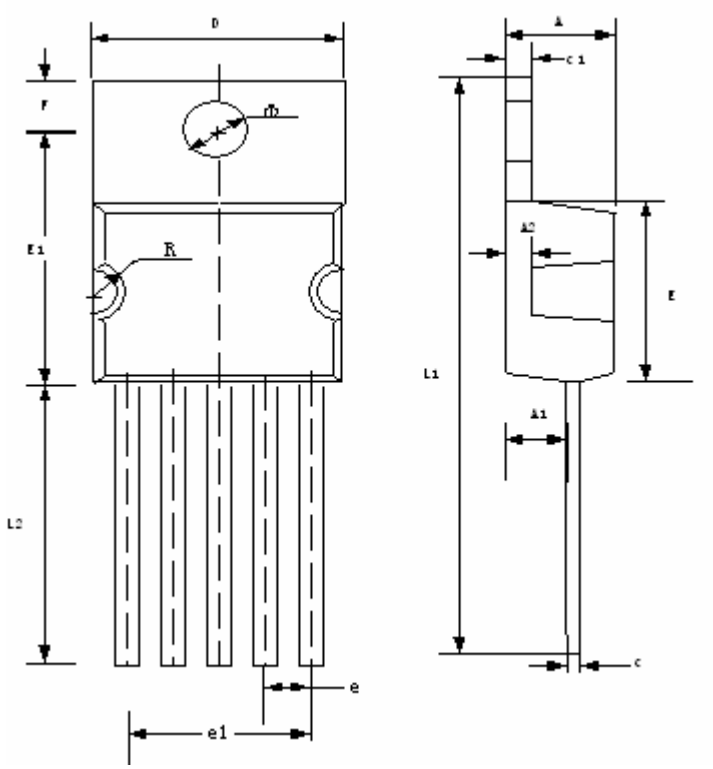

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 4.470 | 4.670 | 0.176 | 0.184 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| B | 1.560 | 1.760 | 0.061 | 0.069 |
| b | 0.710 | 0.910 | 0.028 | 0.036 |
| C | 0.310 | 0.530 | 0.012 | 0.021 |
| 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-220B-5L




| 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 |
| | 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-220-5L (T)




| Symbol | | | 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 |