Simple Switcher Power Converter 150kHz 3A Step-Down Voltage Regulator LM2596

DESCRIPTIONS:

The LM2596 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 LM2596 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.

A standard series of inductors are available from several different manufacturers optimized for use with the LM2596 series. This feature greatly simplifies the design of switch-mode power supplies.

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 80 μA 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:

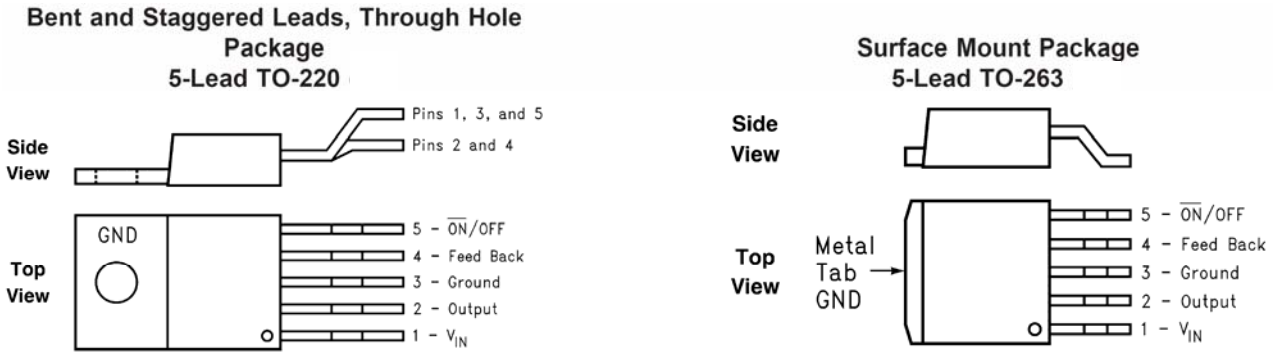
- 3.3V, 5V, 12V, and adjustable output versions
- Adjustable version output voltage range, 1.2V to 37V±4% max over line and load conditions
- Guaranteed 3A output load current
- Input voltage range up to 40V
- Requires only 4 external components
- Excellent line and load regulation specifications
- 150 kHz fixed frequency internal oscillator
- TTL shutdown capability

- Low power standby mode, IQ typically 80 µA
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

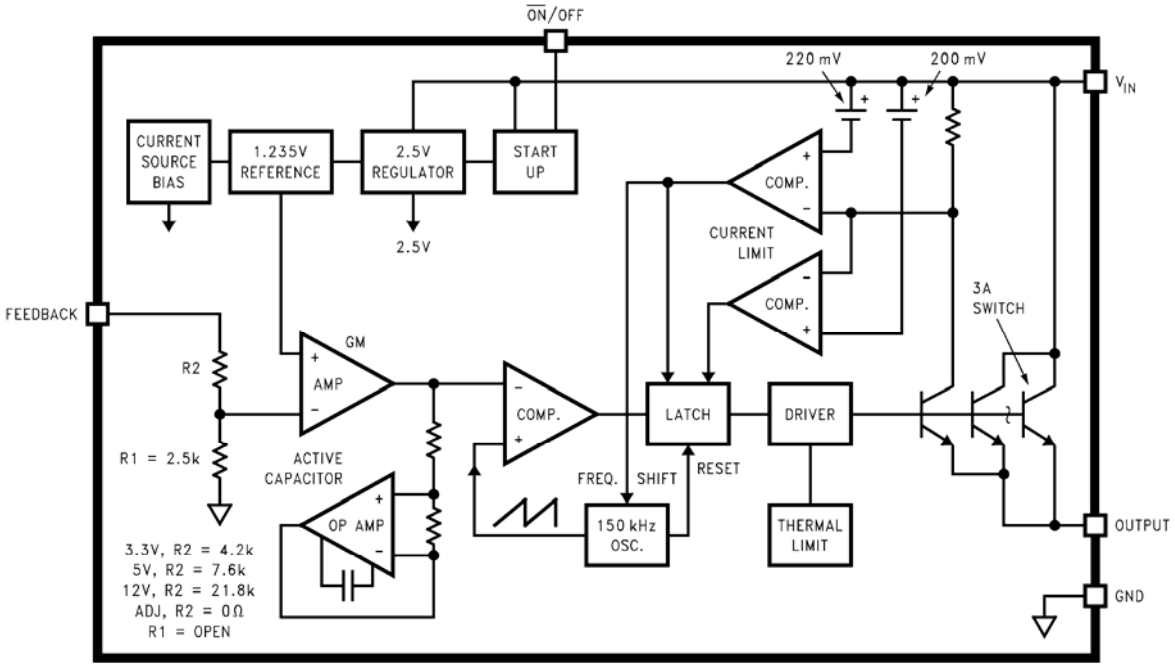
APPLICATIONS:

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

PIN CONNECTION:



BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS: *1

Characteristic			Limit	Unit
Maximum supply voltage			45	V
$\overline{ON}$/OFF pin input voltage			-0.3≤V≤±25	V
Feedback pin voltage			-0.3≤V≤±25	V
Output voltage to ground (steady state)			-1	V
Power dissipation			Internally limited	
Storage temperature range			-65 to +150	°C
ESD susceptibility (human body model) *2			2	kV
Lead temperature	TO-263	Vapor phase(60 sec.)	215	°C
		Infrared (10 sec.)	245	°C
	TO-220	Soldering, 10 sec.	260	°C
Maximum junction temperature			150	°C

ELECTRICAL CHARACTERISTICS:

LM2596-3.3 (Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**) *5

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
System Parameters *5 Test Circuit Figure						
Output voltage	V_{OUT}	4.75V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	3.168/ 3.135	3.3	3.432/ 3.465	V
Efficiency	η	V_{IN} =12V, I_{LOAD} =3A		73		%

LM2596-5.0 (Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**) *5

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
System Parameters *5 Test Circuit Figure						
Output voltage	V_{OUT}	7V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	4.800/ 4.750	5.0	5.200/ 5.250	V
Efficiency	η	V_{IN} =12V, I_{LOAD} =3A		80		%

LM2596-12 (Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**) *5

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
System Parameters *5 Test Circuit Figure						
Output voltage	V_{OUT}	15V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	11.52/ 11.40	12.0	12.48/ 12.60	V
Efficiency	η	V_{IN} =25V, I_{LOAD} =3A		90		%

LM2596-ADJ (Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**) *5

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
System Parameters *5 Test Circuit Figure						
Feedback voltage	V_{FB}	4.5V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A V_{OUT} Programmed for 3V	1.193/ 1.180	1.230	1.267/ 1.280	V
Efficiency	η	V_{IN} =25V, I_{LOAD} =3A		73		%

All Output Voltage Versions (Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless 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)

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
Device parameters						
Feedback bias current	I_b	Adjustable version only, V_{FB}=1.3V		10	50/ 100	nA
Oscillator frequency	f_O	*6	127/ 110	150	173	kHz
Saturation voltage	V_{SAT}	I_{OUT}=3A *7,8		1.16	1.4/ 1.5	V
Max duty cycle(ON)	DC	*8		100		%
Min duty cycle(OFF)		*9		0		
Current limit	I_{CL}	Peak current *7,8	3.6/ 3.4	4.5	6.9/ 7.5	A
Output leakage current	I_L	Output=0V *7,9			50	μA
		Output=-1V *10		2	30	mA

Continued:

Characteristics	Symbol	Test conditions	Min *4	Typ. *3	Max. *4	Unit
Quiescent current	I_Q	*9	5	10		mA
Standby quiescent current	I_{STBY}	ON/OFF pin=5V(OFF) *10		80	200/ 250	μA
Thermal resistance	θ_{JC}	TO-220 or TO-263 package junction to case		2		°C/W
	θ_{JA}	TO-220 package junction to ambient *11		50		
		TO-263 package junction to ambient *12		50		
		TO-263 package junction to ambient *13		30		
		TO-220 package junction to ambient *14		20		
ON/OFF Control Test Circuit Figure						
$\overline{ON}$/OFF pin logic input threshold voltage	V_{IH}	Low (regulator ON)	0.6	1.3		V
	V_{IL}	High (regulator OFF)			2.0	
$\overline{ON}$/OFF pin input current	I_H	V_{LOGIC}=2.5V (regulator OFF)		5	15	μA
	I_L	V_{LOGIC}=0.5V (regulator ON)		0.02	5	

***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.

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

***3:** Typical numbers are at 25°C and represent the most likely norm.

***4:** 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).

***5:** External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator system performance. When the LM2596 is used as shown in the Figure 1test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

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

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

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

*** 9:** 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.

*** 10:** V_{IN} = 40V.

*** 11:** 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.

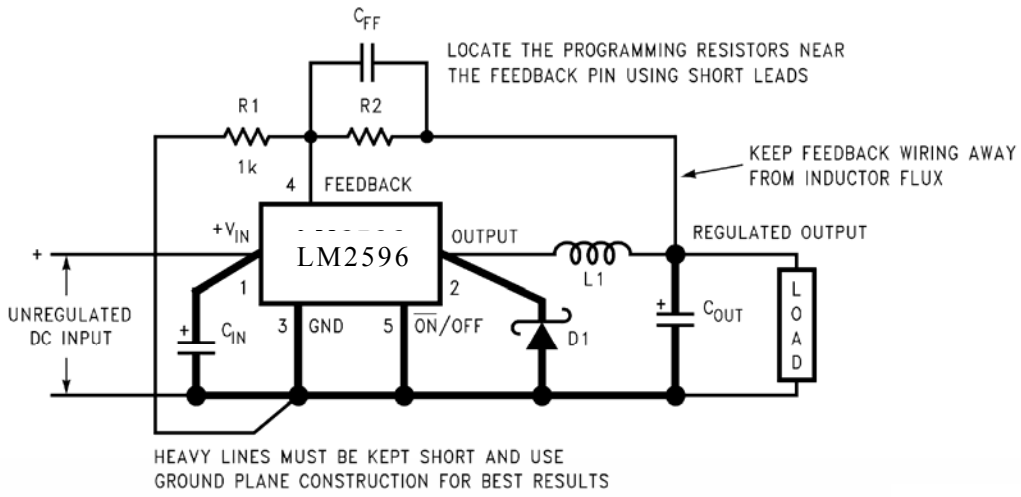
*** 12:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a single printed circuit board with 0.5 in^2 of (1 oz.) copper area.

*** 13:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a single sided printed circuit board with 2.5 in^2 of (1 oz.) copper area.

*** 14:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a double sided printed circuit board with 3 in^2 of (1 oz.) copper area on The LM2596S side of the board, and approximately 16 in^2 of copper on the other side of the p-c board. See Application Information in this data sheet and the thermal model in Switchers Made Simple™ version 4.3 software.

TEST CIRCUIT AND LAYOUT GUIDELINES

Adjustable Output



$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right)$$

where V_{REF} = 1.23V

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

Select R_1 to be approximately 1 kΩ, 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"

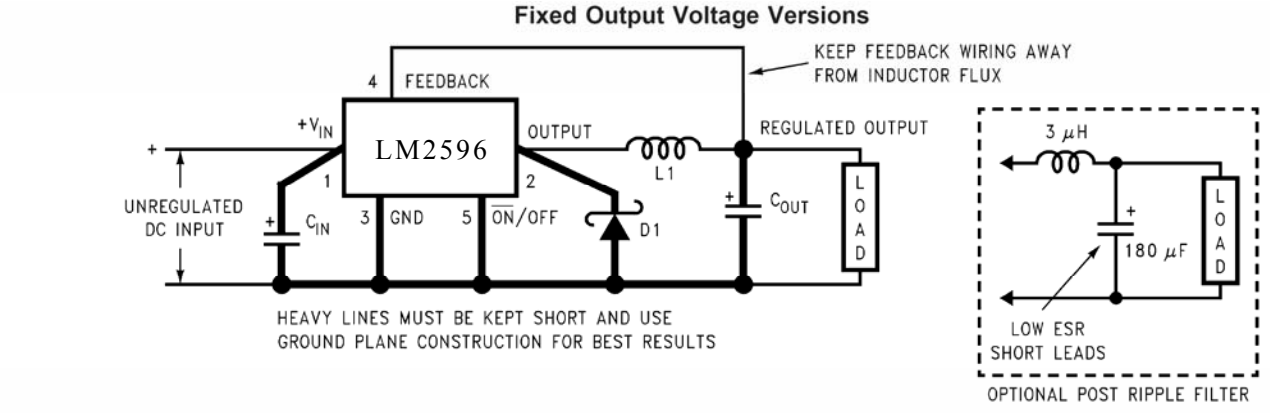
D1 —5A, 40V Schottky Rectifier, 1N5825

L1 —68 µH, L38

R1 —1 kΩ, 1%

C_{FF} —See Application Information Section

Fixed Output

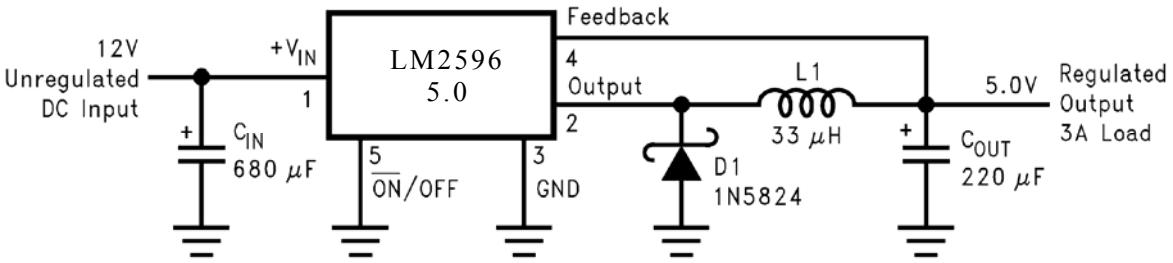


C_{IN} —470 µF, 50V, Aluminum Electrolytic Nichicon "PL Series"
C_{OUT} —220 µF, 25V Aluminum Electrolytic, Nichicon "PL Series"
D1 —5A, 40V Schottky Rectifier, 1N5825
L1 —68 µH, L38

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by **heavy lines should be wide printed circuit traces and should be kept as short as possible.** For best results, external components should be located as close to the switcher lC as possible using ground plane construction or single point grounding.

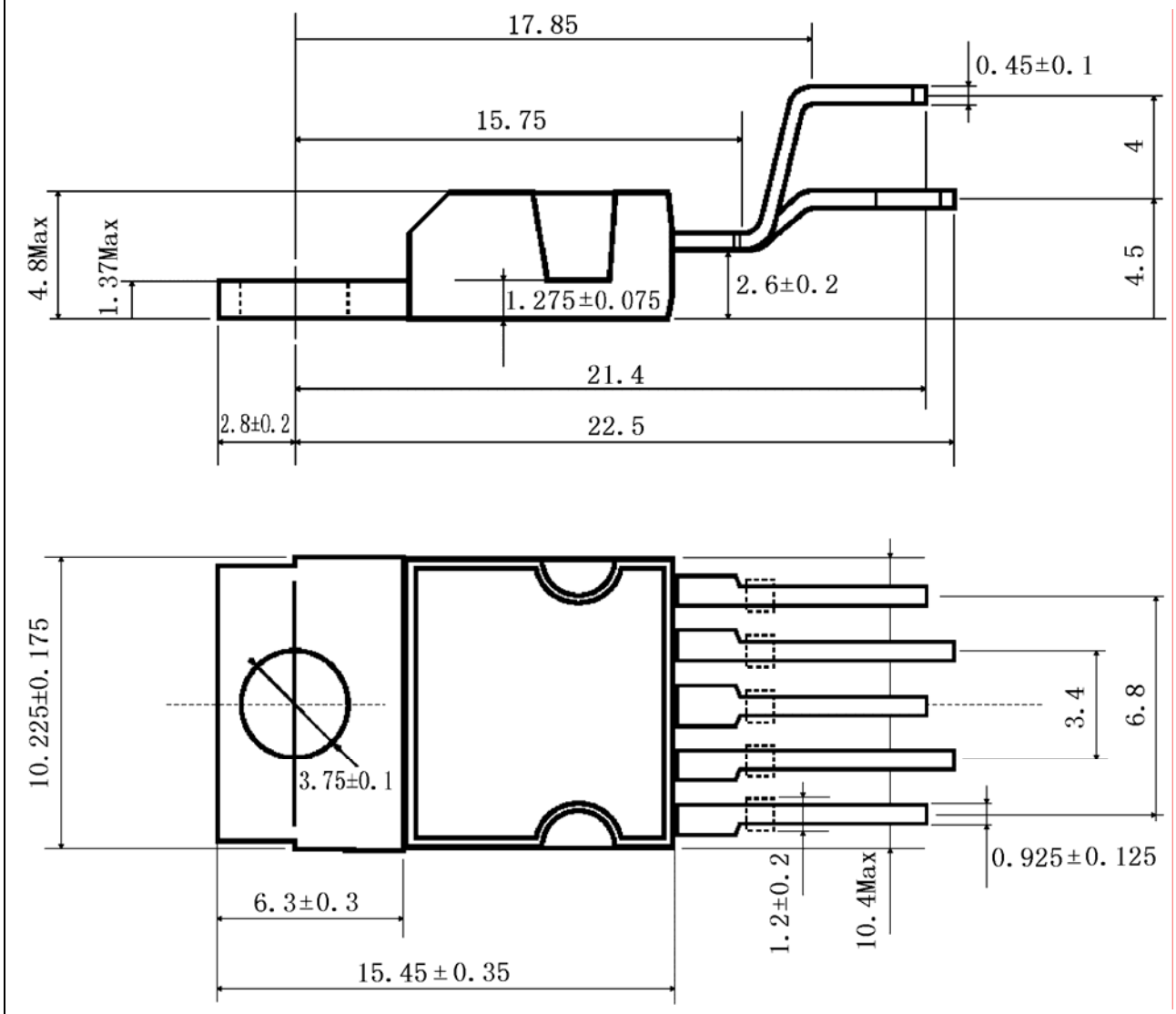
If **open core inductors are used,** special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, lC groundpath and C_{OUT} wiring can cause problems. When using the adjustable version, special care must be taken as to the location of the feedback resistors and the associated wiring. Physically locate both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor. (See application section for more information.)

APPLICATION CIRCUIT

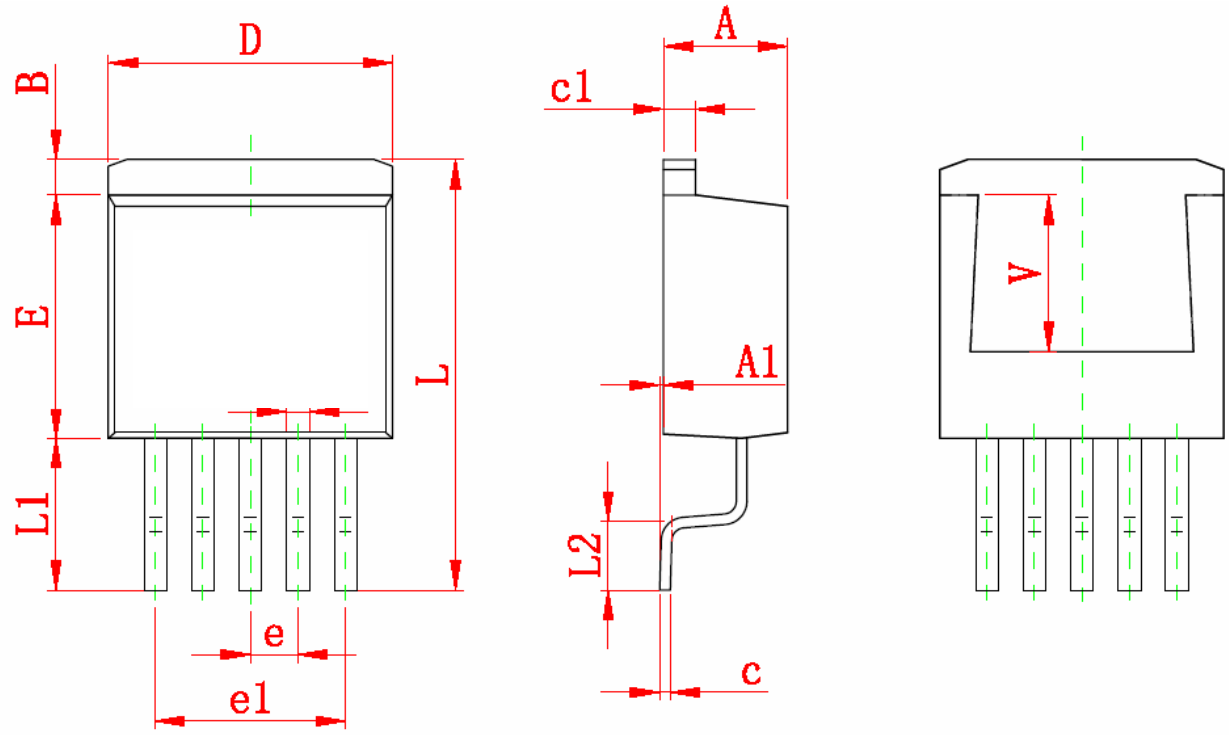


OUTLINE DRAWING:

TO-220 Unit:mm



TO-263 Unit:mm



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	1.700 TYP		0.067 TYP	
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	5.600 REF		0.220 REF	