

## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

- **Fixed and Adjustable Voltage Versions**
- **Output Current up to 1.5A**
- **Low Dropout Voltage 350mV @ 1.5A**
- **Low Ground Current**
- **Accurate 1% Guaranteed Tolerance**
- **Extremely Fast Transient Response**
- **Reverse-battery Protection**
- **“Load Dump” Protection**

The GM66150 series of positive fixed and adjustable regulators are designed to provide up to 1.5A output with high current, high accuracy and extremely low dropout voltage performance. These regulators feature 300 to 350mV (full load) dropout voltages and very low ground current. Although designed for high current loads, these devices are also useful in lower current, extremely low dropout-critical systems, where their minimal dropout voltage and ground current values are important characteristics.

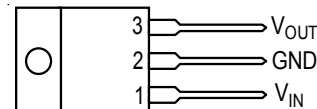
The GM66150's are fully protected against overcurrent, reversed input polarity (or reversed battery connection), reversed lead insertion, over-temperature operation, and transient voltage spikes (positive or negative).

The GM66150's are available in TO-220 and surface-mount TO263 packages.

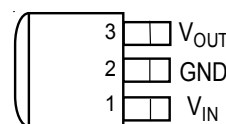
### Applications:

- **High Efficiency Linear Regulators**
- **Post Regulators for Switching Supplies**
- **Battery Powered Equipment**
- **High Efficiency “Green” Computer Systems**
- **Automotive Electronics**

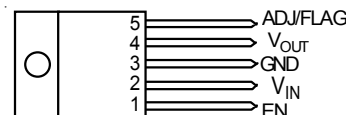
### PIN CONFIGURATIONS



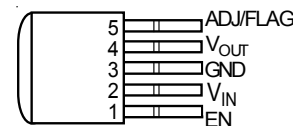
TO-220 3-LEAD



TO-263 (D2PAK)



TO-220 5-LEAD



TO-263 (5-LEAD)

### TYPICAL APPLICATION CIRCUITS

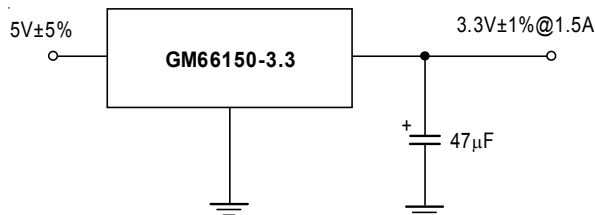


Figure 1. Fixed Voltage Version

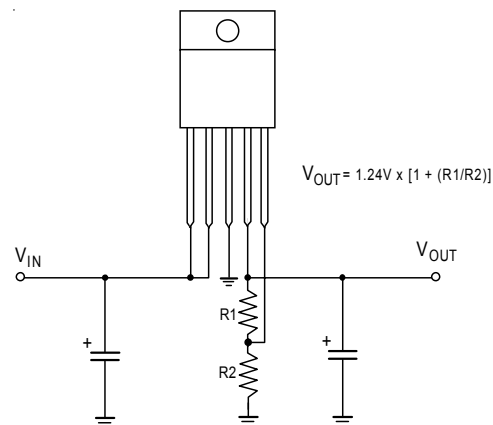


Figure 2. Adjustable Voltage Version

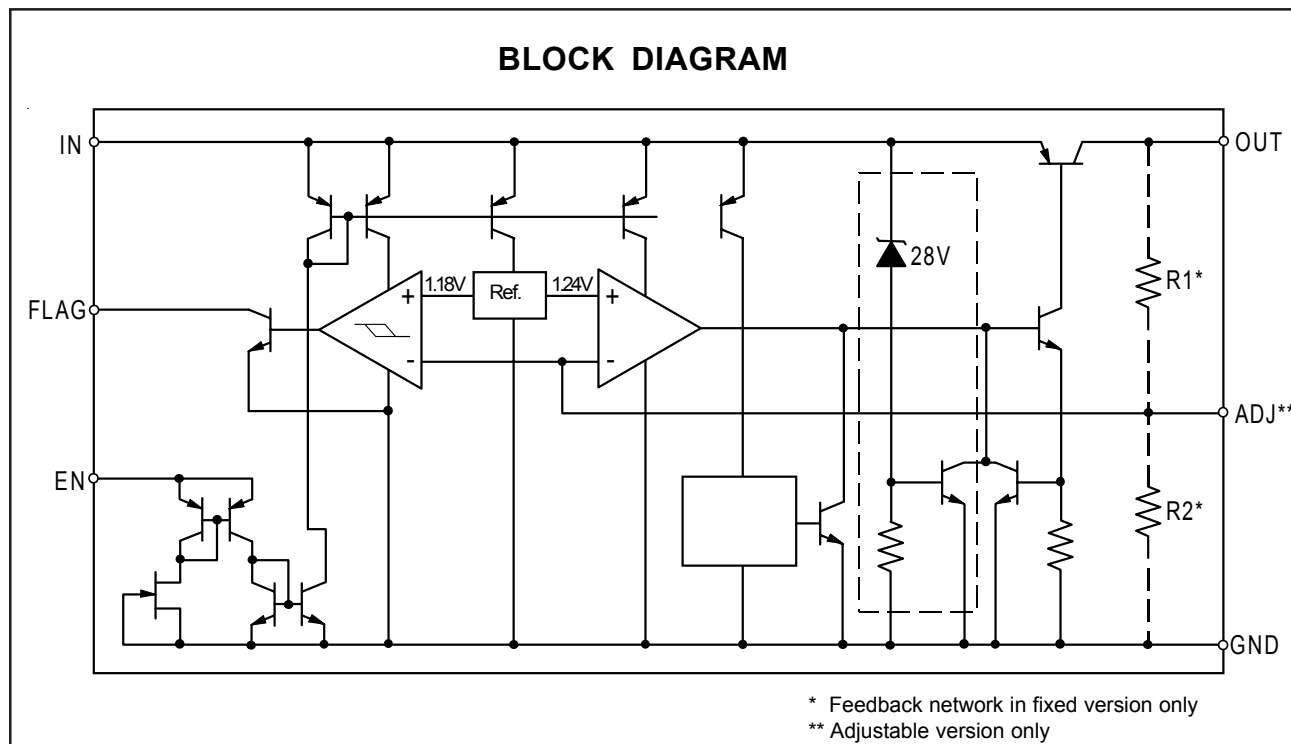
## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

### ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Power Dissipation	$P_D$	Internally limited	W
Input Supply Voltage	$V_{IN}$	-20 to +60	V
Lead Temperature (Soldering, 5 sec)	$T_{LEAD}$	260	°C
Storage Temperature Range	$T_{STG}$	-65 to +150	°C

### ■ OPERATING RATINGS

Parameter	Symbol	Value	Unit
Maximum Operating Input Voltage	$V_{IN}$	26	V
Operating Junction Temperature Range	$T_J$	-40 to +125	°C
Thermal Resistance	$\theta_{JC}$	2.0	°C/W



## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

### ■ ELECTRICAL CHARACTERISTICS

Unless otherwise specified:  $T_J = 25^\circ\text{C}$ ; **Bold** values are guaranteed across the operating temperature range.

Adjustable versions are programmed to 5.0V.

CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage (Note2)	$I_O = 10\text{ mA}$	-1		1	%
	$10\text{mA} \leq I_O \leq I_{FL}, (V_{OUT}+1V) \leq V_{IN} \leq 26V$	-2		2	%
Line Regulation	$I_O = 10\text{ mA}, (V_{OUT}+1V) \leq V_{IN} \leq 26V$		0.06	0.5	%
Load Regulation	$V_{IN} = V_{OUT}+5V, 10\text{mA} \leq I_{OUT} \leq I_{FL}$		0.20	1.0	%
Output Voltage change with Temperature Coef. (Note 6)	$\Delta V_{OUT}/\Delta T$		20	100	ppm/ $^\circ\text{C}$
Dropout Voltage	$\Delta V_{OUT} = -1\%$ (Note 3)				
	$I_O = 100\text{ mA}$		80	200	mV
	$I_O = 750\text{ mA}$		220	600	
	$I_O = 1.5\text{ A}$		350		
Ground Current	$I_O = 750\text{ mA}, V_{IN} = V_{OUT}+1V$ $I_O = 1.5\text{ A}$		8 22	20	mA
Ground Pin Current at Dropout $I_{GNDDO}$	$V_{IN} = 0.5V$ less than specified $V_{OUT}, I_{OUT} = 10\text{ mA}$		0.9		mA
Current Limit	$V_{OUT} = 0V$ (Note 4)		2.1	3.5	A
Output Noise Voltage $e_n$ , (10Hz to 100kHz) $I_O = 100\text{ mA}$	$C_L = 10\mu\text{F}$		400		$\mu\text{V}$ (rms)
	$C_L = 33\mu\text{F}$		260		
Ground Current in Shutdown	$V_{EN} = 0.4V$		2	10 30	$\mu\text{A}$
<b>Reference GM66152/GM66153</b>					
Reference Voltage		1.228 1.215	1.240	1.252 1.265	V V (max)
Reference Voltage	(Note 8)	1.203		1.277	V
Adjust Pin Bias Current			40	80 120	nA
Referencet Voltage change with Temperature Coef.	(Note 7)		20		ppm/ $^\circ\text{C}$
Adjust Pin Bias Current change with Temperature Coef.			0.1		nA/ $^\circ\text{C}$
<b>Flag Output (Error Comparator) GM66151/GM66153</b>					
Output Leakage Current	$V_{OH} = 26V$		0.01	1 2	$\mu\text{A}$
Output Low Voltage	Device set for 5V, $V_N = 4.5V$ $I_{OL} = 250\text{ }\mu\text{A}$		220	300 400	mV
Upper Threshold Voltage	Device set for 5V (Note 9)	40 25	60		mV
Lower Threshold Voltage	Device set for 5V (Note 9)		75	95 140	mV
Hysteresis	Device set for 5V (Note 9)		15		mV
<b>Enable Input GM66151/GM66152</b>					
Input Logic Voltage Low(OFF) High(ON)			2.4	0.8	V
Enable Pin Input Current	$V_{EN} = 26V$		100	600 750	$\mu\text{A}$
	$V_{EN} = 0.8V$			1 2	$\mu\text{A}$
Regulator Output Current In Shutdown	(Note 10)		10	500	$\mu\text{A}$

## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

### ■ ELECTRICAL CHARACTERISTICS (*continued*)

#### Notes:

**Note 1:** Maximum positive supply voltage of 60V must be of limited duration (<100msec) and duty cycle ( $\leq 1\%$ ).

The maximum continuous supply voltage is 26V.

**Note 2:** Full Load current ( $I_{FL}$ ) is defined as 1.5A for the GM66150 series.

**Note 3:** Dropout voltage is defined as the input-to-output differential when the output voltage drops to 99% of its nominal value with  $V_{OUT} + 1V$  applied to  $V_{IN}$ .

**Note 4:**  $V_{IN} = V_{OUT} (\text{nominal}) + 1V$ . For example, use  $V_{IN} = 4.3V$  for a 3.3V regulator or use 6V for a 5V regulator. Employ pulse-testing procedures to minimize temperature rise.

**Note 5:** Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the load current plus the ground pin current.

**Note 6:** Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

**Note 7:** Thermal regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 200mA load pulse at  $V_{IN} = 20V$  (a 4W pulse) for  $T = 10ms$ .

**Note 8:**  $V_{REF} \leq V_{OUT} \leq (V_{IN} - 1V)$ ,  $2.3V \leq V_{IN} \leq 26V$ ,  $10mA < I_L \leq I_{FL}$ ,  $T_J \leq T_{J \text{ MAX}}$ .

**Note 9:** Comparator thresholds are expressed in terms of a voltage differential at the Adjust terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain =  $V_{OUT} / V_{REF} = (R1 + R2)/R2$ . For example, at a programmed output voltage of 5V, the Error output is guaranteed to go low when the output drops by  $95 \text{ mV} \times 5V/1.240 \text{ V} = 384 \text{ mV}$ . Thresholds remain constant as a percent of  $V_{OUT}$  as  $V_{OUT}$  is varied, with the dropout warning occurring at typically 5% below nominal, 7.7% guaranteed.

**Note 10:**  $V_{EN} \leq 0.8V$  and  $V_{IN} \leq 26V$ ,  $V_{OUT} = 0$ .

**Note 11:** When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

### ■ ORDERING INFORMATION

PART No.	PACKAGE	Output Voltage				
		ADJ.	2.5V	3.3V	5.0V	12V
GM66150	TO-263-3	-	GM66150-2.5TA3	GM66150-3.3TA3	GM66150-5.0TA3	GM66150-12TA3
	TO-220-3	-	GM66150-2.5TB3	GM66150-3.3TB3	GM66150-5.0TB3	GM66150-12TB3
GM66151	TO-263-5	-	GM66151-2.5TA5	GM66151-3.3TA5	GM66151-5.0TA5	GM66151-12TA5
	TO-220-5	-	GM66151-2.5TB5	GM66151-3.3TB5	GM66151-5.0TB5	GM66151-12TB5
GM66152	TO-263-5	GM66152-TA5	-	-	-	-
	TO-220-5	GM66152-TB5	-	-	-	-
GM66153	TO-263-5	GM66153-TA5	-	-	-	-
	TO-220-5	GM66153-TB5	-	-	-	-

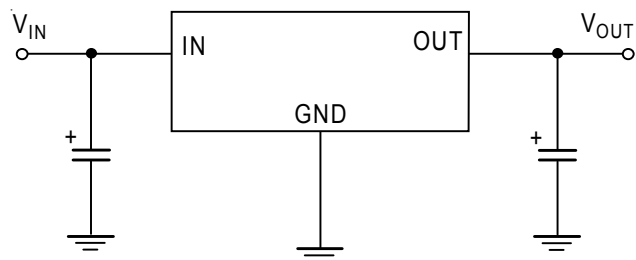
## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

### APPLICATIONS INFORMATION

The GM66150 series are high performance, low-dropout voltage regulators suitable for all moderate to high-current voltage regulator applications. Their 350mV dropout voltage at full load make them especially valuable in battery powered systems and as high efficiency noise filters in “post-regulator” applications. Unlike older NPN-pass transistor designs, where the minimum dropout voltage is limited by the base-emitter voltage drop and collector-emitter saturation voltage, dropout performance of the PNP output of these devices is limited merely by the low  $V_{CE}$  saturation voltage. A trade-off for the low dropout voltage is a varying base drive requirement. But Gamma’s PNP process reduces this drive requirement to merely 1% of the load current.

The GM66150 series of regulators are fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear; output current under overload conditions is constant.

Thermal shutdown disables the device when the die temperature exceeds the 125°C maximum safe operating temperature. Transient protection allows device (and load) survival even when the input voltage spikes between –20V and +60V. When the input voltage exceeds about 35V to 40V, the overvoltage sensor temporarily disables the regulator. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow. GM66151 and GM66152 versions offer a logic level ON/OFF control: when disabled, the devices draw nearly zero current.



**Figure 3. Linear regulators require only two capacitors for operation.**

An additional feature of this regulator family is a common pinout: a design’s current requirement may change up or down yet use the same board layout, as all of these regulators have identical pinouts.

#### Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics. Thermal design requires the following application-specific parameters:

- Maximum ambient temperature,  $T_A$
- Output Current,  $I_{OUT}$
- Output Voltage,  $V_{OUT}$
- Input Voltage,  $V_{IN}$

First, we calculate the power dissipation of the regulator from these numbers and the device parameters from this formula:

$$P_D = I_{OUT} (1.01V_{IN} - V_{OUT})$$

where the ground current is approximated by 1% of  $I_{OUT}$ .

Then the heat sink thermal resistance is determined with this formula:

$$\theta_{SA} = \frac{T_{J(MAX)} - T_A}{P_D} (\theta_{JC} + \theta_{CS})$$

where  $T_{J(MAX)} \leq 125^\circ\text{C}$  and  $\theta_{CS}$  is between 0 and  $2^\circ\text{C/W}$ .

The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage and distribute the heat between this resistor and the regulator. The low dropout properties of Gamma PNP regulators allow very significant reductions in regulator power dissipation and the associated heat sink without compromising performance. When this technique is employed, a capacitor of at least 0.1µF is needed directly between the input and regulator ground.

## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

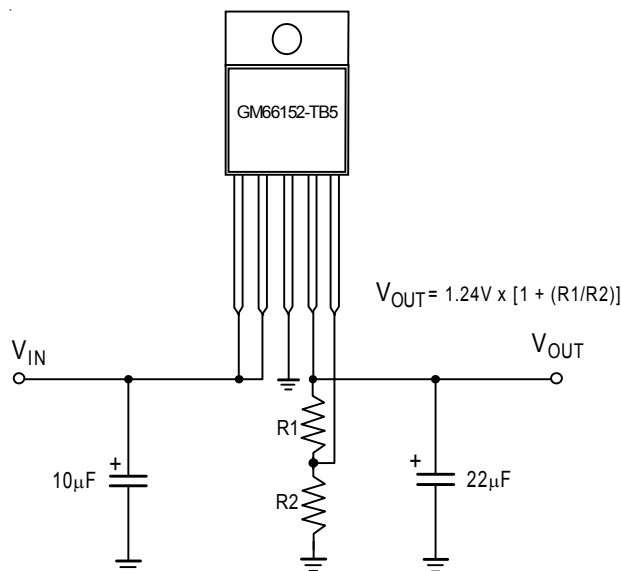
### Capacitor Requirements

For stability and minimum output noise, a capacitor on the regulator output is necessary. The value of this capacitor is dependent upon the output current; lower currents allow smaller capacitors. GM66150 regulators are stable with the minimum capacitor value of 10 $\mu$ F at full load. This capacitor need not be an expensive low ESR type: aluminum electrolytics are adequate. In fact, extremely low ESR capacitors may contribute to instability. Tantalum capacitors are recommended for systems where fast load transient response is important. Where the regulator is powered from a source with a high AC impedance, a 0.1 $\mu$ F capacitor connected between Input and GND is recommended. This capacitor should have good characteristics to above 250kHz.

### Minimum Load Current

The GM66150 regulators are specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. The 5mA minimum load current swamps any expected leakage current across the operating temperature range.

### Adjustable Regulator Design



**Figure 4. Adjustable Regulator with Resistors**

The adjustable regulator versions, GM66152 and GM66153, allow programming the output voltage anywhere between 1.25V and the 26V maximum operating rating of the family. Two resistors are used. Resistors can be quite large, up to 1M $\Omega$ , because of the very high input impedance and low bias current of the sense comparator. The resistor values are calculated by:

$$R_1 = R_2 \left( \frac{V_{OUT}}{1.240} - 1 \right)$$

where  $V_O$  is the desired output voltage.

Figure 4 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation (see above).

### Error Flag

GM66151 and GM66153 versions feature an Error Flag, which looks at the output voltage and signals an error condition when this voltage drops 5% below its expected value. The error flag is an open-collector output that pulls low under fault conditions. It may sink 10mA. Low output voltage signifies a number of possible problems, including an overcurrent fault (the device is in current limit) and low input voltage. The flag output is inoperative during overtemperature shutdown conditions.

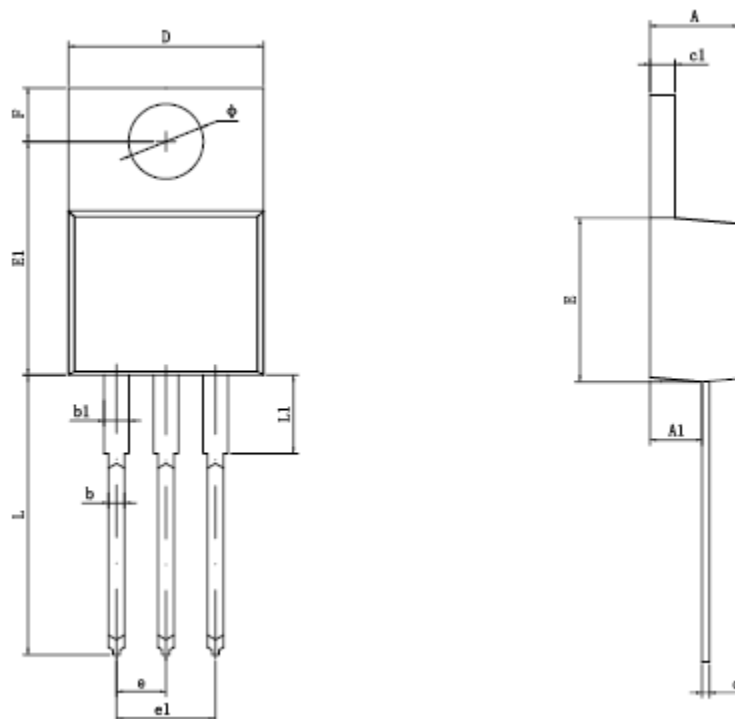
### Enable Input

GM66151 and GM66152 versions feature an enable (EN) input that allows ON/OFF control of the device. Special design allows "zero" current drain when the device is disabled —only microamperes of leakage current flows.

The EN input has TTL/CMOS compatible thresholds for simple interfacing with logic, or may be directly tied to  $\leq 30V$ . Enabling the regulator requires approximately 20 $\mu$ A of current.

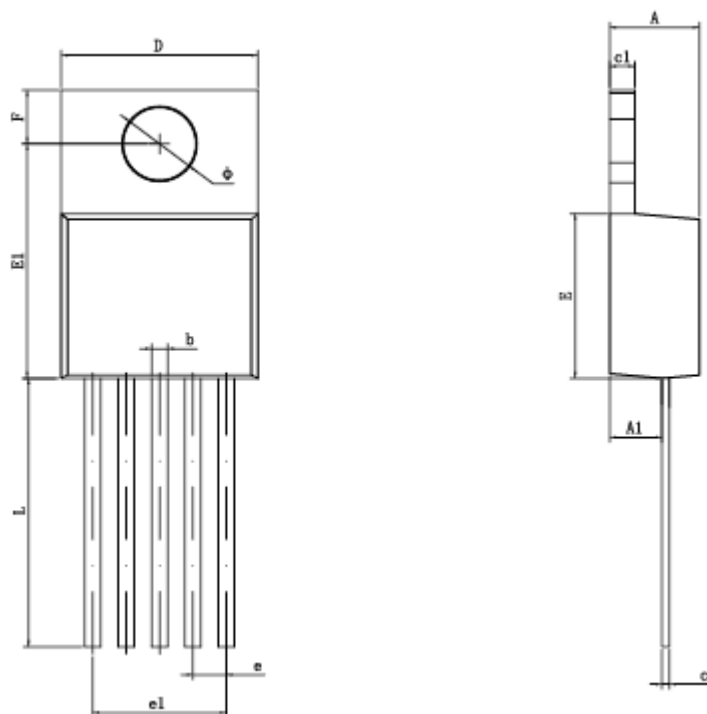
## 1.5A LOW-DROPOUT VOLTAGE REGULATORS

### ■ TO-220-3L PACKAGE OUTLINE DIMENSIONS



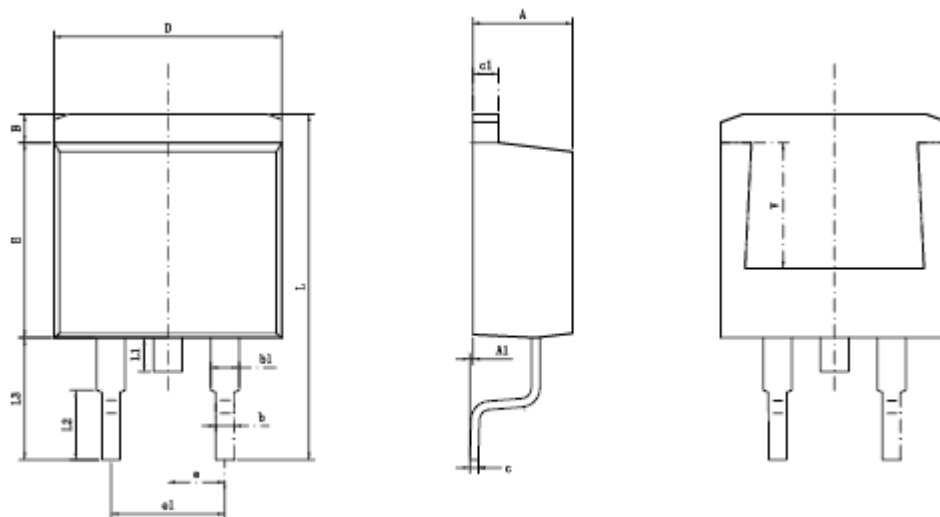
SYMBOL	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
b	0.710	0.910	0.028	0.036
b1	1.170	1.370	0.046	0.054
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	10.010	10.310	0.394	0.406
E	8.500	8.900	0.335	0.350
E1	12.060	12.460	0.475	0.491
e	2.540TYP		0.100TYP	
e1	4.980	5.180	0.196	0.204
F	2.590	2.890	0.102	0.114
L	13.400	13.800	0.528	0.543
L1	3.560	3.960	0.140	0.156
Φ	3.790	3.890	0.149	0.153

**1.5A LOW-DROPOUT VOLTAGE REGULATORS**

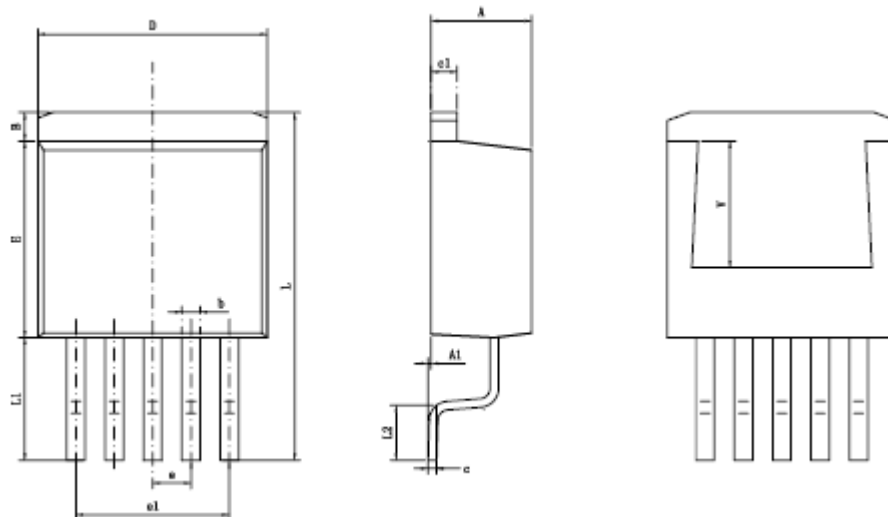
 ■ **TO-220-5L PACKAGE OUTLINE DIMENSIONS**


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
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	9.850	10.150	0.388	0.400
E	8.200	8.600	0.323	0.339
E1	11.760	12.160	0.463	0.479
e	1.700TYP		0.067TYP	
e1	6.700	6.900	0.264	0.272
F	2.590	2.890	0.102	0.114
L	13.500	13.900	0.531	0.547
Φ	3.790	3.890	0.149	0.153



**1.5A LOW-DROPOUT VOLTAGE REGULATORS**
**■ TO-263-2L PACKAGE OUTLINE DIMENSIONS**


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	1.170	1.370	0.046	0.054
b	0.710	0.910	0.028	0.036
b1	1.170	1.370	0.046	0.054
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	8.500	8.900	0.335	0.350
e	2.540TYP		0.100TYP	
e1	4.980	5.180	0.196	0.204
L	15.050	15.450	0.593	0.608
L1	1.300	1.700	0.051	0.067
L2	2.340	2.740	0.092	0.108
L3	5.080	5.480	0.200	0.216
V	5.600REF		0.220REF	

**1.5A LOW-DROPOUT VOLTAGE REGULATORS**
**■ TO-263-5L PACKAGE OUTLINE DIMENSIONS**


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	