

## 1.0A Low Dropout Positive Voltage Regulator

### DESCRIPTION

The LM1117 is a series of low dropout voltage regulators which can provide up to 1A of output current. The LM1117 is available in four fixed voltage, 1.2V, 1.8V, 3.3V and 5.0V. Additionally it is also available in adjustable version. On chip precision trimming adjusts the reference/ output voltage to within  $\pm 2\%$ . Current limit is also trimmed to ensure specified output current and controlled short-circuit current. The LM1117 series is available in SOT-223 and TO-220 packages. A minimum of 10 $\mu$ F tantalum capacitor is required at the output to improve the transient response and stability.

### FEATURES

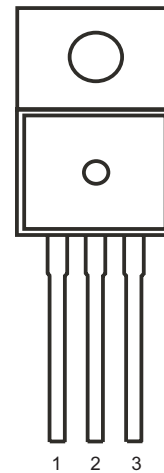
- Adjustable and Fixed of 1.2V, 1.8V, 3.3V, 5.0V
- Space saving SMD types of SOT-223
- 1.2V Drop-out Voltage
- 1.0A Output Current
- Line Regulation Typically at 0.2% max
- Current Limiting and Thermal Protection

### APPLICATION

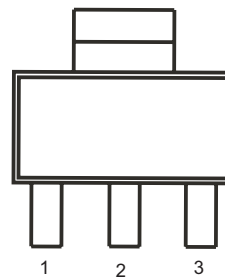
- Post Regulator for switching DC/DC Converter
- High Efficiency Linear Regulator
- Battery Chargers
- PC Add on Card
- Motherboard clock supplies
- LCD Monitor
- Set-top Box

### PIN CONFIGURATION

TO-220



SOT-223



- 1.ADJ/GND
- 2.Output
- 3.Input

Pin2 connected with heat sink

(Top View)

### ORDERING INFORMATION

Temperature Range	Package		Orderable Device	Package Qty
0°C to +70°C	TO-220-3L	Pb-Free	LM1117T-1.2	50Units/Tube
			LM1117T-1.8	
			LM1117T-3.3	
			LM1117T-5.0	
			LM1117T-ADJ	
	SOT-223		LM1117MPX-1.2	2500Units/Tube
			LM1117MPX-1.8	
			LM1117MPX-3.3	
			LM1117MPX-5.0	
			LM1117MPX-ADJ	



## SCHEMATIC DIAGRAM

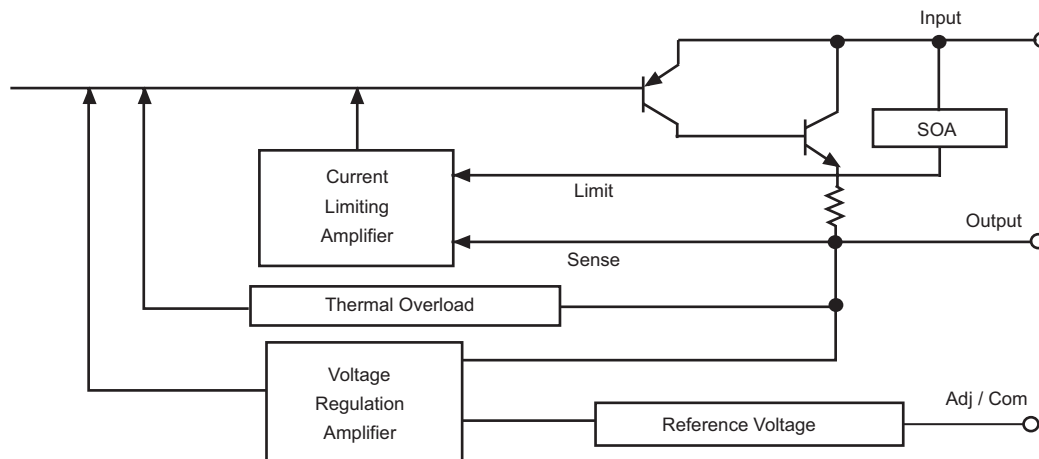


Figure 1. functional diagram

## ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Input voltage	$V_{IN}$	15	V
DC Output current	$I_{OUT}$	$P_D / (V_{IN} - V_O)$	mA
Operating junction temperature range	$T_J$	-25 to 125	°C
Thermal resistance (SOT-223)	$\theta_{JA}$	150	°C/W
Thermal resistance (TO-220)		60	
Maximum power dissipation (SOT-223)	$P_D$	Internally limited	mW
Maximum power dissipation (TO-220)			

## RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Max	Unit
DC Input Voltage	$V_{IN}$	1.224	15	V
Operating Temperature, All Package Types	$T_A$	0	+70	°C

## ELECTRICAL CHARACTERISTICS(T<sub>A</sub>=0 to +70°C)

(V<sub>IN</sub> = 5V, C<sub>O</sub>=10μF, T<sub>A</sub>=25°C, T<sub>J</sub>=-25°C to +125°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Reference Voltage	LM1117-ADJ	V <sub>REF</sub>	I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =2.8V to 12V	1.225	1.250	1.280	V
Output Voltage	LM1117-1.2	V <sub>OUT</sub>	I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =2.7V to 12V	1.176	1.200	1.224	V
	LM1117-1.8		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =3.3V to 12V	1.764	1.800	1.836	
	LM1117-3.3		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =4.8V to 12V	3.240	3.300	3.360	
	LM1117-5.0		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =6.5V to 15V	4.900	5.000	5.100	
Line Regulation	LM1117-ADJ	ΔV <sub>OUT</sub>	I <sub>o</sub> =10mA V <sub>in</sub> =2.8V to 12V		0.1	0.2	%
	LM1117-1.2		I <sub>o</sub> =10mA V <sub>in</sub> =2.7V to 12V		2.0	7.0	mV
	LM1117-1.8		I <sub>o</sub> =10mA V <sub>in</sub> =3.3V to 12V		2.0	7.0	
	LM1117-3.3		I <sub>o</sub> =10mA V <sub>in</sub> =4.8V to 12V		3.0	7.0	
	LM1117-5.0		I <sub>o</sub> =10mA V <sub>in</sub> =6.5V to 15V		4.0	10.0	
Load Regulation	LM1117-ADJ	ΔV <sub>OUT</sub>	I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =3.3		0.2	0.4	%
	LM1117-1.2		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =3.2V		3.0	10.0	mV
	LM1117-1.8		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =3.8V		5.0	15.0	
	LM1117-3.3		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =5.3V		6.0	20.0	
	LM1117-5.0		I <sub>o</sub> =10mA to 1.0A V <sub>in</sub> =7.0V		7.0	25.0	
Drop-out Voltage	ΔV		I <sub>o</sub> =800mA		1.10	1.20	V
			I <sub>o</sub> =1A		1.20	1.30	
Current Limit	I <sub>LIMIT</sub>		V <sub>in</sub> -V <sub>out</sub> =1.5V	1000	1250	1600	mA
Min Load Current	I <sub>O(MIN)</sub>		V <sub>in</sub> -V <sub>out</sub> =13.75V			5	mA
Quiescent Current	I <sub>Q</sub>		V <sub>in</sub> -V <sub>out</sub> =1.5V, I <sub>o</sub> =10mA		5.2	10	mA
Adjust pin Current	I <sub>ADJ</sub>		I <sub>o</sub> =10mA V <sub>in</sub> =1.4V to 10V		50	120	μA
Temperature Drift	TS				0.5		%
RMS Output Noise	RON		Bandwidth in 10Hz to 10kHz		0.003		%V <sub>o</sub>
Ripple Rejection Ratio	RR		120Hz input ripple, C <sub>ADJ</sub> =25μF, V <sub>in</sub> -V <sub>out</sub> =5V, I <sub>o</sub> =1.0A	60	70		dB



## TYPICAL PERFORMANCE CHARACTERISTICS

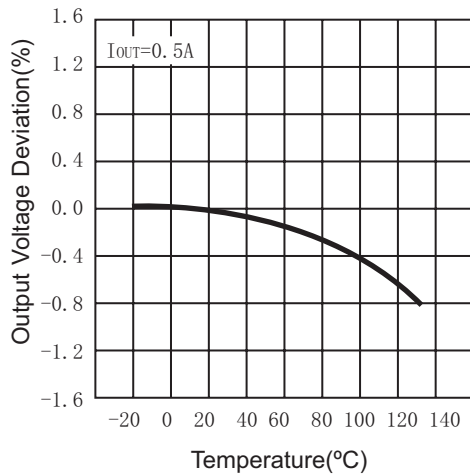


Figure 2. Temperature Stability

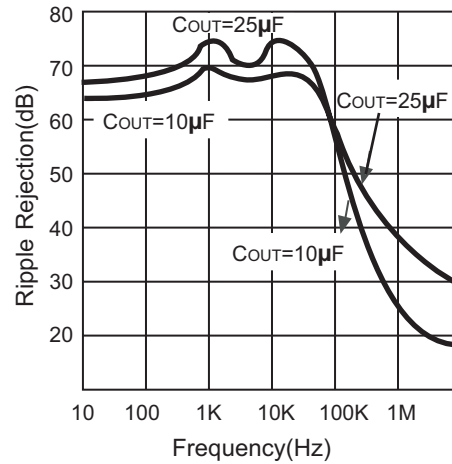


Figure 3. Ripple Rejection(with CADJ 25µF)

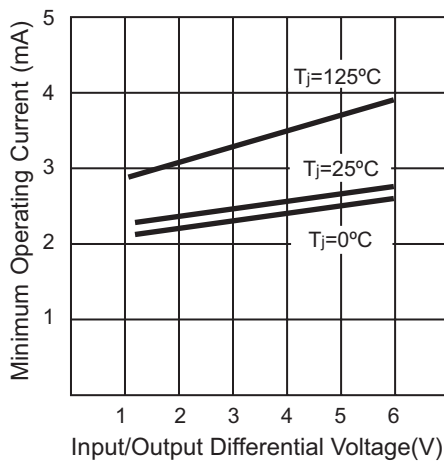


Figure 4. Minimum Load Current(Adjustable)

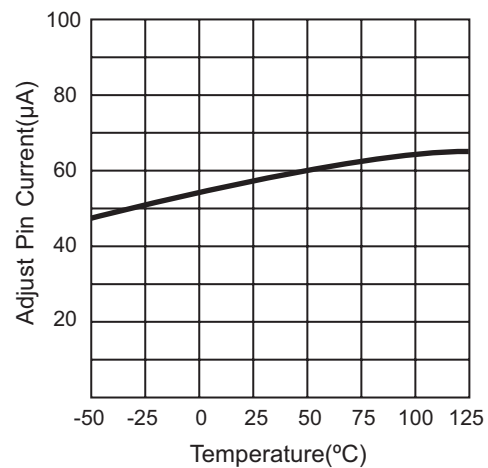


Figure 5. Adjust Pin Current

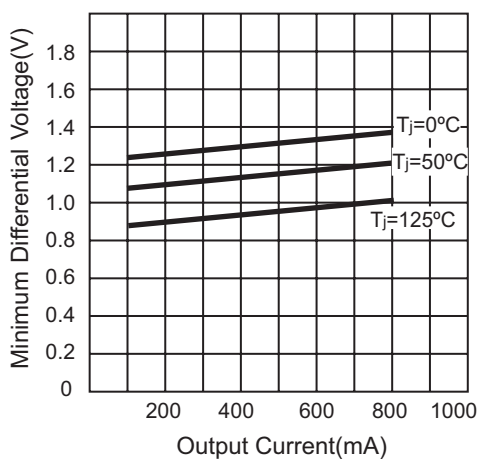


Figure 6. Dropout Voltage vs. Output Current

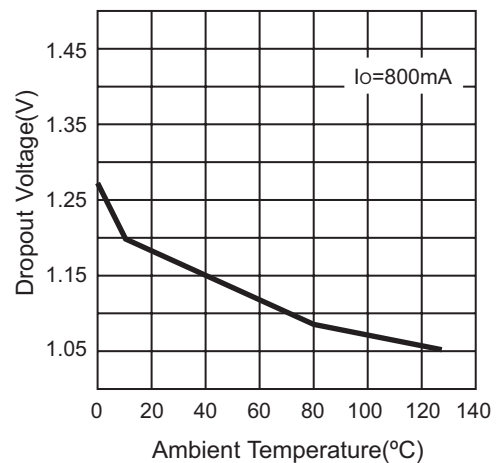


Figure 7. Dropout Voltage vs. Temperature

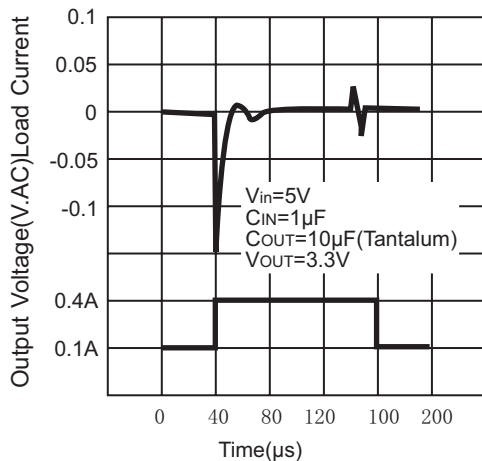


Figure 8. Load Transient Response

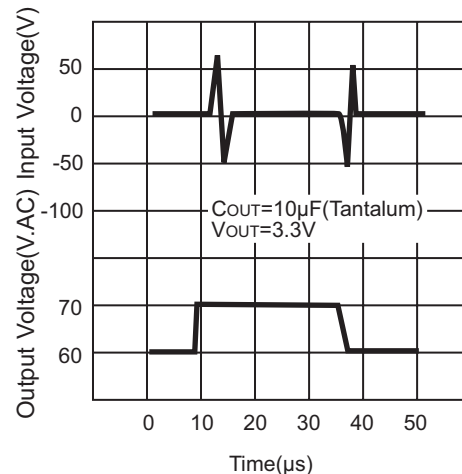


Figure 9. Line Transient Response

## APPLICATION INFORMATION

### External Capacitors/Stability

#### Input Bypass Capacitor

An input capacitor is recommended. A 10µF tantalum on the input is a suitable input bypassing for almost all applications.

#### Adjust Terminal Bypass Capacitor

The adjust terminal can be bypassed to ground with a bypass capacitor ( $C_{ADJ}$ ) to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. At any ripple frequency, the impedance of the  $C_{ADJ}$  should be less than  $R1$  to prevent the ripple from being amplified:

$$(2\pi \cdot f_{RIPPLE} \cdot C_{ADJ}) < R1$$

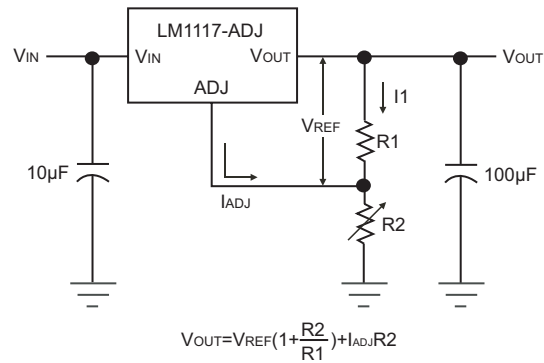
The  $R1$  is the resistor between the output and the adjust pin. Its value is normally in the range of 100-200Ω. For example, with  $R1=124\Omega$  and  $f_{RIPPLE}=120\text{Hz}$ , the  $C_{ADJ}$  should be  $>11\mu\text{F}$ .

#### Output Capacitor

The output capacitor is critical in maintaining regulator stability, and must meet the required conditions for both minimum amount of capacitance and ESR (Equivalent Series Resistance). The minimum output capacitance required by the LM1117 is 10µF, if a tantalum capacitor is used. Any increase of the output capacitance will merely improve the loop stability and transient response. The ESR of the output capacitor should be less than 0.5Ω. In the case of the adjustable regulator, when the  $C_{ADJ}$  is used, a larger output capacitance (22µF tantalum) is required.

#### Output Voltage

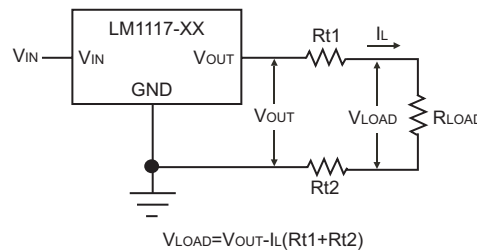
The LM1117 adjustable version develops a 1.25V reference voltage,  $V_{REF}$ , between the output and the adjust terminal. As shown in Figure 10, this voltage is applied across resistor  $R1$  to generate a constant current  $I1$ . The current  $I_{ADJ}$  from the adjust terminal could introduce error to the output. But since it is very small (60µA) compared with the  $I1$  and very constant with line and load changes, the error can be ignored. The constant current  $I1$  then flows through the output set resistor  $R2$  and sets the output voltage to the desired level. For fixed voltage devices,  $R1$  and  $R2$  are integrated inside the devices.



**Figure 10. Basic Adjustable Regulator**

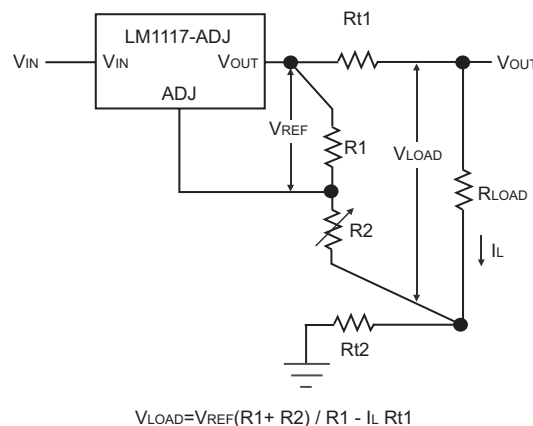
## Load Regulation

The LM1117 regulates the voltage that appears between its output and ground pins, or between its output and adjust pins. In some cases, line resistances can introduce errors to the voltage across the load. To obtain the best load regulation, a few precautions are needed. Figure 11, shows a typical application using a fixed output regulator. The  $R_{t1}$  and  $R_{t2}$  are the line resistances. It is obvious that the  $V_{LOAD}$  is less than the  $V_{OUT}$  by the sum of the voltage drops along the line resistances. In this case, the load regulation seen at the  $R_{LOAD}$  would be degraded from the data sheet specification. To improve this, the load should be tied directly to the output terminal on the positive side and directly tied to the ground terminal on the negative side.



**Figure 11. Typical Application using Fixed Output Regulator**

When the adjustable regulator is used (Figure 12), the best performance is obtained with the positive side of the resistor  $R_1$  tied directly to the output terminal of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 5V regulator with  $0.05\Omega$  resistance between the regulator and load will have a load regulation due to line resistance of  $0.05\Omega \times I_L$ . If  $R_1$  ( $=125\Omega$ ) is connected near the load, the effective line resistance will be  $0.05\Omega(1 + R_2/R_1)$  or in this case, it is 4 times worse. In addition, the ground side of the resistor  $R_2$  can be returned near the ground of the load to provide remote ground sensing and improve load regulation.



**Figure 12. Best Load Regulation Using Adjustable Output Regulator**

## Protection Diodes

Under normal operation, the LM1117 regulators do not need any protection diode. With the adjustable device, the internal resistance between the adjust and output terminals limits the current. No diode is needed to divert the current around the regulator even with capacitor on the adjust terminal. The adjust pin can take a transient signal of  $\pm 25V$  with respect to the output voltage without damaging the device. When an output capacitor is connected to a regulator and the input is shorted to ground, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and rate of decrease of  $V_{IN}$ . In the LM1117 regulators, the internal diode between the output and input pins can withstand microsecond surge currents of 10A to 20A. With an extremely large output capacitor ( $\geq 1000\mu F$ ), and with input instantaneously shorted to ground, the regulator could be damaged. In this case, an external diode is recommended between the output and input pins to protect the regulator, as shown in Figure 13.

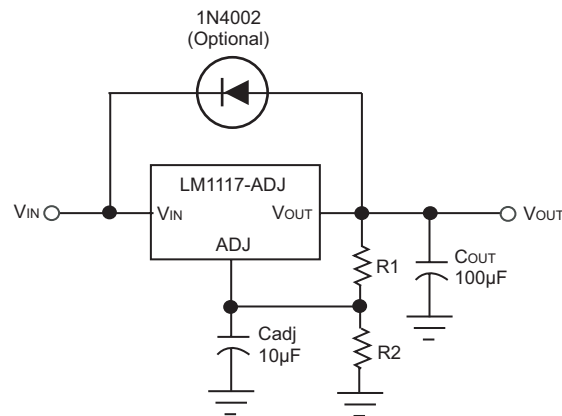
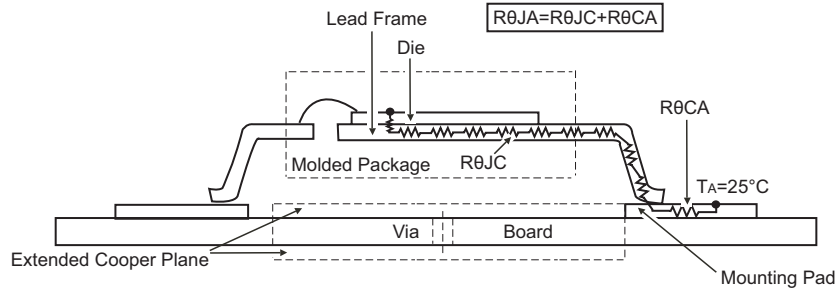


Figure 13. Regulator With Protection Diode

## Heat sink Requirements

When an integrated circuit operates with an appreciable current, its junction temperature is elevated. It is important to quantify its thermal limits in order to achieve acceptable performance and reliability. This limit is determined by summing the individual parts consisting of a series of temperature, rises from the semiconductor junction to the operating environment. A one-dimensional steady-state model of conduction heat transfer is demonstrated in Figure 14. The heat generated at the device junction flows through the die to the die attach pad, through the lead frame to the surrounding case material, to the printed circuit board, and eventually to the ambient environment. Below is a list of variables that may affect the thermal resistance and in turn the need for a heat sink.

<b>R<math>\theta_{JC}</math>(Component Variables)</b>	<b>R<math>\theta_{CA}</math> (Application Variables)</b>
Lead frame Size & Material	Mounting Pad Size, Material, & Location
No. of Conduction Pins	Placement of Mounting Pad
Die Size	PCB Size & Material
Die Attach Material	Traces Length & Width
Molding Compound Size and Material	Adjacent Heat Sources
	Volume of Air
	Ambient Temperature
	Shape of Mounting Pad



**Figure 14. Cross-sectional view of integrated circuit mounted on a printed circuit board.**

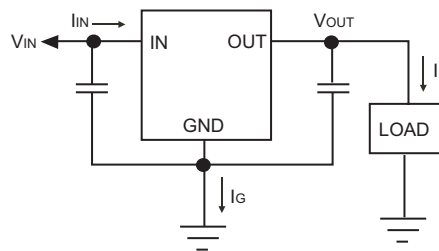
**Note that the case temperature is measured at the point where the leads contact with the mounting pad surface**

The LM1117 regulators have internal thermal shutdown to protect the device from overheating. Under all possible operating conditions, the junction temperature of the LM1117 must be within the range of 0°C to 125°C. A heat sink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heat sink is needed, the power dissipated by the regulator,  $P_D$ , must be calculated:

$$I_{IN} = I_L + I_G$$

$$P_D = (V_{IN} - V_{OUT})I_L + V_{IN}I_G$$

Figure 15 shows the voltages and currents which are present in the circuit.



**Figure 15. Power Dissipation Diagram**

The next parameter which must be calculated is the maximum allowable temperature rise,  $T_R(\max)$ :

$$T_R(\max) = T_J(\max) - T_A(\max)$$

where  $T_J(\max)$  is the maximum allowable junction temperature (125°C), and  $T_A(\max)$  is the maximum ambient temperature which will be encountered in the application. Using the calculated values for  $T_R(\max)$  and  $P_D$ , the maximum allowable value for the junction-to-ambient thermal resistance ( $\theta_{JA}$ ) can be calculated:

$$\theta_{JA} = T_R(\max) / P_D$$

If the maximum allowable value for  $\theta_{JA}$  is found to be  $\geq 136^\circ\text{C}/\text{W}$  for SOT-223 package or  $\geq 79^\circ\text{C}/\text{W}$  for TO-220 package, no heat-sink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for  $\theta_{JA}$  falls below these limits, a heat-sink is required. As a design aid, Table 1 shows the value of the  $\theta_{JA}$  of SOT-223 for different heat-sink area.



Table 1  $\theta_{JA}$  Different Heat-sink Area

Layout	Copper Area		Thermal Resistance
	Top Side (in <sup>2</sup> )*	Bottom Side (in <sup>2</sup> )	$\theta_{JA}$ , °C/W, SOT-223
1	0.0123	0	136
2	0.066	0	123
3	0.3	0	84
4	0.53	0	75
5	0.76	0	69
6	1	0	66
7	0	0.2	115
8	0	0.4	98
9	0	0.6	89
10	0	0.8	82
11	0	1	79
12	0.066	0.066	125
13	0.175	0.175	93
14	0.284	0.284	83
15	0.392	0.392	75
16	0.5	0.5	70

\* Tab of device attached to topside copper.



## TYPICAL APPLICATION CIRCUIT

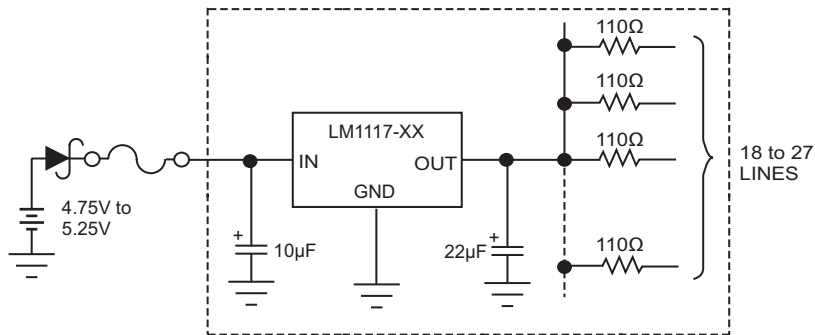
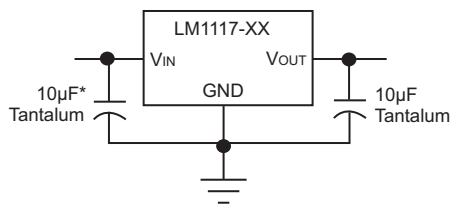


Figure 16. Active Terminator for SCSI-2 Bus



\*Required if the regulator is located far from the power supply filter.

Figure 17. Fixed Output Regulator

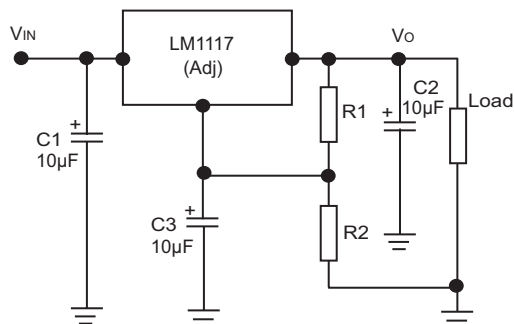
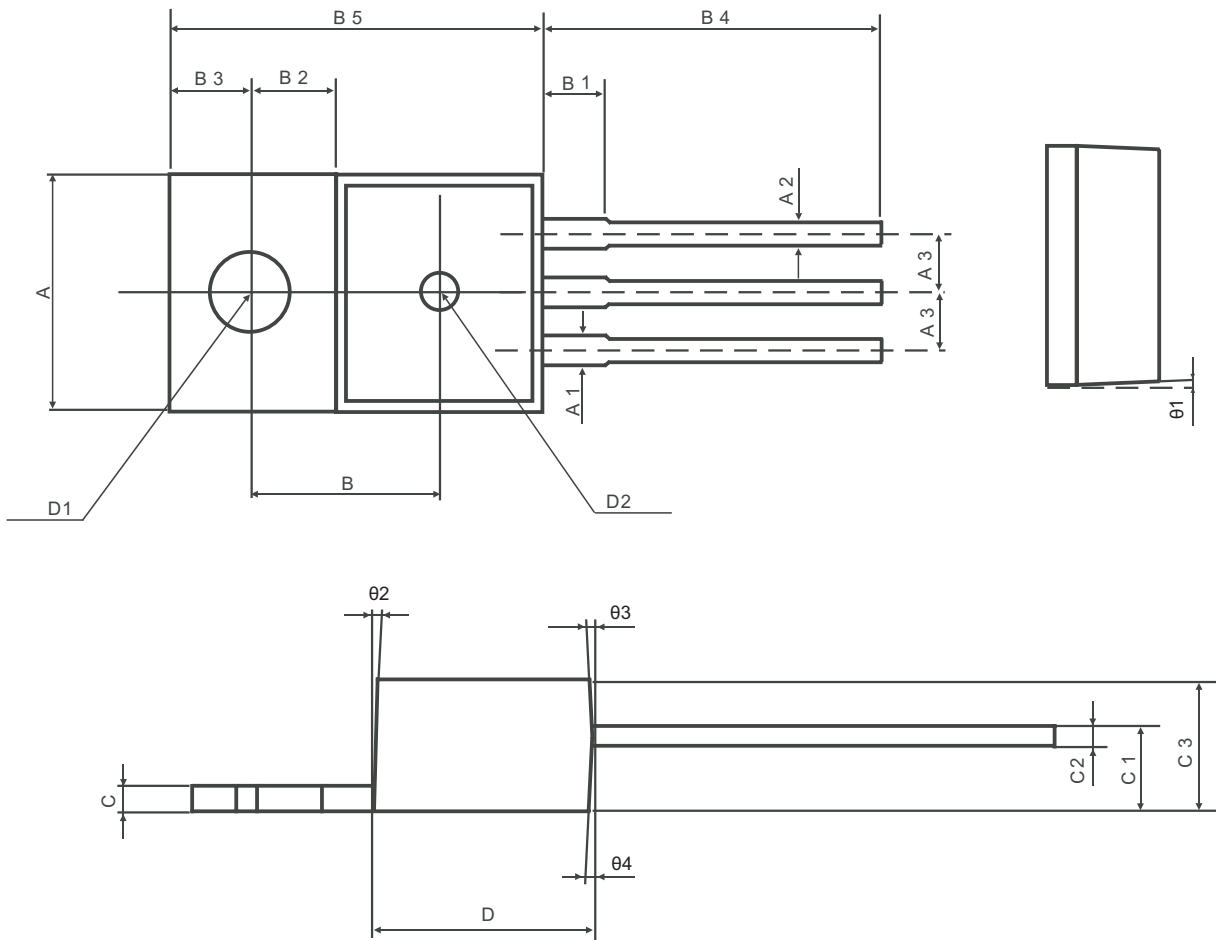


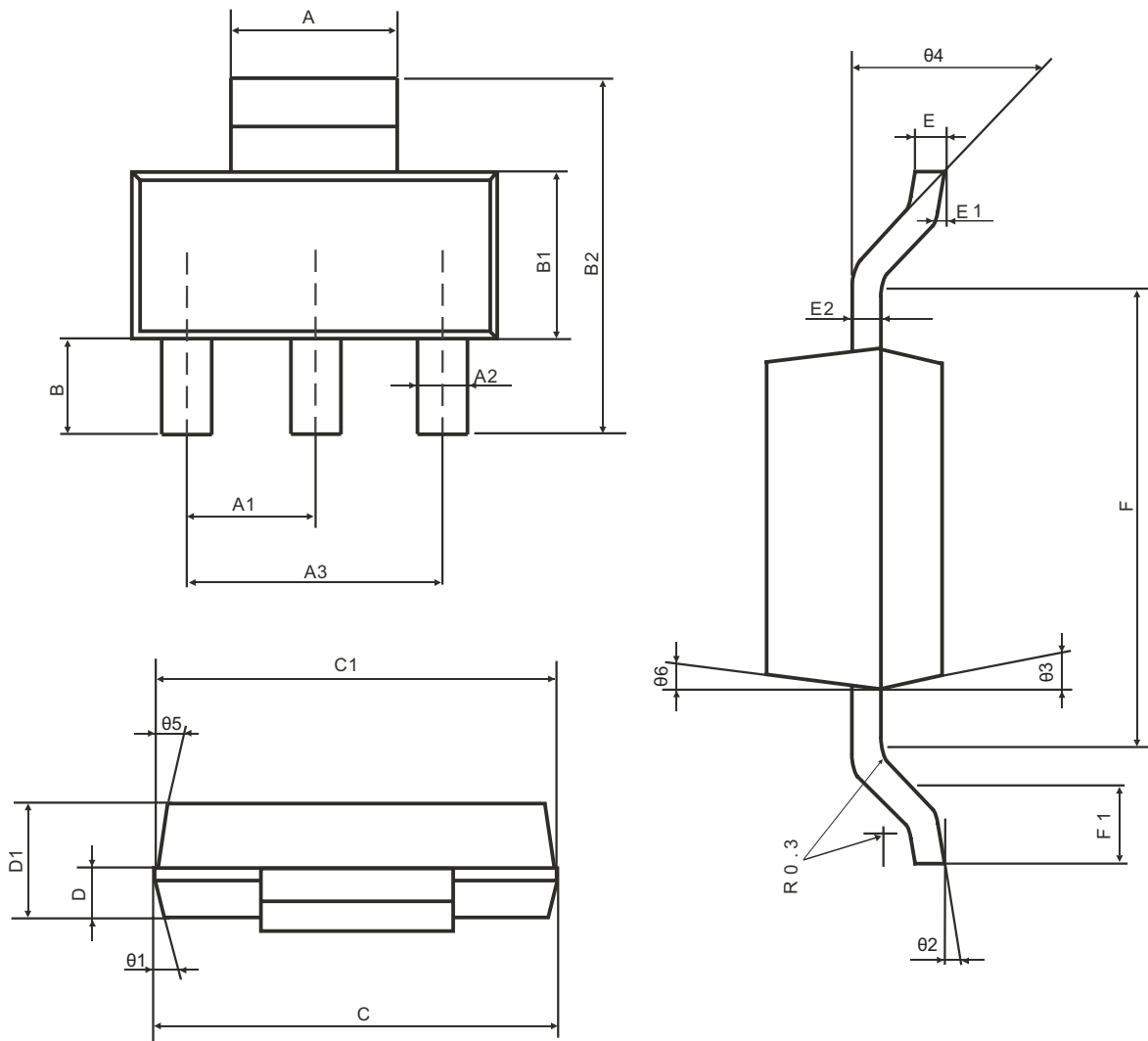
Figure 18. Adjustable- Voltage Model

## PHYSICAL DIMENSIONS TO-220



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	10.10	10.14	C1	2.60(TYP)	
A1	1.27(TYP)		C2	0.38(TYP)	
A2	0.81(TYP)		C3	4.58(TYP)	
A3	2.51	2.56	D	9.20(TYP)	
B	8.20(TYP)		D1	Ø3.84(TYP)	
B1	3.65(TYP)		D2	Ø1.50(TYP)	
B2	3.55(TYP)		θ1	3°(TYP)	
B3	2.74(TYP)		θ2	3°(TYP)	
B4	13.00(TYP)		θ3	3°(TYP)	
B5	15.47	15.51	θ4	3°(TYP)	
C	1.27(TYP)				

## SOT-223



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	2.96	3.02	E	0.30	
A1	2.28		E1	0.03	0.09
A2	0.68	0.74	E2	0.30	
A3	4.57		F	4.63	
B	1.70	1.80	F1	0.90	1.00
B1	3.45	3.55	$\theta 1$	13°	
B2	6.90	7.10	$\theta 2$	3°	9°
C	6.45	6.55	$\theta 3$	13°	
C1	6.35	6.45	$\theta 4$	37.5°	
D	0.67	0.72	$\theta 5$	13°	
D1	1.55	1.65	$\theta 6$	13°	

