

## LM1085

### 3A Low Dropout Positive Regulators

#### General Description

The LM1085 is a series of low dropout positive voltage regulators with a maximum dropout of 1.5V at 3A of load current. It has the same pin-out as National Semiconductor's industry standard LM317.

The LM1085 is available in an adjustable version, which can set the output voltage with only two external resistors. It is also available in three fixed voltages: 3.3V, 5.0V and 12.0V. The fixed versions integrate the adjust resistors.

The LM1085 circuit includes a zener trimmed bandgap reference, current limiting and thermal shutdown.

The LM1085 series is available in TO-220 and TO-263 packages. Refer to the LM1084 for the 5A version, and the LM1086 for the 1.5V version.

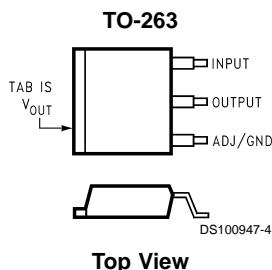
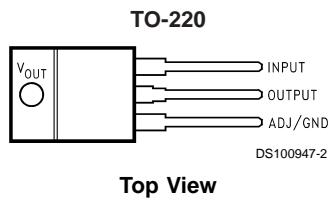
#### Features

- Available in 3.3V, 5.0V, 12V and Adjustable Versions
- Current Limiting and Thermal Protection
- Output Current 3A
- Line Regulation 0.015% (typical)
- Load Regulation 0.1% (typical)

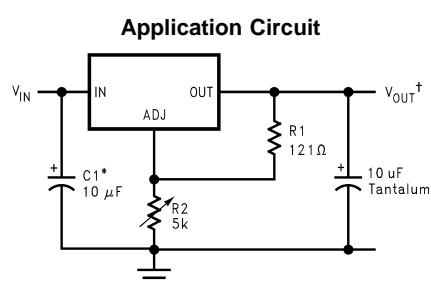
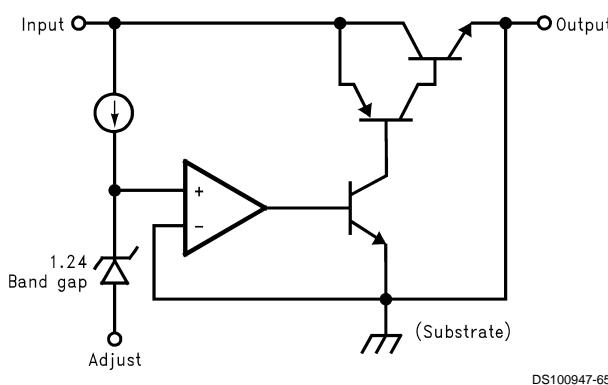
#### Applications

- High Efficiency Linear Regulators
- Battery Charger
- Post Regulation for Switching Supplies
- Constant Current Regulator
- Microprocessor Supply

#### Connection Diagrams



#### Basic Functional Diagram, Adjustable Version

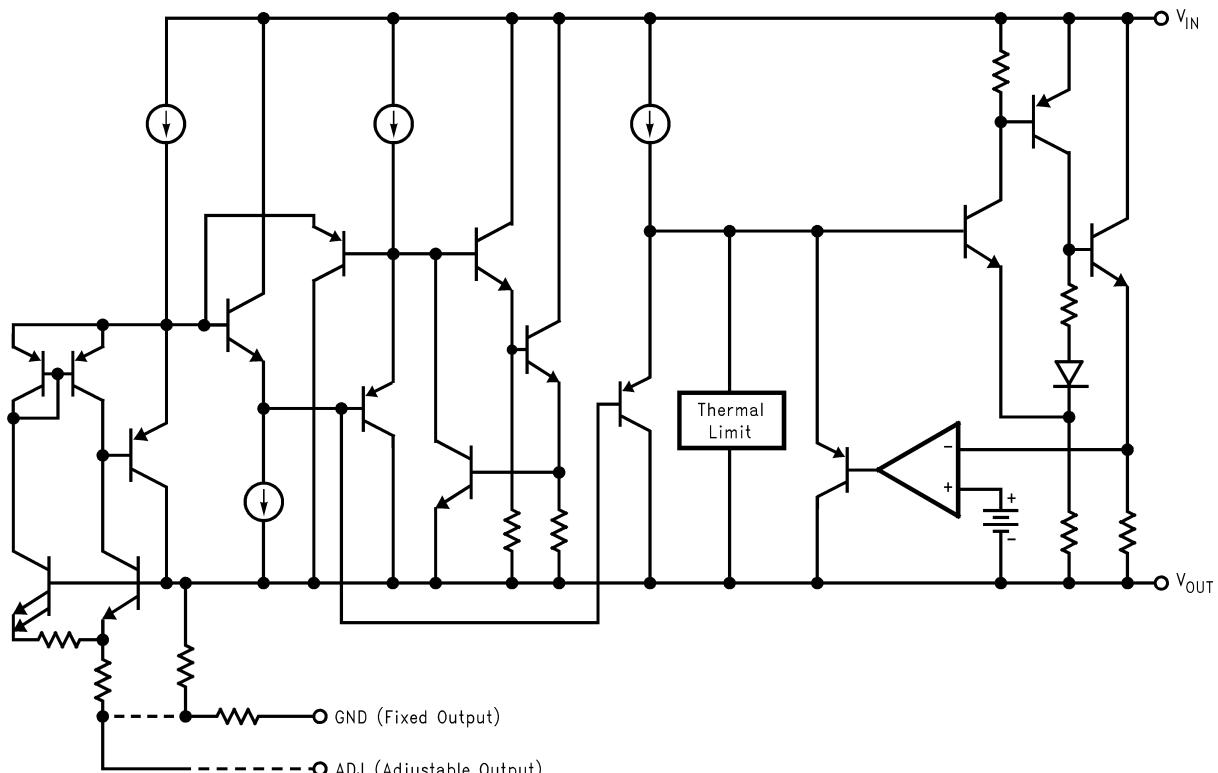


**1.2V to 15V Adjustable Regulator**

## Ordering Information

Package	Temperature Range	Part Number	Transport Media	NSC Drawing
3-lead TO-263	−40°C to +125°C	LM1085IS-ADJ	Rails	TS3B
		LM1085ISX-ADJ	Tape and Reel	
		LM1085IS-12	Rails	
		LM1085ISX-12	Tape and Reel	
		LM1085IS-3.3	Rails	
		LM1085ISX-3.3	Tape and Reel	
		LM1085IS-5.0	Rails	
		LM1085ISX-5.0	Tape and Reel	
3-lead TO-220	−40°C to + 125°C	LM1085IT-ADJ	Rails	T03B
		LM1085IT-12	Rails	
		LM1085IT-3.3	Rails	
		LM1085IT-5.0	Rails	

## Simplified Schematic



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## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Maximum Input to Output Voltage Differential

LM1085-ADJ 29V

LM1085-12 18V

LM1085-3.3 27V

LM1085-5.0 25V

Power Dissipation (Note 2) Internally Limited

Junction Temperature ( $T_J$ )(Note 3) 150°C

Storage Temperature Range -65°C to 150°C

Lead Temperature 260°C, to 10 sec

ESD Tolerance (Note 4) 2000V

## Operating Ratings (Note 1)

Junction Temperature Range ( $T_J$ ) (Note 3)

Control Section -40°C to 125°C

Output Section -40°C to 150°C

## Electrical Characteristics

Typicals and limits appearing in normal type apply for  $T_J = 25^\circ\text{C}$ . Limits appearing in **Boldface** type apply over the entire junction temperature range for operation.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$V_{\text{REF}}$	Reference Voltage	LM1085-ADJ $I_{\text{OUT}} = 10\text{mA}$ , $V_{\text{IN}} - V_{\text{OUT}} = 3\text{V}$ $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $1.5\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 15\text{V}$ (Note 7)	1.238 <b>1.225</b>	1.250 <b>1.250</b>	1.262 <b>1.270</b>	V
$V_{\text{OUT}}$	Output Voltage (Note 7)	LM1085-3.3 $I_{\text{OUT}} = 0\text{mA}$ , $V_{\text{IN}} = 5\text{V}$ $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $4.8\text{V} \leq V_{\text{IN}} \leq 15\text{V}$	3.270 <b>3.235</b>	3.300 <b>3.300</b>	3.330 <b>3.365</b>	V
		LM1085-5.0 $I_{\text{OUT}} = 0\text{mA}$ , $V_{\text{IN}} = 8\text{V}$ $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $6.5\text{V} \leq V_{\text{IN}} \leq 20\text{V}$	4.950 <b>4.900</b>	5.000 <b>5.000</b>	5.050 <b>5.100</b>	V
		LM1085-12 $I_{\text{OUT}} = 0\text{mA}$ , $V_{\text{IN}} = 15\text{V}$ $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $13.5\text{V} \leq V_{\text{IN}} \leq 25\text{V}$	11.880 <b>11.760</b>	12.000 <b>12.000</b>	12.120 <b>12.240</b>	V
$\Delta V_{\text{OUT}}$	Line Regulation (Note 8)	LM1085-ADJ $I_{\text{OUT}} = 10\text{mA}$ , $1.5\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 15\text{V}$		0.015 <b>0.035</b>	0.2 <b>0.2</b>	%
		LM1085-3.3 $I_{\text{OUT}} = 0\text{mA}$ , $4.8\text{V} \leq V_{\text{IN}} \leq 15\text{V}$		0.5 <b>1.0</b>	6 <b>6</b>	mV
		LM1085-5.0 $I_{\text{OUT}} = 0\text{mA}$ , $6.5\text{V} \leq V_{\text{IN}} \leq 20\text{V}$		0.5 <b>1.0</b>	10 <b>10</b>	mV
		LM1085-12 $I_{\text{OUT}} = 0\text{mA}$ , $13.5\text{V} \leq V_{\text{IN}} \leq 25\text{V}$		1.0 <b>2.0</b>	25 <b>25</b>	mV
$\Delta V_{\text{OUT}}$	Load Regulation (Note 8)	LM1085-ADJ $(V_{\text{IN}} - V_{\text{OUT}}) = 3\text{V}$ , $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$		0.1 <b>0.2</b>	0.3 <b>0.4</b>	%
		LM1085-3.3 $V_{\text{IN}} = 5\text{V}$ , $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$		3 <b>7</b>	15 <b>20</b>	mV
		LM1085-5.0 $V_{\text{IN}} = 8\text{V}$ , $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$		5 <b>10</b>	20 <b>35</b>	mV
		LM1085-12 $V_{\text{IN}} = 15\text{V}$ , $0 \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$		12 <b>24</b>	36 <b>72</b>	mV
	Dropout Voltage (Note 9)	LM1085-3.3/5/12/ADJ $\Delta V_{\text{REF}} = 1\%$ , $I_{\text{OUT}} = 3\text{A}$		1.3	1.5	V
$I_{\text{LIMIT}}$	Current Limit	LM1085-ADJ $V_{\text{IN}} - V_{\text{OUT}} = 5\text{V}$ $V_{\text{IN}} - V_{\text{OUT}} = 25\text{V}$	3.2 <b>0.2</b>	5.5 <b>0.5</b>		A
		LM1085-3.3 $V_{\text{IN}} = 8\text{V}$	3.2	5.5		A
		LM1085-5.0 $V_{\text{IN}} = 10\text{V}$	3.2	5.5		A
		LM1085-12 $V_{\text{IN}} = 17\text{V}$	3.2	5.5		A

## Electrical Characteristics (Continued)

Typicals and limits appearing in normal type apply for  $T_J = 25^\circ\text{C}$ . Limits appearing in **Boldface** type apply over the entire junction temperature range for operation.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
	Minimum Load Current (Note 10)	LM1085-ADJ $V_{IN} - V_{OUT} = 25\text{V}$		<b>5.0</b>	<b>10.0</b>	mA
	Quiescent Current	LM1085-3.3 $V_{IN} \leq 18\text{V}$		<b>5.0</b>	<b>10.0</b>	mA
		LM1085-5.0 $V_{IN} \leq 20\text{V}$		<b>5.0</b>	<b>10.0</b>	mA
		LM1085-12 $V_{IN} \leq 25\text{V}$		<b>5.0</b>	<b>10.0</b>	mA
	Thermal Regulation	$T_A = 25^\circ\text{C}$ , 30ms Pulse		.004	0.02	%/W
	Ripple Rejection	$f_{RIPPLE} = 120\text{Hz}$ , $C_{OUT} = 25\mu\text{F}$ Tantalum, $I_{OUT} = 3\text{A}$				
		LM1085-ADJ, $C_{ADJ} = 25\mu\text{F}$ , $(V_{IN} - V_O) = 3\text{V}$	<b>60</b>	<b>75</b>		dB
		LM1085-3.3, $V_{IN} = 6.3\text{V}$	<b>60</b>	<b>72</b>		dB
		LM1085-5.0, $V_{IN} = 8\text{V}$	<b>60</b>	<b>68</b>		dB
		LM1085-12 $V_{IN} = 15\text{V}$	<b>54</b>	<b>60</b>		dB
	Adjust Pin Current	LM1085		55	<b>120</b>	µA
	Adjust Pin Current Change	$10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$ , $1.5\text{V} \leq V_{IN} - V_{OUT} \leq 25\text{V}$		<b>0.2</b>	<b>5</b>	µA
	Temperature Stability			<b>0.5</b>		%
	Long Term Stability	$T_A = 125^\circ\text{C}$ , 1000Hrs		0.3	1.0	%
	RMS Output Noise (% of $V_{OUT}$ )	$10\text{Hz} \leq f \leq 10\text{kHz}$		0.003		%
	Thermal Resistance Junction-to-Case	3-Lead TO-263: Control Section/Output Section 3-Lead TO-220: Control Section/Output Section			0.7/3.0 0.7/3.0	°C/W °C/W

**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 specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

**Note 2:** Power dissipation is kept in a safe range by current limiting circuitry. Refer to Overload Recovery in Application Notes.

**Note 3:** The maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(max)} - T_A)/\theta_{JA}$ . All numbers apply for packages soldered directly into a PC board. Refer to Thermal Considerations in the Application Notes.

**Note 4:** For testing purposes, ESD was applied using human body model,  $1.5\text{k}\Omega$  in series with  $100\text{pF}$ .

**Note 5:** Typical Values represent the most likely parametric norm.

**Note 6:** All limits are guaranteed by testing or statistical analysis.

**Note 7:**  $I_{FULL\ LOAD}$  is defined in the current limit curves. The  $I_{FULL\ LOAD}$  Curve defines the current limit as a function of input-to-output voltage. Note that 30W power dissipation for the LM1085 is only achievable over a limited range of input-to-output voltage.

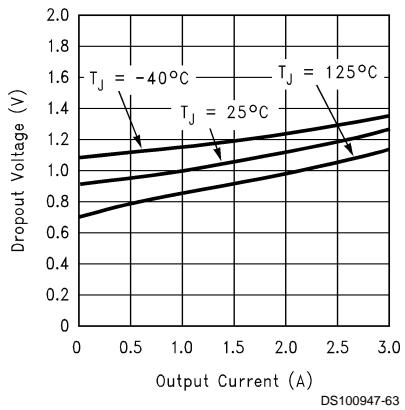
**Note 8:** Load and line regulation are measured at constant junction temperature, and are guaranteed up to the maximum power dissipation of 30W. Power dissipation is determined by the input/output differential and the output current. Guaranteed maximum power dissipation will not be available over the full input/output range.

**Note 9:** Dropout voltage is specified over the full output current range of the device.

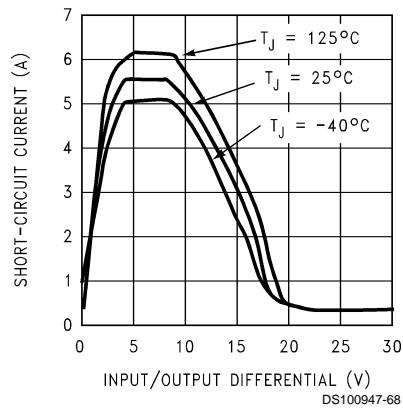
**Note 10:** The minimum output current required to maintain regulation.

## Typical Performance Characteristics

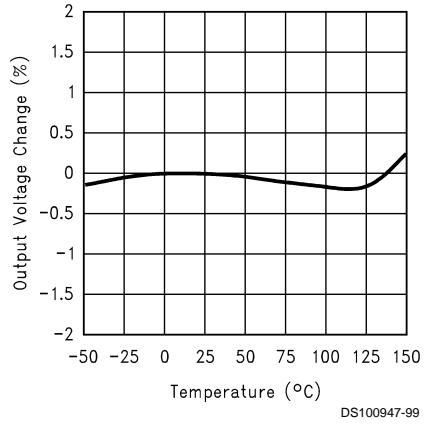
Dropout Voltage vs. Output Current



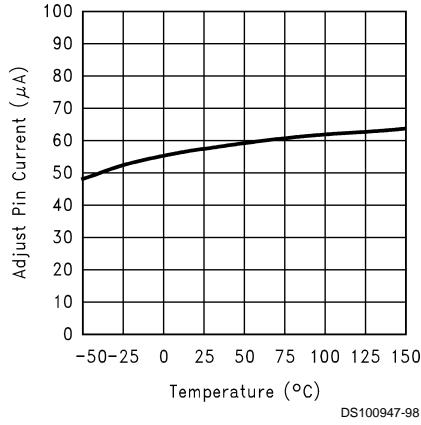
Short-Circuit Current vs. Input/Output Difference



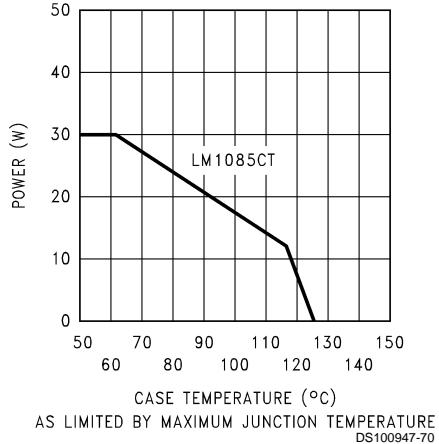
Percent Change in Output Voltage vs. Temperature



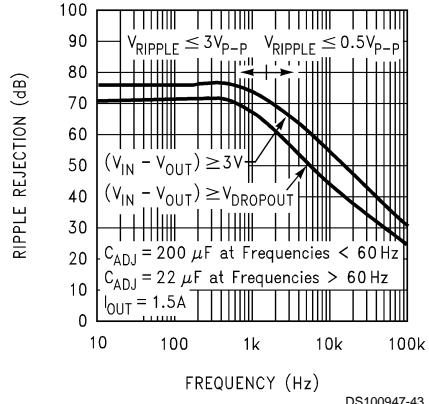
Adjust Pin Current vs. Temperature



Maximum Power Dissipation vs. Temperature

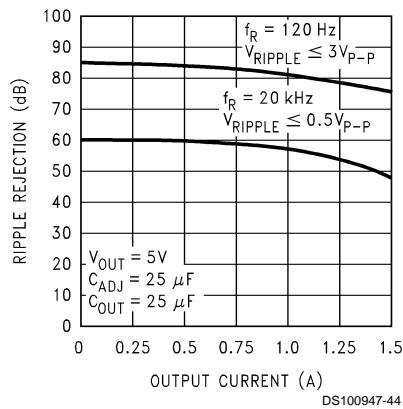


Ripple Rejection vs. Frequency (LM1085-Adj.)



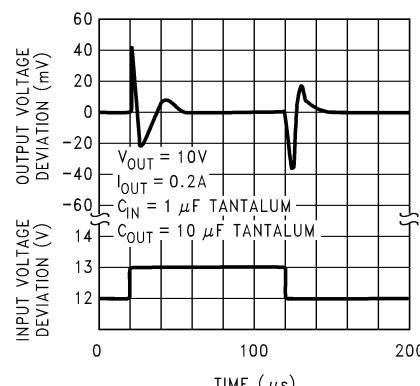
## Typical Performance Characteristics (Continued)

Ripple Rejection vs. Output Current (LM1085-Adj.)



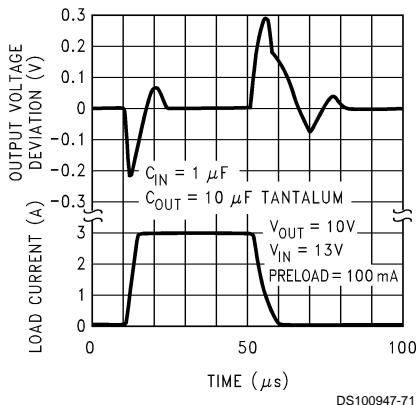
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Line Transient Response



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Load Transient Response

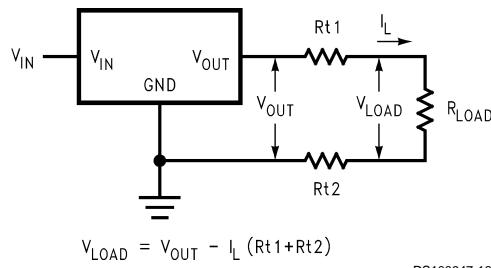


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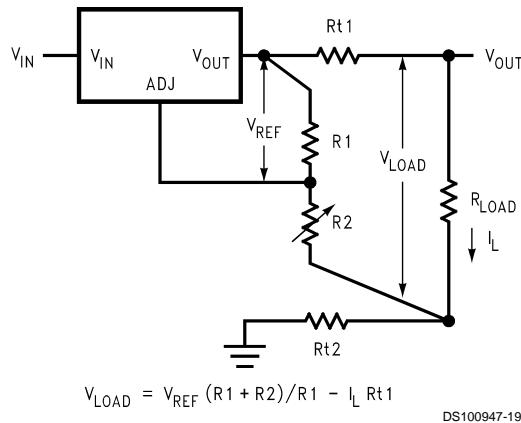
## APPLICATION NOTE (Continued)

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 3. Typical Application using Fixed Output Regulator**

When the adjustable regulator is used (Figure 4), the best performance is obtained with the positive side of the resistor R1 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 R1 (=  $125\Omega$ ) is connected near the load the effective line resistance will be  $0.05\Omega (1 + R2/R1)$  or in this case, it is 4 times worse. In addition, the ground side of the resistor R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.



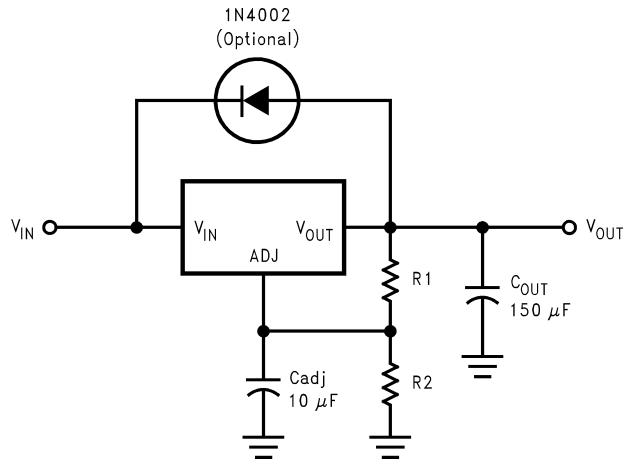
**FIGURE 4. Best Load Regulation using Adjustable Output Regulator**

### 3.0 Protection Diodes

Under normal operation, the LM1085 regulator does not need any protection diode. With the adjustable device, the internal resistance between the adjustment and output terminals limits the current. No diode is needed to divert the current around the regulator even with a capacitor on the adjustment 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, 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 LM1085 regulator, 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, shown in Figure 5.



**FIGURE 5. Regulator with Protection Diode**

### Overload Recovery

Overload recovery refers to regulator's ability to recover from a short circuited output. A key factor in the recovery process is the current limiting used to protect the output from drawing too much power. The current limiting circuit reduces the output current as the input to output differential increases. Refer to short circuit curve in the curve section.

During normal start-up, the input to output differential is small since the output follows the input. But, if the output is shorted, then the recovery involves a large input to output differential. Sometimes during this condition the current limiting circuit is slow in recovering. If the limited current is too low to develop a voltage at the output, the voltage will stabilize at a lower level. Under these conditions it may be necessary to recycle the power of the regulator in order to get the smaller differential voltage and thus adequate start up conditions. Refer to curve section for the short circuit current vs. input differential voltage.

### Thermal Considerations

ICs heats up when in operation, and power consumption is one factor in how hot it gets. The other factor is how well the heat is dissipated. Heat dissipation is predictable by knowing the thermal resistance between the IC and ambient ( $\theta_{JA}$ ). Thermal resistance has units of temperature per power (C/W). The higher the thermal resistance, the hotter the IC.

The LM1085 specifies the thermal resistance for each package as junction to case ( $\theta_{JC}$ ). In order to get the total resistance to ambient ( $\theta_{JA}$ ), two other thermal resistance must be added, one for case to heat-sink ( $\theta_{CH}$ ) and one for heatsink to ambient ( $\theta_{HA}$ ). The junction temperature can be predicted as follows:

$$T_J = T_A + P_D (\theta_{JC} + \theta_{CH} + \theta_{HA}) = T_A + P_D \theta_{JA}$$

$T_J$  is junction temperature,  $T_A$  is ambient temperature, and  $P_D$  is the power consumption of the device. Device power consumption is calculated as follows:

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

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

## APPLICATION NOTE (Continued)

Figure 6 shows the voltages and currents which are present in the circuit.

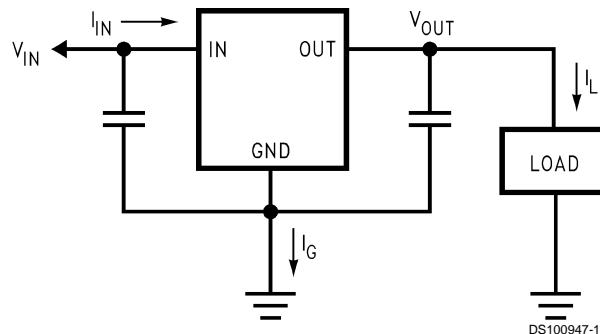


FIGURE 6. Power Dissipation Diagram

Once the devices power is determined, the maximum allowable ( $\theta_{JA(max)}$ ) is calculated as:

$$\theta_{JA(max)} = T_{R(max)}/P_D = T_{J(max)} - T_{A(max)}/P_D$$

The LM1085 has different temperature specifications for two different sections of the IC: the control section and the output section. The Electrical Characteristics table shows the junction to case thermal resistances for each of these sections, while the maximum junction temperatures ( $T_{J(max)}$ ) for each section is listed in the Absolute Maximum section of the datasheet.  $T_{J(max)}$  is 125°C for the control section, while  $T_{J(max)}$  is 150°C for the output section.

$\theta_{JA(max)}$  should be calculated separately for each section as follows:

$$\theta_{JA}(\text{max, CONTROL SECTION}) = (125^\circ\text{C} - T_{A(max)})/P_D$$

$$\theta_{JA}(\text{max, OUTPUT SECTION}) = (150^\circ\text{C} - T_{A(max)})/P_D$$

The required heat sink is determined by calculating its required thermal resistance ( $\theta_{HA(max)}$ ).

$$\theta_{HA(max)} = \theta_{JA(max)} - (\theta_{JC} + \theta_{CH})$$

$\theta_{HA(max)}$  should also be calculated twice as follows:

$$\theta_{HA(max)} = \theta_{JA}(\text{max, CONTROL SECTION}) - (\theta_{JC}(\text{CONTROL SECTION}) + \theta_{CH})$$

$$\theta_{HA(max)} = \theta_{JA}(\text{max, OUTPUT SECTION}) - (\theta_{JC}(\text{OUTPUT SECTION}) + \theta_{CH})$$

If thermal compound is used,  $\theta_{CH}$  can be estimated at 0.2 C/W. If the case is soldered to the heat sink, then a  $\theta_{CH}$  can be estimated as 0 C/W.

After,  $\theta_{HA(max)}$  is calculated for each section, choose the lower of the two  $\theta_{HA(max)}$  values to determine the appropriate heat sink.

If PC board copper is going to be used as a heat sink, then Figure 7 can be used to determine the appropriate area (size) of copper foil required.

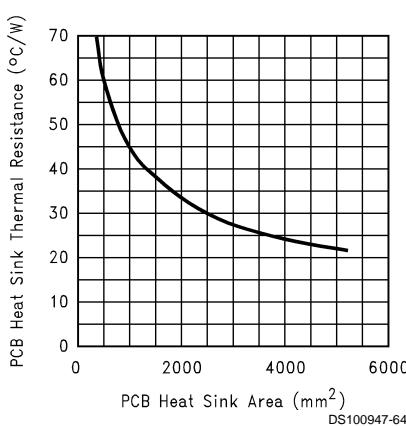
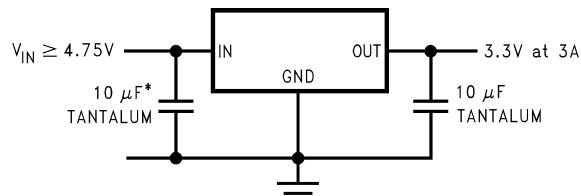


FIGURE 7. Heat sink thermal Resistance vs Area

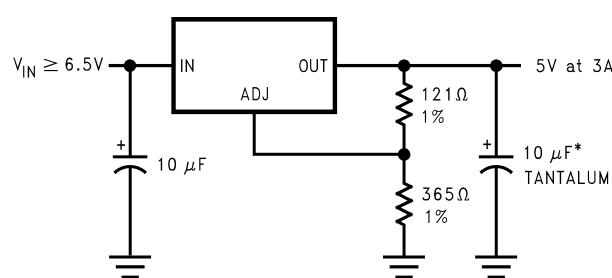
## Typical Applications



\*MAY BE OMITTED IF INPUT SUPPLY IS WELL BYPASSED WITHIN 2" OF THE LM1085

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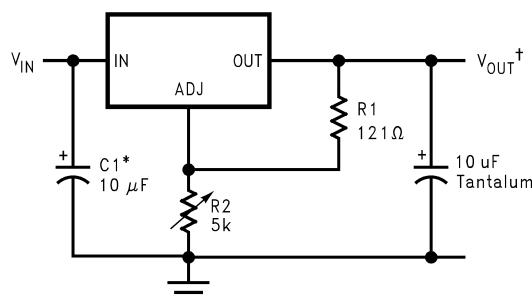
### 5V to 3.3V, 1.5A Regulator



\*REQUIRED FOR STABILITY

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### Adjustable @ 5V

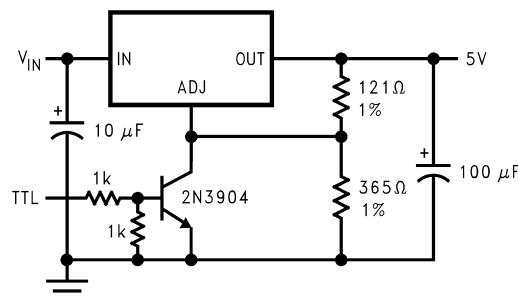


\*NEEDED IF DEVICE IS FAR FROM FILTER CAPACITORS

$$\dagger V_{OUT} = 1.25V \left(1 + \frac{R2}{R1}\right)$$

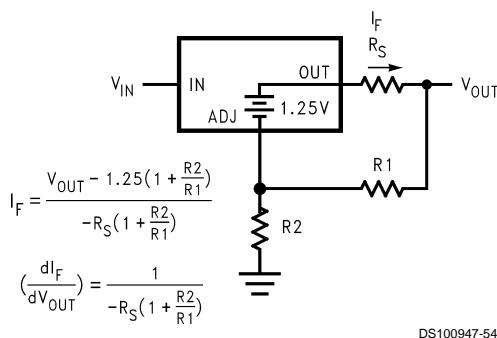
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### 1.2V to 15V Adjustable Regulator



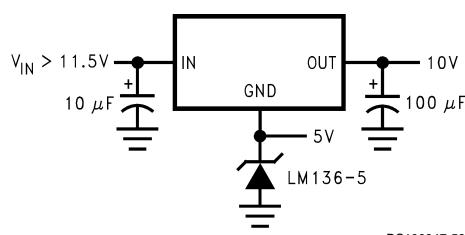
### 5V Regulator with Shutdown

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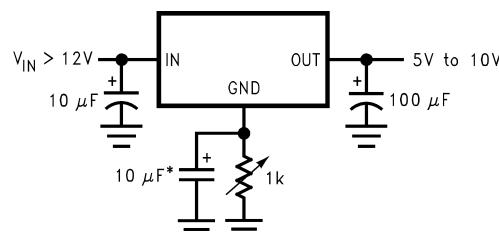
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### Battery Charger



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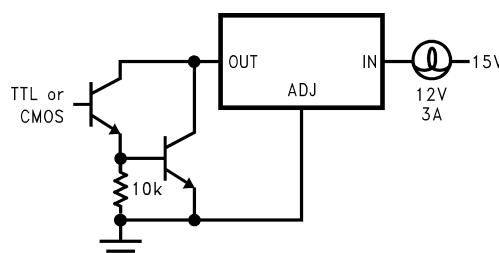
### Regulator with Reference



\*OPTIONAL IMPROVES RIPPLE REJECTION

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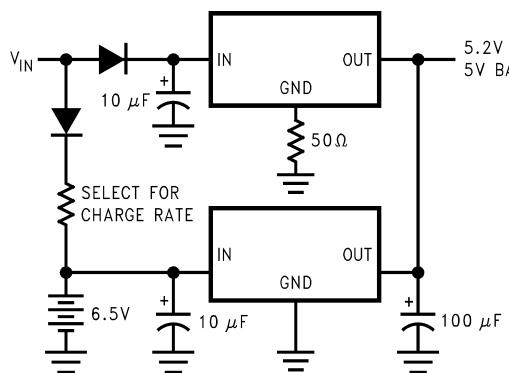
### Adjustable Fixed Regulator



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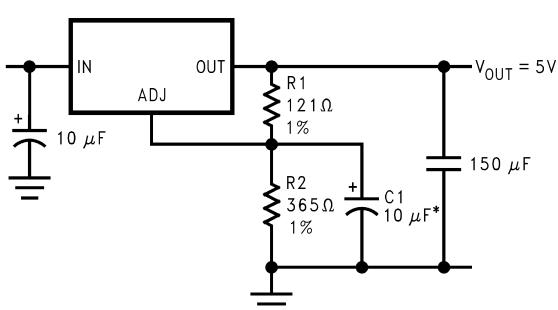
### High Current Lamp Driver Protection

## Typical Applications (Continued)



Battery Backup Regulated Supply

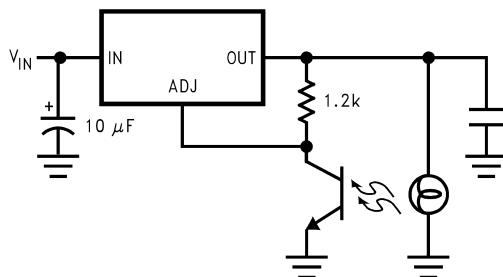
DS100947-59



\*C1 IMPROVES RIPPLE REJECTION.  
 $X_C$  SHOULD BE  $\approx R_1$  AT RIPPLE FREQUENCY

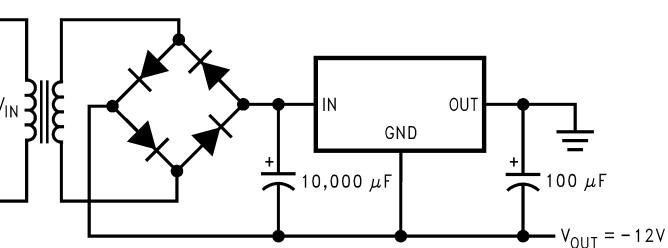
DS100947-60

Ripple Rejection Enhancement



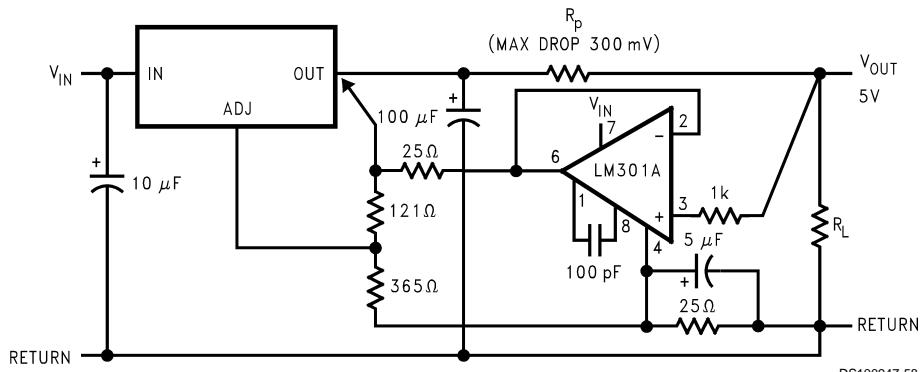
Automatic Light control

DS100947-61



Generating Negative Supply voltage

DS100947-62

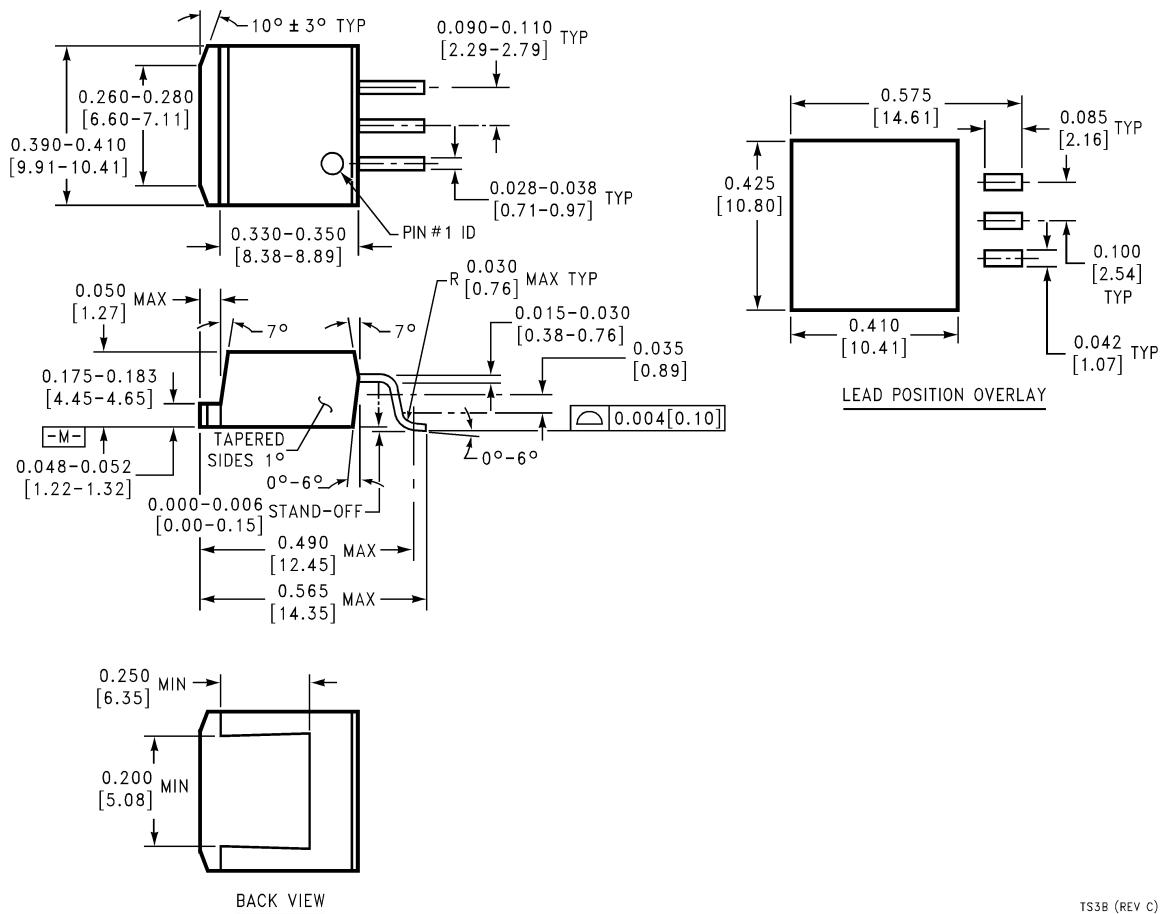


Remote Sensing

DS100947-58

## Physical Dimensions

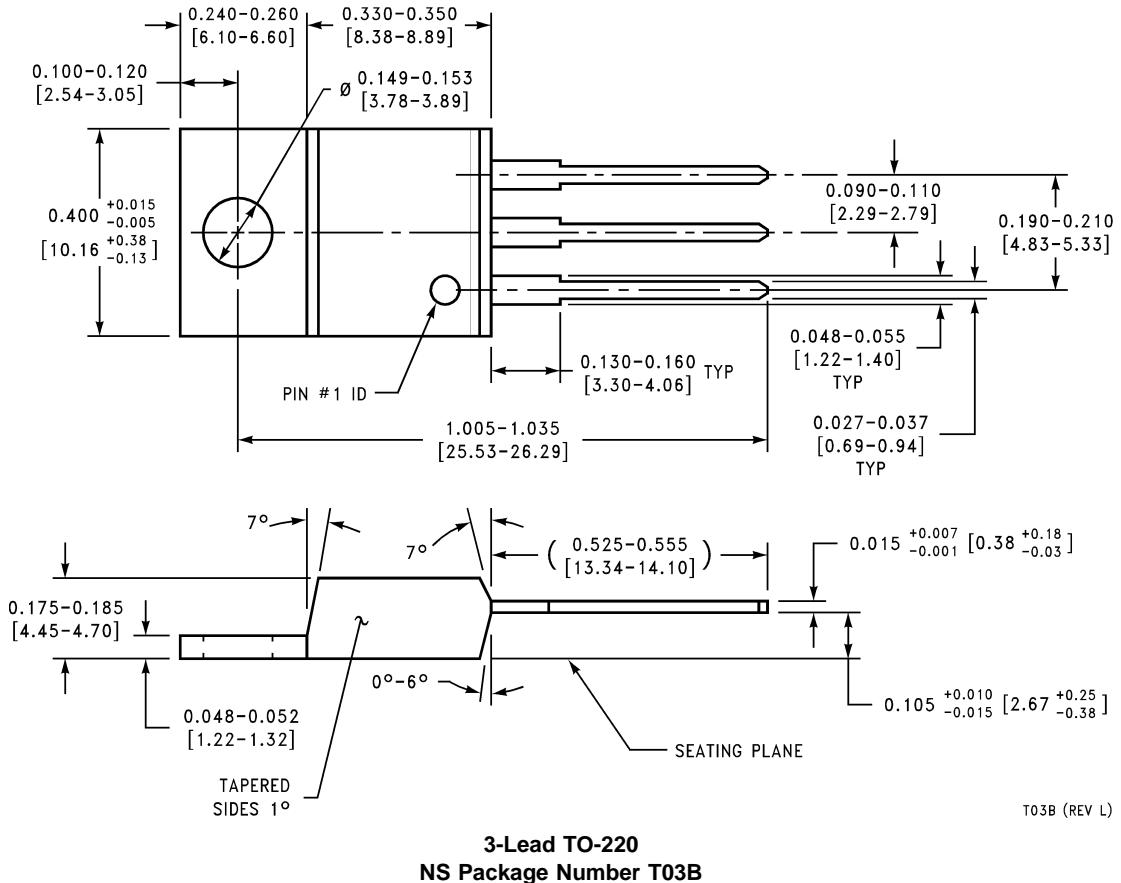
inches (millimeters) unless otherwise noted



TS3B (REV C)

**3-Lead TO-263**  
**NS Package Number TS3B**

## **Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



## LIFE SUPPORT POLICY

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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