

# LM340/LM78XX Series 3-Terminal Positive Regulators

## General Description

The LM140/LM340A/LM340/LM78XXC monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Considerable effort was expended to make the entire series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

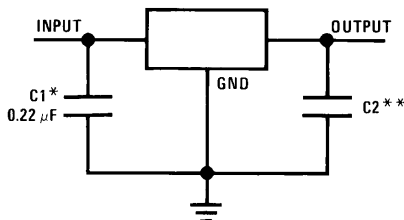
The 5V, 12V, and 15V regulator options are available in the steel TO-3 power package. The LM340A/LM340/LM78XXC series is available in the TO-220 plastic power package, and the LM340-5.0 is available in the SOT-223 package, as well as the LM340-5.0 and LM340-12 in the surface-mount TO-263 package.

## Features

- Complete specifications at 1A load
- Output voltage tolerances of  $\pm 2\%$  at  $T_j = 25^\circ\text{C}$  and  $\pm 4\%$  over the temperature range (LM340A)
- Line regulation of 0.01% of  $V_{OUT}/V$  of  $\Delta V_{IN}$  at 1A load (LM340A)
- Load regulation of 0.3% of  $V_{OUT}/A$  (LM340A)
- Internal thermal overload protection
- Internal short-circuit current limit
- Output transistor safe area protection
- P+ Product Enhancement tested

## Typical Applications

### Fixed Output Regulator

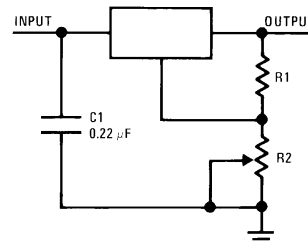


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\*Required if the regulator is located far from the power supply filter.

\*\*Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1  $\mu\text{F}$ , ceramic disc).

### Adjustable Output Regulator

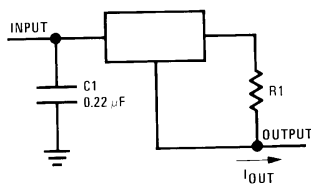


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$$V_{OUT} = 5V + (5V/R1 + I_Q) R2 \quad 5V/R1 > 3 I_Q$$

$$\text{load regulation } (L_r) \approx [(R1 + R2)/R1] \quad (L_r \text{ of LM340-5}).$$

### Current Regulator

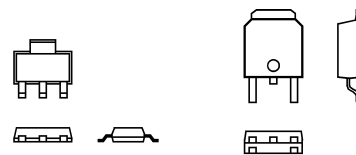


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$$I_{OUT} = \frac{V_{2-3}}{R1} + I_Q$$

$\Delta I_Q = 1.3 \text{ mA}$  over line and load changes.

### Comparison between SOT-223 and D-Pak (TO-252) Packages



SOT-223

TO-252

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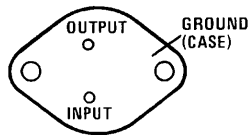
Scale 1:1

## Ordering Information

Package	Temperature Range	Part Number	Packaging Marking	Transport Media	NSC Drawing
3-Lead TO-3	-55°C to +125°C	LM140K-5.0	LM140K 5.0P+	50 Per Tray	K02A
		LM140K-12	LM140K 12P+	50 Per Tray	
		LM140K-15	LM140K 15P+	50 Per Tray	
	0°C to +125°C	LM340K-5.0	LM340K 5.0 7805P+	50 Per Tray	
		LM340K-12	LM340K 12 7812P+	50 Per Tray	
		LM340K-15	LM340K 15 7815P+	50 Per Tray	
3-lead TO-220	0°C to +125°C	LM340AT-5.0	LM340AT 5.0 P+	45 Units/Rail	T03B
		LM340T-5.0	LM340T5 7805 P+	45 Units/Rail	
		LM340T-12	LM340T12 7812 P+	45 Units/Rail	
		LM340T-15	LM340T15 7815 P+	45 Units/Rail	
		LM7808CT	LM7808CT	45 Units/Rail	
3-Lead TO-263	0°C to +125°C	LM340S-5.0	LM340S-5.0 P+	45 Units/Rail	TS3B
		LM340SX-5.0		500 Units Tape and Reel	
		LM340S-12	LM340S-12 P+	45 Units/Rail	
		LM340SX-12		500 Units Tape and Reel	
		LM340AS-5.0	LM340AS-5.0 P+	45 Units/Rail	
		LM340ASX-5.0		500 Units Tape and Reel	
4-Lead SOT-223	0°C to +125°C	LM340MP-5.0	N00A	1k Units Tape and Reel	MP04A
		LM340MPX-5.0		2k Units Tape and Reel	
Unpackaged Die	-55°C to 125°C	LM140KG-5 MD8		Waffle Pack or Gel Pack	DL069089
		LM140KG-12 MD8		Waffle Pack or Gel Pack	DL059093
		LM140KG-15 MD8		Waffle Pack or Gel Pack	DL059093
	0°C to +125°C	LM340-5.0 MDA		Waffle Pack or Gel Pack	DI074056
		LM7808C MDC		Waffle Pack or Gel Pack	DI074056

## Connection Diagrams

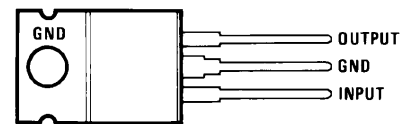
TO-3 Metal Can Package (K)



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Bottom View  
See Package Number K02A

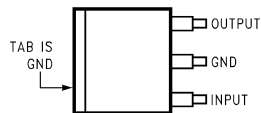
TO-220 Power Package (T)



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Top View  
See Package Number T03B

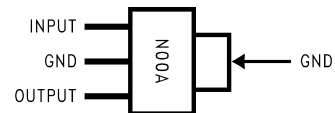
TO-263 Surface-Mount Package (S)



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Top View  
See Package Number TS3B

3-Lead SOT-223



00778143

Top View  
See Package Number MP04A

**Absolute Maximum Ratings** (Note 1)

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

(Note 5)

DC Input Voltage	35V
Internal Power Dissipation (Note 2)	Internally Limited
Maximum Junction Temperature	150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package (K)	300°C

TO-220 Package (T), TO-263

Package (S)

230°C

ESD Susceptibility (Note 3)

2 kV

**Operating Conditions** (Note 1)Temperature Range ( $T_A$ ) (Note 2)

LM140	-55°C to +125°C
LM340A, LM340	0°C to +125°C
LM7808C	0°C to +125°C

**LM340A Electrical Characteristics** $I_{OUT} = 1A$ ,  $0^\circ C \leq T_J \leq +125^\circ C$  (LM340A) unless otherwise specified (Note 4)

Symbol	Output Voltage		5V			12V			15V			Units	
	Input Voltage (unless otherwise noted)		10V			19V			23V				
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
$V_O$	Output Voltage	$T_J = 25^\circ C$	4.9	5	5.1	11.75	12	12.25	14.7	15	15.3	V	
		$P_D \leq 15W$ , $5 mA \leq I_O \leq 1A$	4.8		5.2	11.5		12.5	14.4		15.6	V	
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$	(7.5 $\leq V_{IN} \leq 20$ )			(14.8 $\leq V_{IN} \leq 27$ )			(17.9 $\leq V_{IN} \leq 30$ )			V	
$\Delta V_O$	Line Regulation	$I_O = 500 mA$	10			18			22			mV	
		$\Delta V_{IN}$	(7.5 $\leq V_{IN} \leq 20$ )			(14.8 $\leq V_{IN} \leq 27$ )			(17.9 $\leq V_{IN} \leq 30$ )			V	
		$T_J = 25^\circ C$	3	10		4	18		4	22		mV	
		$\Delta V_{IN}$	(7.5 $\leq V_{IN} \leq 20$ )			(14.5 $\leq V_{IN} \leq 27$ )			(17.5 $\leq V_{IN} \leq 30$ )			V	
		$T_J = 25^\circ C$	4			9			10			mV	
$\Delta V_O$	Load Regulation	$T_J = 25^\circ C$	5 mA $\leq I_O \leq 1.5A$		10	25		12	32		12	35	mV
			250 mA $\leq I_O \leq 750 mA$			15			19			21	mV
		Over Temperature, 5 mA $\leq I_O \leq 1A$	25			60			75			mV	
$I_Q$	Quiescent Current	$T_J = 25^\circ C$	6			6			6			mA	
		Over Temperature	6.5			6.5			6.5			mA	
$\Delta I_Q$	Quiescent Current Change	5 mA $\leq I_O \leq 1A$		0.5			0.5			0.5			mA
		$T_J = 25^\circ C$ , $I_O = 1A$		0.8			0.8			0.8			mA
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$		(7.5 $\leq V_{IN} \leq 20$ )			(14.8 $\leq V_{IN} \leq 27$ )			(17.9 $\leq V_{IN} \leq 30$ )			V
		$I_O = 500 mA$		0.8			0.8			0.8			mA
$V_N$	Output Noise Voltage	$T_A = 25^\circ C$ , 10 Hz $\leq f \leq 100$ kHz		40			75			90			$\mu V$
		$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	$T_J = 25^\circ C$ , $f = 120$ Hz, $I_O = 1A$		68	80		61	72		60	70
or $f = 120$ Hz, $I_O = 500$ mA,				68			61			60		dB	
Over Temperature, $V_{MIN} \leq V_{IN} \leq V_{MAX}$				(8 $\leq V_{IN} \leq 18$ )			(15 $\leq V_{IN} \leq 25$ )			(18.5 $\leq V_{IN} \leq 28.5$ )			V
$R_O$	Dropout Voltage	$T_J = 25^\circ C$ , $I_O = 1A$		2.0			2.0			2.0			V
		$f = 1$ kHz		8			18			19			m $\Omega$
		$T_J = 25^\circ C$		2.1			1.5			1.2			A

**LM340A Electrical Characteristics** (Continued) $I_{OUT} = 1A, 0^{\circ}C \leq T_J \leq +125^{\circ}C$  (LM340A) unless otherwise specified (Note 4)

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Peak Output Current	$T_J = 25^{\circ}C$	2.4			2.4			2.4			A
	Average TC of $V_O$	Min, $T_J = 0^{\circ}C, I_O = 5 mA$	-0.6			-1.5			-1.8			mV/ $^{\circ}C$
$V_{IN}$	Input Voltage Required to Maintain Line Regulation	$T_J = 25^{\circ}C$	7.5			14.5			17.5			V

**LM140 Electrical Characteristics** (Note 4) $-55^{\circ}C \leq T_J \leq +150^{\circ}C$  unless otherwise specified

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_O$	Output Voltage	$T_J = 25^{\circ}C, 5 mA \leq I_O \leq 1A$	4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		$P_D \leq 15W, 5 mA \leq I_O \leq 1A$	4.75		5.25	11.4		12.6	14.25		15.75	V
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$	(8 $\leq V_{IN} \leq 20$ )		(15.5 $\leq V_{IN} \leq 27$ )		(18.5 $\leq V_{IN} \leq 30$ )					V
$\Delta V_O$	Line Regulation	$I_O = 500 mA, T_J = 25^{\circ}C$	$\Delta V_{IN}$	3 50		4 120		4 150				mV
				(7 $\leq V_{IN} \leq 25$ )		(14.5 $\leq V_{IN} \leq 30$ )		(17.5 $\leq V_{IN} \leq 30$ )				V
		$I_O \leq 1A$	$\Delta V_{IN}$	50		120		150				mV
				(7.5 $\leq V_{IN} \leq 20$ )		(14.6 $\leq V_{IN} \leq 27$ )		(17.7 $\leq V_{IN} \leq 30$ )				V
$\Delta V_O$	Load Regulation	$T_J = 25^{\circ}C$	$5 mA \leq I_O \leq 1.5A$	10 50		12 120		12 150				mV
			$250 mA \leq I_P \leq 750 mA$	25		60		75				mV
		$-55^{\circ}C \leq T_J \leq +150^{\circ}C,$ $5 mA \leq I_O \leq 1A$	50		120		150				mV	
$I_Q$	Quiescent Current	$I_O \leq 1A$	$T_J = 25^{\circ}C$	6		6		6				mA
			$-55^{\circ}C \leq T_J \leq +150^{\circ}C$	7		7		7				mA
$\Delta I_Q$	Quiescent Current Change	$5 mA \leq I_O \leq 1A$		0.5		0.5		0.5				mA
		$T_J = 25^{\circ}C, I_O \leq 1A$ $V_{MIN} \leq V_{IN} \leq V_{MAX}$		0.8		0.8		0.8				mA
		$I_O = 500 mA, -55^{\circ}C \leq T_J \leq +150^{\circ}C$ $V_{MIN} \leq V_{IN} \leq V_{MAX}$		(8 $\leq V_{IN} \leq 20$ )		(15 $\leq V_{IN} \leq 27$ )		(18.5 $\leq V_{IN} \leq 30$ )				V
$V_N$	Output Noise Voltage	$T_A = 25^{\circ}C, 10 Hz \leq f \leq 100 kHz$		40		75		90				$\mu V$

**LM140 Electrical Characteristics** (Note 4) (Continued)-55°C ≤ T<sub>J</sub> ≤ +150°C unless otherwise specified

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	I <sub>O</sub> ≤ 1A, T <sub>J</sub> = 25°C	68	80		61	72		60	70		dB
		f = 120 Hz I <sub>O</sub> ≤ 500 mA, -55°C ≤ T <sub>J</sub> ≤ +150°C	68			61			60			dB
		V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(8 ≤ V <sub>IN</sub> ≤ 18)			(15 ≤ V <sub>IN</sub> ≤ 25)			(18.5 ≤ V <sub>IN</sub> ≤ 28.5)			V
R <sub>O</sub>	Dropout Voltage	T <sub>J</sub> = 25°C, I <sub>O</sub> = 1A	2.0			2.0			2.0			V
	Output Resistance	f = 1 kHz	8			18			19			mΩ
	Short-Circuit Current	T <sub>J</sub> = 25°C	2.1			1.5			1.2			A
	Peak Output Current	T <sub>J</sub> = 25°C	2.4			2.4			2.4			A
	Average TC of V <sub>OUT</sub>	0°C ≤ T <sub>J</sub> ≤ +150°C, I <sub>O</sub> = 5 mA	-0.6			-1.5			-1.8			mV/°C
	V <sub>IN</sub>	Input Voltage Required to Maintain Line Regulation	T <sub>J</sub> = 25°C, I <sub>O</sub> ≤ 1A	7.5			14.6			17.7		

**LM340 Electrical Characteristics** (Note 4)0°C ≤ T<sub>J</sub> ≤ +125°C unless otherwise specified

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V <sub>O</sub>	Output Voltage	T <sub>J</sub> = 25°C, 5 mA ≤ I <sub>O</sub> ≤ 1A	4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P <sub>D</sub> ≤ 15W, 5 mA ≤ I <sub>O</sub> ≤ 1A	4.75		5.25	11.4		12.6	14.25		15.75	V
		V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.5 ≤ V <sub>IN</sub> ≤ 27)			(17.5 ≤ V <sub>IN</sub> ≤ 30)			V
ΔV <sub>O</sub>	Line Regulation	I <sub>O</sub> = 500 mA	T <sub>J</sub> = 25°C	3	50	4	120	4	150	mV		
			ΔV <sub>IN</sub>	(7 ≤ V <sub>IN</sub> ≤ 25)			(14.5 ≤ V <sub>IN</sub> ≤ 30)			V		
		0°C ≤ T <sub>J</sub> ≤ +125°C	ΔV <sub>IN</sub>	50			120			150	mV	
			ΔV <sub>IN</sub>	(8 ≤ V <sub>IN</sub> ≤ 20)			(15 ≤ V <sub>IN</sub> ≤ 27)			(18.5 ≤ V <sub>IN</sub> ≤ 30)	V	
		I <sub>O</sub> ≤ 1A	T <sub>J</sub> = 25°C	50			120			150	mV	
			ΔV <sub>IN</sub>	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.6 ≤ V <sub>IN</sub> ≤ 27)			(17.7 ≤ V <sub>IN</sub> ≤ 30)	V	
ΔV <sub>O</sub>	Load Regulation	T <sub>J</sub> = 25°C	5 mA ≤ I <sub>O</sub> ≤ 1.5A	10	50	12	120	12	150	mV		
			250 mA ≤ I <sub>O</sub> ≤ 750 mA	25			60			75	mV	
		5 mA ≤ I <sub>O</sub> ≤ 1A, 0°C ≤ T <sub>J</sub> ≤ +125°C	50			120			150	mV		
I <sub>Q</sub>	Quiescent Current	I <sub>O</sub> ≤ 1A	T <sub>J</sub> = 25°C	8			8			8	mA	
			0°C ≤ T <sub>J</sub> ≤ +125°C	8.5			8.5			8.5	mA	
ΔI <sub>Q</sub>	Quiescent Current Change	5 mA ≤ I <sub>O</sub> ≤ 1A		0.5			0.5			0.5	mA	
		T <sub>J</sub> = 25°C, I <sub>O</sub> ≤ 1A		1.0			1.0			1.0	mA	

## LM340 Electrical Characteristics (Note 4) (Continued)

0°C ≤ T<sub>J</sub> ≤ +125°C unless otherwise specified

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>		(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.8 ≤ V <sub>IN</sub> ≤ 27)			(17.9 ≤ V <sub>IN</sub> ≤ 30)			V
	I <sub>O</sub> ≤ 500 mA, 0°C ≤ T <sub>J</sub> ≤ +125°C V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>		1.0 (7 ≤ V <sub>IN</sub> ≤ 25)			1.0 (14.5 ≤ V <sub>IN</sub> ≤ 30)			1.0 (17.5 ≤ V <sub>IN</sub> ≤ 30)			mA V
V <sub>N</sub>	Output Noise Voltage	T <sub>A</sub> = 25°C, 10 Hz ≤ f ≤ 100 kHz	40			75			90			μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	I <sub>O</sub> ≤ 1A, T <sub>J</sub> = 25°C	62	80		55	72		54	70		dB
		f = 120 Hz	62			55			54			dB
		V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(8 ≤ V <sub>IN</sub> ≤ 18)			(15 ≤ V <sub>IN</sub> ≤ 25)			(18.5 ≤ V <sub>IN</sub> ≤ 28.5)			V
R <sub>O</sub>	Dropout Voltage	T <sub>J</sub> = 25°C, I <sub>O</sub> = 1A	2.0			2.0			2.0			V
	Output Resistance	f = 1 kHz	8			18			19			mΩ
	Short-Circuit Current	T <sub>J</sub> = 25°C	2.1			1.5			1.2			A
	Peak Output Current	T <sub>J</sub> = 25°C	2.4			2.4			2.4			A
	Average TC of V <sub>OUT</sub>	0°C ≤ T <sub>J</sub> ≤ +125°C, I <sub>O</sub> = 5 mA	-0.6			-1.5			-1.8			mV/°C
V <sub>IN</sub>	Input Voltage Required to Maintain Line Regulation	T <sub>J</sub> = 25°C, I <sub>O</sub> ≤ 1A	7.5			14.6			17.7			V

**Note 1:** Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions see the Electrical Characteristics.

**Note 2:** The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation (T<sub>JMAX</sub> = 125°C or 150°C), the junction-to-ambient thermal resistance (θ<sub>JA</sub>), and the ambient temperature (T<sub>A</sub>). P<sub>DMAX</sub> = (T<sub>JMAX</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. If this dissipation is exceeded, the die temperature will rise above T<sub>JMAX</sub> and the electrical specifications do not apply. If the die temperature rises above 150°C, the device will go into thermal shutdown. For the TO-3 package (K, KC), the junction-to-ambient thermal resistance (θ<sub>JA</sub>) is 39°C/W. When using a heatsink, θ<sub>JA</sub> is the sum of the 4°C/W junction-to-case thermal resistance (θ<sub>JC</sub>) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink. For the TO-220 package (T), θ<sub>JA</sub> is 54°C/W and θ<sub>JC</sub> is 4°C/W. If SOT-223 is used, the junction-to-ambient thermal resistance is 174°C/W and can be reduced by a heatsink (see Applications Hints on heatsinking).

If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package: Using 0.5 square inches of copper area, θ<sub>JA</sub> is 50°C/W; with 1 square inch of copper area, θ<sub>JA</sub> is 37°C/W; and with 1.6 or more inches of copper area, θ<sub>JA</sub> is 32°C/W.

**Note 3:** ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

**Note 4:** All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t<sub>w</sub> ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

**Note 5:** Military datasheets are available upon request. At the time of printing, the military datasheet specifications for the LM140K-5.0/883, LM140K-12/883, and LM140K-15/883 complied with the min and max limits for the respective versions of the LM140. The LM140H and LM140K may also be procured as JAN devices on slash sheet JM38510/107.

## LM7808C

### Electrical Characteristics

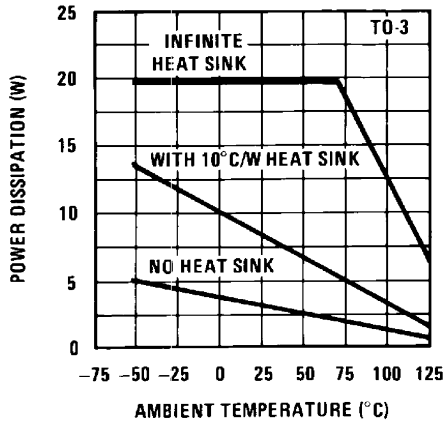
$0^{\circ}\text{C} \leq T_J \leq +150^{\circ}\text{C}$ ,  $V_I = 14\text{V}$ ,  $I_O = 500\text{ mA}$ ,  $C_I = 0.33\text{ }\mu\text{F}$ ,  $C_O = 0.1\text{ }\mu\text{F}$ , unless otherwise specified

Symbol	Parameter		Conditions (Note 6)		LM7808C			Units
					Min	Typ	Max	
$V_O$	Output Voltage		$T_J = 25^{\circ}\text{C}$		7.7	8.0	8.3	V
$\Delta V_O$	Line Regulation		$T_J = 25^{\circ}\text{C}$		$10.5\text{V} \leq V_I \leq 25\text{V}$	6.0	160	mV
					$11.0\text{V} \leq V_I \leq 17\text{V}$	2.0	80	
$\Delta V_O$	Load Regulation		$T_J = 25^{\circ}\text{C}$		$5.0\text{ mA} \leq I_O \leq 1.5\text{A}$	12	160	mV
					$250\text{ mA} \leq I_O \leq 750\text{ mA}$	4.0	80	
$V_O$	Output Voltage		$11.5\text{V} \leq V_I \leq 23\text{V}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{A}$ , $P \leq 15\text{W}$		7.6		8.4	V
$I_Q$	Quiescent Current		$T_J = 25^{\circ}\text{C}$			4.3	8.0	mA
$\Delta I_Q$	Quiescent Current Change	With Line	$11.5\text{V} \leq V_I \leq 25\text{V}$				1.0	mA
		With Load	$5.0\text{ mA} \leq I_O \leq 1.0\text{A}$				0.5	
$V_N$	Noise		$T_A = 25^{\circ}\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$			52		$\mu\text{V}$
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120\text{ Hz}$ , $I_O = 350\text{ mA}$ , $T_J = 25^{\circ}\text{C}$		56	72		dB
$V_{DO}$	Dropout Voltage		$I_O = 1.0\text{A}$ , $T_J = 25^{\circ}\text{C}$			2.0		V
$R_O$	Output Resistance		$f = 1.0\text{ kHz}$			16		$\text{m}\Omega$
$I_{OS}$	Output Short Circuit Current		$T_J = 25^{\circ}\text{C}$ , $V_I = 35\text{V}$			0.45		A
$I_{PK}$	Peak Output Current		$T_J = 25^{\circ}\text{C}$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\text{ mA}$			0.8		$\text{mV}/^{\circ}\text{C}$

**Note 6:** All characteristics are measured with a 0.22  $\mu\text{F}$  capacitor from input to ground and a 0.1  $\mu\text{F}$  capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ( $t_w \leq 10\text{ ms}$ , duty cycle  $\leq 5\%$ ). Output voltage changes due to changes in internal temperature must be taken into account separately.

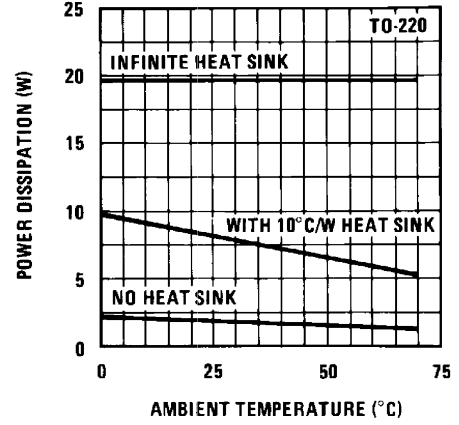
# Typical Performance Characteristics

Maximum Average Power Dissipation



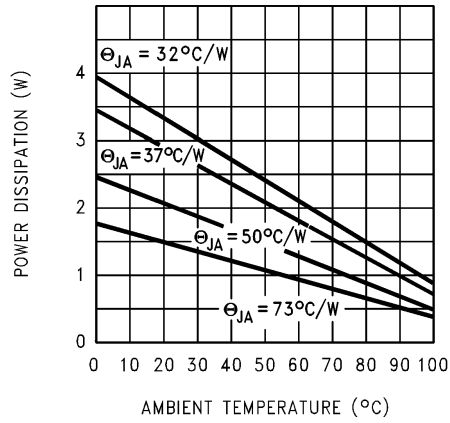
00778122

Maximum Average Power Dissipation



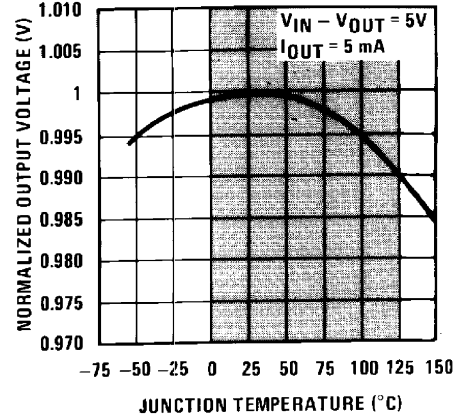
00778123

Maximum Power Dissipation (TO-263)  
(See Note 2)



00778124

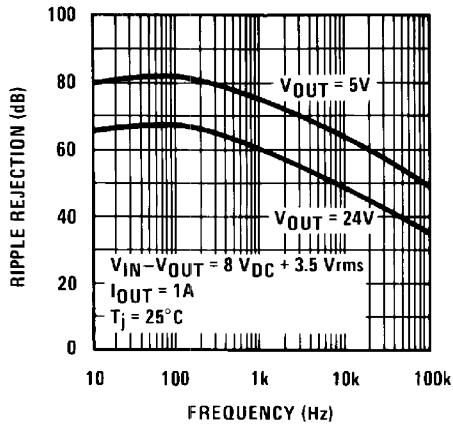
Output Voltage (Normalized to 1V at T<sub>J</sub> = 25°C)



00778125

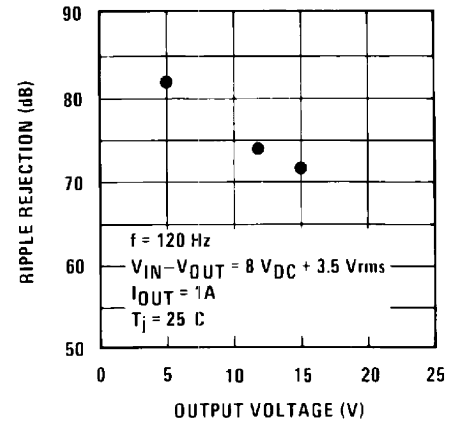
Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Ripple Rejection



00778126

Ripple Rejection

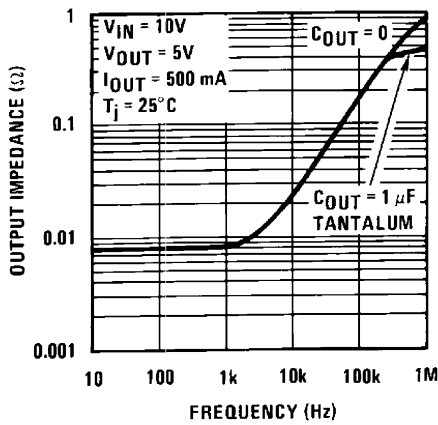


00778127



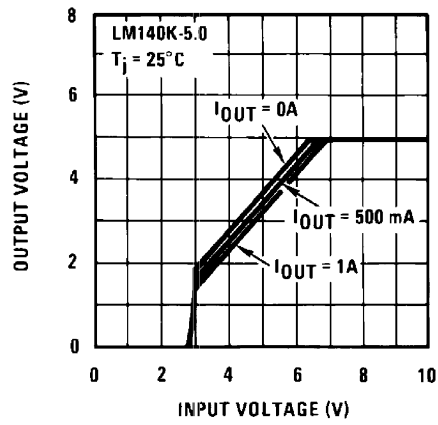
# Typical Performance Characteristics (Continued)

Output Impedance



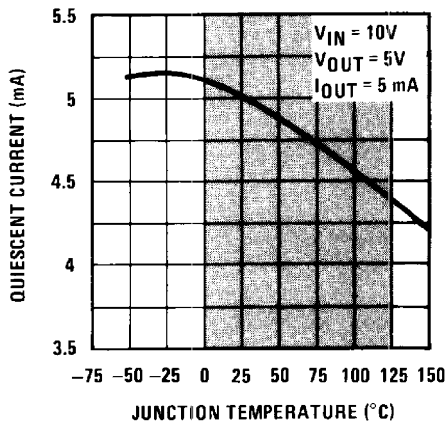
00778128

Dropout Characteristics



00778129

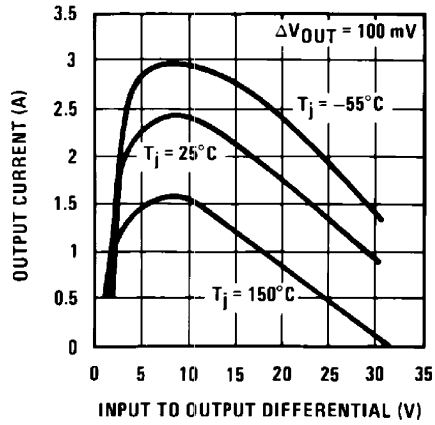
Quiescent Current



00778130

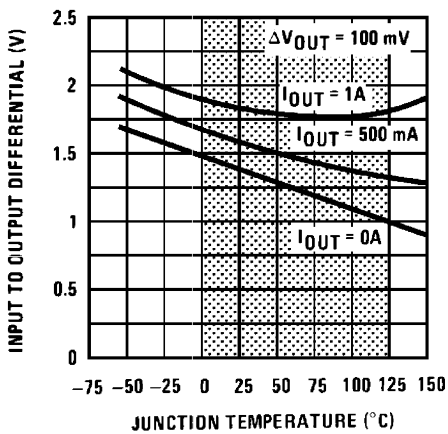
Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Peak Output Current



00778131

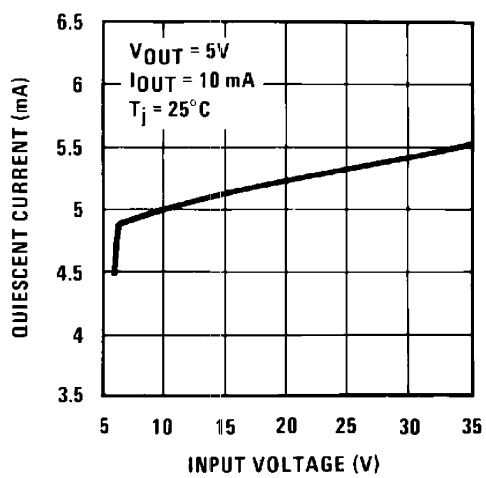
Dropout Voltage



00778132

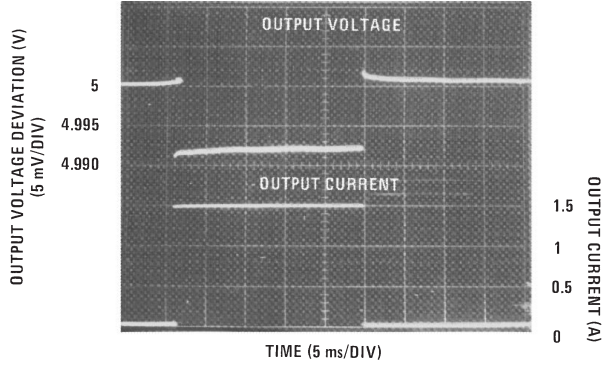
Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Quiescent Current



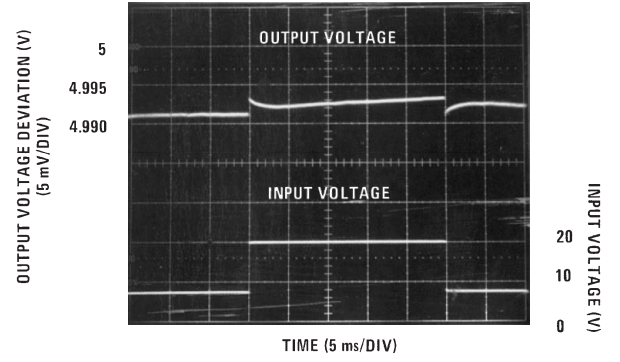
00778133

**Line Regulation**  
 140AK-5.0,  $I_{OUT} = 1A$ ,  $T_A = 25^\circ C$



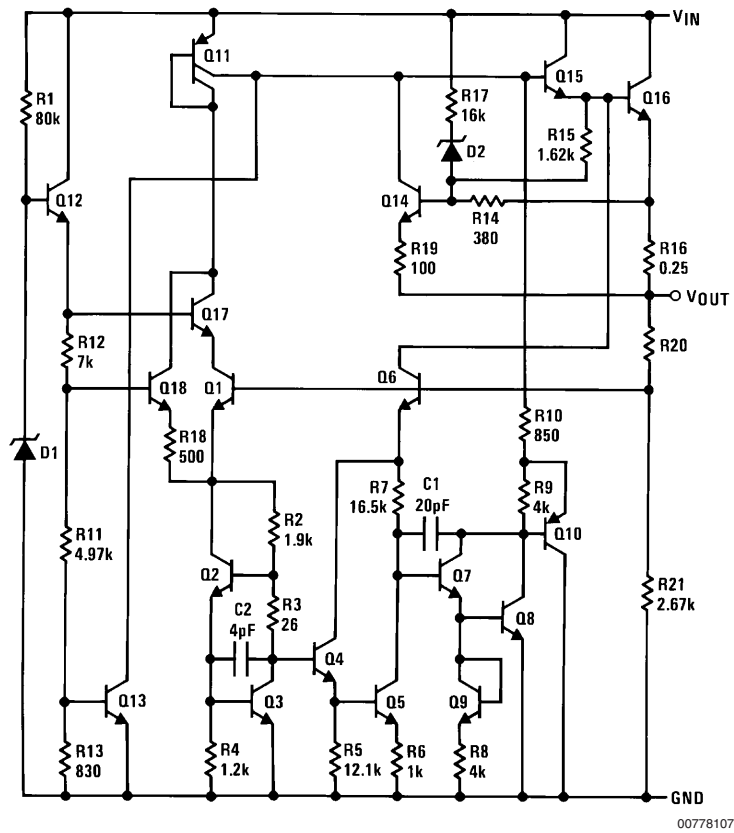
00778105

**Line Regulation**  
 140AK-5.0,  $V_{IN} = 10V$ ,  $T_A = 25^\circ C$



00778106

**Equivalent Schematic**



00778107

## Application Hints

The LM340/LM78XX series is designed with thermal protection, output short-circuit protection and output transistor safe area protection. However, as with *any* IC regulator, it becomes necessary to take precautions to assure that the regulator is not inadvertently damaged. The following describes possible misapplications and methods to prevent damage to the regulator.

### SHORTING THE REGULATOR INPUT

When using large capacitors at the output of these regulators, a protection diode connected input to output (*Figure 1*) may be required if the input is shorted to ground. Without the protection diode, an input short will cause the input to rapidly approach ground potential, while the output remains near the initial  $V_{OUT}$  because of the stored charge in the large output capacitor. The capacitor will then discharge through a large internal input to output diode and parasitic transistors. If the energy released by the capacitor is large enough, this diode, low current metal and the regulator will be destroyed. The fast diode in *Figure 1* will shunt most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance  $\leq 10 \mu\text{F}$ .

### RAISING THE OUTPUT VOLTAGE ABOVE THE INPUT VOLTAGE

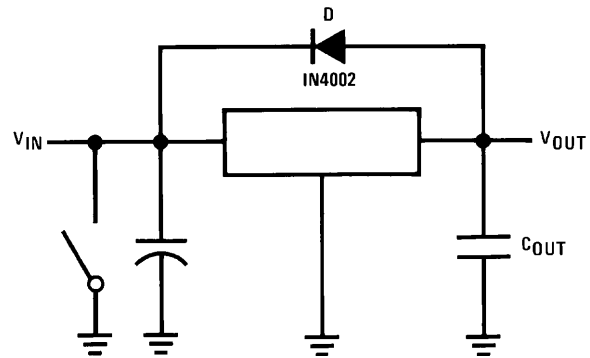
Since the output of the device does not sink current, forcing the output high can cause damage to internal low current paths in a manner similar to that just described in the "Shorting the Regulator Input" section.

### REGULATOR FLOATING GROUND (*Figure 2*)

When the ground pin alone becomes disconnected, the output approaches the unregulated input, causing possible damage to other circuits connected to  $V_{OUT}$ . If ground is reconnected with power "ON", damage may also occur to the regulator. This fault is most likely to occur when plugging in regulators or modules with on card regulators into powered up sockets. Power should be turned off first, thermal limit ceases operating, or ground should be connected first if power must be left on.

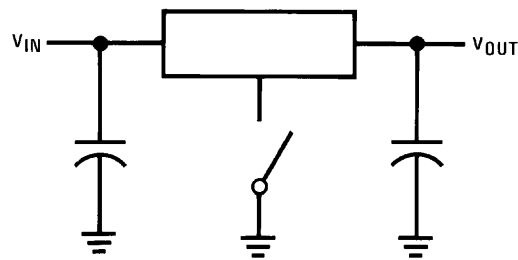
### TRANSIENT VOLTAGES

If transients exceed the maximum rated input voltage of the device, or reach more than 0.8V below ground and have sufficient energy, they will damage the regulator. The solution is to use a large input capacitor, a series input breakdown diode, a choke, a transient suppressor or a combination of these.



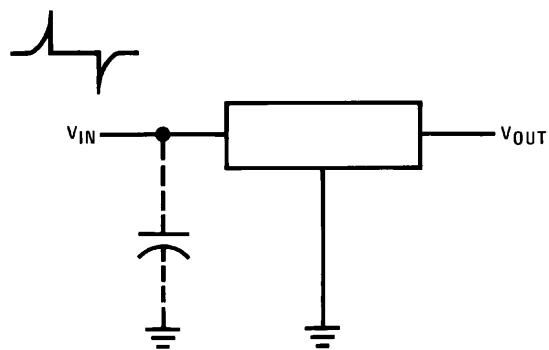
00778108

FIGURE 1. Input Short



00778109

FIGURE 2. Regulator Floating Ground



00778110

FIGURE 3. Transients

When a value for  $\theta_{(H-A)}$  is found using the equation shown, a heatsink must be selected that has a value that is less than or equal to this number.

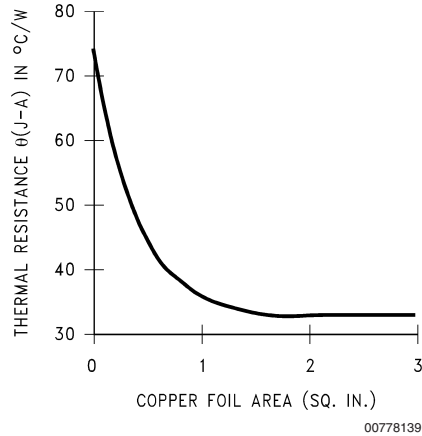
$\theta_{(H-A)}$  is specified numerically by the heatsink manufacturer in this catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

## Application Hints (Continued)

### HEATSINKING TO-263 AND SOT-223 PACKAGE PARTS

Both the TO-263 ("S") and SOT-223 ("MP") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the plane.

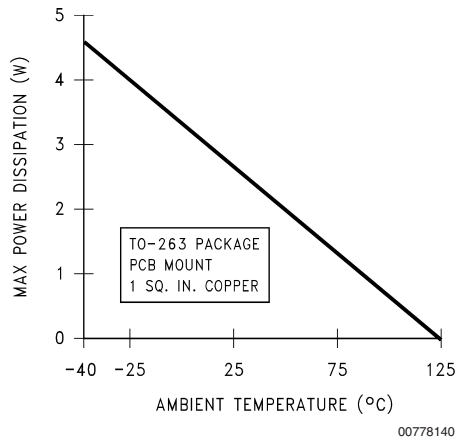
shows for the TO-263 the measured values of  $\theta_{(J-A)}$  for different copper area sizes using a typical PCB with 1 ounce copper and no solder mask over the copper area used for heatsinking.



**FIGURE 4.  $\theta_{(J-A)}$  vs Copper (1 ounce) Area for the TO-263 Package**

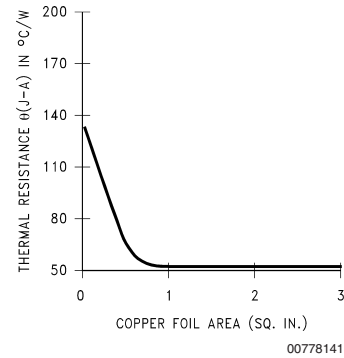
As shown in the figure, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of  $\theta_{(J-A)}$  for the TO-263 package mounted to a PCB is 32°C/W.

As a design aid, Figure 5 shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming  $\theta_{(J-A)}$  is 35°C/W and the maximum junction temperature is 125°C).

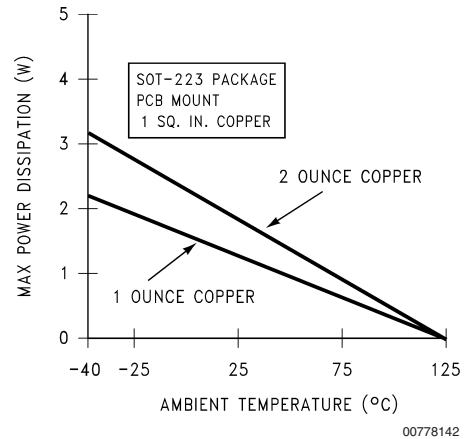


**FIGURE 5. Maximum Power Dissipation vs  $T_{AMB}$  for the TO-263 Package**

Figures 6, 7 show the information for the SOT-223 package. Figure 6 assumes a  $\theta_{(J-A)}$  of 74°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C.



**FIGURE 6.  $\theta_{(J-A)}$  vs Copper (2 ounce) Area for the SOT-223 Package**

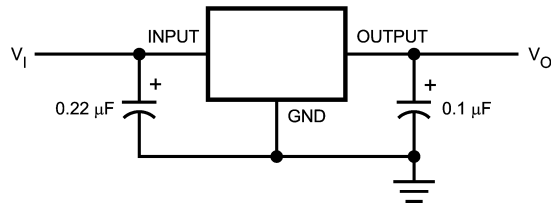


**FIGURE 7. Maximum Power Dissipation vs  $T_{AMB}$  for the SOT-223 Package**

Please see AN-1028 for power enhancement techniques to be used with the SOT-223 package.

## Typical Applications

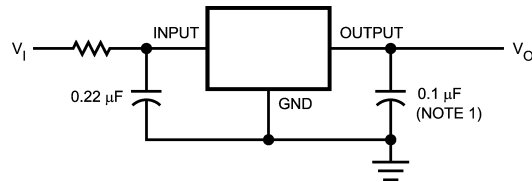
### Fixed Output Regulator



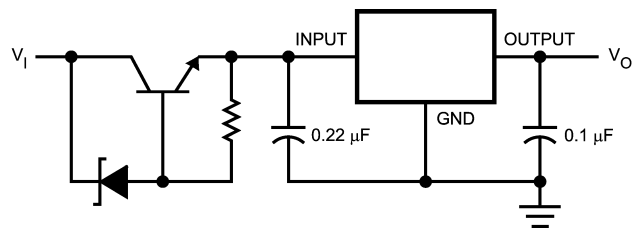
00778113

**Note:** Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

### High Input Voltage Circuits

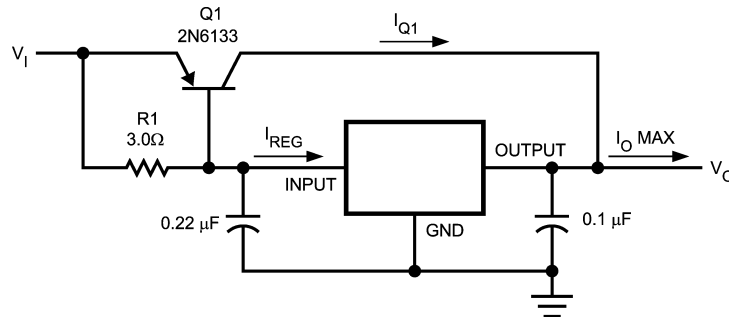


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00778115

### High Current Voltage Regulator



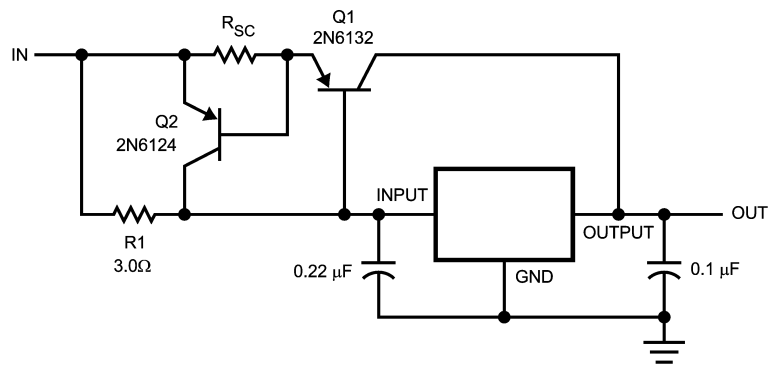
00778116

$$\beta(Q1) \geq \frac{I_{O \text{ Max}}}{I_{REG \text{ Max}}}$$

$$R1 = \frac{0.9}{I_{REG}} = \frac{\beta(Q1) V_{BE(Q1)}}{I_{REG \text{ Max}} (\beta + 1) - I_{O \text{ Max}}}$$

## Typical Applications (Continued)

### High Output Current, Short Circuit Protected

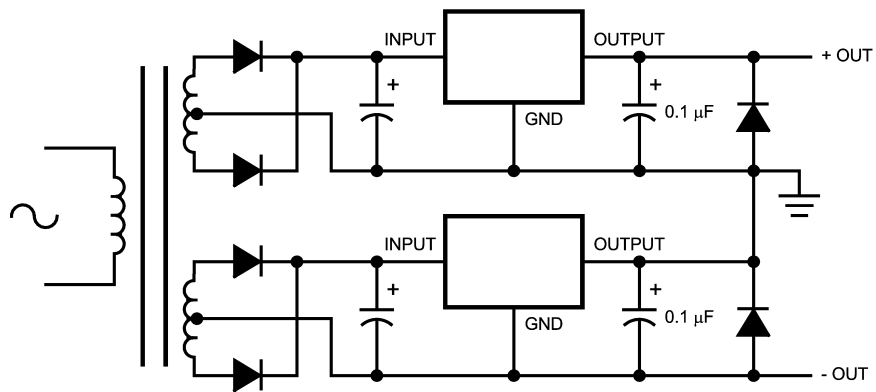


00778117

$$R_{SC} = \frac{0.8}{I_{SC}}$$

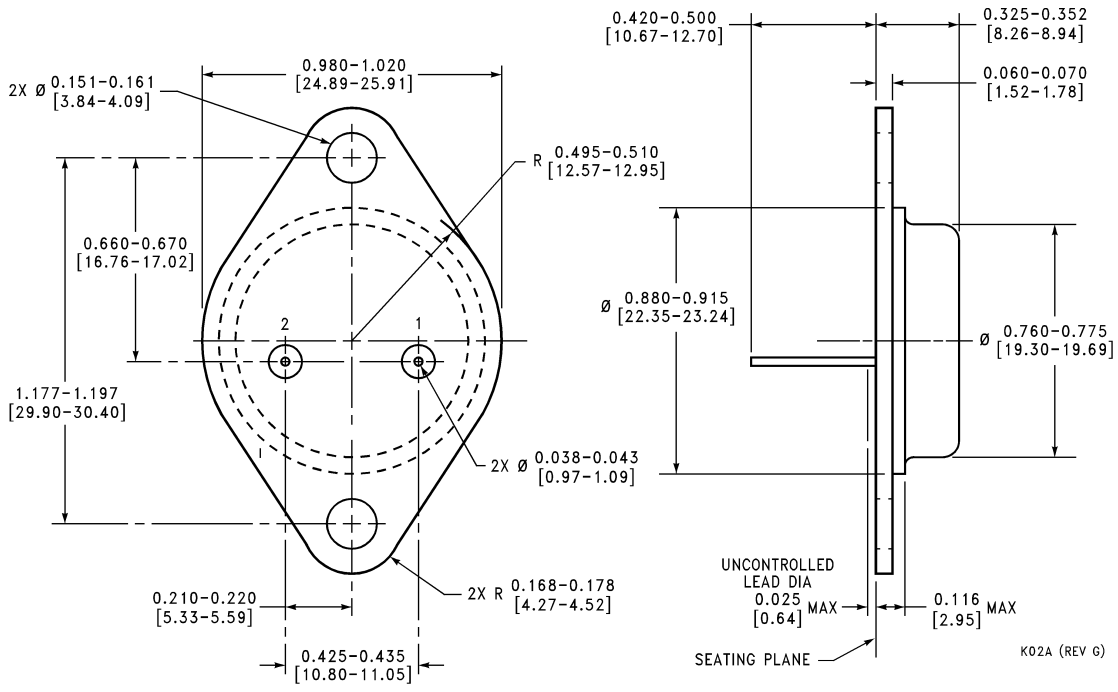
$$R1 = \frac{\beta V_{BE}(Q1)}{I_{REG\ Max} (\beta + 1) - I_{O\ Max}}$$

### Positive and Negative Regulator

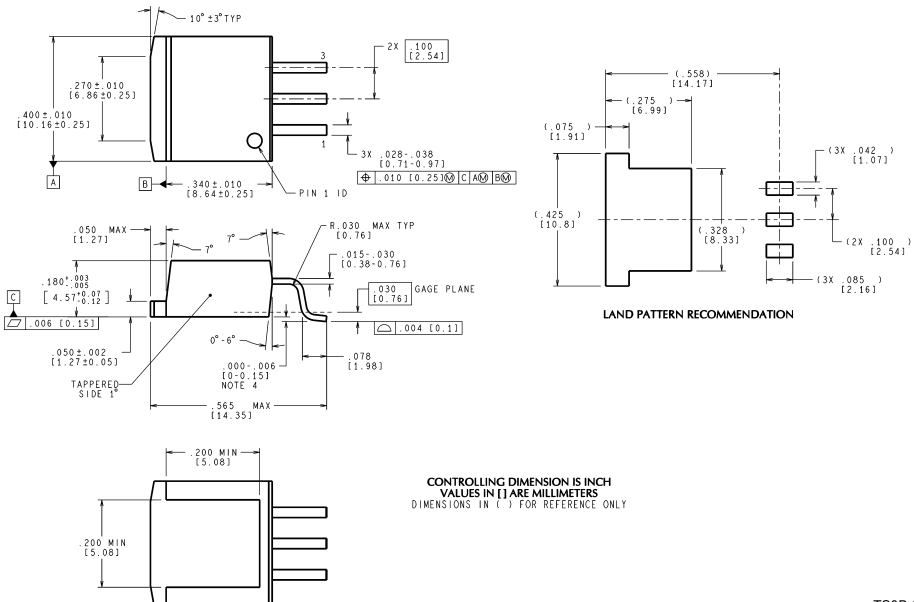


00778118

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



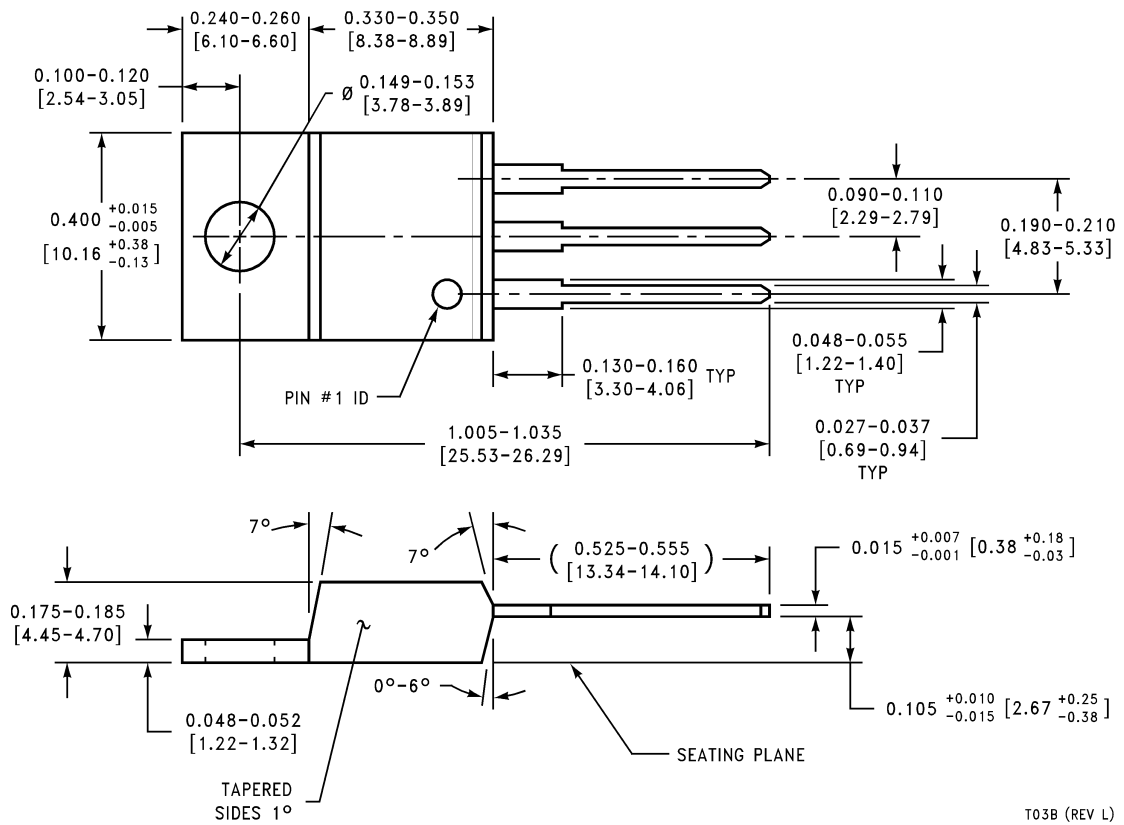
**TO-3 Metal Can Package (K)**  
**NS Package Number K02A**



**TO-263 Surface-Mount Package (S)**  
**NS Package Number TS3B**

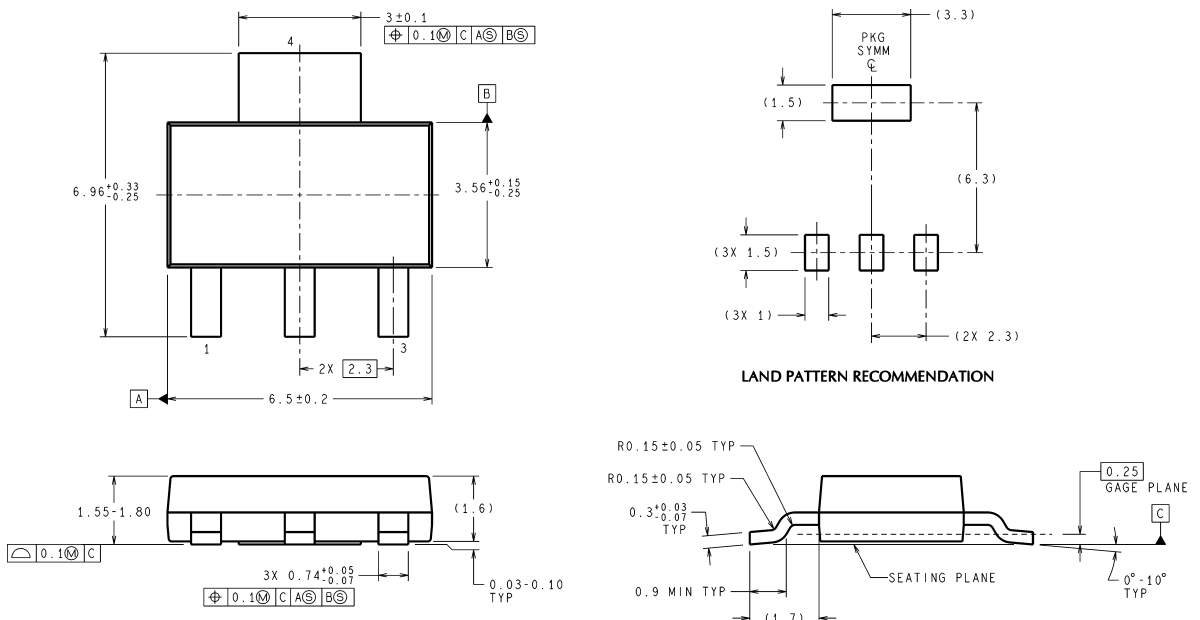
TS3B (Rev F)

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



**TO-220 Power Package (T)  
NS Package Number T03B**

T03B (REV L)



DIMENSIONS ARE IN MILLIMETERS

**3-Lead SOT-23 Package  
NS Package Number MP04A**

MP04A (Rev B)



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