LM340-N/LM78XX Series 3-Terminal Positive Regulators

Check for Samples: LM340-N, LM78xx

FEATURES

- **Complete Specifications at 1A Load**
- **Output Voltage Tolerances of ±2% at T_j = 25°C and ±4% Over the Temperature Range (LM340A)**
- **Line Regulation of 0.01% of V_{OUT}/V of ΔV_{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**

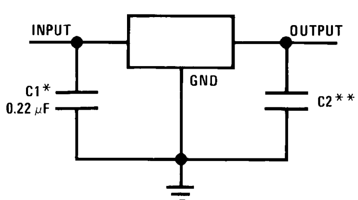
DESCRIPTION

The LM140/LM340A/LM340-N/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.

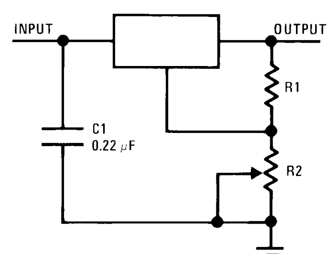
The 5V, 12V, and 15V regulator options are available in the steel TO-3 power package. The LM340A/LM340-N/LM78XXC series is available in the TO-220 plastic power package, and the LM340-N-5.0 is available in the SOT-223 package, as well as the LM340-5.0 and LM340-12 in the surface-mount TO-263 package.

Typical Applications



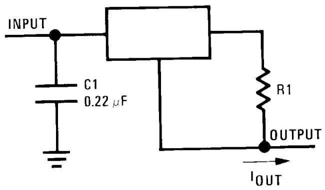
*Required if the regulator is located far from the power supply filter.
**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1 μF, ceramic disc).

Figure 1. Fixed Output Regulator



V_{OUT} = 5V + (5V/R1 + I_Q) R2 5V/R1 > 3 I_Q,
load regulation (L_r) ≈ [(R1 + R2)/R1] (L_r of LM340-5).

Figure 2. Adjustable Output Regulator



$I_{OUT} = \frac{V2\text{-}3}{R1} + I_Q$

ΔI_Q = 1.3 mA over line and load changes.

Figure 3. Current Regulator

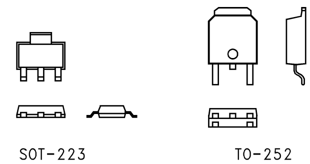


Figure 4. Comparison between SOT-223 and DDPak (TO-263) Packages Scale 1:1

Connection Diagrams

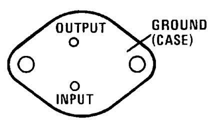


Figure 5. TO-3 Metal Can Package (K) Bottom View See Package Number NDS0002A

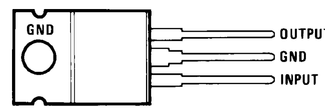


Figure 6. TO-220 Power Package (T) Top View See Package Number NDE0003B

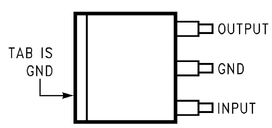


Figure 7. TO-263 Surface-Mount Package (S) Top View See Package Number KTT0003B

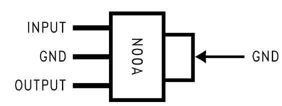


Figure 8. 3-Lead SOT-223 Top View See Package Number DCY

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[(1)(2)(3)]

DC Input Voltage		35V
Internal Power Dissipation[(4)]		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[(5)]		2 kV

(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.

(2) 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.

(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(4) The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation (T_{JMAX} = 125°C or 150°C), the junction-to-ambient thermal resistance (θ_{JA}), and the ambient temperature (T_A). $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above T_{JMAX} 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_{JA}) is 39°C/W. When using a heatsink, θ_{JA} is the sum of the 4°C/W junction-to-case thermal resistance (θ_{JC}) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink. For the TO-220 package (T), θ_{JA} is 54°C/W and θ_{JC} 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_{JA} is 50°C/W; with 1 square inch of copper area, $\theta_{JA}$is 37°C/W; and with 1.6 or more inches of copper area, θ_{JA} is 32°C/W.

(5) ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

Operating Conditions[(1)]

Temperature Range (T_A)[(2)]	LM140	−55°C to +125°C
	LM340A, LM340-N	0°C to +125°C
	LM7808C	0°C to +125°C

(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.

(2) The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation (T_{JMAX} = 125°C or 150°C), the junction-to-ambient thermal resistance (θ_{JA}), and the ambient temperature (T_A). $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above T_{JMAX} 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_{JA}) is 39°C/W. When using a heatsink, θ_{JA} is the sum of the 4°C/W junction-to-case thermal resistance (θ_{JC}) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink. For the TO-220 package (T), θ_{JA} is 54°C/W and θ_{JC} 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_{JA} is 50°C/W; with 1 square inch of copper area, $\theta_{JA}$is 37°C/W; and with 1.6 or more inches of copper area, θ_{JA} is 32°C/W.

LM340A Electrical Characteristics

I_{OUT} = 1A, 0°C ≤ T_J ≤ + 125°C (LM340A) unless otherwise specified(1)

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°C	4.9	5	5.1	11.75	12	12.25	14.7	15	15.3	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A	4.8		5.2	11.5		12.5	14.4		15.6	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)		V
ΔV_O	Line Regulation	I_O = 500 mA			10			18			22	mV
		ΔV_{IN}		(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)		V
		T_J = 25°C		3	10		4	18		4	22	mV
		ΔV_{IN}		(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)		V
		T_J = 25°C			4			9			10	mV
		Over Temperature			12			30			30	mV
		ΔV_{IN}		(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)		V
ΔV_O	Load Regulation	T_J = 25°C, 5 mA ≤ I_O ≤ 1.5A		10	25		12	32		12	35	mV
		T_J = 25°C, 250 mA ≤ I_O ≤ 750 mA			15			19			21	mV
		Over Temperature, 5 mA ≤ I_O ≤ 1A			25			60			75	mV
I_Q	Quiescent Current	T_J = 25°C			6			6			6	mA
		Over Temperature			6.5			6.5			6.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A		0.5			0.5			0.5		mA
		T_J = 25°C, I_O = 1A			0.8			0.8			0.8	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)		V
		I_O = 500 mA			0.8			0.8			0.8	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(8 ≤ V_{IN} ≤ 25)			(15 ≤ V_{IN} ≤ 30)			(17.9 ≤ V_{IN} ≤ 30)		V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	T_J = 25°C, f = 120 Hz, I_O = 1A	68	80		61	72		60	70		dB
		or f = 120 Hz, I_O = 500 mA,	68			61			60			dB
		Over Temperature,										
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)		V
R_O	Dropout Voltage	T_J = 25°C, I_O = 1A		2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz		8			18			19		mΩ
	Short-Circuit Current	T_J = 25°C		2.1			1.5			1.2		A
	Peak Output Current	T_J = 25°C		2.4			2.4			2.4		A
	Average TC of V_O	Min, T_J = 0°C, I_O = 5 mA		−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C	7.5			14.5			17.5			V

(1) 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_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM140 Electrical Characteristics[1]

−55°C ≤ T_J ≤ +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	
V_O	Output Voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 20)			(15.5 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)		V
ΔV_O	Line Regulation	I_O = 500 mA	T_J = 25°C		3	50		4	120		4	150	mV
			ΔV_{IN}		(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)		V
			−55°C ≤ T_J ≤ +150°C			50			120			150	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)		V
		I_O ≤ 1A	T_J = 25°C			50			120			150	mV
			ΔV_{IN}		(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)		V
			−55°C ≤ T_J ≤ +150°C			25			60			75	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)		V
ΔV_O	Load Regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
			250 mA ≤ I_P ≤ 750 mA			25			60			75	mV
		−55°C ≤ T_J ≤ +150°C, 5 mA ≤ I_O ≤ 1A				50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A	T_J = 25°C			6			6			6	mA
			−55°C ≤ T_J ≤ +150°C			7			7			7	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A			0.5			0.5			0.5		mA
		T_J = 25°C, I_O ≤ 1A				0.8			0.8			0.8	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)		V
		I_O = 500 mA, −55°C ≤ T_J ≤ +150°C				0.8			0.8			0.8	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 25)			(15 ≤ V_{IN} ≤ 30)			(18.5 ≤ V_{IN} ≤ 30)		V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	I_O ≤ 1A, T_J = 25°C or	68	80		61	72		60	70		dB
			I_O ≤ 500 mA, −55°C ≤ T_J ≤+150°C	68			61			60			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)		V
R_O	Dropout Voltage	T_J = 25°C, I_O = 1A			2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz			8			18			19		mΩ
	Short-Circuit Current	T_J = 25°C			2.1			1.5			1.2		A
	Peak Output Current	T_J = 25°C			2.4			2.4			2.4		A
	Average TC of V_{OUT}	0°C ≤ T_J ≤ +150°C, I_O = 5 mA			−0.6			−1.5			−1.8		mV/°C

(1) 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_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM140 Electrical Characteristics(1) (continued)

−55°C ≤ T_J ≤ +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	
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C, I_O ≤ 1A	7.5			14.6			17.7			V

LM340-N Electrical Characteristics(1)

0°C ≤ T_J ≤ +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_O	Output Voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)		V
ΔV_O	Line Regulation	I_O = 500 mA	T_J = 25°C		3	50		4	120		4	150	mV
			ΔV_{IN}		(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)		V
			0°C ≤ T_J ≤ +125°C			50			120			150	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)		V
		I_O ≤ 1A	T_J = 25°C			50			120			150	mV
			ΔV_{IN}		(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)		V
			0°C ≤ T_J ≤ +125°C			25			60			75	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)		V
ΔV_O	Load Regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
			250 mA ≤ I_O ≤ 750 mA			25			60			75	mV
		5 mA ≤ I_O ≤ 1A, 0°C ≤ T_J ≤ +125°C				50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A	T_J = 25°C			8			8			8	mA
			0°C ≤ T_J ≤ +125°C			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A			0.5			0.5			0.5		mA
		T_J = 25°C, I_O ≤ 1A				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)		V
		I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)		V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	I_O ≤ 1A, T_J = 25°C	62	80		55	72		54	70		dB
			or I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C	62			55			54			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)		V

(1) 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_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM340-N Electrical Characteristics(1) (continued)

$0°C \le T_J \le +125°C$ 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	
R_O	Dropout Voltage	$T_J = 25°C$, $I_O = 1A$		2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz		8			18			19		mΩ
	Short-Circuit Current	$T_J = 25°C$		2.1			1.5			1.2		A
	Peak Output Current	$T_J = 25°C$		2.4			2.4			2.4		A
	Average TC of V_{OUT}	$0°C \le T_J \le +125°C$, $I_O = 5$ mA		−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	$T_J = 25°C$, $I_O \le 1A$	7.5			14.6			17.7			V

LM7808C Electrical Characteristics

$0°C \le T_J \le +150°C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, unless otherwise specified

Symbol	Parameter		Conditions(1)		LM7808C Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		7.7	8.0	8.3	V
ΔV_O	Line Regulation		$T_J = 25°C$	$10.5V \le V_I \le 25V$		6.0	160	mV
				$11.0V \le V_I \le 17V$		2.0	80	
ΔV_O	Load Regulation		$T_J = 25°C$	$5.0\text{ mA} \le I_O \le 1.5A$		12	160	mV
				$250\text{ mA} \le I_O \le 750$ mA		4.0	80	
V_O	Output Voltage		$11.5V \le V_I \le 23V$, $5.0\text{ mA} \le I_O \le 1.0A$, $P \le 15W$		7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent	With Line	$11.5V \le V_I \le 25V$				1.0	mA
	Current Change	With Load	$5.0\text{ mA} \le I_O \le 1.0A$				0.5	
V_N	Noise		$T_A = 25°C$, $10\text{ Hz} \le f \le 100$ kHz			52		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 120 Hz, $I_O = 350$ mA, $T_J = 25°C$		56	72		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		f = 1.0 kHz			16		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.45		A
I_{PK}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			0.8		mV/°C

(1) 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 ($t_w \le 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

Typical Performance Characteristics

Maximum Average Power Dissipation

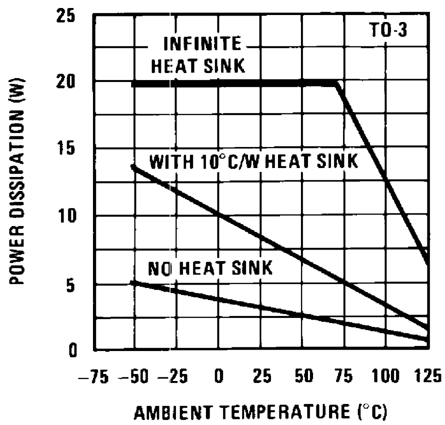


Figure 9.

Maximum Average Power Dissipation

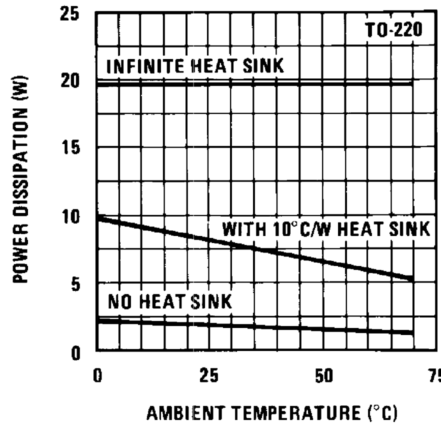


Figure 10.

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

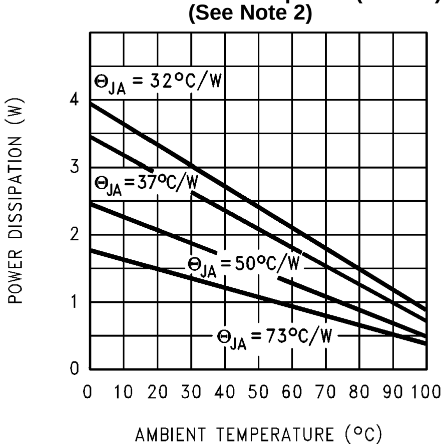
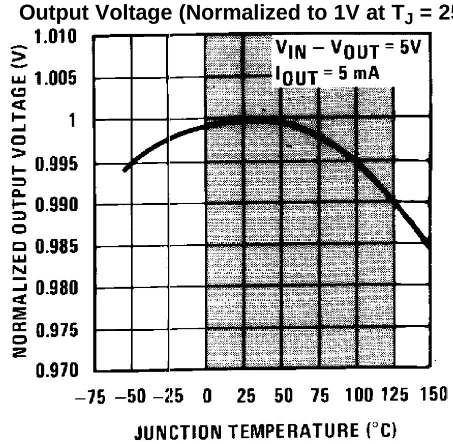


Figure 11.

Output Voltage (Normalized to 1V at T_J = 25°C)



Shaded area refers to LM340A/LM340-N, LM7805C, LM7812C and LM7815C.

Figure 12.

Ripple Rejection

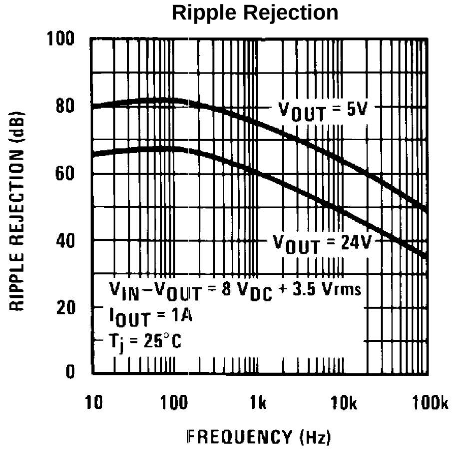


Figure 13.

Ripple Rejection

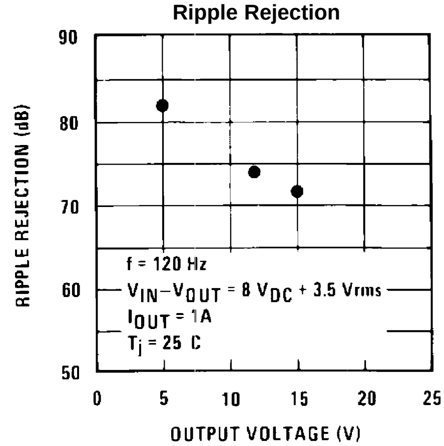


Figure 14.

Typical Performance Characteristics (continued)

Output Impedance

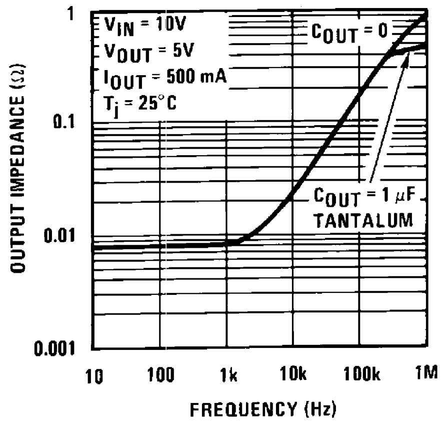


Figure 15.

Dropout Characteristics

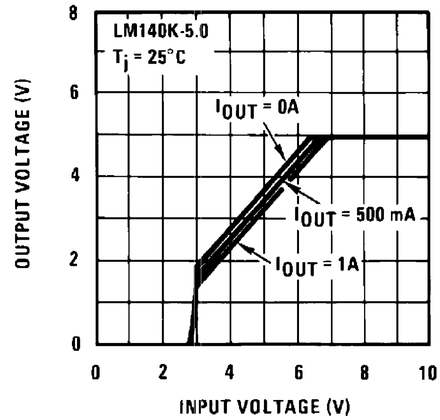
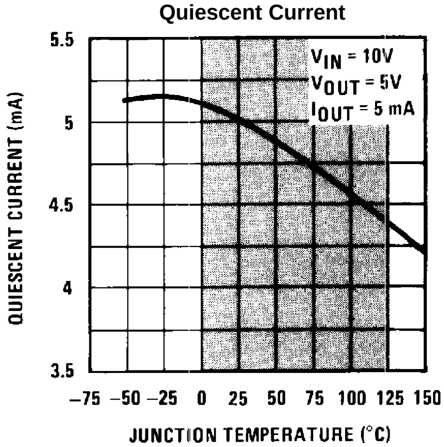


Figure 16.

Quiescent Current



Shaded area refers to LM340A/LM340-N, LM7805C, LM7812C and LM7815C.

Figure 17.

Peak Output Current

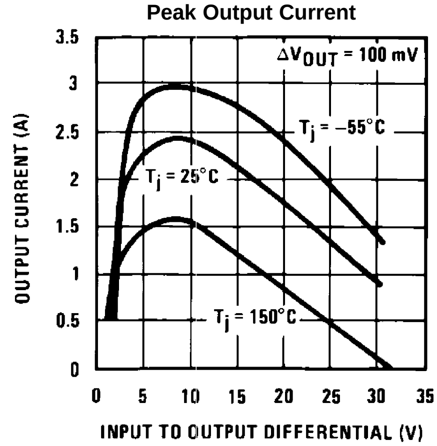
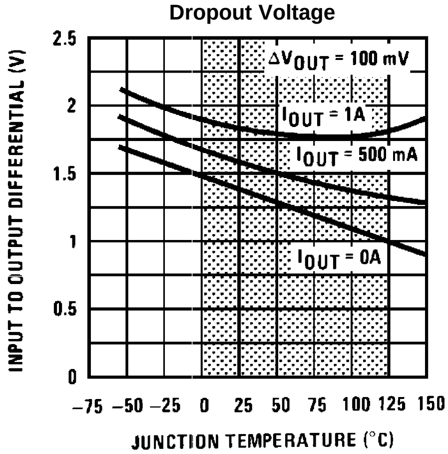


Figure 18.

Dropout Voltage



Shaded area refers to LM340A/LM340-N, LM7805C, LM7812C and LM7815C.

Figure 19.

Quiescent Current

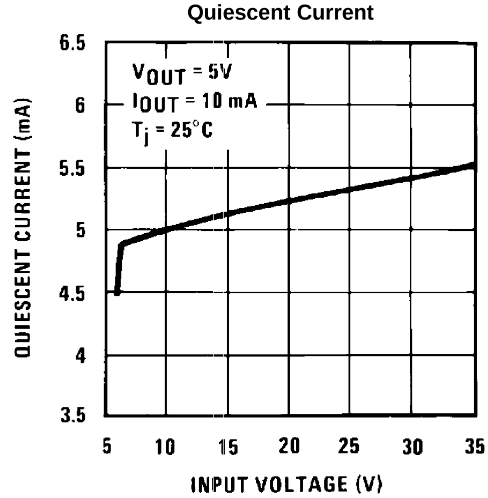


Figure 20.

Typical Performance Characteristics (continued)

Line Regulation
140AK-5.0, I_{OUT} = 1A, T_A = 25°C

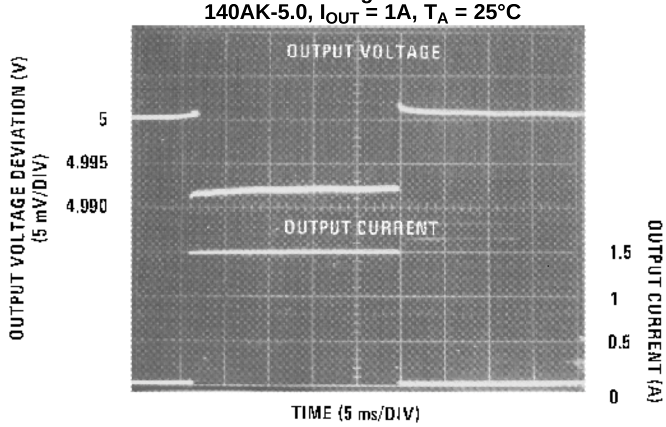


Figure 21.

Line Regulation
140AK-5.0, V_{IN} = 10V, T_A = 25°C

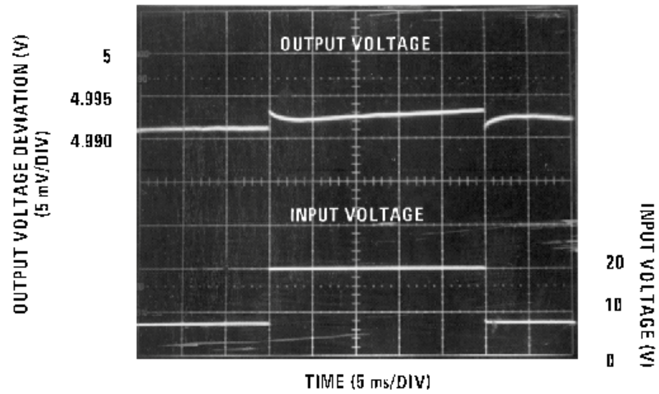
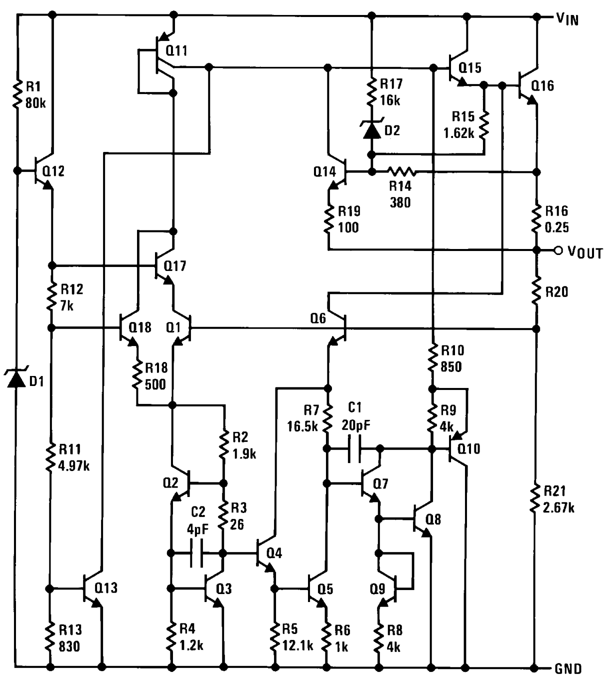


Figure 22.

Equivalent Schematic



APPLICATION HINTS

The LM340-N/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 23) 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 23 will shunt most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance ≤ 10 μF.

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 24)

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.

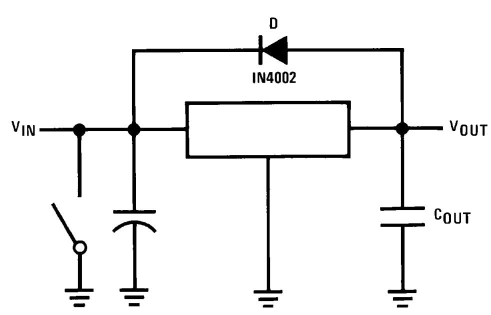


Figure 23. Input Short

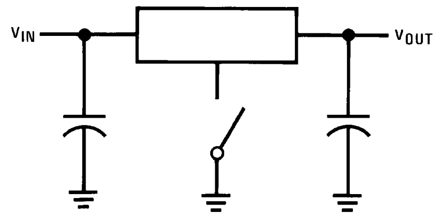


Figure 24. Regulator Floating Ground

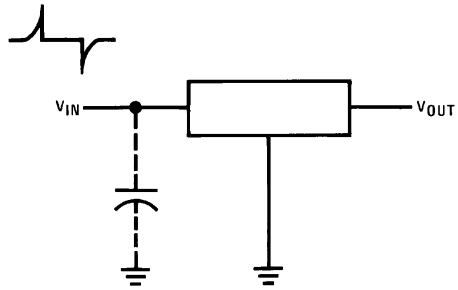


Figure 25. Transients

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.

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*.

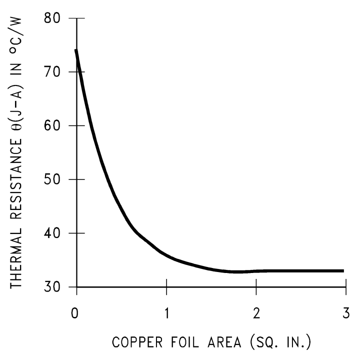


Figure 26. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package

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 27 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).

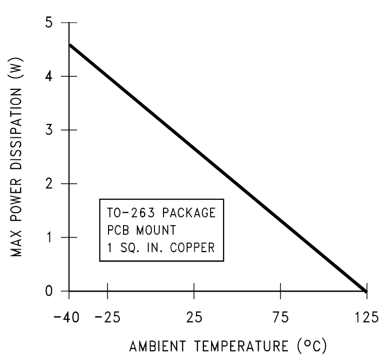


Figure 27. Maximum Power Dissipation vs T_{AMB} for the TO-263 Package

Figure 28 and Figure 29 show the information for the SOT-223 package. Figure 28 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.

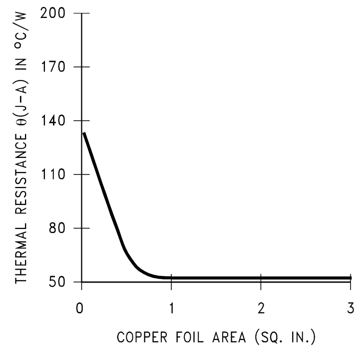


Figure 28. $\theta_{(J–A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

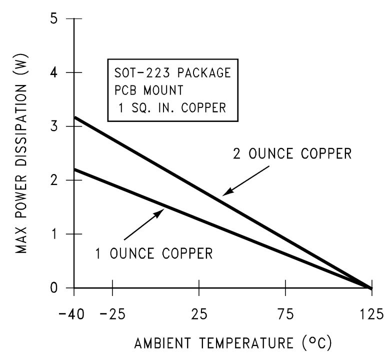
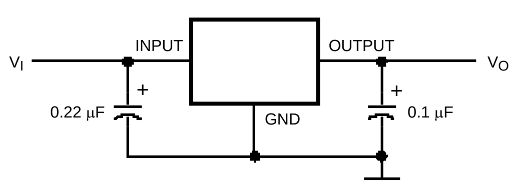


Figure 29. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

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

Typical Applications



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

Figure 30. Fixed Output Regulator

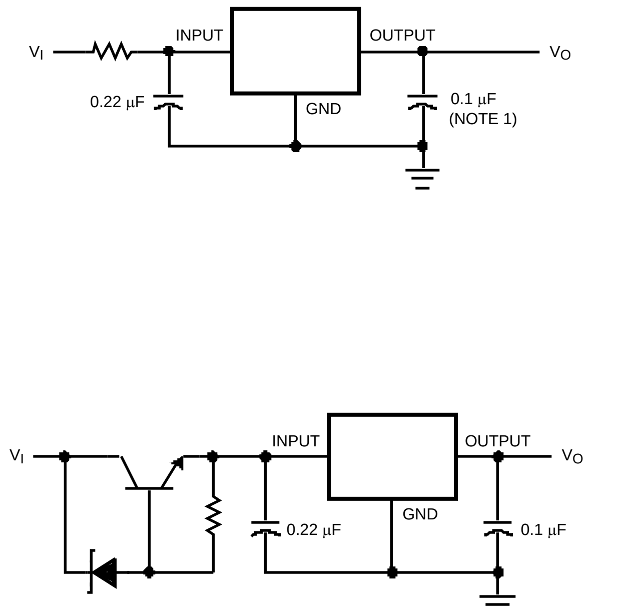
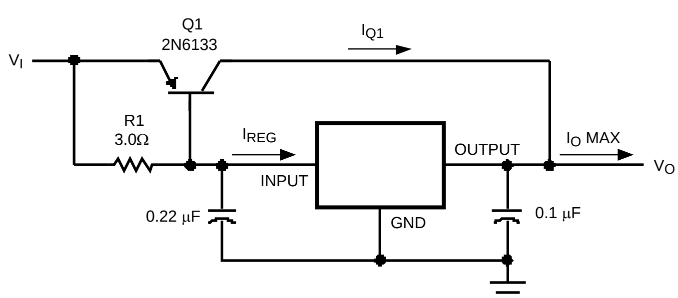


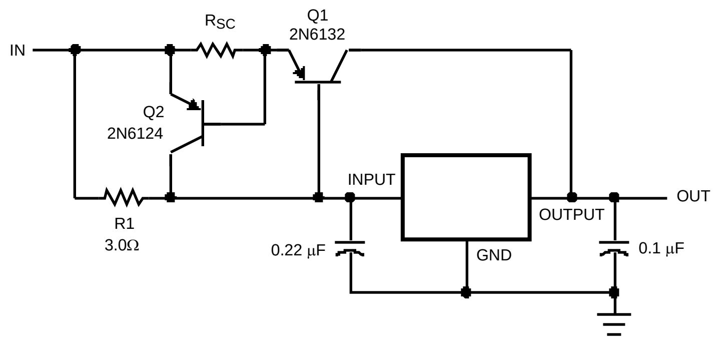
Figure 31. High Input Voltage Circuits



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

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

Figure 32. High Current Voltage Regulator



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

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

Figure 33. High Output Current, Short Circuit Protected

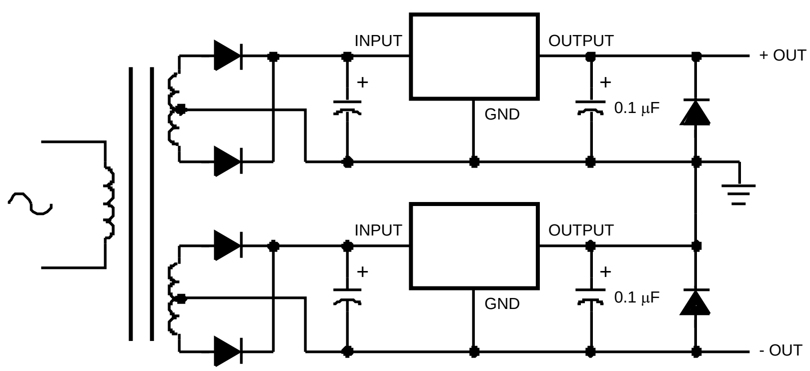


Figure 34. Positive and Negative Regulator

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM340AT-5.0	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	0 to 70	LM340AT 5.0 P+	Samples
LM340AT-5.0/NOPB	ACTIVE	TO-220	NDE	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-1-NA-UNLIM	0 to 70	LM340AT 5.0 P+	Samples
LM340K-5.0	ACTIVE	TO-3	NDS	2	50	TBD	POST-PLATE	Level-1-NA-UNLIM	0 to 70	LM340K -5.0 7805P+	Samples
LM340K-5.0/NOPB	ACTIVE	TO-3	NDS	2	50	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	0 to 70	LM340K -5.0 7805P+	Samples
LM340MP-5.0	ACTIVE	SOT-223	DCY	4	1000	TBD	CU SNPB	Level-1-260C-UNLIM	0 to 70	N00A	Samples
LM340MP-5.0/NOPB	ACTIVE	SOT-223	DCY	4	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	N00A	Samples
LM340MPX-5.0/NOPB	ACTIVE	SOT-223	DCY	4	2000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	N00A	Samples
LM340S-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	0 to 70	LM340S -12 P+	Samples
LM340S-5.0	ACTIVE	DDPAK/ TO-263	KTT	3	45	TBD	CU SNPB	Level-3-235C-168 HR	0 to 70	LM340S -5.0 P+	Samples
LM340S-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	0 to 70	LM340S -5.0 P+	Samples
LM340SX-12	ACTIVE	DDPAK/ TO-263	KTT	3	500	TBD	CU SNPB	Level-3-235C-168 HR	0 to 70	LM340S -12 P+	Samples
LM340SX-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	0 to 70	LM340S -12 P+	Samples
LM340SX-5.0	ACTIVE	DDPAK/ TO-263	KTT	3	500	TBD	CU SNPB	Level-3-235C-168 HR	0 to 70	LM340S -5.0 P+	Samples
LM340SX-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	0 to 70	LM340S -5.0 P+	Samples
LM340T-12	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	0 to 70	LM340T12 7812 P+	Samples
LM340T-12/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM340T12 7812 P+	Samples
LM340T-15	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	0 to 70	LM340T15 7815 P+	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM340T-15/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM340T15 7815 P+	Samples
LM340T-5.0	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	0 to 70	LM340T5 7805 P+	Samples
LM340T-5.0/LB01	ACTIVE	TO-220	NDG	3	45	TBD	CU SNPB	Level-3-235C-168 HR		LM340T5 7805 P+	Samples
LM340T-5.0/LF01	ACTIVE	TO-220	NDG	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-4-260C-72 HR		LM340T5 7805 P+	Samples
LM340T-5.0/NOPB	ACTIVE	TO-220	NDE	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-1-NA-UNLIM	0 to 70	LM340T5 7805 P+	Samples
LM7812CT	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	0 to 70	LM340T12 7812 P+	Samples
LM7812CT/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70		Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

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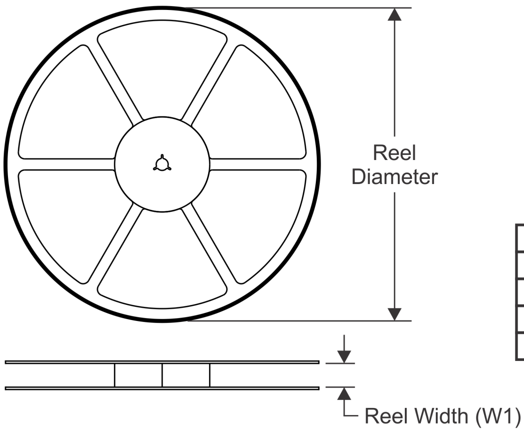
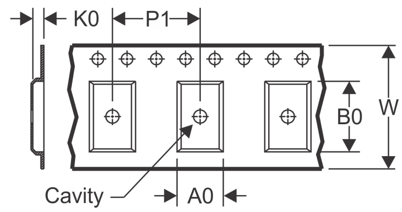
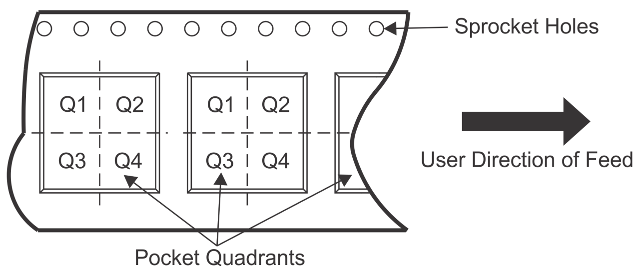
TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

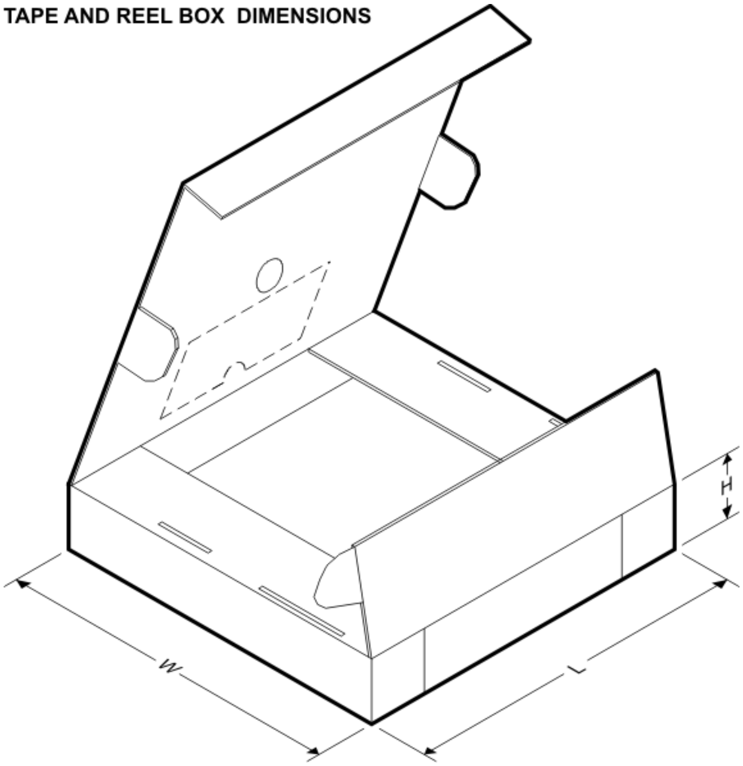
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM340MP-5.0	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340MP-5.0/NOPB	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340MPX-5.0/NOPB	SOT-223	DCY	4	2000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340SX-12	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM340SX-12/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM340SX-5.0	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM340SX-5.0/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2

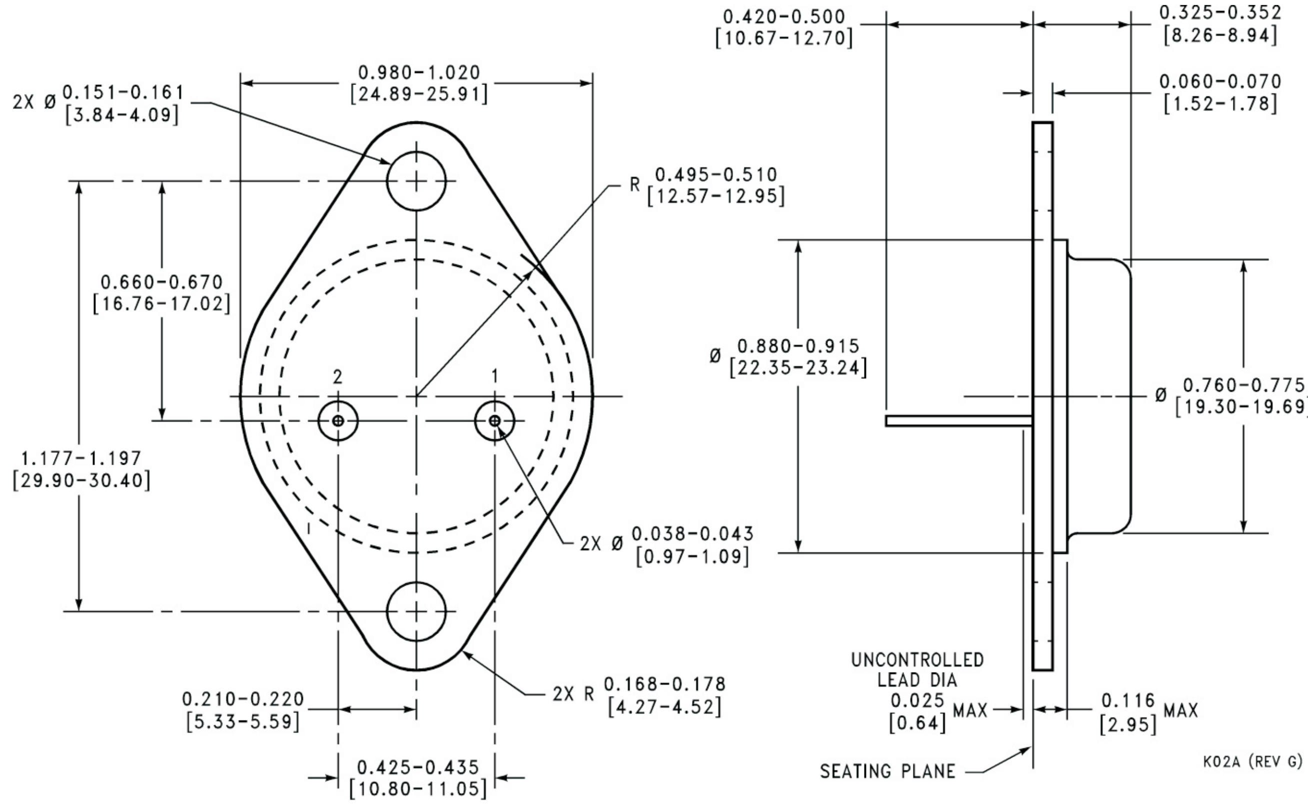
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

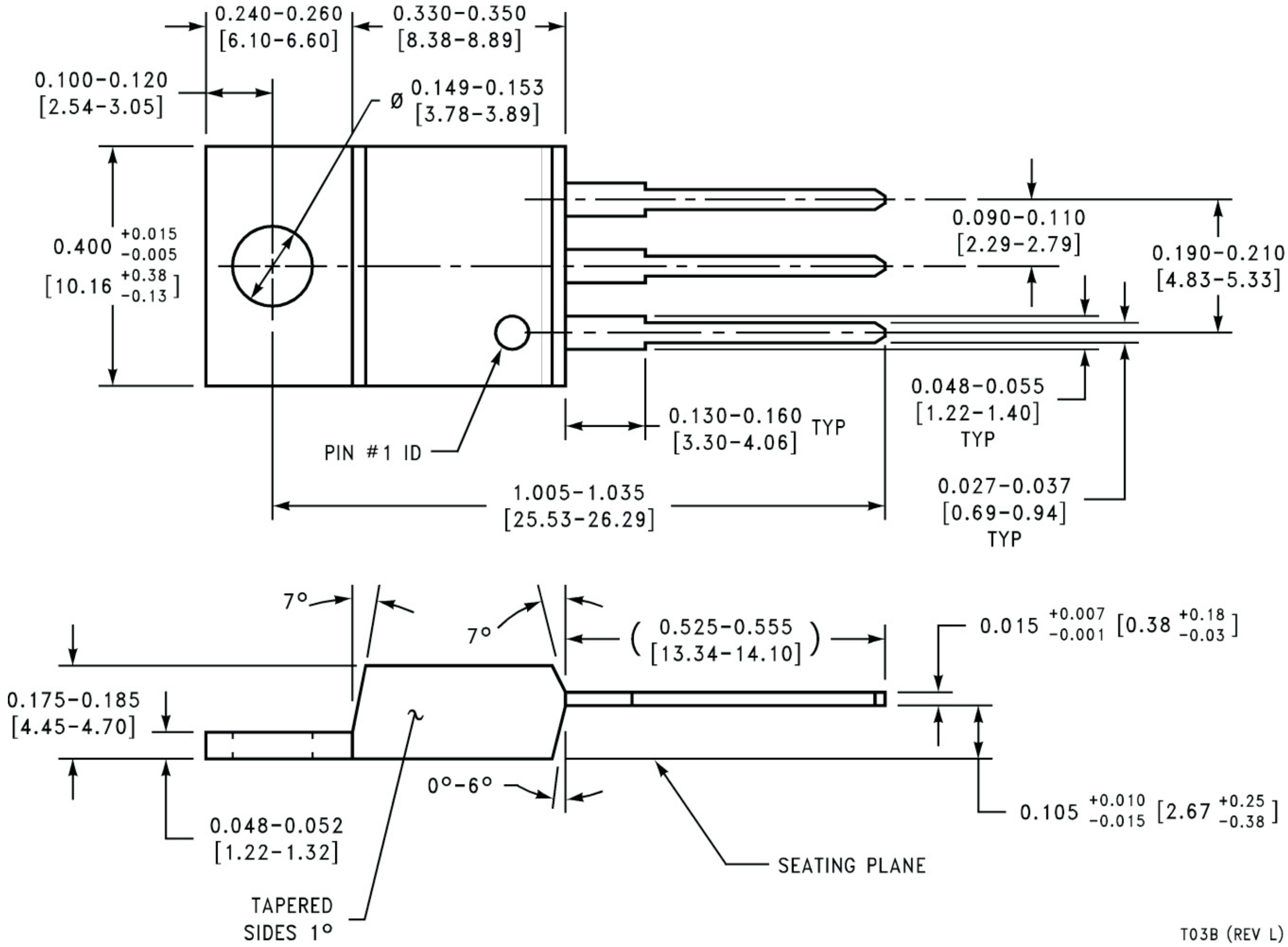
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM340MP-5.0	SOT-223	DCY	4	1000	349.0	337.0	45.0
LM340MP-5.0/NOPB	SOT-223	DCY	4	1000	349.0	337.0	45.0
LM340MPX-5.0/NOPB	SOT-223	DCY	4	2000	354.0	340.0	35.0
LM340SX-12	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0
LM340SX-12/NOPB	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0
LM340SX-5.0	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0
LM340SX-5.0/NOPB	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0

NDS0002A

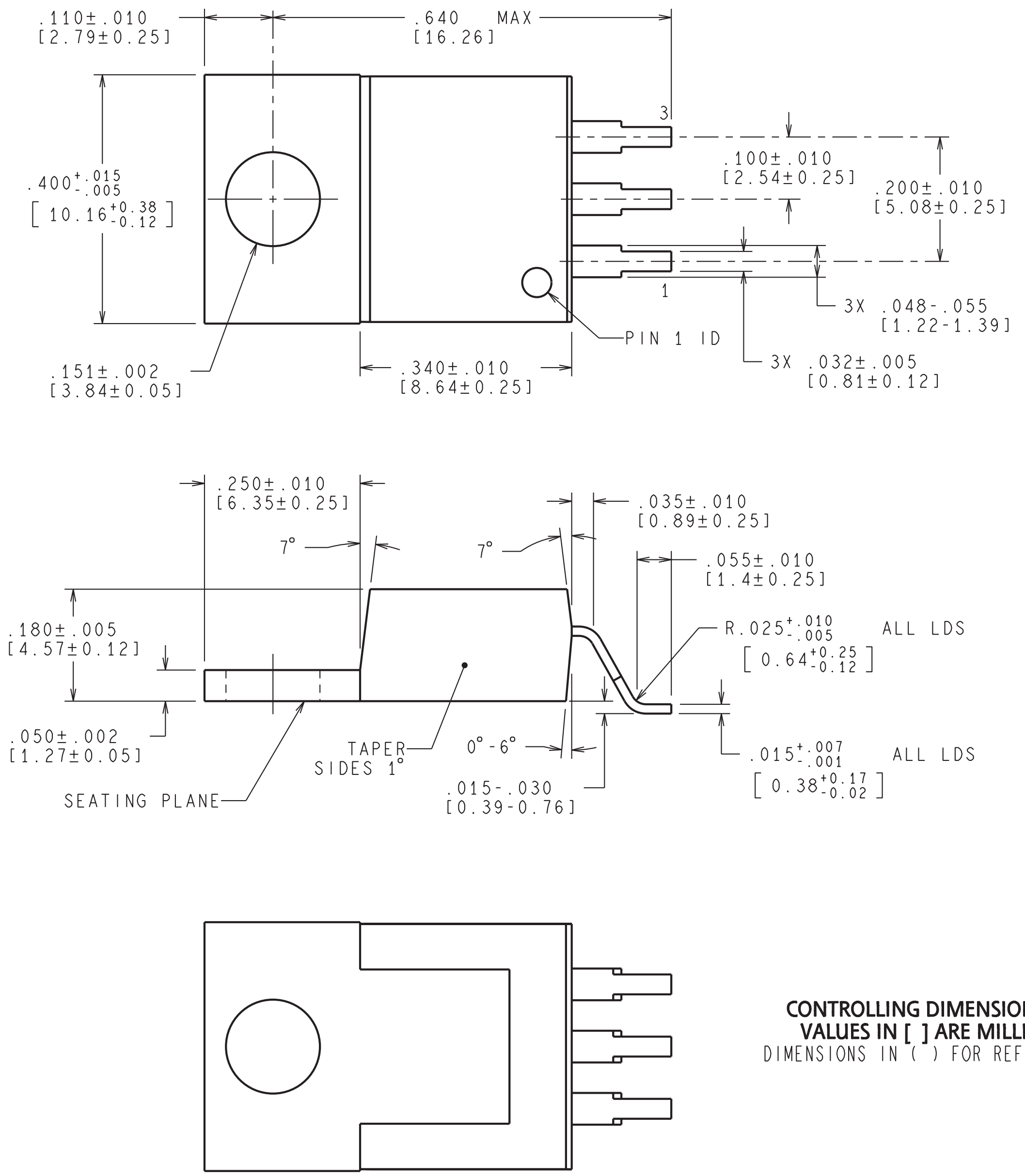


2X Ø 0.151–0.161 [3.84–4.09]
0.980–1.020 [24.89–25.91]
R 0.495–0.510 [12.57–12.95]
0.660–0.670 [16.76–17.02]
2
1
1.177–1.197 [29.90–30.40]
2X Ø 0.038–0.043 [0.97–1.09]
2X R 0.168–0.178 [4.27–4.52]
0.210–0.220 [5.33–5.59]
0.425–0.435 [10.80–11.05]
0.420–0.500 [10.67–12.70]
0.325–0.352 [8.26–8.94]
0.060–0.070 [1.52–1.78]
Ø 0.880–0.915 [22.35–23.24]
Ø 0.760–0.775 [19.30–19.69]
UNCONTROLLED LEAD DIA 0.025 [0.64] MAX
0.116 [2.95] MAX
SEATING PLANE
K02A (REV G)

NDE0003B


0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.090–0.110
[2.29–2.79]
0.190–0.210
[4.83–5.33]
0.048–0.055
[1.22–1.40]
TYP
0.130–0.160 TYP
[3.30–4.06]
PIN #1 ID
1.005–1.035
[25.53–26.29]
0.027–0.037
[0.69–0.94]
TYP
7°
7°
(0.525–0.555)
[13.34–14.10]
0.015 +0.007 −0.001 [0.38 +0.18 −0.03]
0.175–0.185
[4.45–4.70]
0°–6°
0.105 +0.010 −0.015 [2.67 +0.25 −0.38]
0.048–0.052
[1.22–1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

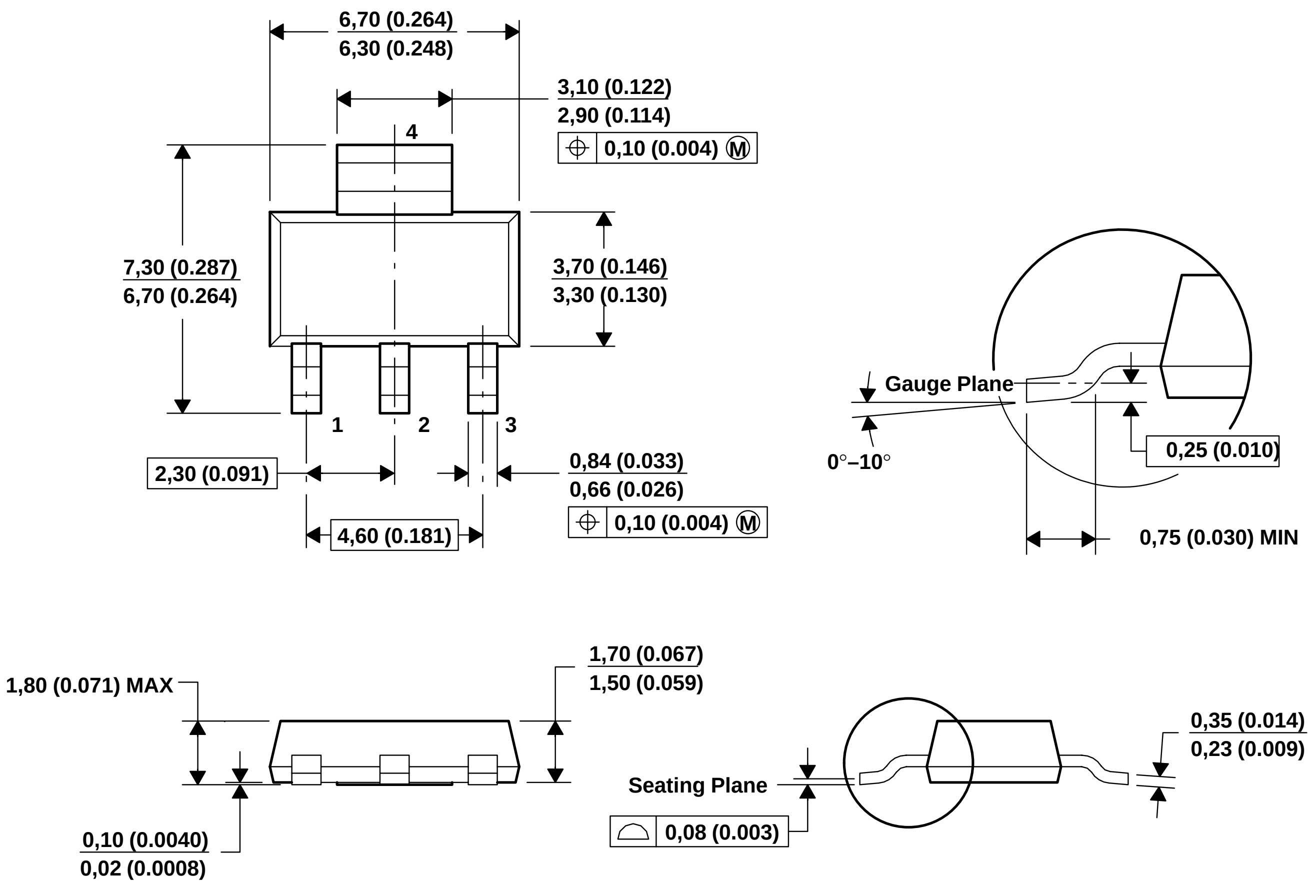
NDG0003F



CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

T03F (Rev B)

DCY (R-PDSO-G4) **PLASTIC SMALL-OUTLINE**



4202506/B 06/2002

NOTES:
- A. All linear dimensions are in millimeters (inches).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion.
- D. Falls within JEDEC TO-261 Variation AA.

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