National Semiconductor

LM140A/LM140/LM340A/LM340 Series 3-Terminal Positive Regulators

General Description

The LM140A/LM140/LM340A/LM340 series of positive 3-terminal voltage regulators are designed to provide superior performance as compared to the previously available 78XX series regulator. Computer programs were used to optimize the electrical and thermal performance of the packaged IC which results in outstanding ripple rejection, superior line and load regulation in high power applications (over 15W).

With these advances in design, the LM340 is now guaranteed to have line and load regulation that is a factor of 2 better than previously available devices. Also, all parameters are guaranteed at 1A vs 0.5A output current. The LM140A/LM340A provide tighter output voltage tolerance, ±2% along with 0.01%/V line regulation and 0.3%/A load regulation.

Current limiting is included to limit peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over limiting die temperature.

Considerable effort was expended to make the LM140-XX 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.

Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

The entire LM140A/LM140/LM340A/LM340 series of regulators is available in the metal TO-3 power package and the LM340A/LM340 series is also available in the TO-220 plastic power package.

For output voltages other than 5V, 12V, and 15V, the LM117 series provides an output voltage range from +1.2V to +57V.

Features

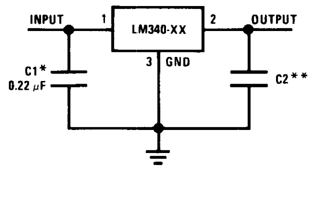
- Complete specifications at 1A load
- Output voltage tolerances of ±2% at T_j = 25°C and ±4% over the temperature range (LM140A/LM340A)
- Fixed output voltages available 5, 12, and 15V
- Line regulation of 0.01% of $V_{OUT}/V\ \Delta V_{IN}$ at 1A load (LM140A/LM340A)
- Load regulation of 0.3% of $V_{OUT}/A\ \Delta I_{LOAD}$ (LM140A/LM340A)
- Internal thermal overload protection
- Internal short-circuit current limit
- Output transistor safe area protection
- 100% thermal limit burn-in
- Special circuitry allows start-up even if output is pulled to negative voltage (± supplies)

LM140 Series Package and Power Capability

DEVICE	PACKAGE	RATED POWER DISSIPATION	DESIGN LOAD CURRENT
LM140 LM340	TO-3	20W	1.5A
LM340T	TO-220	15W	1.5A
LM341	TO-202	7.5W	0.5A
LM342	TO-202	7.5W	0.25A
LM140L LM340L	TO-39	2W	0.1A
LM340L	TO-92+	1.2W	0.1A

Typical Applications

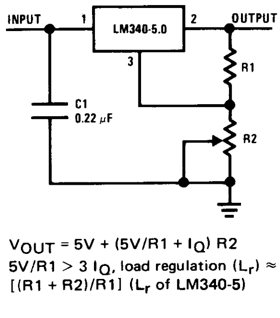
Fixed Output Regulator



*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)

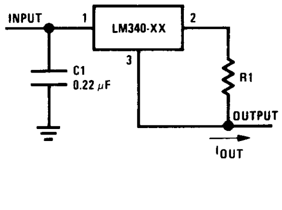
Adjustable Output Regulator



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

$5V/R1 > 3\ I_Q$, load regulation $(L_r) \approx [(R1 + R2)/R1]$ (L_r of LM340-5)

Current Regulator



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

ΔI_Q = 1.3 mA over line and load changes

Absolute Maximum Ratings

Input Voltage (V_O = 5V, 12V, 15V)	35V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range (T_A)	
LM140A/LM140	−55°C to +125°C
LM340A/LM340	0°C to +70°C
Maximum Junction Temperature	
(TO-3 Package K, KC)	150°C
(TO-220 Package T)	125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 Seconds)	
TO-3 Package K, KC	300°C
TO-220 Package T	230°C

Electrical Characteristics LM140A/LM340A (Note 2)

I_{OUT} = 1A, −55°C ≤ Tj ≤ +150°C (LM140A), or 0°C ≤ Tj ≤ +125°C (LM340A) unless otherwise specified.

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	Tj = 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
		Tj = 25°C		3	10		4	18		4	22	mV
		ΔV_{IN}	(7.3 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)			V
		Tj = 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	Tj = 25°C, 5 mA ≤ I_O ≤ 1.5A		10	25		12	32		12	35	mV
		Tj = 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	Tj = 25°C			6			6			6	mA
		Over Temperature			6.5			6.5			6.5	mA
ΔI_Q	Quiescent Current Change	5mA ≤ I_O ≤ 1A			0.5			0.5			0.5	mA
		Tj = 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	Tj = 25°C, f = 120 Hz, I_O = 1A or	68	80		61	72		60	70		dB
		f = 120 Hz, I_O = 500 mA, Over Temperature,	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
	Dropout Voltage	Tj = 25°C, I_O = 1A		2.0			2.0			2.0		V
R_O	Output Resistance	f = 1 kHz		8			18			19		mΩ
	Short-Circuit Current	Tj = 25°C		2.1			1.5			1.2		A
	Peak Output Current	Tj = 25°C		2.4			2.4			2.4		A
	Average TC of V_O	Min, Tj = 0°C, I_O = 5mA		−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	Tj = 25°C	7.3			14.5			17.5			v

Note 1: Thermal resistance of the TO-3 package (K, KC) is typically 4°C/W junction to case and 35°C/W case to ambient. Thermal resistance of the TO-220 package (T) is typically 4°C/W junction to case and 50°C/W case to ambient.

Note 2: All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. 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.

Electrical Characteristics LM140 (Note 2) −55°C ≤ T_j ≤ +150°C unless otherwise noted.

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}	(7.3 ≤ 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° ≤ 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
	Dropout Voltage	T_j = 25°C, I_{OUT} = 1A			2.0			2.0			2.0		V
R_O	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
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_j = 25°C, I_O ≤ 1A		7.3			14.6			17.7			V

Note 2: All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. 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.

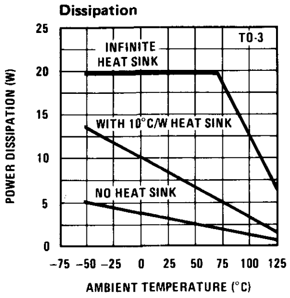
Electrical Characteristics LM340 (Note 2) 0°C ≤ Tj ≤ +125°C unless otherwise noted.

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	$T_j = 25°C$, $5\text{ mA} \le I_O \le 1\text{A}$		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		$P_D \le 15\text{W}$, $5\text{ mA} \le I_O \le 1\text{A}$		4.75		5.25	11.4		12.6	14.25		15.75	V
		$V_{MIN} \le V_{IN} \le V_{MAX}$			$(7 \le V_{IN} \le 20)$			$(14.5 \le V_{IN} \le 27)$			$(17.5 \le V_{IN} \le 30)$		V
ΔV_O	Line Regulation	$I_O = 500\text{ mA}$	$T_j = 25°C$		3	50		4	120		4	150	mV
			ΔV_{IN}		$(7 \le V_{IN} \le 25)$			$(14.5 \le V_{IN} \le 30)$			$(17.5 \le V_{IN} \le 30)$		V
			$0°C \le T_j \le +125°C$			50			120			150	mV
			ΔV_{IN}		$(8 \le V_{IN} \le 20)$			$(15 \le V_{IN} \le 27)$			$(18.5 \le V_{IN} \le 30)$		V
		$I_O \le 1\text{A}$	$T_j = 25°C$			50			120			150	mV
			ΔV_{IN}		$(7.3 \le V_{IN} \le 20)$			$(14.6 \le V_{IN} \le 27)$			$(17.7 \le V_{IN} \le 30)$		V
			$0°C \le T_j \le +125°C$			25			60			75	mV
			ΔV_{IN}		$(8 \le V_{IN} \le 12)$			$(16 \le V_{IN} \le 22)$			$(20 \le V_{IN} \le 26)$		V
ΔV_O	Load Regulation	$T_j = 25°C$	$5\text{ mA} \le I_O \le 1.5\text{ A}$		10	50		12	120		12	150	mV
			$250\text{ mA} \le I_O \le 750\text{ mA}$			25			60			75	mV
		$5\text{ mA} \le I_O \le 1\text{A}$, $0°C \le T_j \le +125°C$				50			120			150	mV
I_Q	Quiescent Current	$I_O \le 1\text{A}$	$T_j = 25°C$			8			8			8	mA
			$0°C \le T_j \le +125°C$			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	$5\text{ mA} \le I_O \le 1\text{A}$				0.5			0.5			0.5	mA
		$T_j = 25°C$, $I_O \le 1\text{A}$				1.0			1.0			1.0	mA
		$V_{MIN} \le V_{IN} \le V_{MAX}$			$(7.5 \le V_{IN} \le 20)$			$(14.8 \le V_{IN} \le 27)$			$(17.9 \le V_{IN} \le 30)$		V
		$I_O \le 500\text{ mA}$, $0°C \le T_j \le +125°C$				1.0			1.0			1.0	mA
		$V_{MIN} \le V_{IN} \le V_{MAX}$			$(7 \le V_{IN} \le 25)$			$(14.5 \le V_{IN} \le 30)$			$(17.5 \le V_{IN} \le 30)$		V
V_N	Output Noise Voltage	$T_A = 25°C$, $10\text{ Hz} \le f \le 100\text{ kHz}$			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	$f = 120\text{ Hz}$	$I_O \le 1\text{A}$, $T_j = 25°C$ or	62	80		55	72		54	70		dB
			$I_O \le 500\text{ mA}$, $0°C \le T_j \le +125°C$	62			55			54			dB
		$V_{MIN} \le V_{IN} \le V_{MAX}$			$(8 \le V_{IN} \le 18)$			$(15 \le V_{IN} \le 25)$			$(18.5 \le V_{IN} \le 28.5)$		V
R_O	Dropout Voltage	$T_j = 25°C$, $I_{OUT} = 1\text{A}$			2.0			2.0			2.0		V
	Output Resistance	$f = 1\text{ kHz}$			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}	$0°C \le T_j \le +125°C$, $I_O = 5\text{ mA}$			−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	$T_j = 25°C$, $I_O \le 1\text{A}$		7.3			14.6			17.7			V

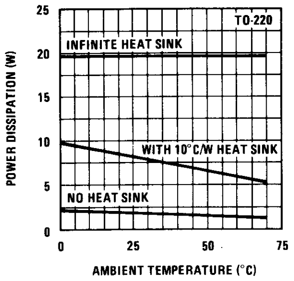
Note 2: All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \le 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

Typical Performance Characteristics

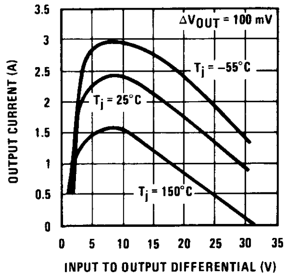
Maximum Average Power Dissipation



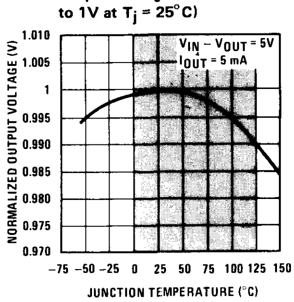
Maximum Average Power Dissipation



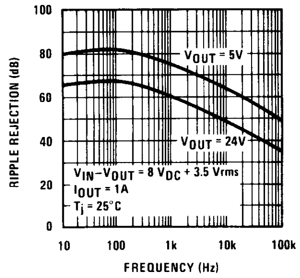
Peak Output Current



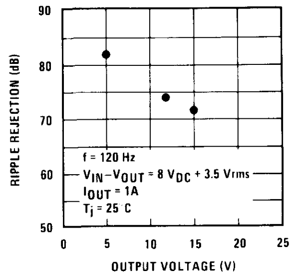
Output Voltage (Normalized to 1V at T_j = 25°C)



Ripple Rejection

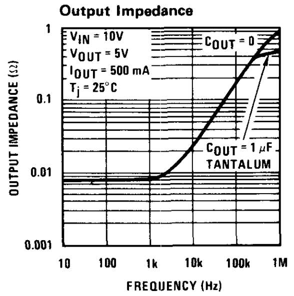


Ripple Rejection

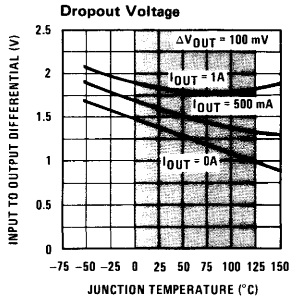


Note. Shaded area refers to LM340A/LM340

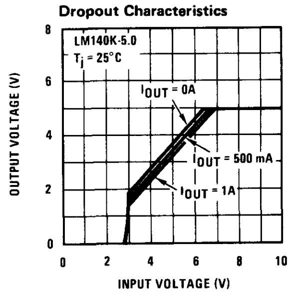
Output Impedance



Dropout Voltage

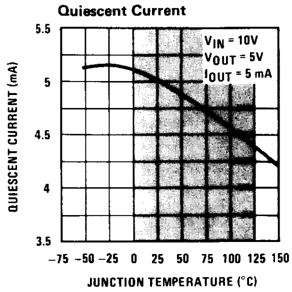


Dropout Characteristics

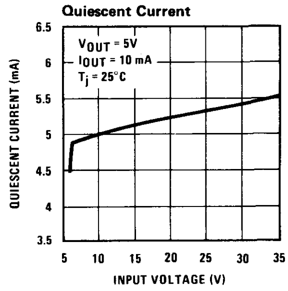


Note. Shaded area refers to LM340A/LM340

Quiescent Current



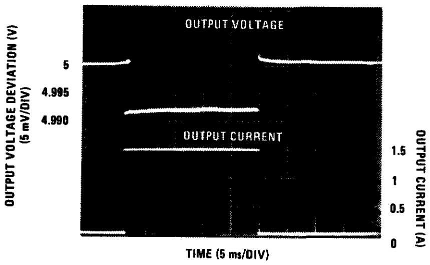
Quiescent Current



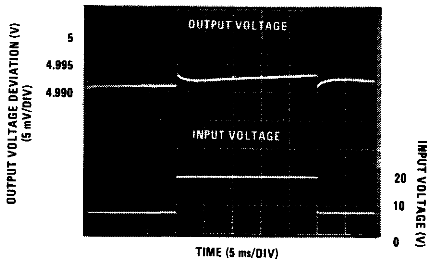
Note. Shaded area refers to LM340A/LM340

Typical Performance Characteristics (Continued)

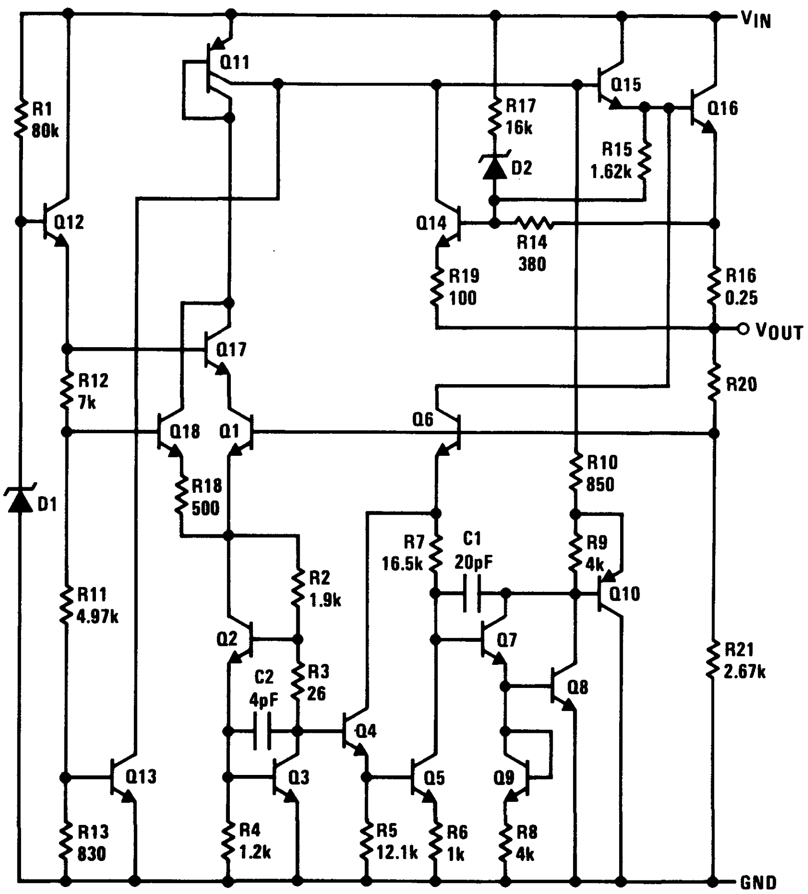
Load Regulation
140AK-5.0, V_{IN} = 10V, T_A = 25°C



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



Equivalent Schematic



Application Hints

The LM340 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 that have V_{OUT} greater than 6V, 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 reverse biased emitter-base junction of the pass device, Q16, which breaks down at 6.5V and forward biases the base-collector junction. If the energy released by the capacitor into the emitter-base junction is large enough, the junction and the regulator will be destroyed. The fast diode in *Figure 1* will shunt the capacitor's discharge current around the regulator.

Raising the Output Voltage above the Input Voltage: Since the output of the LM340 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 340, 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.

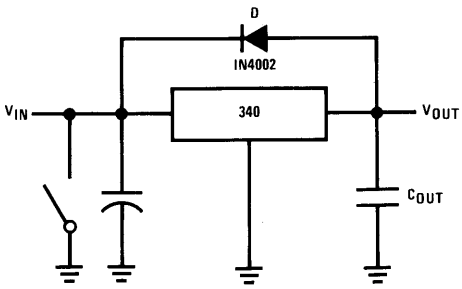


FIGURE 1. Input Short

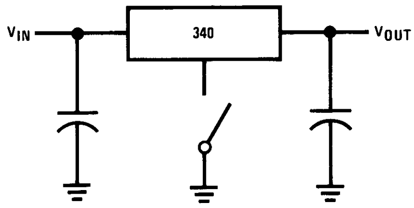


FIGURE 2. Regulator Floating Ground

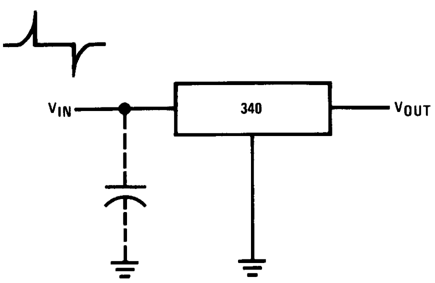
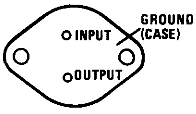


FIGURE 3. Transients

Connection Diagrams

TO-3 Metal Can Package (K and KC)



BOTTOM VIEW

Steel Package Order Numbers:

LM140AK-5.0	LM140K-5.0	LM340AK-5.0	LM340K-5.0
LM140AK-12	LM140K-12	LM340AK-12	LM340K-12
LM140AK-15	LM140K-15	LM340AK-15	LM340K-15

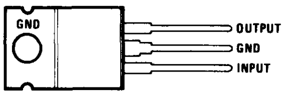
See Package K02A

Aluminum Package Order Numbers:

LM340KC-5.0
LM340KC-12
LM340KC-15

See Package KC02A

TO-220 Power Package (T)



TOP VIEW

Plastic Package Order Numbers:

LM340AT-5.0	LM340T-5.0
LM340AT-12	LM340T-12
LM340AT-15	LM340T-15

See Package TO3B