

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, $\pm 2\%$ 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 steel TO-3 power package. The

LM340A/LM340 series is also available in the TO-220 plastic power package as well as an aluminum TO-3 package.

For output voltages other than 5V, 12V, and 15V, the LM117 and LM117HV series provide an output voltage range from +1.2V to +57V.

Features

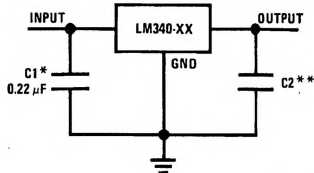
- Complete specifications at 1A load
- Output voltage tolerances of $\pm 2\%$ at $T_j = 25^\circ\text{C}$ and $\pm 4\%$ over the temperature range (LM140A/LM340A)
- Fixed output voltages available 5, 12, and 15V
- Line regulation of 0.01% of V_{OUT}/V of ΔV_{IN} at 1A load (LM140A/LM340A)
- Load regulation of 0.3% of V_{OUT}/A (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 ($\pm$ supplies)

LM140 Series Package and Power Capability

Device	Package	Rated Power Dissipation	Design Output Current
LM140/LM340	TO-3 (K)	20W	1.5A
LM340	TO-220 (T)	15W	1.5A

Typical Applications

Fixed Output Regulator

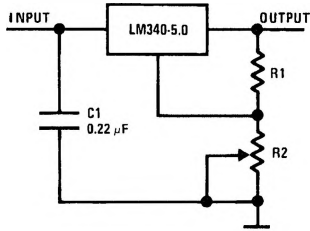


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*Required if the regulator is located far from the power supply filter.

**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1 μF , ceramic disc).

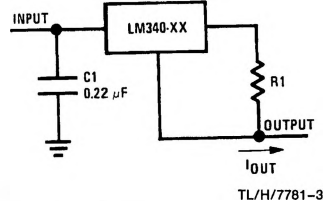
Adjustable Output Regulator



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

Current Regulator



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

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

Absolute Maximum Ratings

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

(Note 3)

Input Voltage ($V_O = 5V, 12V, 15V$)	35V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range (T_A)	–55°C to +125°C
LM140A/LM140	–55°C to +125°C
LM340A/LM340	0°C to +70°C

Maximum Junction Temperature	150°C
(TO-3 Package K, KC)	150°C
(TO-220 Package T)	150°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package K, KC	300°C
TO-220 Package T	230°C
ESD Tolerance (Note 4)	2000V

Electrical Characteristics LM140A/LM340A (Note 2)

$I_{OUT} = 1A$, –55°C ≤ T_J ≤ +150°C (LM140A), or 0°C ≤ T_J ≤ +125°C (LM340A) 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 _I = 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 V _{MIN} ≤ V _{IN} ≤ V _{MAX}	4.8 (7.5 ≤ V _{IN} ≤ 20)		5.2	11.5 (14.8 ≤ V _{IN} ≤ 27)		12.5	14.4 (17.9 ≤ V _{IN} ≤ 30)		15.6	V V
ΔV _O	Line Regulation	I _O = 500 mA ΔV _{IN}	10 (7.5 ≤ V _{IN} ≤ 20)			18 (14.8 ≤ V _{IN} ≤ 27)			22 (17.9 ≤ V _{IN} ≤ 30)			mV V
		T _i = 25°C ΔV _{IN}	3 10 (7.5 ≤ V _{IN} ≤ 20)			4 18 (14.5 ≤ V _{IN} ≤ 27)			4 22 (17.5 ≤ V _{IN} ≤ 30)			mV V
		T _j = 25°C Over Temperature ΔV _{IN}	4 12 (8 ≤ V _{IN} ≤ 12)			9 30 (16 ≤ V _{IN} ≤ 22)			10 30 (20 ≤ V _{IN} ≤ 26)			mV mV V
		ΔV _O	Load Regulation	T _j = 25°C 5 mA ≤ I _O ≤ 1.5A 250 mA ≤ I _O ≤ 750 mA	10	25		12	32		12	35
	15						19			21		
I _Q	Quiescent Current	Over Temperature, 5 mA ≤ I _O ≤ 1A	25			60			75			mV
ΔI _Q	Quiescent Current Change	T _j = 25°C Over Temperature			6 6.5			6 6.5			6 6.5	mA mA
		5 mA ≤ I _O ≤ 1A	0.5			0.5			0.5			mA
		T _j = 25°C, I _O = 1A V _{MIN} ≤ V _{IN} ≤ V _{MAX}	0.8 (7.5 ≤ V _{IN} ≤ 20)			0.8 (14.8 ≤ V _{IN} ≤ 27)			0.8 (17.9 ≤ V _{IN} ≤ 30)			mA V
		I _O = 500 mA V _{MIN} ≤ V _{IN} ≤ V _{MAX}	0.8 (8 ≤ V _{IN} ≤ 25)			0.8 (15 ≤ V _{IN} ≤ 30)			0.8 (17.9 ≤ V _{IN} ≤ 30)			mA 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 or f = 120 Hz, I _O = 500 mA, Over Temperature, V _{MIN} ≤ V _{IN} ≤ V _{MAX}	68	80		61	72		60	70		dB dB
			68			61			60			V
R _O	Dropout Voltage Output Resistance Short-Circuit Current Peak Output Current Average TC of V _O	T _j = 25°C, I _O = 1A	2.0			2.0			2.0			V
		f = 1 kHz	8			18			19			mΩ
		T _j = 25°C	2.1			1.5			1.2			A
		T _j = 25°C	2.4			2.4			2.4			A
		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

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

Note 3: Refer to RETS140A-12K for LM140K-12, RETS140A-15K for LM140K-15, or RETS140A-05K for LM140K-5.0 military drawing specifications.

Note 4: Human body model, 1.5 kΩ in series with 100 pF.

Electrical Characteristics LM140 (Note 2) $-55^{\circ}\text{C} \leq T_j \leq +150^{\circ}\text{C}$ 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 ≤ 1 A	4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V	
		P _D ≤ 15W, 5 mA ≤ I _O ≤ 1 A	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 ≤ 1 A	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 ≤ 1.5 A		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 ≤ 1 A			50			120			150	mV
I _O	Quiescent Current	I _O ≤ 1 A	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 ≤ 1 A				0.5		0.5			0.5	mA	
		T _J = 25°C, I _O ≤ 1 A			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		
ΔV _{IN} ΔV _{OUT}	Ripple Rejection	f = 120 Hz	I _O ≤ 1 A, T _J = 25°C or I _O ≤ 500 mA, −55°C ≤ T _J ≤ +150°C	68	80	61	72	60	70		dB		
		V _{MIN} ≤ V _{IN} ≤ V _{MAX}		68		61		60			dB		
				(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 = 1 A			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		
V _{IN}	Input Voltage Required to Maintain Line Regulation	T _J = 25°C, I _O ≤ 1 A			7.5		14.6		17.7		V		

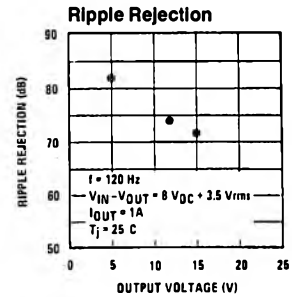
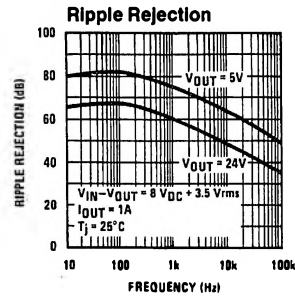
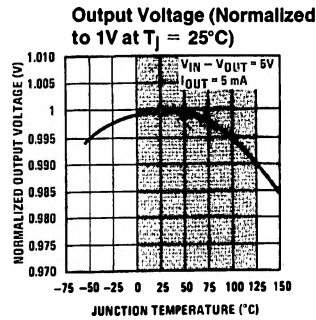
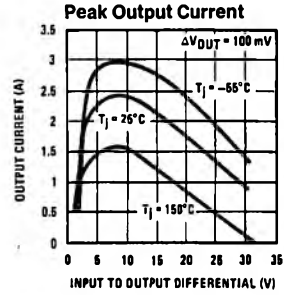
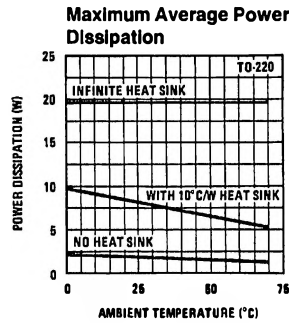
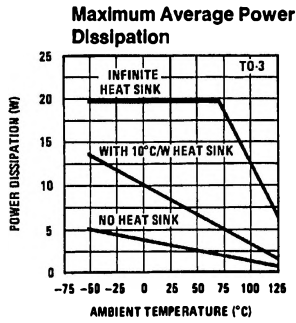
Note 2: All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF . All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10\text{ ms}$, duty cycle $\leq 5\%$). Output voltage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

Electrical Characteristics LM340 (Note 2) $0^{\circ}\text{C} \leq T_j \leq +125^{\circ}\text{C}$ unless otherwise specified

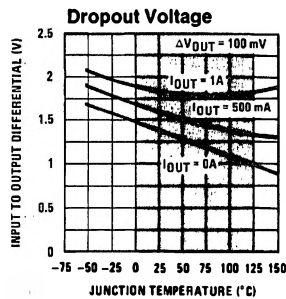
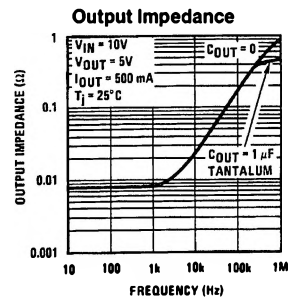
Symbol	Output Voltage		5V			12V			15V			Units			
	Input Voltage (unless otherwise noted)		10V			19V			23V						
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max				
V _O	Output Voltage	T _J = 25°C, 5 mA ≤ I _O ≤ 1A	4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V			
		P _D ≤ 15W, 5 mA ≤ I _O ≤ 1A	4.75	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		
		I _O ≤ 1A	ΔV _{IN}	(8 ≤ V _{IN} ≤ 20)			(15 ≤ V _{IN} ≤ 27)			(18.5 ≤ V _{IN} ≤ 30)			V		
			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		
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 _N	Output Noise Voltage	T _A = 25°C, 10 Hz ≤ f ≤ 100 kHz		40			75			90			μV		
		ΔV _{IN} ΔV _{OUT}	Ripple Rejection	f = 120 Hz	{ I _O ≤ 1A, T _J = 25°C or I _O ≤ 500 mA, 0°C ≤ T _J ≤ +125°C	62 80		55 72		54 70		dB			
						62		55		54		dB			
R _O	Dropout Voltage Output Resistance Short-Circuit Current Peak Output Current Average TC of V _{OUT}	T _J = 25°C, I _O = 1A f = 1 kHz T _J = 25°C T _J = 25°C 0°C ≤ T _J ≤ +125°C, I _O = 5 mA	V _{MIN} ≤ V _{IN} ≤ V _{MAX}			(8 ≤ V _{IN} ≤ 18)			(15 ≤ V _{IN} ≤ 25)			(18.5 ≤ V _{IN} ≤ 28.5)			V
			2.0			2.0			2.0			V			
			8			18			19			mΩ			
			2.1			1.5			1.2			A			
			2.4			2.4			2.4			A			
			-0.6			-1.5			-1.8			mV/°C			
V _{IN}	Input Voltage Required to Maintain Line Regulation	T _J = 25°C, I _O ≤ 1A	7.5			14.6			17.7			V			

Note 2: All characteristics are measured with a capacitor across the input of $0.22\text{ }\mu\text{F}$ and a capacitor across the output of $0.1\text{ }\mu\text{F}$. 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.

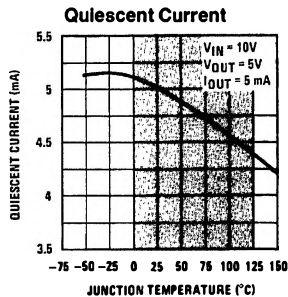
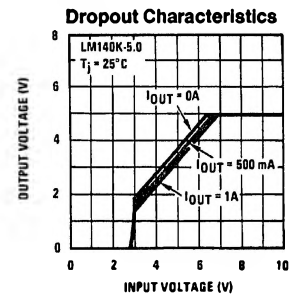
Typical Performance Characteristics



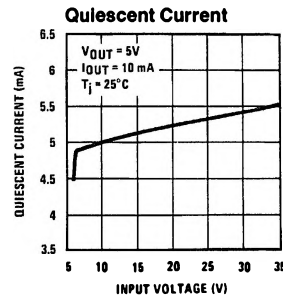
Note: Shaded area refers to LM340A/LM340.



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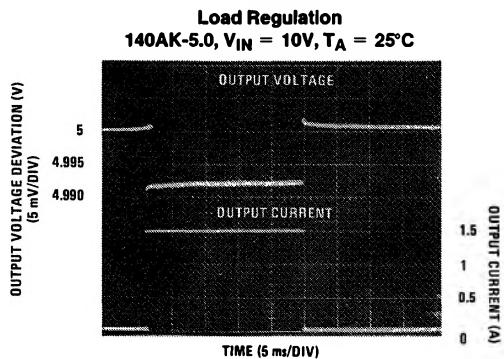


Note: Shaded area refers to LM340A/LM340.

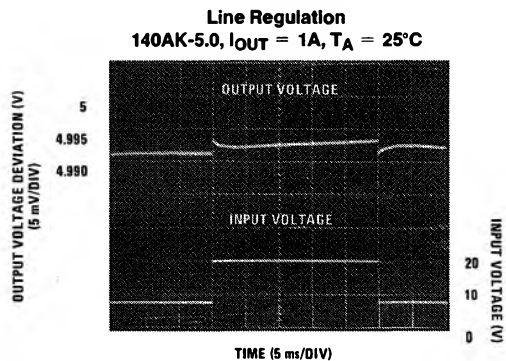


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Typical Performance Characteristics (Continued)

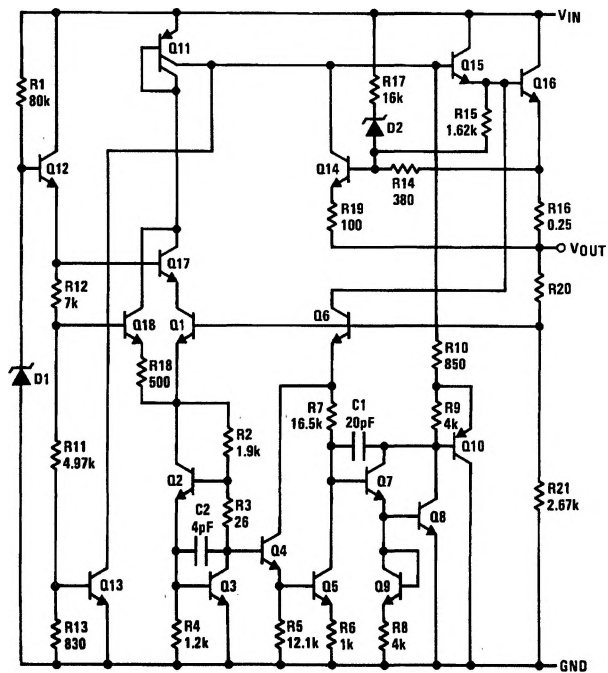


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Equivalent Schematic



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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, 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 $\leq 10 \mu\text{F}$.

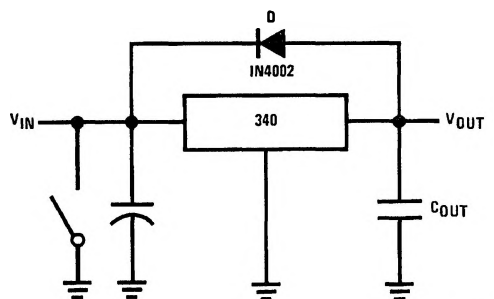


FIGURE 1. Input Short

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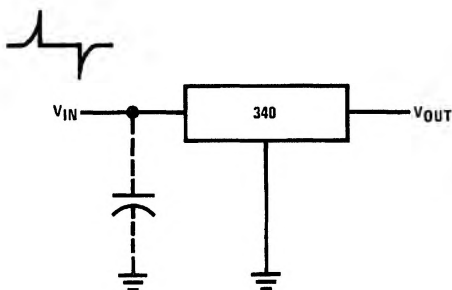


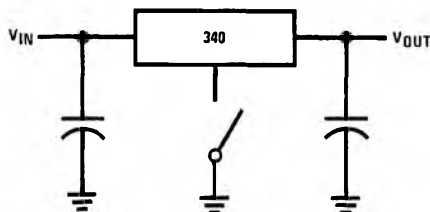
FIGURE 3. Transients

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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.

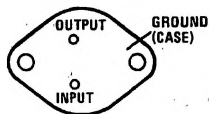


TL/H/7781-9

FIGURE 2. Regulator Floating Ground

Connection Diagrams

TO-3 Metal Can Package (K and KC)



Bottom View

TL/H/7781-11

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

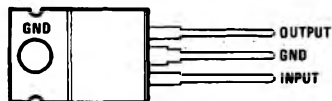
See Package Number K02A

Aluminum Package Order Numbers:

LM340KC-5.0
LM340KC-12
LM340KC-15

See Package Number KC02A

TO-220 Power Package (T)



Top View

TL/H/7781-12

Plastic Package Order Numbers:

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

See Package Number T03B