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T-58-11-13

National Semiconductor

LM140A/LM140/LM340A/LM340/LM7800/LM7800C Series 3-Terminal Positive Regulators

General Description

The LM140A/LM140/LM340A/LM340/LM7800/LM7800C 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 entire series of regulators is available in the steel TO-3 power package. The LM340A/LM340/LM7800/LM7800C series is also available in the TO-220 plastic power package.

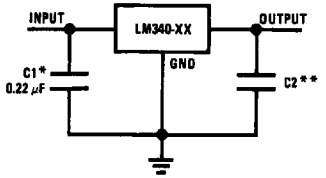
Features

- Complete specifications at 1A load
- Output voltage tolerances of ±2% at T_j = 25°C and ±4% over the temperature range (LM140A/LM340A)
- 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
- P+ Product Enhancement tested

Device	Output Voltages	Packages
LM140A/LM140	5, 12, 15	TO-3 (K)
LM340A/LM340	5, 12, 15	TO-3 (K), TO-220 (T)
LM7800	8, 18, 24	TO-3 (K), TO-220 (T)
LM7800C	5, 6, 8, 12, 15, 18, 24	TO-3 (K), TO-220 (T)

Typical Applications

Fixed Output Regulator

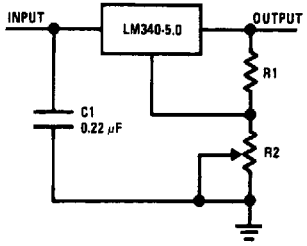


TL/H/7781–1

*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).

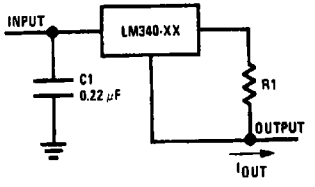
Adjustable Output Regulator



TL/H/7781–2

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).

Current Regulator



TL/H/7781–3

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

ΔI_Q = 1.3 mA over line and load changes.

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	
All Devices except LM7824/LM7824C	35V
LM7824/LM7824C	40V
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, KC)	300°C
TO-220 Package (T)	230°C
ESD Susceptibility (Note 3)	2 kV

Operating Conditions (Note 1)

Temperature Range (T_A) (Note 2)	
LM140A, LM140, LM7808, LM7818, LM7824	−55°C to +125°C
LM340A, LM340, LM7805C, LM7812C, LM7815C	0°C to +70°C
LM7806C, LM7808C, LM7818C, LM7824C	0°C to +125°C

LM140A/LM340A

Electrical Characteristics

I_{OUT} = 1A, −55°C ≤ T_J ≤ +150°C (LM140A), or 0°C ≤ T_J ≤ + 125°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°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_J = 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 15		12	32 19		12	35 21	mV mV
		Over Temperature, 5 mA ≤ I_O ≤ 1A			25			60			75	mV
I_Q	Quiescent Current	T_J = 25°C Over Temperature			6 6.5			6 6.5			6 6.5	mA 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 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 68 (8 ≤ V_{IN} ≤ 18)	80		61 61 (15 ≤ V_{IN} ≤ 25)	72		60 60 (18.5 ≤ V_{IN} ≤ 28.5)	70		dB dB 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 f = 1 kHz T_J = 25°C T_J = 25°C Min, T_J = 0°C, I_O = 5 mA		2.0 8 2.1 2.4 −0.6			2.0 18 1.5 2.4 −1.5			2.0 19 1.2 2.4 −1.8		V mΩ A A mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C	7.5			14.5			17.5			V

LM140

Electrical Characteristics (Note 4) $-55°C \le T_J \le +150°C$ unless otherwise specified

Symbol	Parameter	Conditions		5V 10V Min	Typ	Max	12V 19V Min	Typ	Max	15V 23V Min	Typ	Max	Units
	Output Voltage Input Voltage (unless otherwise noted)												
V_O	Output Voltage	$T_J = 25°C$, 5 mA $\le I_O \le$ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		$P_D \le$ 15W, 5 mA $\le I_O \le$ 1A $V_{MIN} \le V_{IN} \le V_{MAX}$		4.75 (8 ≤ V_{IN} ≤ 20)		5.25	11.4 (15.5 ≤ V_{IN} ≤ 27)		12.6	14.25 (18.5 ≤ V_{IN} ≤ 30)		15.75	V V
ΔV_O	Line Regulation	I_O = 500 mA	$T_J = 25°C$ ΔV_{IN}		3 (7 ≤ V_{IN} ≤ 25)	50		4 (14.5 ≤ V_{IN} ≤ 30)	120		4 (17.5 ≤ V_{IN} ≤ 30)	150	mV V
			$-55°C \le T_J \le +150°C$ ΔV_{IN}		50 (8 ≤ V_{IN} ≤ 20)			120 (15 ≤ V_{IN} ≤ 27)			150 (18.5 ≤ V_{IN} ≤ 30)		mV V
		$I_O \le$ 1A	$T_J = 25°C$ ΔV_{IN}		50 (7.5 ≤ V_{IN} ≤ 20)			120 (14.6 ≤ V_{IN} ≤ 27)			150 (17.7 ≤ V_{IN} ≤ 30)		mV V
			$-55°C \le T_J \le +150°C$ ΔV_{IN}		25 (8 ≤ V_{IN} ≤ 12)			60 (16 ≤ V_{IN} ≤ 22)			75 (20 ≤ V_{IN} ≤ 26)		mV V
ΔV_O	Load Regulation	$T_J = 25°C$	5 mA $\le I_O \le$ 1.5A 250 mA $\le I_P \le$ 750 mA		10	50 25		12	120 60		12	150 75	mV mV
		$-55°C \le T_J \le +150°C$, 5 mA $\le I_O \le$ 1A				50			120			150	mV
I_Q	Quiescent Current	$I_O \le$ 1A	$T_J = 25°C$ $-55°C \le T_J \le +150°C$			6 7			6 7			6 7	mA mA
ΔI_Q	Quiescent Current Change	5 mA $\le I_O \le$ 1A				0.5			0.5			0.5	mA
		$T_J = 25°C$, $I_O \le$ 1A $V_{MIN} \le V_{IN} \le V_{MAX}$			0.8 (8 ≤ V_{IN} ≤ 20)			0.8 (15 ≤ V_{IN} ≤ 27)			0.8 (18.5 ≤ V_{IN} ≤ 30)		mA V
		I_O = 500 mA, $-55°C \le T_J \le +150°C$ $V_{MIN} \le V_{IN} \le V_{MAX}$			0.8 (8 ≤ V_{IN} ≤ 25)			0.8 (15 ≤ V_{IN} ≤ 30)			0.8 (18.5 ≤ 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	f = 120 Hz	$I_O \le$ 1A, $T_J = 25°C$ or $I_O \le$ 500 mA, $-55°C \le T_J \le +150°C$	68 68	80		61 61	72		60 60	70		dB dB
		$V_{MIN} \le V_{IN} \le V_{MAX}$		(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}	$0°C \le T_J \le +150°C$, I_O = 5 mA			−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	$T_J = 25°C$, $I_O \le$ 1A		7.5			14.6			17.7			V

Electrical Characteristics (Note 4) $0°C \le T_J \le +125°C$ unless otherwise specified

Symbol	Parameter	Conditions	5V / 10V Min	5V / 10V Typ	5V / 10V Max	12V / 19V Min	12V / 19V Typ	12V / 19V Max	15V / 23V Min	15V / 23V Typ	15V / 23V Max	Units
	Output Voltage		5V			12V			15V			
	Input Voltage (unless otherwise noted)		10V			19V			23V			
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
		$P_D \le 15W$, 5 mA ≤ I_O ≤ 1A, $V_{MIN} \le V_{IN} \le V_{MAX}$	4.75 ($7.5 \le V_{IN} \le 20$)		5.25	11.4 ($14.5 \le V_{IN} \le 27$)		12.6	14.25 ($17.5 \le V_{IN} \le 30$)		15.75	V V
ΔV_O	Line Regulation	I_O = 500 mA, $T_J = 25°C$, ΔV_{IN}		3 ($7 \le V_{IN} \le 25$)	50		4 ($14.5 \le V_{IN} \le 30$)	120		4 ($17.5 \le V_{IN} \le 30$)	150	mV V
		$0°C \le T_J \le +125°C$, ΔV_{IN}		($8 \le V_{IN} \le 20$)	50		($15 \le V_{IN} \le 27$)	120		($18.5 \le V_{IN} \le 30$)	150	mV V
		$I_O \le$ 1A, $T_J = 25°C$, ΔV_{IN}		($7.5 \le V_{IN} \le 20$)	50		($14.6 \le V_{IN} \le 27$)	120		($17.7 \le V_{IN} \le 30$)	150	mV V
		$0°C \le T_J \le +125°C$, ΔV_{IN}		($8 \le V_{IN} \le 12$)	25		($16 \le V_{IN} \le 22$)	60		($20 \le V_{IN} \le 26$)	75	mV 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, $0°C \le T_J \le +125°C$			50			120			150	mV
I_Q	Quiescent Current	$I_O \le$ 1A, $T_J = 25°C$			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 mA ≤ I_O ≤ 1A			0.5			0.5			0.5	mA
		$T_J = 25°C$, I_O ≤ 1A, $V_{MIN} \le V_{IN} \le V_{MAX}$		($7.5 \le V_{IN} \le 20$)	1.0		($14.8 \le V_{IN} \le 27$)	1.0		($17.9 \le V_{IN} \le 30$)	1.0	mA V
		$I_O \le$ 500 mA, $0°C \le T_J \le +125°C$, $V_{MIN} \le V_{IN} \le V_{MAX}$		($7 \le V_{IN} \le 25$)	1.0		($14.5 \le V_{IN} \le 30$)	1.0		($17.5 \le V_{IN} \le 30$)	1.0	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	f = 120 Hz, $I_O \le$ 1A, $T_J = 25°C$	62	80		55	72		54	70		dB
		f = 120 Hz, or $I_O \le$ 500 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_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

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_{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.

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

Note 5: A military RETS specification is available on request. At the time of printing, the military RETS specifications for the LM140AK-5.0/883, LM140AK-12/883, and LM140AK-15/883 complied with the min and max limits for the respective versions of the LM140A. At the time of printing, the military RETS 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/883, LM140K/883, and LM140AK/883 may also be procured as a Standard Military Drawing.

LM7806C Electrical Characteristics

$0°C \le T_J \le +150°C$, $V_I = 11V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		5.75	6.0	6.25	V
ΔV_O	Line Regulation		$T_J = 25°C$	$8.0V \le V_I \le 25V$		5.0	120	mV
				$9.0V \le V_I \le 13V$		1.5	60	
ΔV_O	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		14	120	mV
				$250\ mA \le I_O \le 750\ mA$		4.0	60	
V_O	Output Voltage		$8.0V \le V_I \le 21V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		5.7		6.3	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$8.0V \le V_I \le 25V$				1.3	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$				0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$			45		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$		59	75		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$			9		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			550		mA
I_{PK}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$, $0°C \le T_A \le +125°C$			0.8		mV/°C

LM7808/LM7808C Electrical Characteristics

$-55°C \le T_J \le +150°C$ (LM7808) or $0°C \le T_J \le +150°C$ (LM7808C), $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)			LM7808			LM7808C			Units
						Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage		$T_J = 25°C$			7.7	8.0	8.3	7.7	8.0	8.3	V
ΔV_O	Line Regulation		$T_J = 25°C$	$10.5V \le V_I \le 25V$			6.0	80		6.0	160	mV
				$11.0V \le V_I \le 17V$			2.0	40		2.0	80	
ΔV_O	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$			12	100		12	160	mV
				$250\ mA \le I_O \le 750\ mA$			4.0	40		4.0	80	
V_O	Output Voltage		$11.5V \le V_I \le 23V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$			7.6		8.4	7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$				4.3	6.0		4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$11.5V \le V_I \le 25V$					0.8			1.0	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$					0.5			0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$				64	320		52		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$			62	72		56	72		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$				2.0	2.5		2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$				16			16		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$				0.75	1.2		0.45		A
I_{PK}	Peak Output Current		$T_J = 25°C$			1.3	2.2	3.3		2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$	LM7808	$-55°C \le T_A \le +25°C$			0.4				mV/°C/V_O
				LM7808	$+25°C \le T_A \le +125°C$			0.3				
				LM7808C						0.8		mV/°C

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

LM7818/LM7818C

Electrical Characteristics

$-55°C \le T_J \le +150°C$ (LM7818) or $0°C \le T_J \le +150°C$ (LM7818C), $V_I = 27V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)			LM7818			LM7818C			Units
						Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage		$T_J = 25°C$			17.3	18.0	18.7	17.3	18.0	18.7	V
ΔV_O	Line Regulation		$T_J = 25°C$		$21V \le V_I \le 33V$		15	180		15	360	mV
					$24V \le V_I \le 30V$		5.0	90		5.0	180	
ΔV_O	Load Regulation		$T_J = 25°C$		$5.0\ mA \le I_O \le 1.5A$		12	180		12	360	mV
					$250\ mA \le I_O \le 750\ mA$		4.0	90		4.0	180	
V_O	Output Voltage		$22V \le V_I \le 33V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$			17.1		18.9	17.1		18.9	V
I_Q	Quiescent Current		$T_J = 25°C$				4.5	6.0		4.5	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$22V \le V_I \le 33V$					0.8			1.0	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$					0.5			0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$				144	720		110		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$			59	69		53	69		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$				2.0			2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$				22			22		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$				0.75			0.20		A
I_{PK}	Peak Output Current		$T_J = 25°C$			1.3	2.2	3.3		2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$	LM7818	$-55°C \le T_A \le +25°C$			0.4				$mV/°C/V_O$
				LM7818	$+25°C \le T_A \le +125°C$			0.3				
				LM7818C						1.0		mV/°C

LM7824/LM7824C

Electrical Characteristics

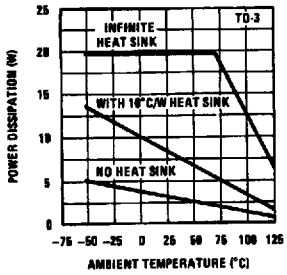
$-55°C \le T_J \le +150°C$ (LM7824) or $0°C \le T_J \le +150°C$ (LM7824C), $V_I = 33V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)			LM7824			LM7824C			Units
						Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage		$T_J = 25°C$			23.0	24.0	25.0	23.0	24.0	25.0	V
ΔV_O	Line Regulation		$T_J = 25°C$		$27V \le V_I \le 38V$		18	240		18	480	mV
					$30V \le V_I \le 36V$		6.0	120		6.0	240	
ΔV_O	Load Regulation		$T_J = 25°C$		$5.0\ mA \le I_O \le 1.5A$		12	240		12	480	mV
					$250\ mA \le I_O \le 750\ mA$		4.0	120		4.0	240	
V_O	Output Voltage		$28V \le V_I \le 38V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$			22.8		25.2	22.8		25.2	V
I_Q	Quiescent Current		$T_J = 25°C$				4.6	6.0		4.6	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$28V \le V_I \le 38V$					0.8			1.0	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$					0.5			0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$				192	960		170		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$			56	66		50	66		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$				2.0	2.5		2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$				28			28		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$				0.75	1.2		0.15		A
I_{PK}	Peak Output Current		$T_J = 25°C$			1.3	2.2	3.3		2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$	LM7824	$-55°C \le T_A \le +25°C$			0.4				$mV/°C/V_O$
				LM7824	$+25°C \le T_A \le +125°C$			0.3				
				LM7824C						1.5		mV/°C

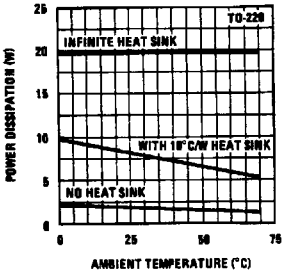
Note 4: All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \le 10$ ms, duty cycle $\le 5\%$). Output voltage changes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

Typical Performance Characteristics

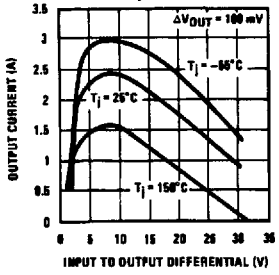
Maximum Average Power Dissipation



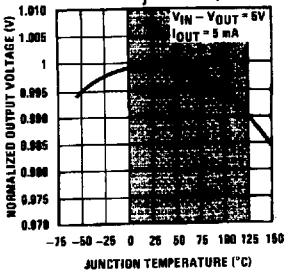
Maximum Average Power Dissipation



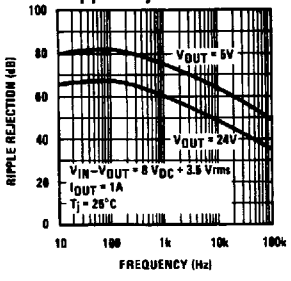
Peak Output Current



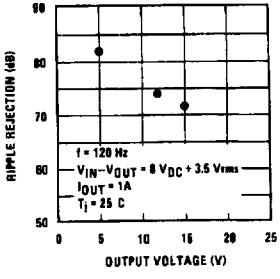
Output Voltage (Normalized to 1V at T_J = 25°C)



Ripple Rejection

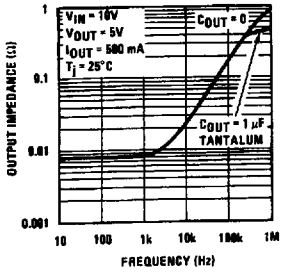


Ripple Rejection

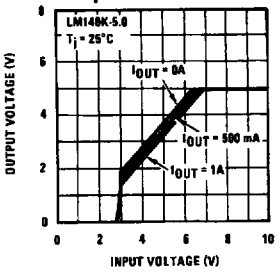


Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

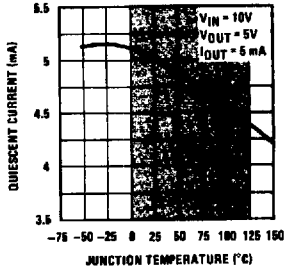
Output Impedance



Dropout Characteristics

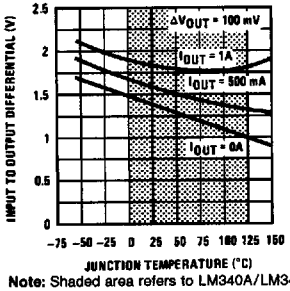


Quiescent Current

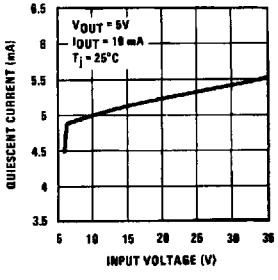


Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Dropout Voltage



Quiescent Current



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

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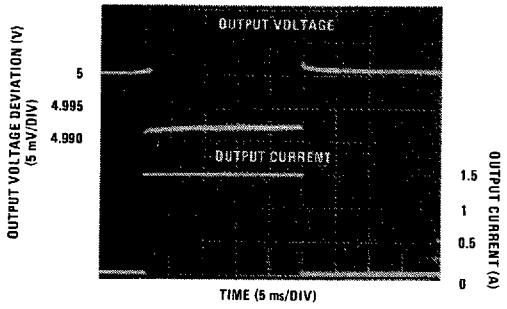
Typical Performance Characteristics (Continued)

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



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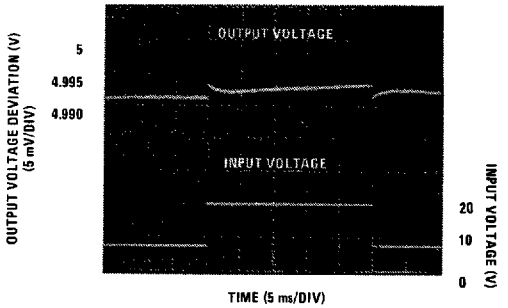
Line Regulation
140AK-5.0, I_{OUT} = 1A, T_A = 25°C



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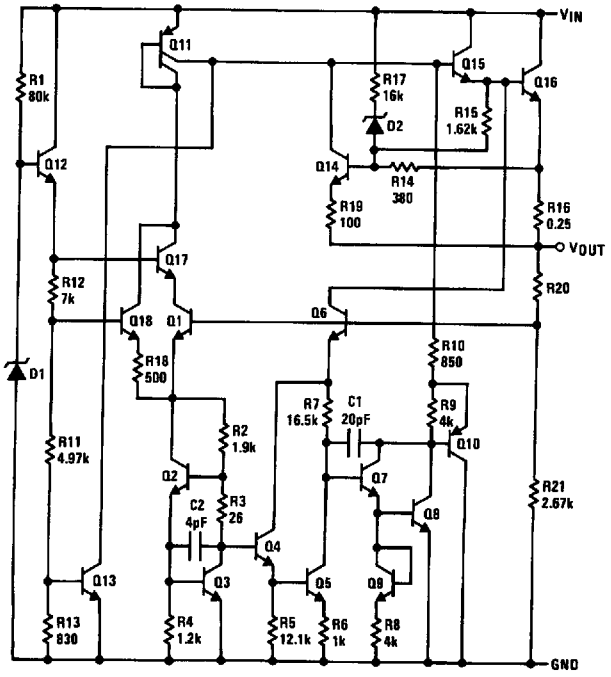
Equivalent Schematic

NATL SEMICOND (LINEAR)



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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 ≤ 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 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.

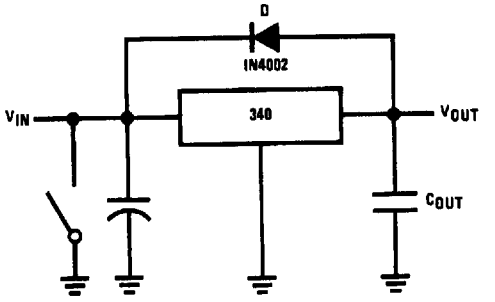

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FIGURE 1. Input Short

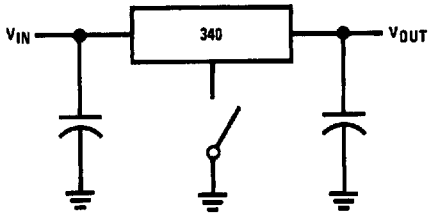

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FIGURE 2. Regulator Floating Ground

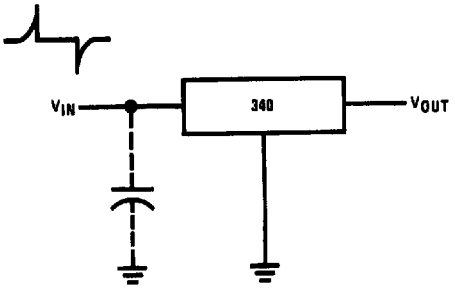

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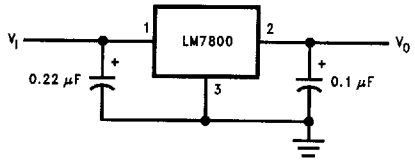
FIGURE 3. Transients

Typical Applications

Fixed Output Regulator



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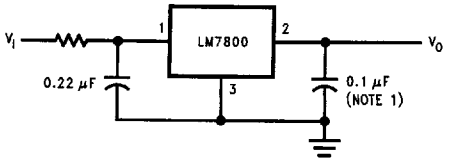
Note 1: Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

High Input Voltage Circuits



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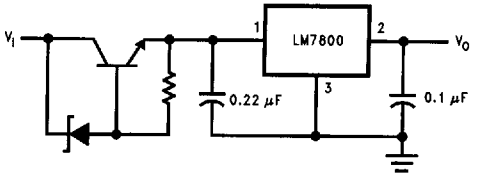

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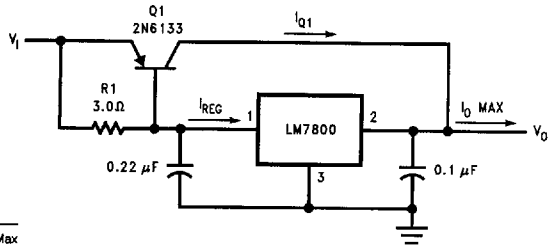
High Current Voltage Regulator



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

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

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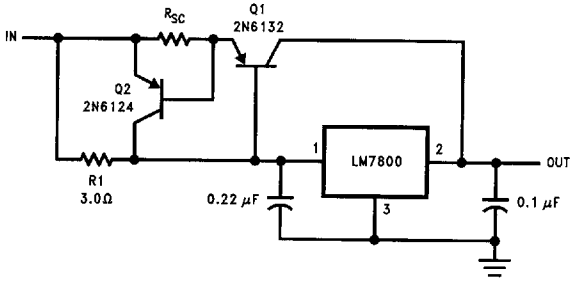
High Output Current, Short Circuit Protected



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

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

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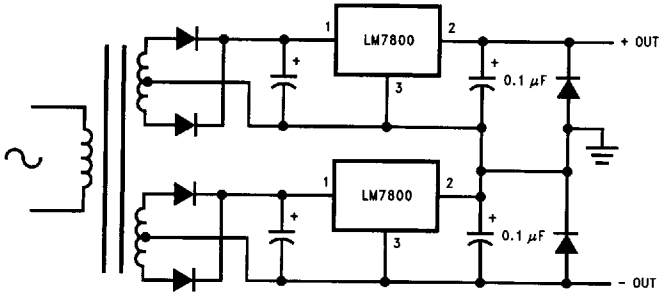
Positive and Negative Regulator



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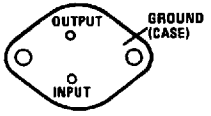
Connection Diagrams and Ordering Information

TO-3 Metal Can Package (K and KC)



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Bottom View

Steel Package Order Numbers:

LM140AK-5.0	LM140AK-12	LM140AK-15
LM140K-5.0	LM140K-12	LM140K-15
LM140AK-5.0/883	LM140AK-12/883	LM140AK-15/883
LM140K-5.0/883	LM140K-12/883	LM140K-15/883
LM340AK-5.0	LM340AK-12	LM340AK-15
LM340K-5.0	LM340K-12	LM340K-15
LM7806CK	LM7808CK	LM7808K
LM7818CK	LM7818K	LM7824CK
	LM7824K	

See Package Number K02A

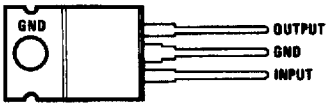
Aluminum Package Order Numbers:

LM340KC-5.0
LM340KC-12
LM340KC-15
LM7805CK
LM7812CK
LM7815CK

See Package Number KC02A

NATL SEMICOND (LINEAR)

TO-220 Power Package (T)



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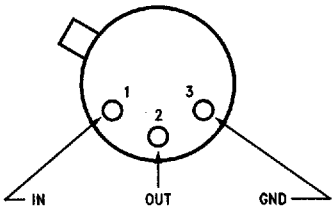
Top View

Plastic Package Order Numbers:

LM340AT-5.0	LM340T-5.0
LM340AT-12	LM340T-12
LM340AT-15	LM340T-15
LM7805CT	LM7812CT
LM7815CT	LM7806CT
LM7808CT	LM7818CT
	LM7824CT

See Package Number T03B

TO-39 Metal Can Package (H)



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Top View

Metal Can Order Numbers†:

LM140H-5.0/883	LM140H-6.0/883
LM140H-8.0/883	LM140H-12/883
LM140H-15/883	LM140H-24/883

See Package Number H03A

†The specifications for the LM140H/883 devices are not contained in this datasheet. If specifications for these devices are required, contact the National Semiconductor Sales Office/Distributors.