

LM120/LM320 Series 3-Terminal Negative Regulators

General Description

The LM120 series are three-terminal negative regulators with a fixed output voltage of $-5V$, $-12V$, and $-15V$, and up to 1.5A load current capability. Where other voltages are required, the LM137 series provides an output voltage range of $-1.2V$ to $-4.7V$.

The LM120 need only one external component—a compensation capacitor at the output, making them easy to apply. Worst case guarantees on output voltage deviation due to any combination of line, load or temperature variation assure satisfactory system operation.

Exceptional effort has been made to make the LM120 Series immune to overload conditions. The regulators have current limiting which is independent of temperature, combined with thermal overload protection. Internal current limiting protects against momentary faults while thermal shutdown prevents junction temperatures from exceeding safe limits during prolonged overloads.

Although primarily intended for fixed output voltage applications, the LM120 Series may be programmed for higher output voltages with a simple resistive divider. The low quiescent drain current of the devices allows this technique to be used with good regulation.

Features

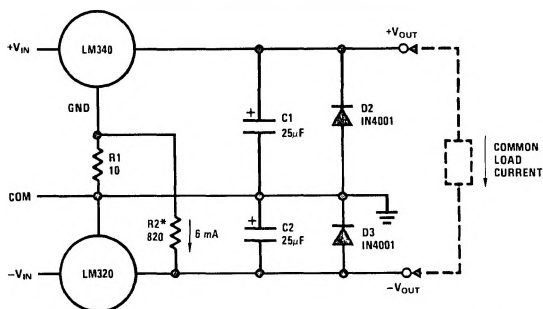
- Preset output voltage error less than $\pm 3\%$
- Preset current limit
- Internal thermal shutdown
- Operates with input-output voltage differential down to 1V
- Excellent ripple rejection
- Low temperature drift
- Easily adjustable to higher output voltage

LM120 Series Packages and Power Capability

Device	Package	Rated Power Dissipation	Design Load Current
LM120	TO-3	20W	1.5A
LM320	TO-39	2W	0.5A
LM320T	TO-220	15W	1.5A
LM320M	TO-202	7.5W	0.5A

Typical Applications

Preventing Positive Regulator Latch-Up

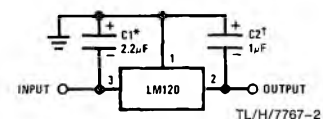


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R1 & D1 allow the positive regulator to "start-up" when $+V_{IN}$ is delayed relative to $-V_{IN}$ and a heavy load is drawn between the outputs. Without R1 & D1, most three-terminal regulators will not start with heavy (0.1A-1A) load current flowing to the negative regulator, even though the positive output is clamped by D2.

*R2 is optional. Ground pin current from the positive regulator flowing through R1 will increase $+V_{OUT} \approx 60$ mV if R2 is omitted.

Fixed Regulator



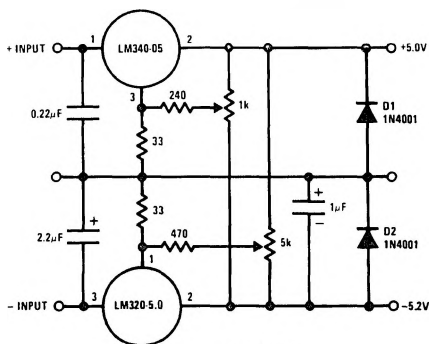
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*Required if regulator is separated from filter capacitor by more than 3". For value given, capacitor must be solid tantalum. 25 μ F aluminum electrolytic may be substituted.

†Required for stability. For value given, capacitor must be solid tantalum. 25 μ F aluminum electrolytic may be substituted. Values given may be increased without limit.

For output capacitance in excess of 100 μ F, a high current diode from input to output (1N4001, etc.) will protect the regulator from momentary input shorts.

Dual Trimmed Supply



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—5 Volt Regulators (Note 3)

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 5)

Input-Output Voltage Differential

Junction Temperatures

Storage Temperature Range

Lead Temperature (Soldering, 10 sec.)

Plastic

25V

See Note 1

–65°C to +150°C

300°C

260°C

Power Dissipation

Input Voltage

Internally Limited

–25V

Electrical Characteristics

Parameter	Order Numbers	Metal Can Package												Power Plastic Package						Units							
		LM120K-5.0 (TO-3)				LM320K-5.0 (TO-3)				LM120H-5.0 (TO-39)				LM320H-5.0 (TO-39)				LM320T-5.0 (TO-220)				LM320MP-5.0 (TO-202)					
		Min	Typ	Max	Units	Min	Typ	Max	Units	Min	Typ	Max	Units	Min	Typ	Max	Units	Min	Typ		Max	Units	Min	Typ	Max	Units	
Design Output Current (I_D) Device Dissipation (P_D)		1.5A 20W																									
Conditions (Note 1)		0.5A 2W																									
Output Voltage	$T_J = 25^\circ\text{C}, V_{IN} = 10\text{V}, I_{LOAD} = 5\text{mA}$	–5.1	–5	–4.9	–5	–5.2	–5	–4.8	–5.1	–5	–4.9	–5	–4.8	–5.2	–5	–4.8	–5.2	–5	–4.8	–5.2	–5	–4.8	–5.2	–5	–4.8	V	
Line Regulation	$T_J = 25^\circ\text{C}, I_{LOAD} = 5\text{mA}, V_{MIN} \leq V_{IN} \leq V_{MAX}$		10	25	10	40	10	25	10	25	10	40	10	25	10	40	10	25	10	40	10	40	10	40	10	40	mV
Input Voltage		–25		–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	–7	–25	V	
Ripple Rejection	$f = 120\text{Hz}$	54	64	54	64	54	64	54	64	54	64	54	64	54	64	54	64	54	64	54	64	54	64	54	64	dB	
Load Regulation, (Note 2)	$T_J = 25^\circ\text{C}, V_{IN} = 10\text{V}, 5\text{mA} \leq I_{LOAD} \leq I_D$		50	75	60	100	60	100	30	50	30	50	30	50	30	50	30	50	30	50	30	50	30	50	30	mV	
Output Voltage, (Note 1)	$-7.5\text{V} \leq V_{IN} \leq V_{MAX}, 5\text{mA} \leq I_{LOAD} \leq I_D, P \leq P_D$	–5.20		–4.80	–5.25	–4.75	–5.20	–4.80	–5.20	–4.75	–5.20	–4.80	–5.20	–4.75	–5.25	–4.75	–5.25	–4.75	–5.25	–4.75	–5.25	–4.75	–5.25	–4.75	–5.25	V	
Quiescent Current	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	mA
Quiescent Current Change	$T_J = 25^\circ\text{C}, V_{MIN} \leq V_{IN} \leq V_{MAX}, 5\text{mA} \leq I_{LOAD} \leq I_D$		0.1	0.4	0.1	0.4	0.1	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.05	mA	
Output Noise Voltage	$T_A = 25^\circ\text{C}, C_L = 1\mu\text{F}, I_L = 5\text{mA}, V_{IN} = 10\text{V}, 10\text{Hz} \leq f \leq 100\text{kHz}$		150		150		150		150		150		150		150		150		150		150		150		150	μV	
Long Term Stability			5	50	5	50	5	50	5	50	5	50	5	50	5	50	5	50	5	50	5	50	5	50	5	mV	
Thermal Resistance Junction to Case			3	35	3	35	3	35	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	°C/W	
Thermal Resistance Junction to Ambient			35	35	35	35	35	35	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	°C/W	

Note 1: This specification applies over $-55^\circ\text{C} \leq T_J \leq +150^\circ\text{C}$ for the LM120 and $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$ for the LM320.

Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. To ensure constant junction temperature, low duty cycle, pulse testing is used. The LM120/LM320 series does low thermal feedback, improving line and load regulation. On all other tests, even though power dissipation is internally limited, electrical specifications apply only up to P_D .

Note 3: For -5V 3 amp regulators, see LM145 data sheet.

Note 4: Thermal resistance of typically 85°C/W (in 400 linear feet air flow), 22°C/W (in static air) junction to ambient, of typically 21°C/W junction to case.

Note 5: Refer to RETS120-5H drawing for LM120H-5.0 or RETS120-5K drawing for LM120-5K military specifications.

— 12 Volt Regulators

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 4)

Power Dissipation

Internally Limited

Input Voltage

–35V

Input-Output Voltage Differential

30V

Junction Temperatures

See Note 1

Storage Temperature Range

–65°C to +150°C

Lead Temperature (Soldering, 10 sec.)

300°C

Electrical Characteristics

Parameter	Conditions (Note 1)	Metal Can Package						Power Plastic Package												
		LM120K-12 (TO-3)		LM320K-12 (TO-3)		LM120H-12 (TO-39)		LM320H-12 (TO-39)		LM320T-12 (TO-220)		LM320MP-12 (TO-202)								
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max							
Order Numbers																				
Design Output Current (I _P)																				
Device Dissipation (P _D)																				
Output Voltage	T _J = 25°C, V _{IN} = 17V, I _{LOAD} = 5 mA	–12.3	–12	–11.7	–12.4	–12	–11.6	–12.3	–12	–11.7	–12.4	–12	–11.6	–12.4	–12	–11.6	–12.5	–12	–11.5	V
Line Regulation	T _J = 25°C, I _{LOAD} = 5 mA, V _{MIN} ≤ V _{IN} ≤ V _{MAX}	4	10	4	20	4	10	4	10	4	20	4	20	4	20	4	24	4	24	mV
Input Voltage		–32	–14	–32	–14	–32	–14	–32	–14	–32	–14	–32	–14	–32	–14.5	–32	–14.5	–32	–14.5	V
Ripple Rejection	f = 120 Hz	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	dB
Load Regulation, (Note 2)	T _J = 25°C, V _{IN} = 17V, 5 mA ≤ I _{LOAD} ≤ I _D	30	80	30	80	30	80	10	25	10	25	10	40	30	80	30	100	40	100	mV
Output Voltage, (Note 1)	14.5V ≤ V _{IN} ≤ V _{MAX} , 5 mA ≤ I _{LOAD} ≤ I _D , P ≤ P _D	–12.5		–11.5	–12.6	–11.4	–12.5	–11.5	–12.6	–11.4	–12.6	–11.5	–12.6	–11.4	–12.6	–11.4	–12.6	–11.4	–12.6	V
Quiescent Current	V _{MIN} ≤ V _{IN} ≤ V _{MAX}	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	mA
Quiescent Current Change	T _J = 25°C, V _{MIN} ≤ V _{IN} ≤ V _{MAX} , 5 mA ≤ I _{LOAD} ≤ I _D	0.1	0.4	0.1	0.4	0.1	0.4	0.05	0.4	0.05	0.4	0.05	0.4	0.1	0.4	0.1	0.4	0.05	0.3	mA
Output Noise Voltage	T _A = 25°C, C _L = 1 μF, I _L = 5 mA, V _{IN} = 17V, 10 Hz ≤ f ≤ 100 kHz	400		400		400		400		400		400		400		400		400		μV
Long Term Stability		12	120	12	120	12	120	12	120	12	120	12	120	12	120	12	120	12	120	mV
Thermal Resistance Junction to Case		3		3		3		Note 3		Note 3		Note 3		Note 3		Note 3		Note 3		°C/W
Junction to Ambient		35		35		35		Note 3		Note 3		Note 3		Note 3		Note 3		Note 3		°C/W

Note 1: This specification applies over –55°C ≤ T_J ≤ +150°C for the LM120 and 0°C ≤ T_J ≤ +125°C for the LM320.

Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. To ensure constant junction temperature, low duty cycle, pulse testing is used. The LM120/LM320 series does have low thermal feedback, improving line and load regulation. On all other tests, even though power dissipation is internally limited, electrical specifications apply only up to P_D.

Note 3: Thermal resistance of typically 85°C/W (in 400 linear feet/min air flow), 224°C/W (in static air) junction to ambient, of typically 21°C/W junction to case.

Note 4: Refer to RETS120H-12 drawing for LM120H-12 or RETS120-12K drawing for LM120K-12 military specifications.

— 15 Volt Regulators

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 4)

Input-Output Voltage Differential 30V
 Junction Temperatures See Note 1
 Storage Temperature Range -65°C to +150°C
 Lead Temperature (Soldering, 10 sec.) 300°C

Power Dissipation Internally Limited
 Input Voltage -40V
 LM120/LM320 -35V
 LM320T/LM320MP

Electrical Characteristics

Parameter	Conditions (Note 1)	Metal Can Package												Power Plastic Package												
		LM120K-15 (TO-3)				LM320K-15 (TO-3)				LM120H-15 (TO-39)				LM320H-15 (TO-39)				LM320T-15 (TO-220)		LM320MP-15 (TO-202)						
		1A 20W	Min	Typ	Max	1A 20W	Min	Typ	Max	0.2A 2W	Min	Typ	Max	0.2A 2W	Min	Typ	Max	1A 15W	Min	Typ	Max	0.5A 7.5W	Min	Typ	Max	
Design Output Current (I_O) Device Dissipation (P_D)																										
Output Voltage	T _J = 25°C, V _{IN} = 20V, I _{LOAD} = 5 mA	-15.3	-15	-14.7	-15.4	-15	-14.6	-15.3	-15	-14.7	-15.4	-15	-14.6	-15.3	-15	-14.7	-15.4	-15	-14.6	-15.5	-15	-14.5	-15.6	-15	-14.4	V
Line Regulation	T _J = 25°C, I _{LOAD} = 5 mA, V _{MIN} ≤ V _{IN} ≤ V _{MAX}	5	10	20	5	20	10	5	10	20	5	20	10	5	20	10	5	20	10	5	20	10	5	30	mV	
Input Voltage		-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17	-35	-17.5	-35	-17.5	V
Ripple Rejection	f = 120 Hz	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	56	80	dB
Load Regulation, (Note 2)	T _J = 25°C, V _{IN} = 20V, 5 mA ≤ I _{LOAD} ≤ I _O	30	80	30	80	30	80	10	25	30	80	10	25	30	80	10	25	30	80	30	80	30	80	30	80	mV
Output Voltage, (Note 1)	17.5V ≤ V _{IN} ≤ V _{MAX} ; 5 mA ≤ I _{LOAD} ≤ I _O , P ≤ P _D	-15.5	-14.5	-15.6	-14.4	-15.5	-14.4	-15.5	-14.5	-15.6	-14.4	-15.5	-14.5	-15.6	-14.4	-15.7	-14.3	-15.7	-14.3	-15.7	-14.3	-15.7	-14.3	-15.7	-14.3	V
Quiescent Current	V _{MIN} ≤ V _{IN} ≤ V _{MAX}	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	mA
Quiescent Current Change	T _J = 25°C V _{MIN} ≤ V _{IN} ≤ V _{MAX} 5 mA ≤ I _{LOAD} ≤ I _O	0.1	0.4	0.1	0.4	0.1	0.4	0.05	0.4	0.1	0.4	0.05	0.4	0.03	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.05	0.3	mA
Output Noise Voltage	T _A = 25°C, C _L = 1 μF, I _L = 5 mA, V _{IN} = 20V, 10 Hz ≤ f ≤ 100 kHz	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	μV
Long Term Stability		15	150	15	150	15	150	15	150	15	150	15	150	15	150	15	150	15	150	15	150	15	150	15	150	mV
Thermal Resistance Junction to Case		3	35	3	35	3	35	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	°C/W
Junction to Ambient		3	35	3	35	3	35	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	°C/W

Note 1: This specification applies over -55°C ≤ T_J ≤ +150°C for the LM120 and 0°C ≤ T_J ≤ +125°C for the LM320.

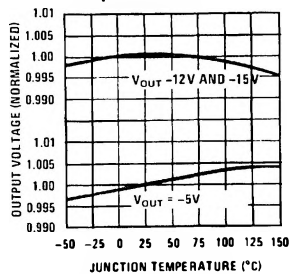
Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. To ensure constant junction temperature, low duty cycle, pulse testing is used. The LM120/LM320 series does have low thermal feedback, improving line and load regulation. On all other tests, even though power dissipation is internally limited, electrical specifications apply only up to P_D.

Note 3: Thermal resistance of typically 85°C/W (in 400 linear feet/min air flow), 22°C/W (in static air) junction to ambient, of typically 21°C/W junction to case.

Note 4: Refer to RETS120-15H drawing for LM120H-15 or RETS120-15K drawing for LM120K-15 military specifications.

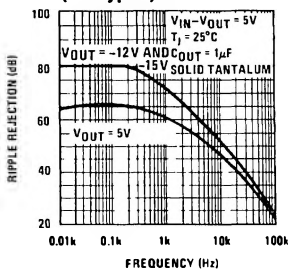
Typical Performance Characteristics

Output Voltage vs Temperature

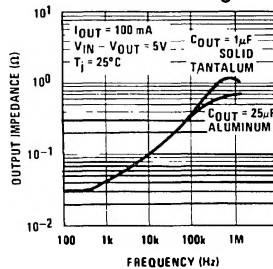


Note: Shaded portion refers to LM320 series regulators.

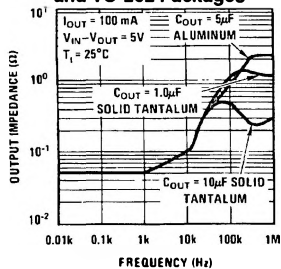
Ripple Rejection (All Types)



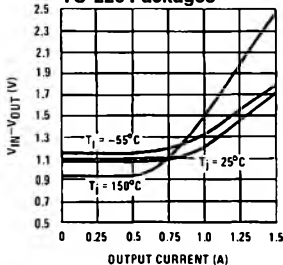
Output Impedance TO-3 and TO-220 Packages



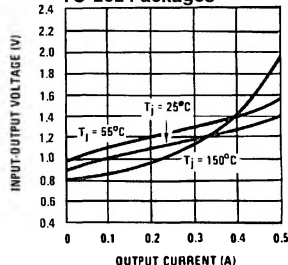
Output Impedance TO-5 and TO-202 Packages



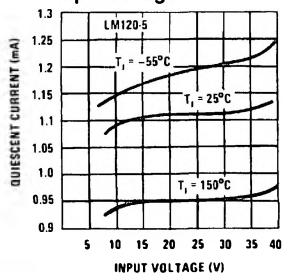
Minimum Input-Output Differential TO-3 and TO-220 Packages



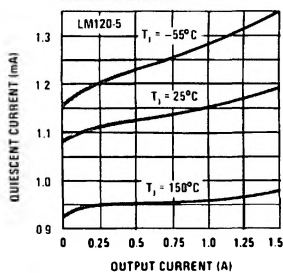
Minimum Input-Output Differential TO-5 and TO-202 Packages



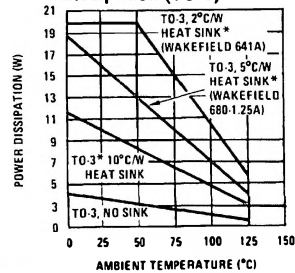
Quiescent Current vs Input Voltage



Quiescent Current vs Load Current



Maximum Average Power Dissipation (TO-3)

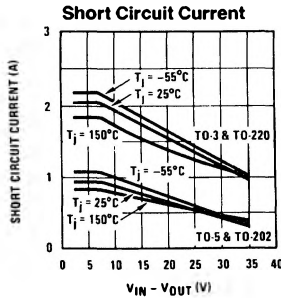
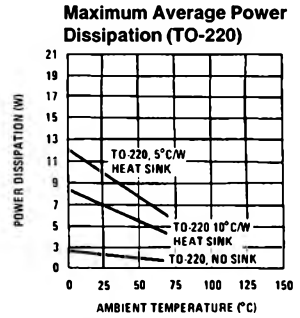
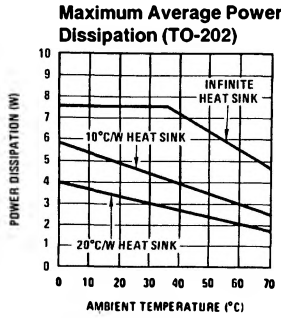
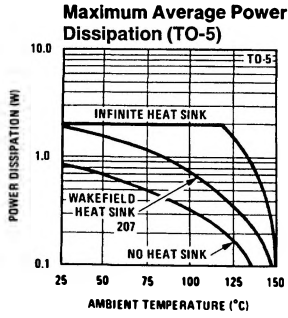


Note: Shaded area shows operating range of TO-5 and TO-202 packages.

*These curves for LM120 and LM220. Derate 25°C further for LM320.

TL/H/7767-4

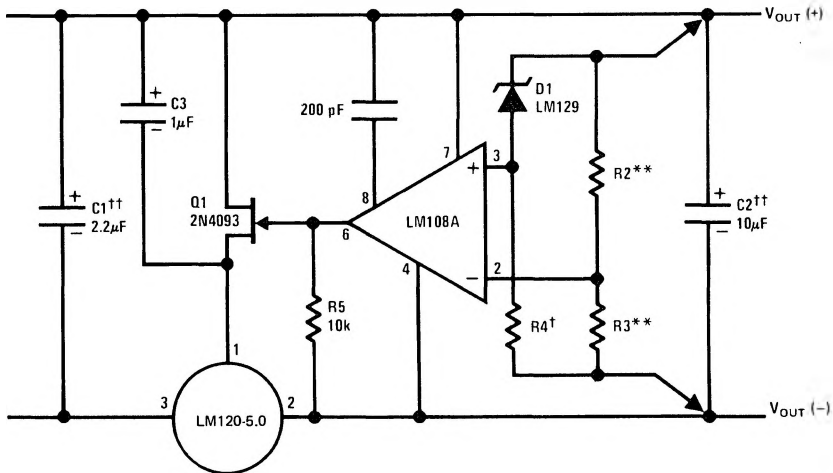
Typical Performance Characteristics (Continued)



TL/H/7767-5

Typical Applications (Continued)

High Stability 1 Amp Regulator



TL/H/7767-6

Load and line regulation — 0.01% temperature stability — 0.2%

††Determines Zener current.

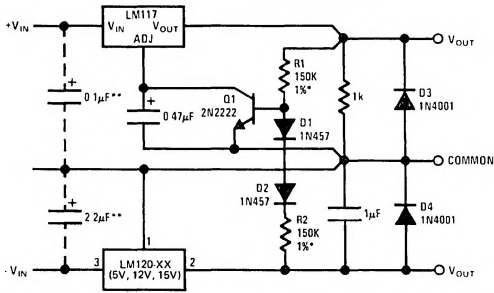
†Solid tantalum.

An LM120-12 or LM120-15 may be used to permit higher input voltages, but the regulated output voltage must be at least -15V when using the LM120-12 and -18V for the LM120-15.

**Select resistors to set output voltage. 2 ppm/°C tracking suggested.

Typical Applications (Continued)

Wide Range Tracking Regulator

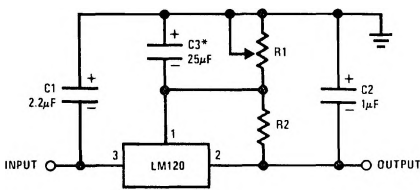


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*Resistor tolerance of R1 and R2 determine matching of (+) and (-) inputs.

**Necessary only if raw supply capacitors are more than 3" from regulators
An LM3086N array may substitute for Q1, D1 and D2 for better stability and tracking. In the array diode transistors Q5 and Q4 (in parallel) make up D2; similarly, Q1 and Q2 become D1 and Q3 replaces the 2N2222.

Variable Output



TL/H/7767-9

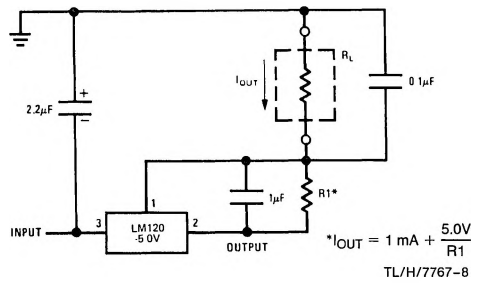
*Optional. Improves transient response and ripple rejection.

$$V_{OUT} = V_{SET} \frac{R1 + R2}{R2}$$

SELECT R2 AS FOLLOWS:

- LM120-5 - 300Ω
- LM120-12 - 750Ω
- LM120-15 - 1k

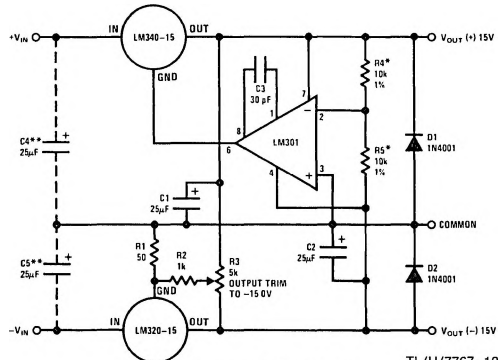
Current Source



*I_{OUT} = 1 mA + $\frac{5.0V}{R1}$

TL/H/7767-8

± 15V, 1 Amp Tracking Regulators



TL/H/7767-12

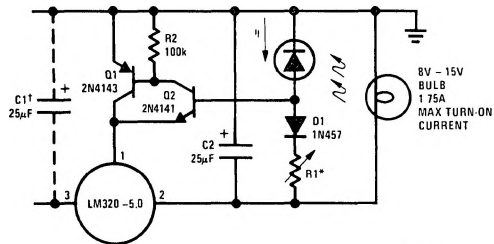
Performance (Typical)

Load Regulation at ΔI _L = 1A	10 mV	1 mV
Output Ripple, C _{IN} = 3000 μF, I _L = 1A	100 μVrms	100 μVrms
Temperature Stability	+ 50 mV	+ 50 mV
Output Noise 10 Hz ≤ f ≤ 10 kHz	150 μVrms	150 μVrms

*Resistor tolerance of R4 and R5 determine matching of (+) and (-) outputs.

**Necessary only if raw supply filter capacitors are more than 2" from regulators.

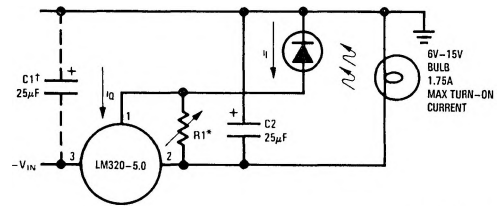
Light Controllers Using Silicon Photo Cells



TL/H/7767-10

*Lamp brightness increases until $i_l = 5V/R1$ (i_l can be set as low as 1 μA).

†Necessary only if raw supply filter capacitor is more than 2" from LM320MP.

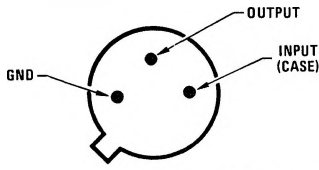


TL/H/7767-11

*Lamp brightness increases until $i_l = i_Q$ (1 mA) + 5V/R1.

†Necessary only if raw supply filter capacitor is more than 2" from LM320.

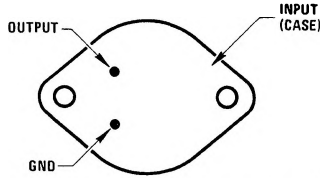
Connection Diagrams



TL/H/7767-13

Bottom View

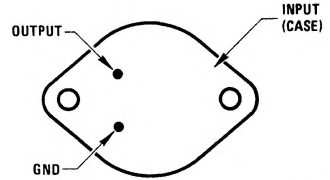
Metal Can Package TO-39 (H)
 Order Number LM120H-5.0,
 LM120H-12, LM120H-15, LM320H-
 5.0, LM320H-12 or LM320H-15
 See NS Package Number H03A



TL/H/7767-14

Bottom View

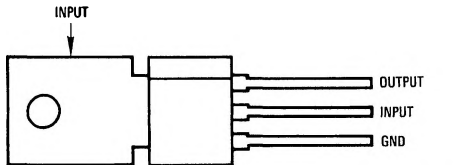
Steel Metal Can Package TO-3 (K)
 Order Number LM120K-5.0,
 LM120K-12, LM120K-15, LM320K-
 5.0, LM320K-12 or LM320K-15
 See NS Package Number K02A



TL/H/7767-15

Bottom View

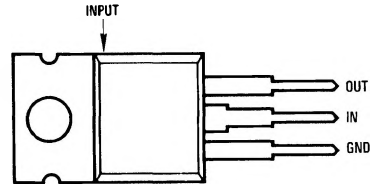
Aluminum Metal Can Package TO-3 (KC)
 Order Number LM320KC-5.0,
 LM320KC-12 or LM320KC-15
 See NS Package Number KC02A



TL/H/7767-16

Front View

Power Package TO-202 (P)
 Order Number LM320MP-5.0,
 LM320MP-12 or LM320MP-15
 See NS Package Number P03A



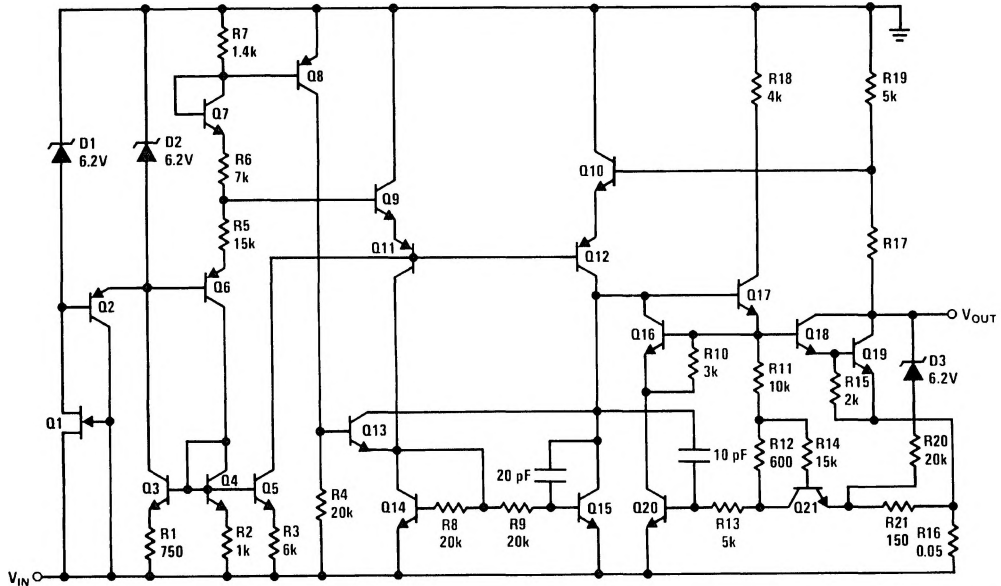
TL/H/7767-17

Front View

Power Package TO-220 (T)
 Order Number LM320T-5.0, LM320T-12 or LM320T-15
 See NS Package Number T03B

Schematic Diagrams

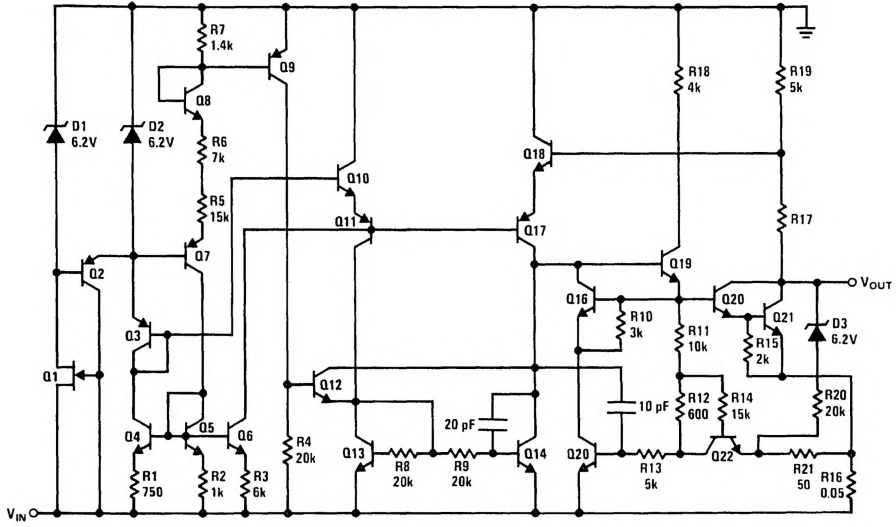
- 5V



TL/H/7767-18

Schematic Diagrams (Continued)

- 12V and - 15V



TL/H/7767-19