National Semiconductor

Voltage Regulators

LM120 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 -47V.

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 ±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

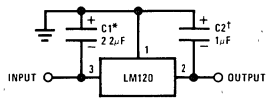
LM120 Series Packages and Power Capability

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
LM320ML*	TO-202	7.5W	0.25A
LM320L*	TO-92+	1.2W	0.1A

*Electrical specifications shown on separate data sheet

Typical Applications

Fixed Regulator

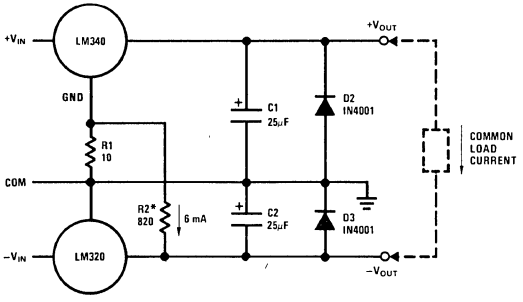


*Required if regulator is separated from filter capacitor by more than 3". For value given, capacitor must be solid tantalum. 25μF aluminum electrolytic may be substituted.

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

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

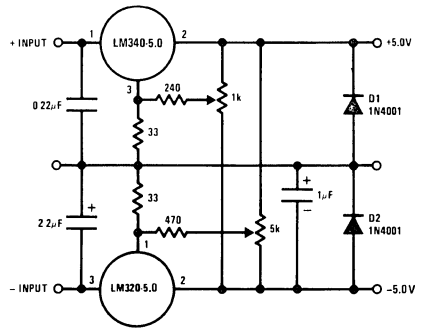
Preventing Positive Regulator Latch-Up



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 $+V_{OUT}$ ≈ 60 mV if R2 is omitted.

Dual Trimmed Supply



−5 VOLT REGULATORS (Note 3)

Absolute Maximum Ratings

Power Dissipation	Internally Limited
Input Voltage	−25V
Input-Output Voltage Differential	25V
Junction Temperatures	See Note 1
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

Electrical Characteristics

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)			
DESIGN OUTPUT CURRENT (I_D) DEVICE DISSIPATION (P_D)		1.5A 20W			1.5A 20W			0.5A 2W			0.5A 2W			1.5A 15W			0.5A 7.5W			
PARAMETER	CONDITIONS (NOTE 1)	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	$T_J = 25°C$, $V_{IN} = 10V$, $I_{LOAD} = 5$ mA	−5.1	−5	−4.9	−5.2	−5	−4.8	−5.1	−5.0	−4.9	−5.2	−5.0	−4.8	−5.2	−5.0	−4.8	−5.2	−5.0	−4.8	V
Line Regulation	$T_J = 25°C$, $I_{LOAD} = 5$ mA, $V_{MIN} \leq V_{IN} \leq V_{MAX}$		10	25		10	40		10	25		10	40		10	40		10	40	mV
Input Voltage		−25		−7	−25		−7	−25		−7	−25		−7	−25		−7.5	−25		−7.5	V
Ripple Rejection	f = 120 Hz	54	64		54	64		54	64		54	64		54	64		54	64		dB
Load Regulation, (Note 2)	$T_J = 25°C$, $V_{IN} = 10V$, $5\text{ mA} \leq I_{LOAD} \leq I_D$		50	75		50	100		30	50		30	50		50	100		40	100	mV
Output Voltage, (Note 1)	$-7.5V \leq V_{IN} \leq V_{MAX}$, $5\text{ mA} \leq I_{LOAD} \leq I_D$, $P \leq P_D$	−5.20		−4.80	−5.25		−4.75	−5.20		−4.80	−5.25		−4.75	−5.25		−4.75	−5.25	−5.0	−4.75	V
Quiescent Current	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		1	2		1	2		1	2		1	2		1	2		1	2	mA
Quiescent Current Change	$T_J = 25°C$																			
	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		0.1	0.4		0.1	0.4		0.05	0.4		0.05	0.4		0.1	0.4		0.05	0.3	mA
	$5\text{ mA} \leq I_{LOAD} \leq I_D$		0.1	0.4		0.1	0.4		0.04	0.4		0.04	0.4		0.1	0.4		0.04	0.25	mA
Output Noise Voltage	$T_A = 25°C$, $C_L = 1\mu F$, $I_L = 5$ mA, $V_{IN} = 10V$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		150			150			150			150			150			150		μV
Long Term Stability			5	50		5	50		5	50		5	50		10			10		mV
Thermal Resistance																				
Junction to Case				3			3			15			15		4			12		°C/W
Junction to Ambient				35			35			150			150		50			70		°C/W

Note 1: This specification applies over $-55°C \leq T_J \leq +150°C$ for the LM120 and $0°C \leq T_J \leq +125°C$ 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: For −5V 3 amp regulators, see LM145 data sheet.

−12 VOLT REGULATORS

Absolute Maximum Ratings

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 seconds)	300°C

Electrical Characteristics

ORDER NUMBERS		METAL CAN PACKAGE												POWER PLASTIC PACKAGE						UNITS
		LM120K-12 (TO-3)			LM320K-12 (TO-3)			LM120H-12 (TO-39)			LM320H-12 (TO-39)			LM320T-12 (TO-220)			LM320MP-12 (TO-202)			
DESIGN OUTPUT CURRENT (I_D) DEVICE DISSIPATION (P_D)		1A 20W			1A 20W			0.2A 2W			0.2A 2W			1A 15W			0.5A 7.5W			
PARAMETER	CONDITIONS (NOTE 1)	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
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, $V_{MIN} \leq V_{IN} \leq V_{MAX}$		4	10		4	20		4	10		4	20		4	20		4	24	mV
Input Voltage		−32		−14	−32		−14	−32		−14	−32		−14	−32		−14.5	−32		−14.5	V
Ripple Rejection	f = 120 Hz	56	80		56	80		56	80		56	80		56	80		56	80		dB
Load Regulation, (Note 2)	$T_J = 25°C$, $V_{IN} = 17V$, $5\text{ mA} \leq I_{LOAD} \leq I_D$		30	80		30	80		10	25		10	40		30	80		40	100	mV
Output Voltage, (Note 1)	$14.5V \leq V_{IN} \leq V_{MAX}$, $5\text{ mA} \leq I_{LOAD} \leq I_D$, $P \leq P_D$	−12.5		−11.5	−12.6		−11.4	−12.5		−11.5	−12.6		−11.4	−12.6		−11.4	−12.6		−11.4	V
Quiescent Current	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		2	4		2	4		2	4		2	4		2	4		2	4	mA
Quiescent Current Change	$T_J = 25°C$																			
	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		0.1	0.4		0.1	0.4		0.05	0.4		0.05	0.4		0.1	0.4		0.05	0.3	mA
	$5\text{ mA} \leq I_{LOAD} \leq I_D$		0.1	0.4		0.1	0.4		0.03	0.4		0.03	0.4		0.1	0.4		0.04	0.25	mA
Output Noise Voltage	$T_A = 25°C$, $C_L = 1\mu F$, $I_L = 5$ mA, $V_{IN} = 17V$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		400			400			400			400			400			400		μV
Long Term Stability			12	120		12	120		12	120		12	120		24			24		mV
Thermal Resistance																				
Junction to Case				3			3			15			15		4			12		°C/W
Junction to Ambient				35			35			150			150		50			70		°C/W

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

–15 VOLT REGULATORS

Absolute Maximum Ratings

Power Dissipation	Internally Limited
Input Voltage	
LM120/LM320	–40V
LM320T/LM320MP	–35V
Input-Output Voltage Differential	30V
Junction Temperatures	See Note 1
Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

Electrical Characteristics

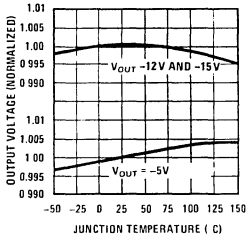
ORDER NUMBERS		METAL CAN PACKAGE												POWER PLASTIC PACKAGE						UNITS
		LM120K-15 (TO-3)			LM320K-15 (TO-3)			LM120H-15 (TO-39)			LM320H-15 (TO-39)			LM320T-15 (TO-220)			LM320MP-15 (TO-202)			
DESIGN OUTPUT CURRENT (I_D) DEVICE DISSIPATION (P_D)		1A 20W			1A 20W			0.2A 2W			0.2A 2W			1A 15W			0.5A 7.5W			
PARAMETER	CONDITIONS (NOTE 1)	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
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	–15.5	–15	–14.5	–15.6	–15	–14.4	V
Line Regulation	T_J = 25°C, I_{LOAD} = 5 mA, $V_{MIN} \leq V_{IN} \leq V_{MAX}$		5	10		5	20		5	10		5	20		5	20		5	30	mV
Input Voltage		–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		dB
Load Regulation, (Note 2)	T_J = 25°C, V_{IN} = 20V, 5 mA $\leq I_{LOAD} \leq I_D$		30	80		30	80		10	25		10	40		30	80		40	100	mV
Output Voltage, (Note 1)	17.5V $\leq V_{IN} \leq V_{MAX}$, 5 mA $\leq I_{LOAD} \leq I_D$, $P < P_D$	–15.5		–14.5	–15.6		–14.4	–15.5		–14.5	–15.6		–14.4	–15.7		–14.3	–15.7		–14.3	V
Quiescent Current	$V_{MIN} < V_{IN} \leq V_{MAX}$		2	4		2	4		2	4		2	4		2	4		2	4	mA
Quiescent Current Change	T_J = 25°C																			
	$V_{MIN} \leq V_{IN} \leq V_{MAX}$		0.1	0.4		0.1	0.4		0.05	0.4		0.05	0.4		0.1	0.4		0.05	0.3	mA
	5 mA $\leq I_{LOAD} \leq I_D$		0.1	0.4		0.1	0.4		0.03	0.4		0.03	0.4		0.1	0.4		0.04	0.25	mA
Output Noise Voltage	T_A = 25°C, C_L = 1μF, I_L = 5 mA, V_{IN} = 20V, 10 Hz $\leq f \leq$ 100 kHz		400			400			400			400			400			400		μV
Long Term Stability			15	150		15	150		15	150		15	150		30			30		mV
Thermal Resistance																				
Junction to Case				3			3			15			15		4			12		°C/W
Junction to Ambient				35			35			150			150		50			70		°C/W

Note 1: This specification applies over –55°C $\leq T_J \leq$ +150°C for the LM120 and 0°C $\leq T_J \leq$ +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.

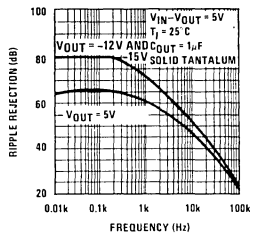
ypical Performance Characteristics

Output Voltage vs Temperature

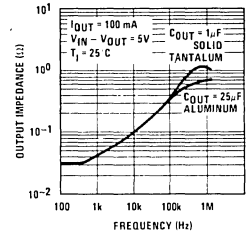


Note: Shaded portion refers to LM320 series regulators.

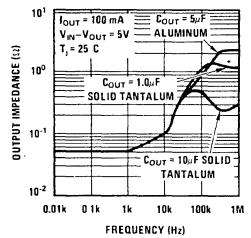
Ripple Rejection (All Types)



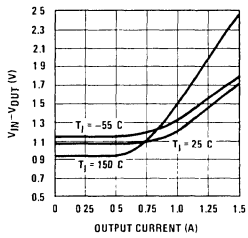
Output Impedance TO-3 and TO-220 Packages



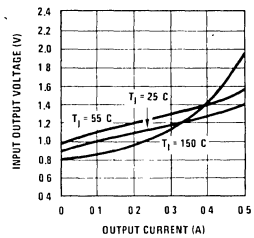
Output Impedance TO-5 and TO-202 Packages



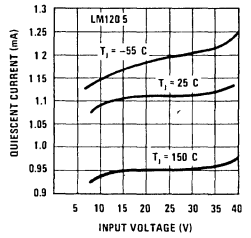
Minimum Input-Output Differential TO-3 and TO-220 Packages



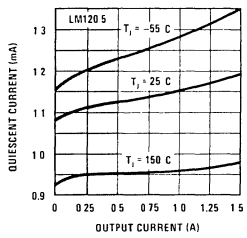
Minimum Input-Output Differential TO-5 and TO-202 Packages



Quiescent Current vs Input Voltage

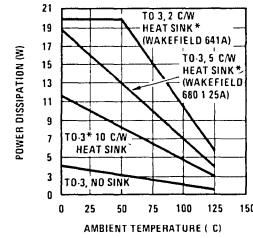


Quiescent Current vs Load Current



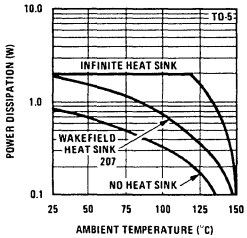
Note: Shaded area shows operating range of TO-5 and TO-202 packages.

Maximum Average Power Dissipation (TO-3)

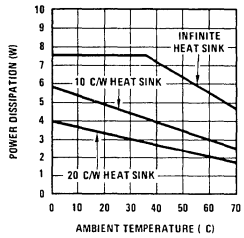


*These curves for LM120 and LM220. Derate 25°C further for LM320.

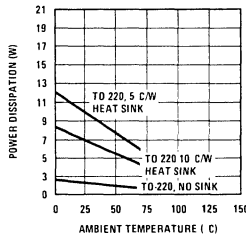
Maximum Average Power Dissipation (TO-5)



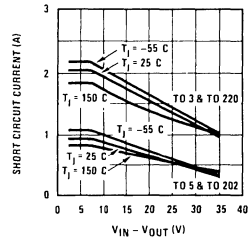
Maximum Average Power Dissipation (TO-202)



Maximum Average Power Dissipation (TO-220)

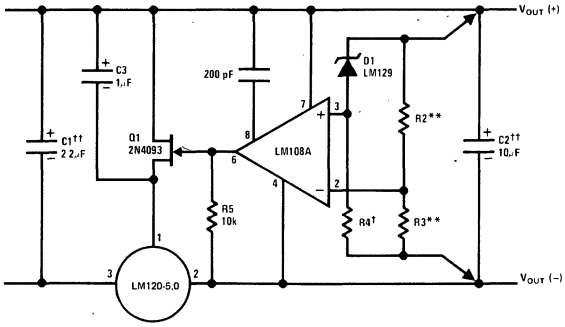


Short Circuit Current



Typical Applications (cont'd.)

High Stability 1 Amp Regulator



Load and line regulation 0.01% temperature stability 0.2%

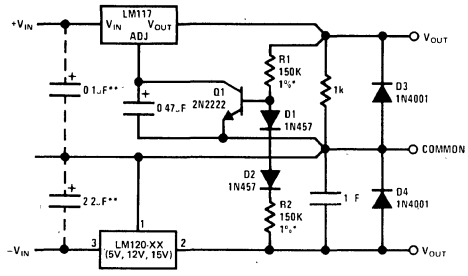
†Determines Zener current

††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.

Wide Range Tracking Regulator

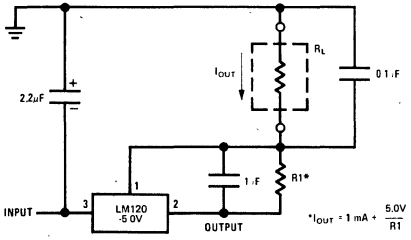


*Resistor tolerance of R1 and R2 determine matching of (+) and (−) inputs

**Necessary only if raw supply capacitors are more than 3" from regulators

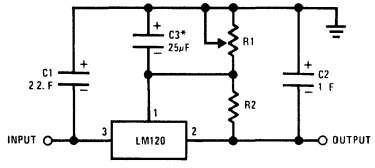
An LM3086N array may substitute for Q1, D1 and D2 for better stability and tracking. In the array diode, transistors Q5 and Q4 (in parallel) make up D2, similarly, Q1 and Q2 become D1 and D3 replaces the 2N2222

Current Source



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

Variable Output



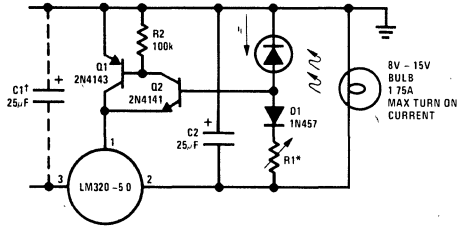
*Optional. Improves transient response and ripple rejection

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

SELECT R2 AS FOLLOWS

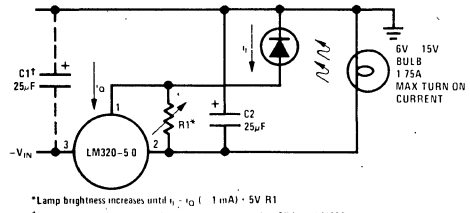
LM120-5	300Ω
LM120-12	750Ω
LM120-15	1K

Light Controllers Using Silicon Photo Cells



*Lamp brightness increases until I_L = 5V/R1 (I_L can be set as low as 1. A)

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

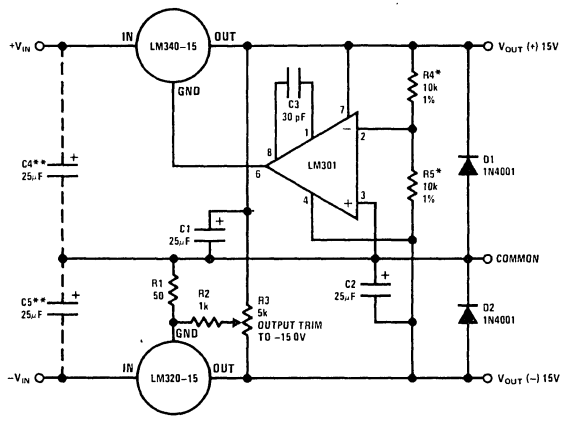


*Lamp brightness increases until $I_L - I_Q$ (1 mA) = 5V R1

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

Typical Applications (cont'd.)

±15V, 1 Amp Tracking Regulators

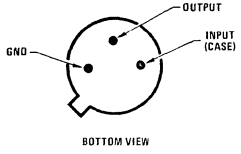


Performance (Typical)

Load Regulation at ΔI_L = 1A	10 mV	1 mV
Output Ripple, C_{IN} = 3000μF, I_L = 1A	100μVrms	100μVrms
Temperature Stability	+50 mV	+50 mV
Output Noise 10 Hz ≤ f ≤ 10 kHz	150μVrms	150μVrms

*Resistor tolerance of R4 and R5 determine matching of (+) and (−) outputs.
**Necessary only if raw supply filter capacitors are more than 2" from regulators.

Connection Diagrams

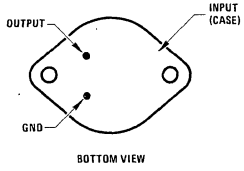


BOTTOM VIEW

Metal Can Package (TO-39) (H)
Order Numbers:

LM120H-5.0 LM120H-12 LM120H-15
LM320H-5.0 LM320H-12 LM320H-15

See Package H03A

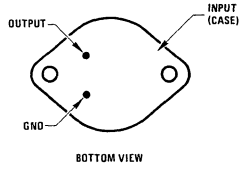


BOTTOM VIEW

Steel Metal Can Package TO-3 (K)
Order Numbers:

LM120K-5.0 LM120K-12 LM120K-15
LM320K-5.0 LM320K-12 LM320K-15

See Package K02A

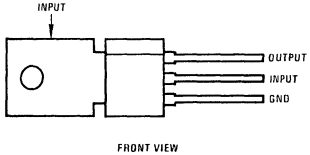


BOTTOM VIEW

Aluminum Metal Can Package TO-3 (KC)
Order Numbers:

LM320KC-5.0 LM320KC-12
LM320KC-15

See Package KC02A



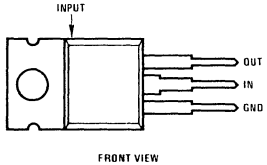
FRONT VIEW

Power Package TO-202 (P)
Order Numbers:

LM320MP-5.0
LM320MP-12
LM320MP-15

See Package P03A

For Tab Formed TO-202
Order Numbers:
LM320MP-5.0TB
LM320MP-12TB
LM320MP-15TB
See Package P03E



FRONT VIEW

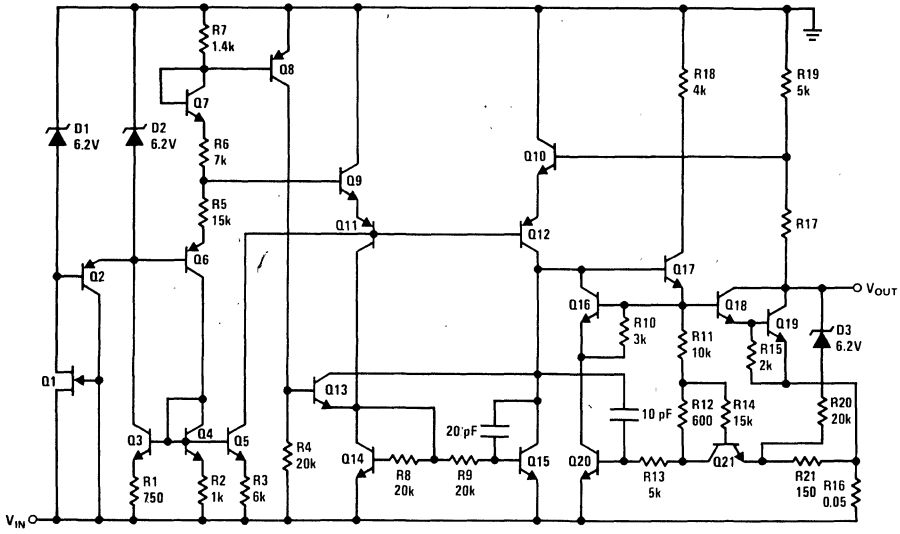
Power Package TO-220 (T)
Order Numbers:

LM320T-5.0
LM320T-12
LM320T-15

See Package T03B

Schematic Diagrams

-5V



-12V and -15V