

# 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 and LM137HV series provide 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.

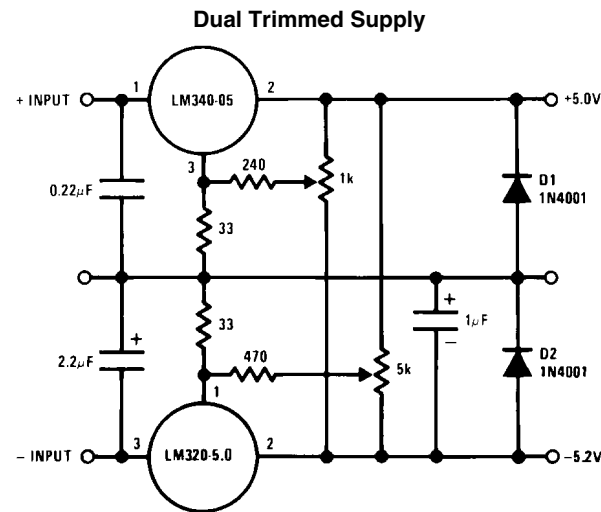
## Features

- Preset output voltage error less than  $\pm 3\%$
- 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

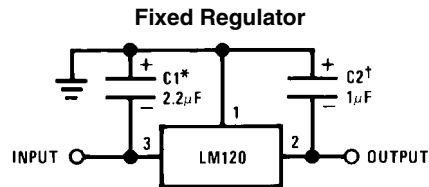
### LM120 Series Packages and Power Capability

| Device      | Package    | Rated Power Dissipation | Design Load Current |
|-------------|------------|-------------------------|---------------------|
| LM120/LM320 | TO-3 (K)   | 20W                     | 1.5A                |
|             | TO-39 (H)  | 2W                      | 0.5A                |
| LM320       | TO-220 (T) | 15W                     | 1.5A                |

## Typical Applications



776703



776702

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

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

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

**Absolute Maximum Ratings****-5 Volt Regulators** (Notes 5, 3)

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

Power Dissipation Internally Limited  
Input Voltage -25V

Input-Output Voltage Differential 25V  
Junction Temperatures (Note 1)  
Storage Temperature Range -65°C to +150°C  
Lead Temperature  
(Soldering, 10 sec.) 300°C  
Plastic 260°C

**-5 Volt Regulators  
Electrical Characteristics** (Note 3)

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

## -5 Volt Regulators

### Electrical Characteristics (Note 3)

| Order Numbers   |  | Metal Can Package     |      |          |                       |      |          | Units              |
|---|--|-----------------------|------|----------|-----------------------|------|----------|--------------------|
|   |  | LM120H-5.0<br>(TO-39) |      |          | LM320H-5.0<br>(TO-39) |      |          |                    |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 0.5A<br>2W            |      |          |                       |      |          |                    |
| Parameter   | Conditions (Note 1)  | Min                   | Typ  | Max      | Min                   | Typ  | Max      |                    |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 10\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$   | -5.1                  | -5   | -4.9     | -5.2                  | -5   | -4.8     | V                  |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$  |                       | 10   | 25       |                       | 10   | 40       | mV                 |
| Input Voltage   |  | -25                   |      | -7       | -25                   |      | -7       | V                  |
| Ripple Rejection  | $f = 120\text{ Hz}$  | 54                    | 64   |          | 54                    | 64   |          | dB                 |
| Load Regulation,<br>(Note 2)                                    | $T_J = 25^\circ\text{C}$ , $V_{IN} = 10\text{V}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                       | 30   | 50       |                       | 30   | 50       | mV                 |
| Output Voltage,<br>(Note 1)                                     | $-7.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$   | -5.20                 |      | -4.80    | -5.25                 |      | -4.75    | V                  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                       | 1    | 2        |                       | 1    | 2        | mA                 |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                       | 0.05 | 0.4      |                       | 0.05 | 0.4      | mA                 |
|   |  |                       | 0.04 | 0.4      |                       | 0.04 | 0.4      | mA                 |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1\ \mu\text{F}$ , $I_L = 5\text{ mA}$ ,<br>$V_{IN} = 10\text{V}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ |                       | 150  |          |                       | 150  |          | $\mu\text{V}$      |
| Long Term Stability   |  |                       | 5    | 50       |                       | 5    | 50       | mV                 |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient   |  |                       |      | (Note 4) |                       |      | (Note 4) | $^\circ\text{C/W}$ |
|   |  |                       |      | (Note 4) |                       |      | (Note 4) | $^\circ\text{C/W}$ |

## -5 Volt Regulators

### Electrical Characteristics (Note 3)

| Order Numbers   |  | Power Plastic Package  |            |            | Units              |
|---|--|------------------------|------------|------------|--------------------|
|   |  | LM320T-5.0<br>(TO-220) |            |            |                    |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 1.5A<br>15W            |            |            |                    |
| Parameter   | Conditions (Note 1)  | Min                    | Typ        | Max        |                    |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 10\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$   | -5.2                   | -5         | -4.8       | V                  |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$  |                        | 10         | 40         | mV                 |
| Input Voltage   |  | -25                    |            | -7.5       | V                  |
| Ripple Rejection  | $f = 120\text{ Hz}$  | 54                     | 64         |            | dB                 |
| Load Regulation,<br>(Note 2)                                    | $T_J = 25^\circ\text{C}$ , $V_{IN} = 10\text{V}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                        | 50         | 100        | mV                 |
| Output Voltage,<br>(Note 1)                                     | $-7.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$   | -5.25                  |            | -4.75      | V                  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                        | 1          |            | mA                 |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                        | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA           |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1\text{ }\mu\text{F}$ , $I_L = 5\text{ mA}$ ,<br>$V_{IN} = 10\text{V}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ |                        | 150        |            | $\mu\text{V}$      |
| Long Term Stability   |  |                        | 10         |            | mV                 |
| Thermal Resistance  |  |                        |            |            |                    |
| Junction to Case  |  |                        | 4          |            | $^\circ\text{C/W}$ |
| Junction to Ambient   |  |                        | 50         |            | $^\circ\text{C/W}$ |

**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 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.

**Note 4:** Thermal resistance of typically  $85^\circ\text{C/W}$  (in 400 linear feet air flow),  $224^\circ\text{C/W}$  (in static air) junction to ambient, of typically  $21^\circ\text{C/W}$  junction to case.

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

**Absolute Maximum Ratings****-12 Volt Regulators** (Note 9)

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

Power Dissipation Internally Limited  
Input Voltage -35V

Input-Output Voltage Differential 30V  
Junction Temperatures (Note 6)  
Storage Temperature Range -65°C to +150°C  
Lead Temperature (Soldering, 10 sec.) 300°C

**-12 Volt Regulators  
Electrical Characteristics**

| Order Numbers   |  | Metal Can Package   |     |       |                     |     |       | Units              |
|---|--|---------------------|-----|-------|---------------------|-----|-------|--------------------|
|   |  | LM120K-12<br>(TO-3) |     |       | LM320K-12<br>(TO-3) |     |       |                    |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 1A<br>20W           |     |       |                     |     |       |                    |
| Parameter   | Conditions (Note 6)  | Min                 | Typ | Max   | Min                 | Typ | Max   |                    |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$   | -12.3               | -12 | -11.7 | -12.4               | -12 | -11.6 | V                  |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$  |                     | 4   | 10    |                     | 4   | 20    | mV                 |
| Input Voltage   |  | -32                 |     | -14   | -32                 |     | -14   | V                  |
| Ripple Rejection  | $f = 120\text{ Hz}$  | 56                  | 80  |       | 56                  | 80  |       | dB                 |
| Load Regulation,<br>(Note 7)                                    | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                     | 30  | 80    |                     | 30  | 80    | mV                 |
| Output Voltage,<br>(Note 6)                                     | $14.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$   | -12.5               |     | -11.5 | -12.6               |     | -11.4 | V                  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                     | 2   | 4     |                     | 2   | 4     | mA                 |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                     | 0.1 | 0.4   |                     | 0.1 | 0.4   | mA                 |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1\text{ }\mu\text{F}$ , $I_L = 5\text{ mA}$ ,<br>$V_{IN} = 17\text{V}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ |                     | 400 |       |                     | 400 |       | $\mu\text{V}$      |
| Long Term Stability   |  |                     | 12  | 120   |                     | 12  | 120   | mV                 |
| Thermal Resistance<br>Junction to Case                          |  |                     |     | 3     |                     |     | 3     | $^\circ\text{C/W}$ |
| Junction to Ambient   |  |                     |     | 35    |                     |     | 35    | $^\circ\text{C/W}$ |

**-12 Volt Regulators  
Electrical Characteristics**

| Order Numbers   |   | Metal Can Package    |     |       |                      |     |       | Units |
|---|---|----------------------|-----|-------|----------------------|-----|-------|-------|
|   |   | LM120H-12<br>(TO-39) |     |       | LM320H-12<br>(TO-39) |     |       |       |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |   | 0.2A<br>2W           |     |       |                      |     |       |       |
| Parameter   | Conditions (Note 6)   | Min                  | Typ | Max   | Min                  | Typ | Max   |       |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$              | -12.3                | -12 | -11.7 | -12.4                | -12 | -11.6 | V     |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$ |                      | 4   | 10    |                      | 4   | 20    | mV    |

| Order Numbers   |  | Metal Can Package    |              |                      |                      |              |                      | Units                                    |
|---|--|----------------------|--------------|----------------------|----------------------|--------------|----------------------|--|
|   |  | LM120H-12<br>(TO-39) |              |                      | LM320H-12<br>(TO-39) |              |                      |  |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 0.2A<br>2W           |              |                      |                      |              |                      |  |
| Parameter   | Conditions (Note 6)  | Min                  | Typ          | Max                  | Min                  | Typ          | Max                  |  |
| Input Voltage   |  | -32                  |              | -14                  | -32                  |              | -14                  | V  |
| Ripple Rejection  | $f = 120 \text{ Hz}$   | 56                   | 80           |                      | 56                   | 80           |                      | dB                                       |
| Load Regulation,<br>(Note 7)                                    | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                      | 10           | 25                   |                      | 10           | 40                   | mV                                       |
| Output Voltage,<br>(Note 6)                                     | $14.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$  | -12.5                |              | -11.5                | -12.6                |              | -11.4                | V  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                      | 2            | 4                    |                      | 2            | 4                    | mA                                       |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                      | 0.05<br>0.03 | 0.4<br>0.4           |                      | 0.05<br>0.03 | 0.4<br>0.4           | mA<br>mA                                 |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1 \mu\text{F}$ , $I_L = 5 \text{ mA}$ ,<br>$V_{IN} = 17\text{V}$ , $10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ |                      | 400          |                      |                      | 400          |                      | $\mu\text{V}$                            |
| Long Term Stability   |  |                      | 12           | 120                  |                      | 12           | 120                  | mV                                       |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient   |  |                      |              | (Note 8)<br>(Note 8) |                      |              | (Note 8)<br>(Note 8) | $^\circ\text{C/W}$<br>$^\circ\text{C/W}$ |

## -12 Volt Regulators Electrical Characteristics

| Order Numbers   |  | Power Plastic Package |            |            | Units         |
|---|--|-----------------------|------------|------------|---------------|
|   |  | LM320T-12<br>(TO-220) |            |            |               |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 1A<br>15W             |            |            |               |
| Parameter   | Conditions (Note 6)  | Min                   | Typ        | Max        |               |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$I_{LOAD} = 5 \text{ mA}$  | -12.4                 | -12        | -11.6      | V             |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5 \text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                       | 4          | 20         | mV            |
| Input Voltage   |  | -32                   |            | -14.5      | V             |
| Ripple Rejection  | $f = 120 \text{ Hz}$   | 56                    | 80         |            | dB            |
| Load Regulation,<br>(Note 7)                                    | $T_J = 25^\circ\text{C}$ , $V_{IN} = 17\text{V}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                       | 30         | 80         | mV            |
| Output Voltage,<br>(Note 6)                                     | $14.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$  | -12.6                 |            | -11.4      | V             |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                       | 2          | 4          | mA            |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                       | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA      |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1 \mu\text{F}$ , $I_L = 5 \text{ mA}$ ,<br>$V_{IN} = 17\text{V}$ , $10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ |                       | 400        |            | $\mu\text{V}$ |
| Long Term Stability   |  |                       | 24         |            | mV            |

| Order Numbers                   |                     | Power Plastic Package |     |     | Units                       |
|---------------------------------|---------------------|-----------------------|-----|-----|-----------------------------|
|                                 |                     | LM320T-12<br>(TO-220) |     |     |                             |
| Design Output Current ( $I_D$ ) |                     | 1A                    |     |     |                             |
| Device Dissipation ( $P_D$ )    |                     | 15W                   |     |     |                             |
| Parameter                       | Conditions (Note 6) | Min                   | Typ | Max |                             |
| Thermal Resistance              |                     |                       |     |     |                             |
| Junction to Case                |                     |                       | 4   |     | $^{\circ}\text{C}/\text{W}$ |
| Junction to Ambient             |                     |                       | 50  |     | $^{\circ}\text{C}/\text{W}$ |

**Note 6:** 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 7:** 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 8:** Thermal resistance of typically  $85^{\circ}\text{C}/\text{W}$  (in 400 linear feet/min air flow),  $224^{\circ}\text{C}/\text{W}$  (in static air) junction to ambient, of typically  $21^{\circ}\text{C}/\text{W}$  junction to case.

**Note 9:** Refer to RETS120H-12 drawing for LM120H-12 or RETS120-12K drawing for LM120K-12 military specifications.

**Absolute Maximum Ratings****-15 Volt Regulators** (Note 13)

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

Power Dissipation Internally Limited  
Input Voltage

LM120/LM320 -40V  
LM320T -35V  
Input-Output Voltage Differential 30V  
Junction Temperatures (Note 10)  
Storage Temperature Range -65°C to +150°C  
Lead Temperature (Soldering, 10 sec.) 300°C

**-15 Volt Regulators  
Electrical Characteristics**

| Order Numbers   |  | Metal Can Package   |     |       |                     |     |       | Units              |
|---|--|---------------------|-----|-------|---------------------|-----|-------|--------------------|
|   |  | LM120K-15<br>(TO-3) |     |       | LM320K-15<br>(TO-3) |     |       |                    |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 1A<br>20W           |     |       |                     |     |       |                    |
| Parameter   | Conditions (Note 10)   | Min                 | Typ | Max   | Min                 | Typ | Max   |                    |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$   | -15.3               | -15 | -14.7 | -15.4               | -15 | -14.6 | V                  |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$  |                     | 5   | 10    |                     | 5   | 20    | mV                 |
| Input Voltage   |  | -35                 |     | -17   | -35                 |     | -17   | V                  |
| Ripple Rejection  | $f = 120\text{ Hz}$  | 56                  | 80  |       | 56                  | 80  |       | dB                 |
| Load Regulation,<br>(Note 11)                                   | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                     | 30  | 80    |                     | 30  | 80    | mV                 |
| Output Voltage,<br>(Note 10)                                    | $17.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$   | -15.5               |     | -14.5 | -15.6               |     | -14.4 | V                  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                     | 2   | 4     |                     | 2   | 4     | mA                 |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5\text{ mA} \leq I_{LOAD} \leq I_D$   |                     | 0.1 | 0.4   |                     | 0.1 | 0.4   | mA                 |
|   |  |                     | 0.1 | 0.4   |                     | 0.1 | 0.4   | mA                 |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1\ \mu\text{F}$ , $I_L = 5\text{ mA}$ ,<br>$V_{IN} = 20\text{V}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ |                     | 400 |       |                     | 400 |       | $\mu\text{V}$      |
| Long Term Stability   |  |                     | 15  | 150   |                     | 15  | 150   | mV                 |
| Thermal Resistance  | Junction to Case   |                     |     | 3     |                     |     | 3     | $^\circ\text{C/W}$ |
|   | Junction to Ambient  |                     |     | 35    |                     |     | 35    | $^\circ\text{C/W}$ |

**-15 Volt Regulators  
Electrical Characteristics**

| Order Numbers   |   | Metal Can Package    |     |       |                      |     |       | Units |
|---|---|----------------------|-----|-------|----------------------|-----|-------|-------|
|   |   | LM120H-15<br>(TO-39) |     |       | LM320H-15<br>(TO-39) |     |       |       |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |   | 0.2A<br>2W           |     |       |                      |     |       |       |
| Parameter   | Conditions (Note 10)  | Min                  | Typ | Max   | Min                  | Typ | Max   |       |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$I_{LOAD} = 5\text{ mA}$              | -15.3                | -15 | -14.7 | -15.4                | -15 | -14.6 | V     |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5\text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$ |                      | 5   | 10    |                      | 5   | 20    | mV    |



| Order Numbers   |  | Metal Can Package    |      |           |                      |      |           | Units              |
|---|--|----------------------|------|-----------|----------------------|------|-----------|--------------------|
|   |  | LM120H-15<br>(TO-39) |      |           | LM320H-15<br>(TO-39) |      |           |                    |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 0.2A<br>2W           |      |           |                      |      |           |                    |
| Parameter   | Conditions (Note 10)   | Min                  | Typ  | Max       | Min                  | Typ  | Max       |                    |
| Input Voltage   |  | -35                  |      | -17       | -35                  |      | -17       | V                  |
| Ripple Rejection  | $f = 120 \text{ Hz}$   | 56                   | 80   |           | 56                   | 80   |           | dB                 |
| Load Regulation,<br>(Note 11)                                   | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                      | 10   | 25        |                      | 10   | 40        | mV                 |
| Output Voltage,<br>(Note 10)                                    | $17.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$  | -15.5                |      | -14.5     | -15.6                |      | -14.4     | V                  |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                      | 2    | 4         |                      | 2    | 4         | mA                 |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                      | 0.05 | 0.4       |                      | 0.05 | 0.4       | mA                 |
|   |  |                      | 0.03 | 0.4       |                      | 0.03 | 0.4       | mA                 |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1 \mu\text{F}$ , $I_L = 5 \text{ mA}$ ,<br>$V_{IN} = 20\text{V}$ , $10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ |                      | 400  |           |                      | 400  |           | $\mu\text{V}$      |
| Long Term Stability   |  |                      | 15   | 150       |                      | 15   | 150       | mV                 |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient   |  |                      |      | (Note 12) |                      |      | (Note 12) | $^\circ\text{C/W}$ |
|   |  |                      |      | (Note 12) |                      |      | (Note 12) | $^\circ\text{C/W}$ |

## -15 Volt Regulators Electrical Characteristics

| Order Numbers   |  | Power Plastic Package |     |       | Units         |
|---|--|-----------------------|-----|-------|---------------|
|   |  | LM320T-15<br>(TO-220) |     |       |               |
| Design Output Current ( $I_D$ )<br>Device Dissipation ( $P_D$ ) |  | 1A<br>15W             |     |       |               |
| Parameter   | Conditions (Note 10)   | Min                   | Typ | Max   |               |
| Output Voltage  | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$I_{LOAD} = 5 \text{ mA}$  | -15.5                 | -15 | -14.5 | V             |
| Line Regulation   | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 5 \text{ mA}$ ,<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                       | 5   | 20    | mV            |
| Input Voltage   |  | -35                   |     | -17.5 | V             |
| Ripple Rejection  | $f = 120 \text{ Hz}$   | 56                    | 80  |       | dB            |
| Load Regulation,<br>(Note 11)                                   | $T_J = 25^\circ\text{C}$ , $V_{IN} = 20\text{V}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                       | 30  | 80    | mV            |
| Output Voltage,<br>(Note 10)                                    | $17.5\text{V} \leq V_{IN} \leq V_{MAX}$ ,<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$ , $P \leq P_D$  | -15.7                 |     | -14.3 | V             |
| Quiescent Current   | $V_{MIN} \leq V_{IN} \leq V_{MAX}$   |                       | 2   | 4     | mA            |
| Quiescent Current<br>Change                                     | $T_J = 25^\circ\text{C}$<br>$V_{MIN} \leq V_{IN} \leq V_{MAX}$<br>$5 \text{ mA} \leq I_{LOAD} \leq I_D$  |                       | 0.1 | 0.4   | mA            |
|   |  |                       | 0.1 | 0.4   | mA            |
| Output Noise Voltage  | $T_A = 25^\circ\text{C}$ , $C_L = 1 \mu\text{F}$ , $I_L = 5 \text{ mA}$ ,<br>$V_{IN} = 20\text{V}$ , $10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ |                       | 400 |       | $\mu\text{V}$ |
| Long Term Stability   |  |                       | 30  |       | mV            |

|                                 |                      |                       |     |     |       |
|---------------------------------|----------------------|-----------------------|-----|-----|-------|
| Order Numbers                   |                      | Power Plastic Package |     |     | Units |
|                                 |                      | LM320T-15<br>(TO-220) |     |     |       |
| Design Output Current ( $I_D$ ) |                      | 1A                    |     |     |       |
| Device Dissipation ( $P_D$ )    |                      | 15W                   |     |     |       |
| Parameter                       | Conditions (Note 10) | Min                   | Typ | Max |       |
| Thermal Resistance              |                      |                       |     |     |       |
| Junction to Case                |                      |                       | 4   |     | °C/W  |
| Junction to Ambient             |                      |                       | 50  |     | °C/W  |

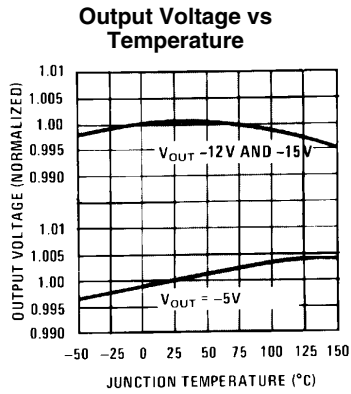
**Note 10:** This specification applies over  $-55^\circ\text{C} \leq T_J \leq +150^\circ\text{C}$  for the LM120 and  $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  for the LM320.

**Note 11:** 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  $P_D$ .

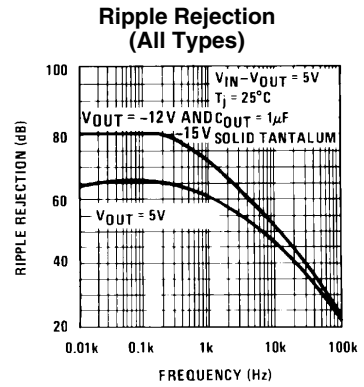
**Note 12:** Thermal resistance of typically  $85^\circ\text{C/W}$  (in 400 linear feet/min air flow),  $224^\circ\text{C/W}$  (in static air) junction to ambient, of typically  $21^\circ\text{C/W}$  junction to case.

**Note 13:** Refer to RETS120-15H drawing for LM120H-15 or RETS120-15K drawing for LM120K-15 military specifications.

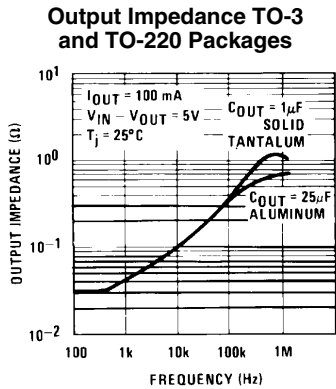
### Typical Performance Characteristics



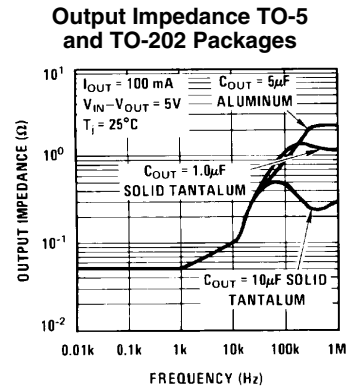
776720



776721

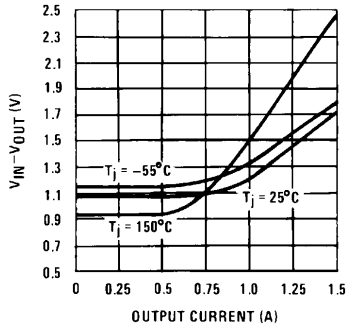


776722



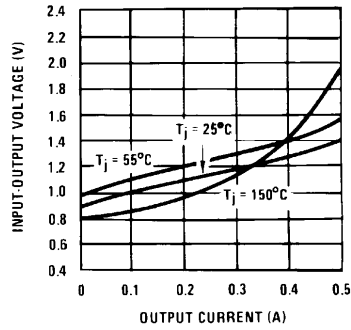
776723

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



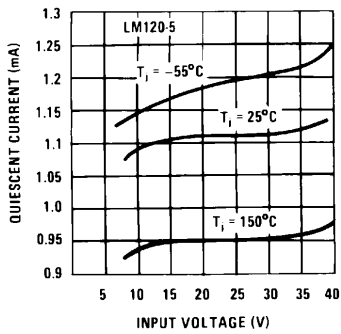
776724

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



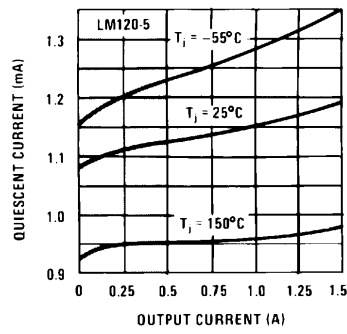
776725

Quiescent Current vs Input Voltage



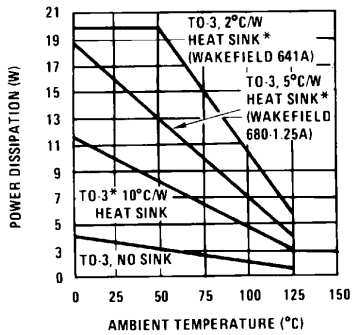
776726

Quiescent Current vs Load Current



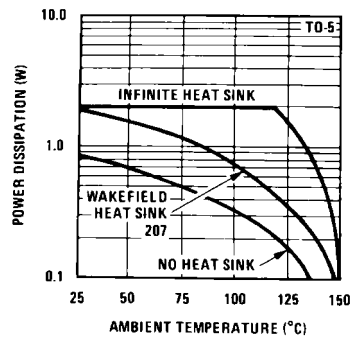
776727

Maximum Average Power Dissipation (TO-3)



776728

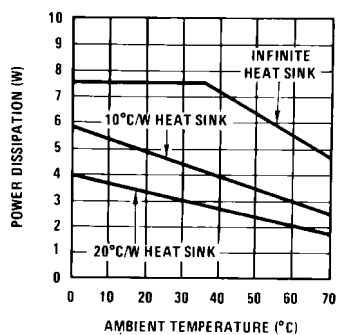
Maximum Average Power Dissipation (TO-5)



776729

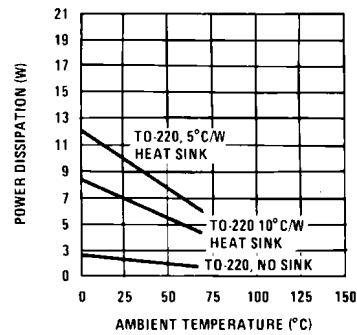
\*These curves for LM120. Derate 25°C further for LM320.

Maximum Average Power Dissipation (TO-202)

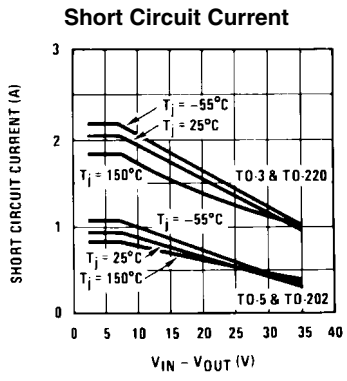


776730

Maximum Average Power Dissipation (TO-220)



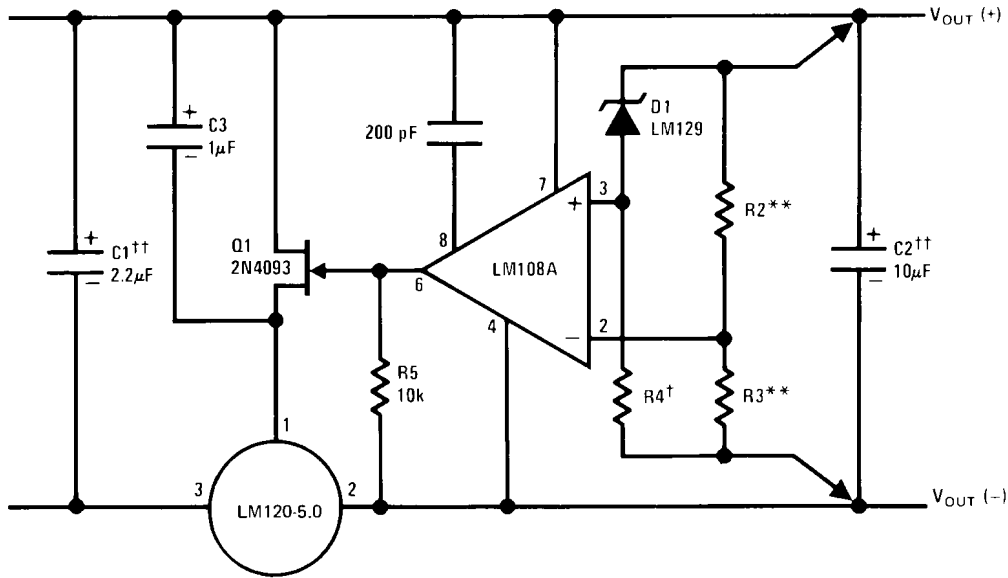
776731



776732

# Typical Applications

## High Stability 1 Amp Regulator



776706

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

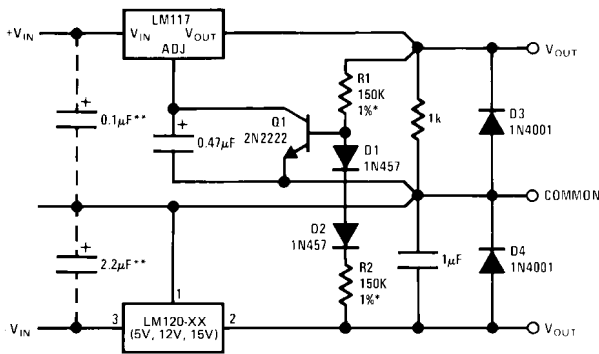
†Determines Zener current.

††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



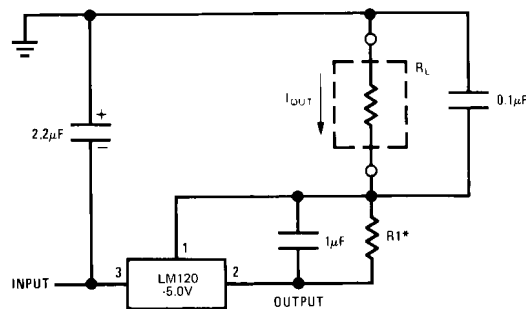
776707

\*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.

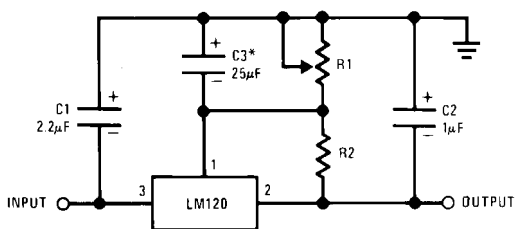
## Current Source



776708

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

## Variable Output Current Source



776709

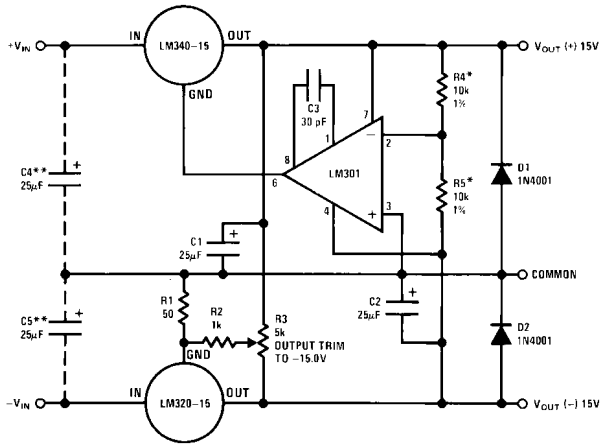
SELECT R2 AS FOLLOWS:

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

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

\*C3 optional. Improves transient response and ripple rejection.

±15V, 1 Amp Tracking Regulators



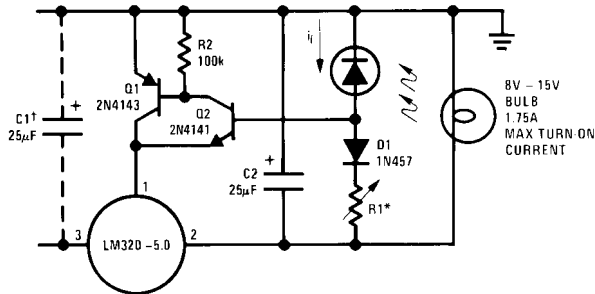
776712

Performance (Typical)

|   |                   |                   |
|---|-------------------|-------------------|
| Load Regulation at $\Delta I_L = 1A$              | 10 mV             | 1 mV              |
| Output Ripple, $C_{IN} = 3000 \mu F$ , $I_L = 1A$ | 100 $\mu V_{rms}$ | 100 $\mu V_{rms}$ |
| Temperature Stability                             | +50 mV            | +50 mV            |
| Output Noise 10 Hz $\leq f \leq 10$ kHz           | 150 $\mu V_{rms}$ | 150 $\mu V_{rms}$ |

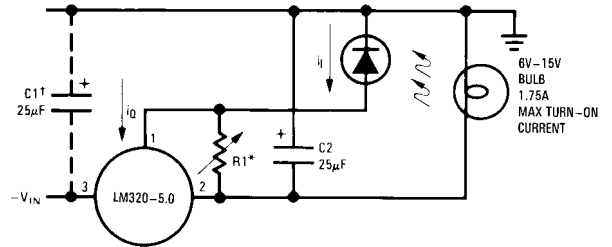
\*Resistor tolerance of R4 and R5 determine matching of (+) and (-) outputs.  
 \*\*Necessary only if raw supply filter capacitors are more than 2 inches from regulators.

Light Controllers Using Silicon Photo Cells



776710

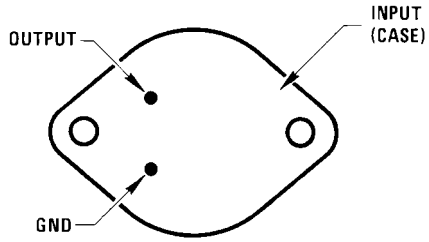
\*Lamp brightness increases until  $i_l = 5V/R1$  ( $i_l$  can be set as low as 1  $\mu A$ ).  
 †Necessary only if raw supply filter capacitor is more than 2 inches from LM320MP.



776711

\*Lamp brightness increases until  $i_l = i_O (1 mA) + 5V/R1$ .  
 †Necessary only if raw supply filter capacitor is more than 2 inches from LM320.

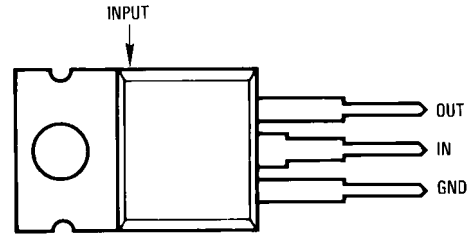
## Connection Diagrams



776714

### Bottom View

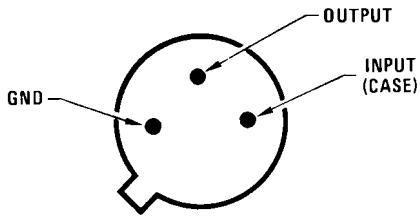
Steel Metal Can Package TO-3 (K)  
 Order Number LM120K-5.0/883, LM120K-12/883,  
 LM120K-15/883, LM320K-5.0, LM320K-12 or LM320K-15  
 See NS Package Number K02A



776717

### Front View

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

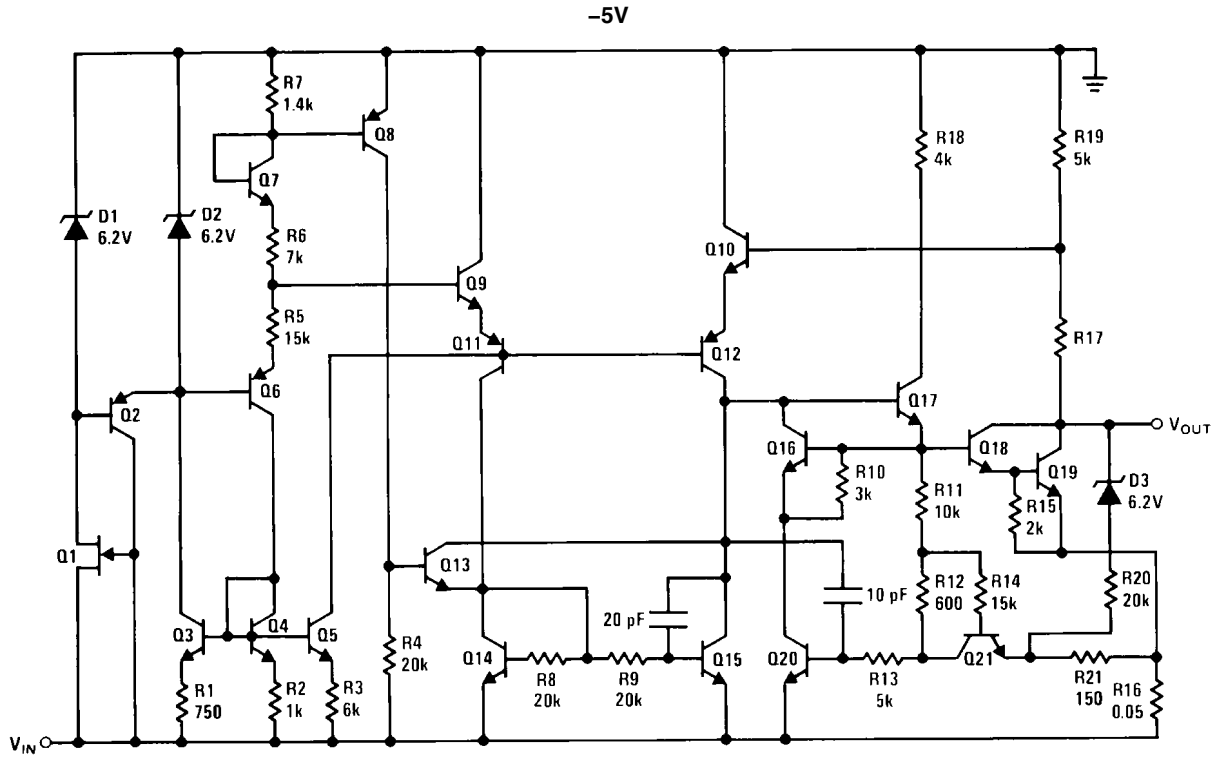


776713

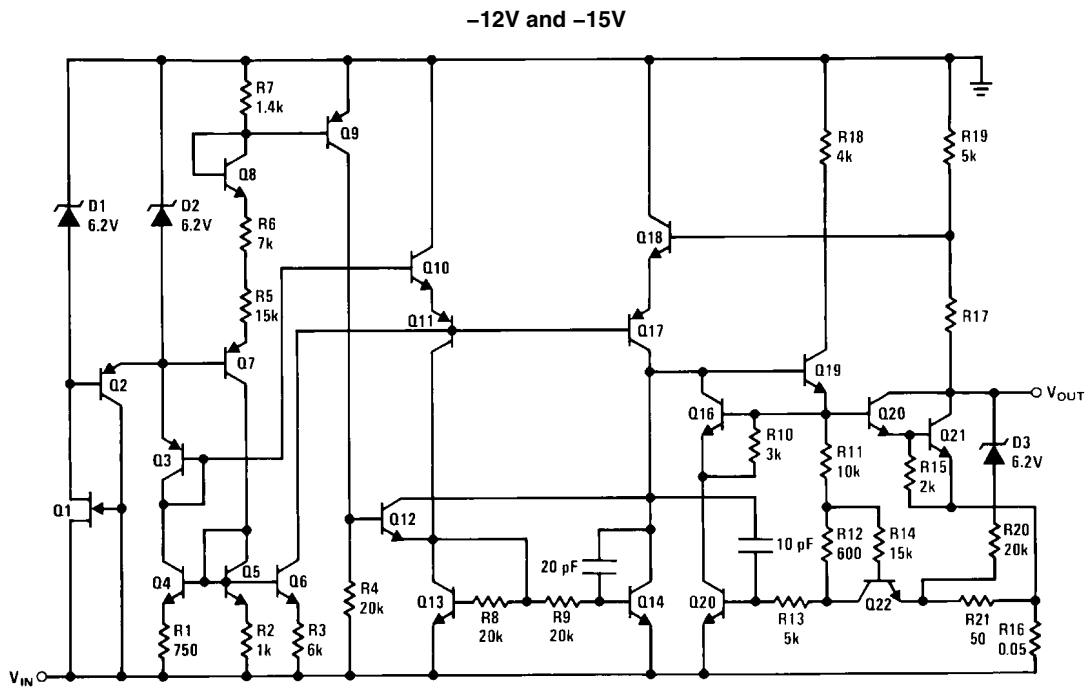
### Bottom View

Metal Can Package TO-39 (H)  
 Order Number LM120H-5.0, LM120H-12, LM120H-15,  
 LM120H-5.0/883, LM120H-12/883, LM120H-15/883,  
 LM320H-5.0, LM320H-12 or LM320H-15  
 See NS Package Number H03A

# Schematic Diagrams



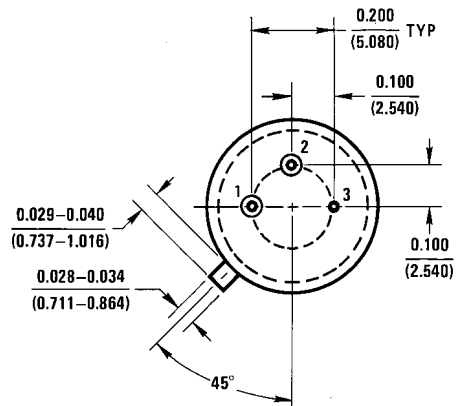
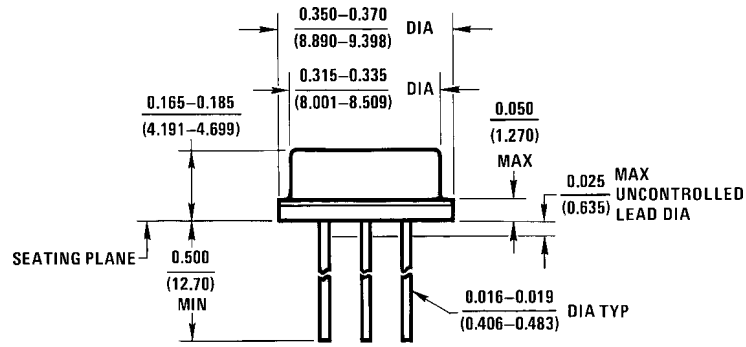
776718



776719

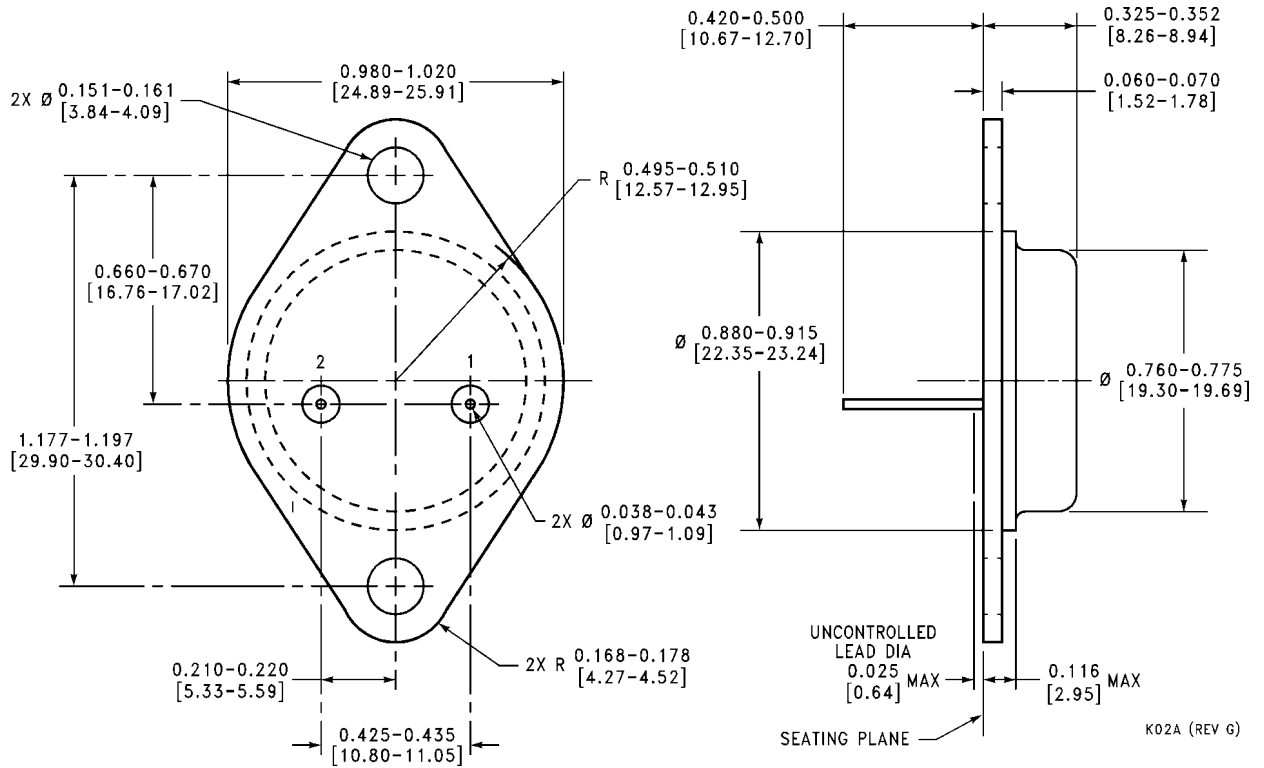


**Physical Dimensions** inches (millimeters) unless otherwise noted

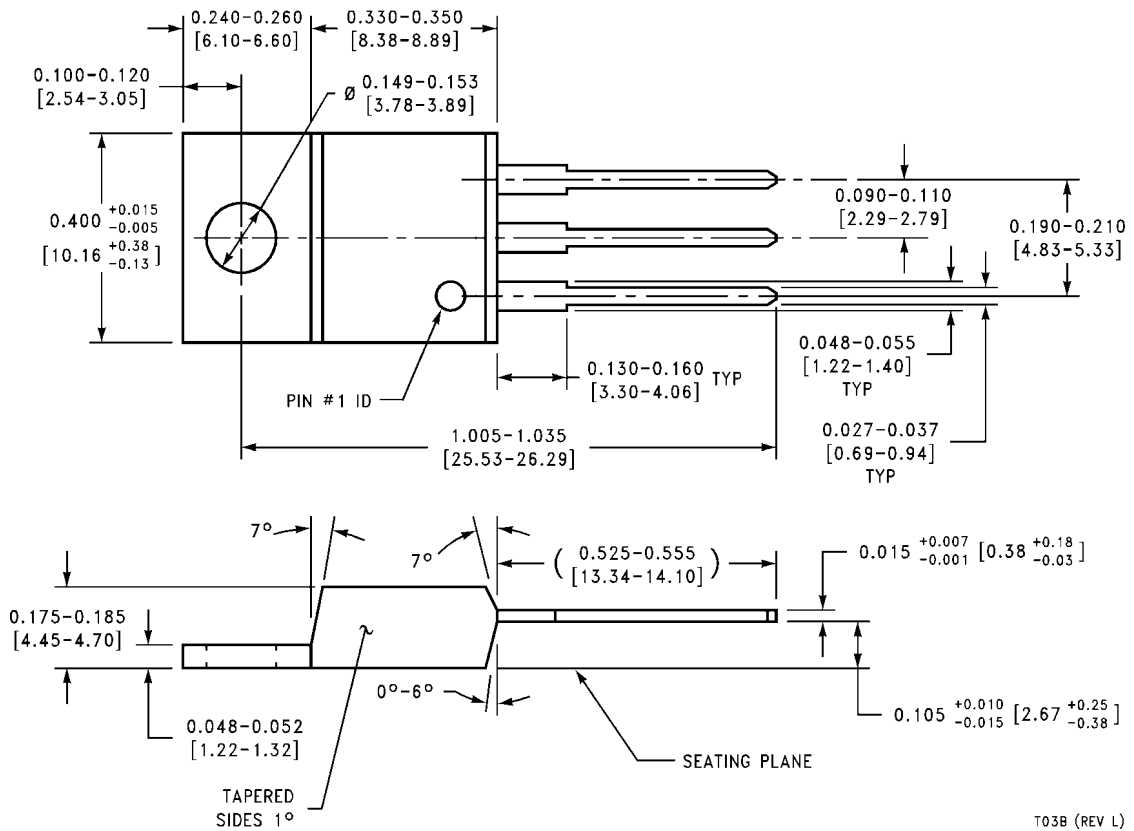


H03A (REV B)

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



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



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

# Notes

LM120/LM320

## Notes

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| Audio                          | <a href="http://www.national.com/audio">www.national.com/audio</a>           | Analog University       | <a href="http://www.national.com/AU">www.national.com/AU</a>                       |
| Clock Conditioners             | <a href="http://www.national.com/timing">www.national.com/timing</a>         | App Notes               | <a href="http://www.national.com/appnotes">www.national.com/appnotes</a>           |
| Data Converters                | <a href="http://www.national.com/adc">www.national.com/adc</a>               | Distributors            | <a href="http://www.national.com/contacts">www.national.com/contacts</a>           |
| Displays                       | <a href="http://www.national.com/displays">www.national.com/displays</a>     | Green Compliance        | <a href="http://www.national.com/quality/green">www.national.com/quality/green</a> |
| Ethernet                       | <a href="http://www.national.com/ethernet">www.national.com/ethernet</a>     | Packaging               | <a href="http://www.national.com/packaging">www.national.com/packaging</a>         |
| Interface                      | <a href="http://www.national.com/interface">www.national.com/interface</a>   | Quality and Reliability | <a href="http://www.national.com/quality">www.national.com/quality</a>             |
| LVDS                           | <a href="http://www.national.com/lvds">www.national.com/lvds</a>             | Reference Designs       | <a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>       |
| Power Management               | <a href="http://www.national.com/power">www.national.com/power</a>           | Feedback                | <a href="http://www.national.com/feedback">www.national.com/feedback</a>           |
| Switching Regulators           | <a href="http://www.national.com/switchers">www.national.com/switchers</a>   |                         |  |
| LDOs                           | <a href="http://www.national.com/ldo">www.national.com/ldo</a>               |                         |  |
| LED Lighting                   | <a href="http://www.national.com/led">www.national.com/led</a>               |                         |  |
| PowerWise                      | <a href="http://www.national.com/powerwise">www.national.com/powerwise</a>   |                         |  |
| Serial Digital Interface (SDI) | <a href="http://www.national.com/sdi">www.national.com/sdi</a>               |                         |  |
| Temperature Sensors            | <a href="http://www.national.com/tempensors">www.national.com/tempensors</a> |                         |  |
| Wireless (PLL/VCO)             | <a href="http://www.national.com/wireless">www.national.com/wireless</a>     |                         |  |

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