

## LM120/LM320-N Series 3-Terminal Negative Regulators

Check for Samples: [LM120](#), [LM320-N](#)

### 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

### 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 specifications on output voltage deviation due to any combination of line, load or temperature variation assure satisfactory system operation.

### Typical Applications

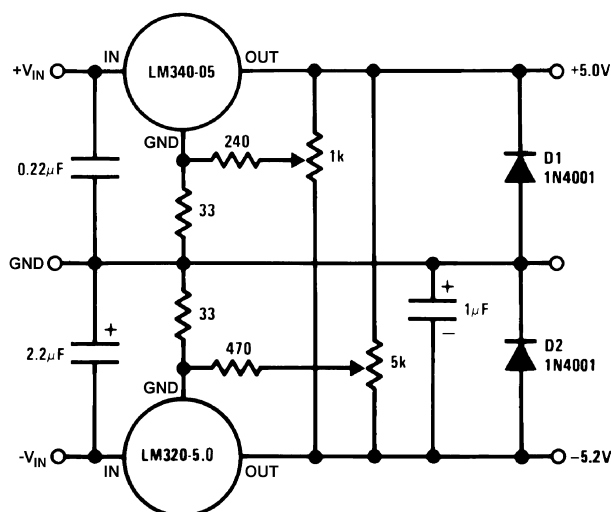


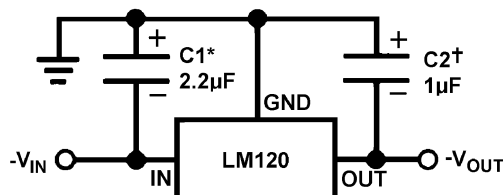
Figure 1. Dual Trimmed Supply

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.

Table 1. LM120 Series Packages and Power Capability

| Device        | Package      | Rated Power Dissipation | Design Load Current |
|---------------|--------------|-------------------------|---------------------|
| LM120/LM320-N | TO-3 (NDS)   | 20W                     | 1.5A                |
|               | TO (NDT)     | 2W                      | 0.5A                |
| LM320-N       | TO-220 (NDE) | 15W                     | 1.5A                |



\*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.

Figure 2. Fixed Regulator



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS–5 VOLT REGULATORS<sup>(1)(2)(3)</sup>

|                                   |                    |
|-----------------------------------|--------------------|
| Power Dissipation                 | Internally Limited |
| Input Voltage                     | –25V               |
| Input-Output Voltage Differential | 25V                |
| Junction Temperatures             | <sup>(4)</sup>     |
| Storage Temperature Range         | –65°C to +150°C    |
| Lead Temperature                  |                    |
| (Soldering, 10 sec.)              | 300°C              |
| Plastic                           | 260°C              |

(1) Refer to RETS120-5H drawing for LM120H-5.0 or RETS120-5K drawing for LM120-5K military specifications.

(2) For –5V 3 amp regulators, see LM145 data sheet.

(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(4) 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-N.

## LM120K-5.0 AND LM320K-5.0 ELECTRICAL CHARACTERISTICS<sup>(1)</sup>

| Order Numbers                                                                   |                                                                                                                             | Metal Can Package    |            |            |                      |            |            | Units    |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------|------------|------------|----------------------|------------|------------|----------|
|                                                                                 |                                                                                                                             | LM120K-5.0<br>(TO-3) |            |            | LM320K-5.0<br>(TO-3) |            |            |          |
| Design Output Current (I <sub>D</sub> )<br>Device Dissipation (P <sub>D</sub> ) |                                                                                                                             | 1.5A<br>20W          |            |            |                      |            |            |          |
| Parameter                                                                       | Conditions <sup>(2)</sup>                                                                                                   | Min                  | Typ        | Max        | Min                  | Typ        | Max        |          |
| Output Voltage                                                                  | T <sub>J</sub> = 25°C, V <sub>IN</sub> =10V,<br>I <sub>LOAD</sub> = 5 mA                                                    | –5.1                 | –5         | –4.9       | –5.2                 | –5         | –4.8       | V        |
| Line Regulation                                                                 | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                      | 10         | 25         |                      | 10         | 40         | mV       |
| Input Voltage                                                                   |                                                                                                                             | –25                  |            | –7         | –25                  |            | –7         | V        |
| Ripple Rejection                                                                | f = 120 Hz                                                                                                                  | 54                   | 64         |            | 54                   | 64         |            | dB       |
| Load Regulation,<br>(3)                                                         | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 10V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                      | 50         | 75         |                      | 60         | 100        | mV       |
| Output Voltage,<br>(2)                                                          | –7.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | –5.20                |            | –4.80      | –5.25                |            | –4.75      | V        |
| Quiescent Current                                                               | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                      | 1          | 2          |                      | 1          | 2          | mA       |
| Quiescent Current<br>Change                                                     | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                      | 0.1<br>0.1 | 0.4<br>0.4 |                      | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA |
| Output Noise Voltage                                                            | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 10V, 10 Hz ≤ f ≤ 100 kHz          |                      | 150        |            |                      | 150        |            | μV       |
| Long Term Stability                                                             |                                                                                                                             |                      | 5          | 50         |                      | 5          | 50         | mV       |
| Thermal Resistance                                                              |                                                                                                                             |                      |            |            |                      |            |            |          |
| Junction to Case                                                                |                                                                                                                             |                      |            | 3          |                      |            | 3          | °C/W     |
| Junction to Ambient                                                             |                                                                                                                             |                      |            | 35         |                      |            | 35         | °C/W     |

(1) For –5V 3 amp regulators, see LM145 data sheet.

(2) 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-N.

(3) 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-N 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  $P_D$ .

**LM120H-5.0 ELECTRICAL CHARACTERISTICS<sup>(1)</sup>**

| Order Numbers                                                                   |                                                                                                                             | Metal Can Package  |      |       | Units |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|--------------------|------|-------|-------|
|                                                                                 |                                                                                                                             | LM120H-5.0<br>(TO) |      |       |       |
| Design Output Current (I <sub>D</sub> )<br>Device Dissipation (P <sub>D</sub> ) |                                                                                                                             | 0.5A<br>2W         |      |       |       |
| Parameter                                                                       | Conditions <sup>(2)</sup>                                                                                                   | Min                | Typ  | Max   |       |
| Output Voltage                                                                  | T <sub>J</sub> = 25°C, V <sub>IN</sub> =10V,<br>I <sub>LOAD</sub> = 5 mA                                                    | -5.1               | -5   | -4.9  | V     |
| Line Regulation                                                                 | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                    | 10   | 25    | mV    |
| Input Voltage                                                                   |                                                                                                                             | -25                |      | -7    | V     |
| Ripple Rejection                                                                | f = 120 Hz                                                                                                                  | 54                 | 64   |       | dB    |
| Load Regulation,<br>(3)                                                         | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 10V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                    | 30   | 50    | mV    |
| Output Voltage,<br>(4)                                                          | -7.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -5.20              |      | -4.80 | V     |
| Quiescent Current                                                               | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                    | 1    | 2     | mA    |
| Quiescent Current<br>Change                                                     | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                    | 0.05 | 0.4   | mA    |
|                                                                                 |                                                                                                                             |                    | 0.04 | 0.4   | mA    |
| Output Noise Voltage                                                            | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 10V, 10 Hz ≤ f ≤ 100 kHz          |                    | 150  |       | μV    |
| Long Term Stability                                                             |                                                                                                                             |                    | 5    |       | mV    |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient                   |                                                                                                                             |                    |      | (5)   | °C/W  |
|                                                                                 |                                                                                                                             |                    |      | (5)   | °C/W  |

(1) For -5V 3 amp regulators, see LM145 data sheet.

(2) 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-N.

(3) 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-N 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  $P_D$ .

(4) 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-N.

(5) 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.

**ABSOLUTE MAXIMUM RATINGS-12 VOLT REGULATORS<sup>(1)(2)</sup>**

|                                   |                                             |
|-----------------------------------|---------------------------------------------|
| Power Dissipation                 | Internally Limited                          |
| Input Voltage                     | -35V                                        |
| Input-Output Voltage Differential | 30V                                         |
| Junction Temperatures             | (3)                                         |
| Storage Temperature Range         | $-65^\circ\text{C}$ to $+150^\circ\text{C}$ |
| Lead Temperature                  |                                             |
| (Soldering, 10 sec.)              | 300°C                                       |

(1) Refer to RETS120H-12 drawing for LM120H-12 or RETS120-12K drawing for LM120K-12 military specifications.

(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(3) 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-N.

**LM120K-12 ELECTRICAL CHARACTERISTICS**

| Order Numbers                                                 |                                                                                                                             | Metal Can Package   |            |            | Units        |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------|------------|------------|--------------|
|                                                               |                                                                                                                             | LM120K-12<br>(TO-3) |            |            |              |
| Design Output Current (I <sub>D</sub> )                       |                                                                                                                             | 1A                  |            |            |              |
| Device Dissipation (P <sub>D</sub> )                          |                                                                                                                             | 20W                 |            |            |              |
| Parameter                                                     | Conditions <sup>(1)</sup>                                                                                                   | Min                 | Typ        | Max        |              |
| Output Voltage                                                | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,<br>I <sub>LOAD</sub> = 5 mA                                                   | -12.3               | -12        | -11.7      | V            |
| Line Regulation                                               | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                     | 4          | 10         | mV           |
| Input Voltage                                                 |                                                                                                                             | -32                 |            | -14        | V            |
| Ripple Rejection                                              | f = 120 Hz                                                                                                                  | 56                  | 80         |            | dB           |
| Load Regulation,<br><sup>(2)</sup>                            | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                     | 30         | 80         | mV           |
| Output Voltage,<br><sup>(3)</sup>                             | 14.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -12.5               |            | -11.5      | V            |
| Quiescent Current                                             | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                     | 2          | 4          | mA           |
| Quiescent Current<br>Change                                   | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                     | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA     |
| Output Noise Voltage                                          | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 17V, 10 Hz ≤ f ≤ 100 kHz          |                     | 400        |            | μV           |
| Long Term Stability                                           |                                                                                                                             |                     | 12         | 120        | mV           |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient |                                                                                                                             |                     |            | 3<br>35    | °C/W<br>°C/W |

(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-N.

(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-N 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  $P_D$ .

(3) 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-N.

**LM120H-12 ELECTRICAL CHARACTERISTICS**

| Order Numbers                           |                                                                                                           | Metal Can Package |     |       | Units |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------|-----|-------|-------|
|                                         |                                                                                                           | LM120H-12<br>(TO) |     |       |       |
| Design Output Current (I <sub>O</sub> ) |                                                                                                           | 0.2A              |     |       |       |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                           | 2W                |     |       |       |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                 | Min               | Typ | Max   |       |
| Output Voltage                          | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,<br>I <sub>LOAD</sub> = 5 mA                                 | -12.3             | -12 | -11.7 | V     |
| Line Regulation                         | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> |                   | 4   | 10    | mV    |
| Input Voltage                           |                                                                                                           | -32               |     | -14   | V     |
| Ripple Rejection                        | f = 120 Hz                                                                                                | 56                | 80  |       | dB    |
| Load Regulation,                        | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,                                                             |                   | 10  | 25    | mV    |

(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-N.

**LM120H-12 ELECTRICAL CHARACTERISTICS (continued)**

| Order Numbers                           |                                                                                                                             | Metal Can Package |              |            | Units    |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------|--------------|------------|----------|
|                                         |                                                                                                                             | LM120H-12<br>(TO) |              |            |          |
| Design Output Current (I <sub>D</sub> ) |                                                                                                                             | 0.2A              |              |            |          |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                                             | 2W                |              |            |          |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                                   | Min               | Typ          | Max        |          |
| (2)                                     | 5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                                                                   |                   |              |            |          |
| Output Voltage,<br>(1)                  | 14.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -12.5             |              | -11.5      | V        |
| Quiescent Current                       | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                   | 2            | 4          | mA       |
| Quiescent Current<br>Change             | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                   | 0.05<br>0.03 | 0.4<br>0.4 | mA<br>mA |
| Output Noise Voltage                    | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 17V, 10 Hz ≤ f ≤ 100 kHz          |                   | 400          |            | μV       |
| Long Term Stability                     |                                                                                                                             |                   | 12           | 120        | mV       |
| Thermal Resistance<br>Junction to Case  |                                                                                                                             |                   |              | (3)        | °C/W     |
| Junction to Ambient                     |                                                                                                                             |                   |              | (3)        | °C/W     |

- (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-N 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  $P_D$ .
- (3) 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.

**LM320T-12 ELECTRICAL CHARACTERISTICS**

| Order Numbers                           |                                                                                                                             | Power Plastic Package |            |            | Units    |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------|------------|------------|----------|
|                                         |                                                                                                                             | LM320T-12<br>(TO-220) |            |            |          |
| Design Output Current (I <sub>D</sub> ) |                                                                                                                             | 1A                    |            |            |          |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                                             | 15W                   |            |            |          |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                                   | Min                   | Typ        | Max        |          |
| Output Voltage                          | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,<br>I <sub>LOAD</sub> = 5 mA                                                   | -12.4                 | -12        | -11.6      | V        |
| Line Regulation                         | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                       | 4          | 20         | mV       |
| Input Voltage                           |                                                                                                                             | -32                   |            | -14.5      | V        |
| Ripple Rejection                        | f = 120 Hz                                                                                                                  | 56                    | 80         |            | dB       |
| Load Regulation,<br>(2)                 | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 17V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                       | 30         | 80         | mV       |
| Output Voltage,<br>(1)                  | 14.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -12.6                 |            | -11.4      | V        |
| Quiescent Current                       | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                       | 2          | 4          | mA       |
| Quiescent Current<br>Change             | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                       | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA |

- (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-N.
- (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-N 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  $P_D$ .

**LM320T-12 ELECTRICAL CHARACTERISTICS (continued)**

| Order Numbers                           |                                                                                                                    | Power Plastic Package |     |     | Units |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------|-----|-----|-------|
|                                         |                                                                                                                    | LM320T-12<br>(TO-220) |     |     |       |
| Design Output Current (I <sub>D</sub> ) |                                                                                                                    | 1A                    |     |     |       |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                                    | 15W                   |     |     |       |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                          | Min                   | Typ | Max |       |
| Output Noise Voltage                    | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 17V, 10 Hz ≤ f ≤ 100 kHz |                       | 400 |     | μV    |
| Long Term Stability                     |                                                                                                                    |                       | 24  |     | mV    |
| Thermal Resistance<br>Junction to Case  |                                                                                                                    |                       | 4   |     | °C/W  |
| Junction to Ambient                     |                                                                                                                    |                       | 50  |     | °C/W  |

**ABSOLUTE MAXIMUM RATINGS–15 VOLT REGULATORS <sup>(1)(2)</sup>**

|                                          |                                               |
|------------------------------------------|-----------------------------------------------|
| Power Dissipation                        | Internally Limited                            |
| Input Voltage                            |                                               |
| LM120/LM320-N                            | –40V                                          |
| LM320T                                   | –35V                                          |
| Input-Output Voltage Differential        | 30V                                           |
| Junction Temperatures                    | <sup>(3)</sup>                                |
| Storage Temperature Range                | –65 $^\circ\text{C}$ to +150 $^\circ\text{C}$ |
| Lead Temperature<br>(Soldering, 10 sec.) | 300 $^\circ\text{C}$                          |

(1) Refer to RETS120-15H drawing for LM120H-15 or RETS120-15K drawing for LM120K-15 military specifications.

(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(3) 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-N.

**LM120K-15 AND LM320K-15 ELECTRICAL CHARACTERISTICS**

| Order Numbers                           |                                                                                                                | Metal Can Package   |     |       |                     |     |       | Units |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------|---------------------|-----|-------|---------------------|-----|-------|-------|
|                                         |                                                                                                                | LM120K-15<br>(TO-3) |     |       | LM320K-15<br>(TO-3) |     |       |       |
| Design Output Current (I <sub>D</sub> ) |                                                                                                                | 1A                  |     |       |                     |     |       |       |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                                | 20W                 |     |       |                     |     |       |       |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                      | Min                 | Typ | Max   | Min                 | Typ | Max   |       |
| Output Voltage                          | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>I <sub>LOAD</sub> = 5 mA                                      | -15.3               | -15 | -14.7 | -15.4               | -15 | -14.6 | V     |
| Line Regulation                         | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>      |                     | 5   | 10    |                     | 5   | 20    | mV    |
| Input Voltage                           |                                                                                                                | -35                 |     | -17   | -35                 |     | -17   | V     |
| Ripple Rejection                        | f = 120 Hz                                                                                                     | 56                  | 80  |       | 56                  | 80  |       | dB    |
| Load Regulation,<br>(2)                 | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                     |                     | 30  | 80    |                     | 30  | 80    | mV    |
| Output Voltage,<br>(1)                  | 17.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub> | -15.5               |     | -14.5 | -15.6               |     | -14.4 | V     |
| Quiescent Current                       | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                          |                     | 2   | 4     |                     | 2   | 4     | mA    |

(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-N.

(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-N 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  $P_D$ .

**LM120K-15 AND LM320K-15 ELECTRICAL CHARACTERISTICS (continued)**

| Order Numbers                           |                                                                                                                    | Metal Can Package   |     |                     |     |     |     | Units |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------|-----|---------------------|-----|-----|-----|-------|
|                                         |                                                                                                                    | LM120K-15<br>(TO-3) |     | LM320K-15<br>(TO-3) |     |     |     |       |
| Design Output Current (I <sub>b</sub> ) |                                                                                                                    | 1A                  |     |                     |     |     |     |       |
| Device Dissipation (P <sub>D</sub> )    |                                                                                                                    | 20W                 |     |                     |     |     |     |       |
| Parameter                               | Conditions <sup>(1)</sup>                                                                                          | Min                 | Typ | Max                 | Min | Typ | Max |       |
| Quiescent Current<br>Change             | T <sub>J</sub> = 25°C                                                                                              |                     |     |                     |     |     |     |       |
|                                         | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                              |                     | 0.1 | 0.4                 |     | 0.1 | 0.4 | mA    |
|                                         | 5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                                                          |                     | 0.1 | 0.4                 |     | 0.1 | 0.4 | mA    |
| Output Noise Voltage                    | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 20V, 10 Hz ≤ f ≤ 100 kHz |                     | 400 |                     |     | 400 |     | μV    |
| Long Term Stability                     |                                                                                                                    |                     | 15  | 150                 |     | 15  | 150 | mV    |
| Thermal Resistance                      |                                                                                                                    |                     |     |                     |     |     |     |       |
| Junction to Case                        |                                                                                                                    |                     |     | 3                   |     |     | 3   | °C/W  |
| Junction to Ambient                     |                                                                                                                    |                     |     | 35                  |     |     | 35  | °C/W  |

**LM120H-15 ELECTRICAL CHARACTERISTICS**

| Order Numbers                                                 |                                                                                                                             | Metal Can Package |              |                                  | Units        |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------|--------------|----------------------------------|--------------|
|                                                               |                                                                                                                             | LM120H-15<br>(TO) |              |                                  |              |
| Design Output Current (I <sub>D</sub> )                       |                                                                                                                             | 0.2A              |              |                                  |              |
| Device Dissipation (P <sub>D</sub> )                          |                                                                                                                             | 2W                |              |                                  |              |
| Parameter                                                     | Conditions <sup>(1)</sup>                                                                                                   | Min               | Typ          | Max                              |              |
| Output Voltage                                                | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>I <sub>LOAD</sub> = 5 mA                                                   | -15.3             | -15          | -14.7                            | V            |
| Line Regulation                                               | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                   | 5            | 10                               | mV           |
| Input Voltage                                                 |                                                                                                                             | -35               |              | -17                              | V            |
| Ripple Rejection                                              | f = 120 Hz                                                                                                                  | 56                | 80           |                                  | dB           |
| Load Regulation,<br><sup>(2)</sup>                            | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                   | 10           | 25                               | mV           |
| Output Voltage,<br><sup>(1)</sup>                             | 17.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -15.5             |              | -14.5                            | V            |
| Quiescent Current                                             | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                   | 2            | 4                                | mA           |
| Quiescent Current<br>Change                                   | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                   | 0.05<br>0.03 | 0.4<br>0.4                       | mA<br>mA     |
| Output Noise Voltage                                          | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 20V, 10 Hz ≤ f ≤ 100 kHz          |                   | 400          |                                  | μV           |
| Long Term Stability                                           |                                                                                                                             |                   | 15           | 150                              | mV           |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient |                                                                                                                             |                   |              | <sup>(3)</sup><br><sup>(3)</sup> | °C/W<br>°C/W |

(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-N.

(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-N 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  $P_D$ .

(3) 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.

**LM320T-15 ELECTRICAL CHARACTERISTICS**

| Order Numbers                                                 |                                                                                                                             | Power Plastic Package |            |            | Units        |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------|------------|------------|--------------|
|                                                               |                                                                                                                             | LM320T-15<br>(TO-220) |            |            |              |
| Design Output Current (I <sub>D</sub> )                       |                                                                                                                             | 1A                    |            |            |              |
| Device Dissipation (P <sub>D</sub> )                          |                                                                                                                             | 15W                   |            |            |              |
| Parameter                                                     | Conditions <sup>(1)</sup>                                                                                                   | Min                   | Typ        | Max        |              |
| Output Voltage                                                | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>I <sub>LOAD</sub> = 5 mA                                                   | -15.5                 | -15        | -14.5      | V            |
| Line Regulation                                               | T <sub>J</sub> = 25°C, I <sub>LOAD</sub> = 5 mA,<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                   |                       | 5          | 20         | mV           |
| Input Voltage                                                 |                                                                                                                             | -35                   |            | -17.5      | V            |
| Ripple Rejection                                              | f = 120 Hz                                                                                                                  | 56                    | 80         |            | dB           |
| Load Regulation,<br><sup>(2)</sup>                            | T <sub>J</sub> = 25°C, V <sub>IN</sub> = 20V,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub>                                  |                       | 30         | 80         | mV           |
| Output Voltage,<br><sup>(1)</sup>                             | 17.5V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> ,<br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> , P ≤ P <sub>D</sub>              | -15.7                 |            | -14.3      | V            |
| Quiescent Current                                             | V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>                                                                       |                       | 2          | 4          | mA           |
| Quiescent Current<br>Change                                   | T <sub>J</sub> = 25°C<br>V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub><br>5 mA ≤ I <sub>LOAD</sub> ≤ I <sub>D</sub> |                       | 0.1<br>0.1 | 0.4<br>0.4 | mA<br>mA     |
| Output Noise Voltage                                          | T <sub>A</sub> = 25°C, C <sub>L</sub> = 1 μF, I <sub>L</sub> = 5 mA,<br>V <sub>IN</sub> = 20V, 10 Hz ≤ f ≤ 100 kHz          |                       | 400        |            | μV           |
| Long Term Stability                                           |                                                                                                                             |                       | 30         |            | mV           |
| Thermal Resistance<br>Junction to Case<br>Junction to Ambient |                                                                                                                             |                       | 4<br>50    |            | °C/W<br>°C/W |

(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-N.

(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-N 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  $P_D$ .

## TYPICAL PERFORMANCE CHARACTERISTICS

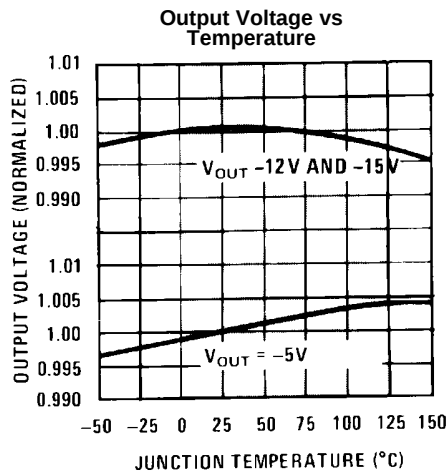


Figure 3.

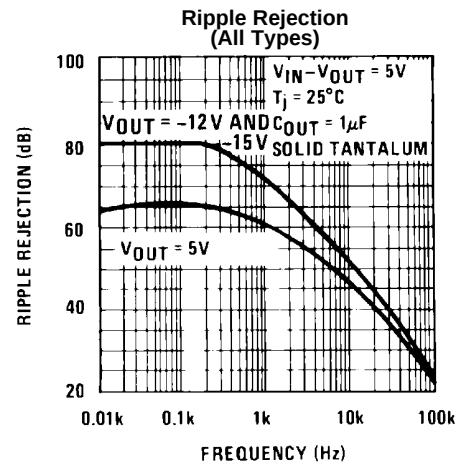


Figure 4.

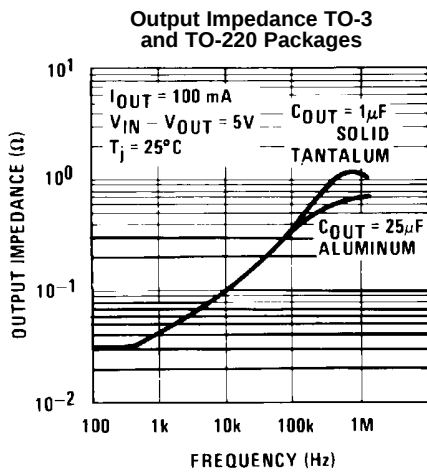


Figure 5.

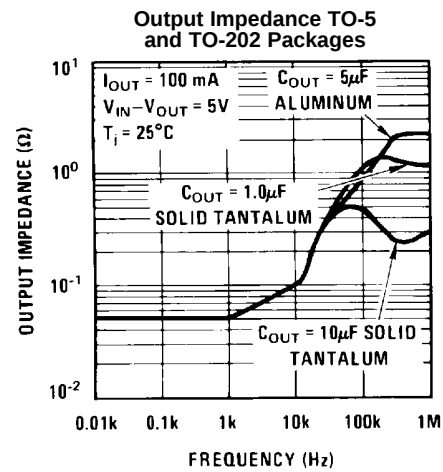


Figure 6.

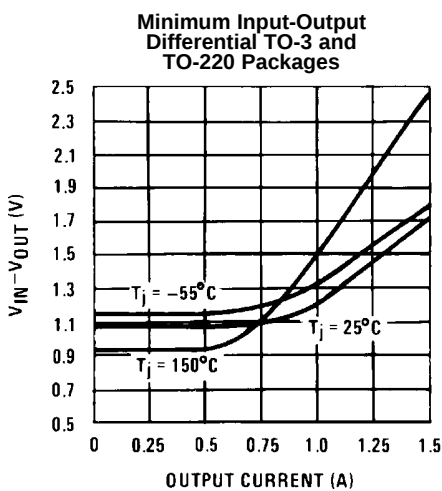


Figure 7.

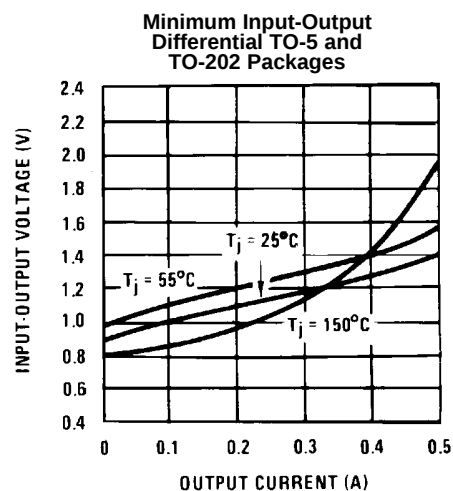


Figure 8.

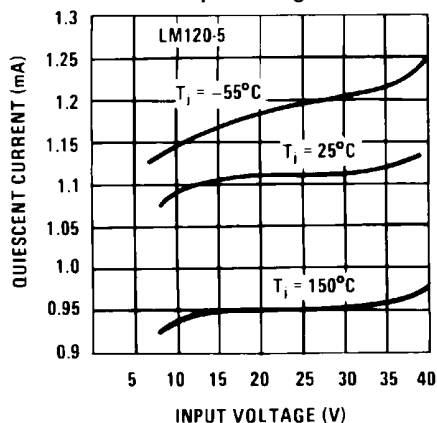
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)****Quiescent Current vs  
Input Voltage**

Figure 9.

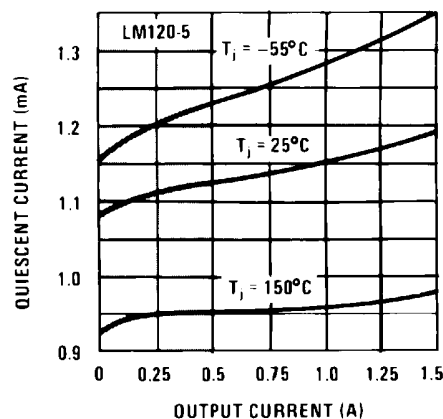
**Quiescent Current vs  
Load Current**

Figure 10.

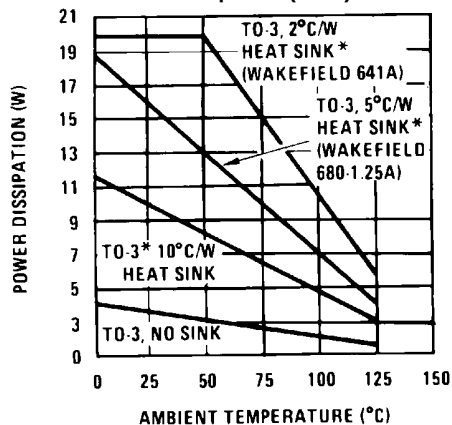
**Maximum Average Power  
Dissipation (TO-3)**

Figure 11.

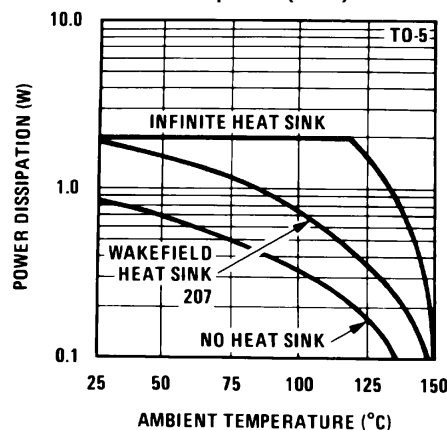
\*These curves for LM120. Derate 25 $^\circ\text{C}$  further for LM320-N.**Maximum Average Power  
Dissipation (TO-5)**

Figure 12.

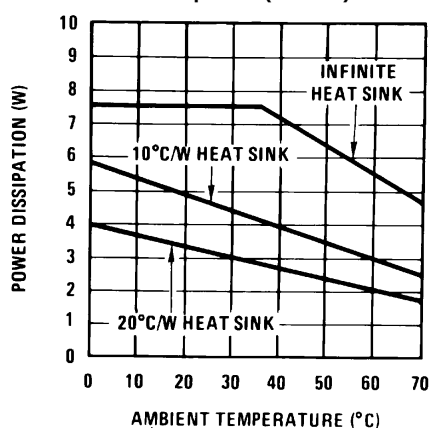
**Maximum Average Power  
Dissipation (TO-202)**

Figure 13.

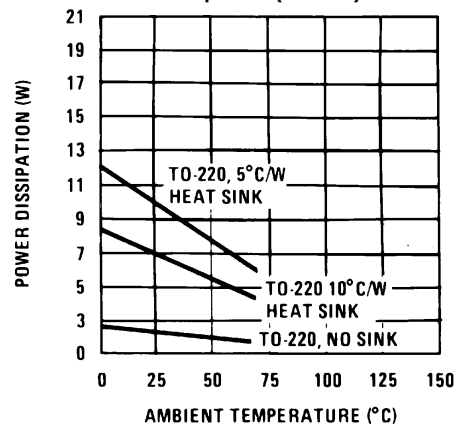
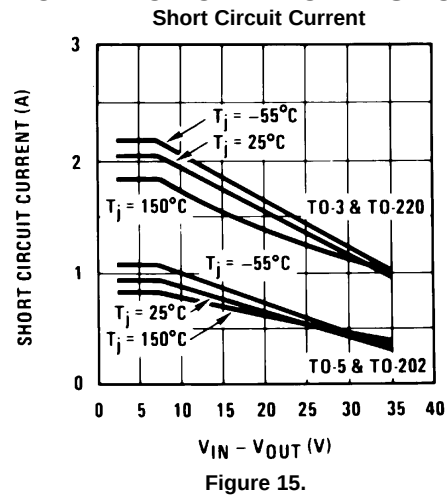
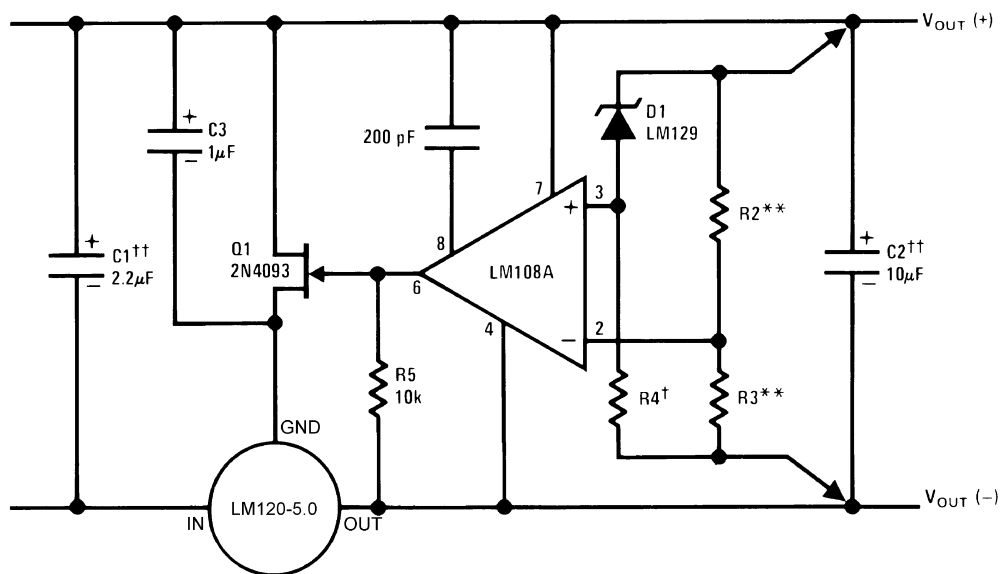
**Maximum Average Power  
Dissipation (TO-220)**

Figure 14.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



## TYPICAL APPLICATIONS



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

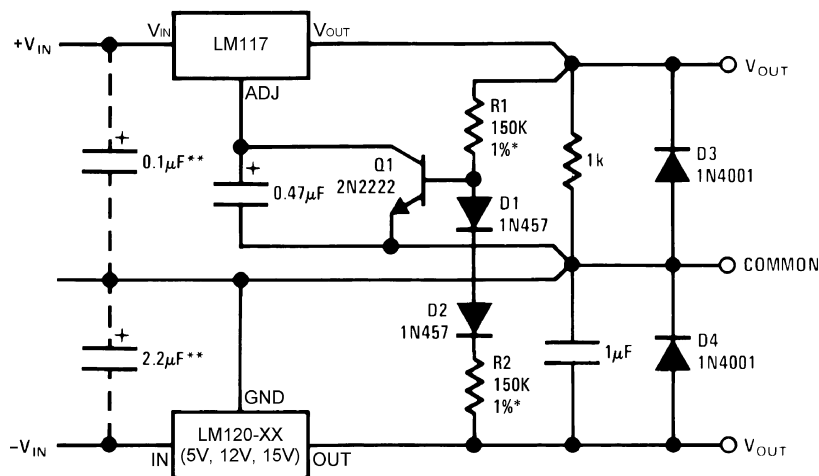
†Determines Zener current.

††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.

**Figure 16. High Stability 1 Amp 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 Q3 replaces the 2N2222.

**Figure 17. Wide Range Tracking Regulator**

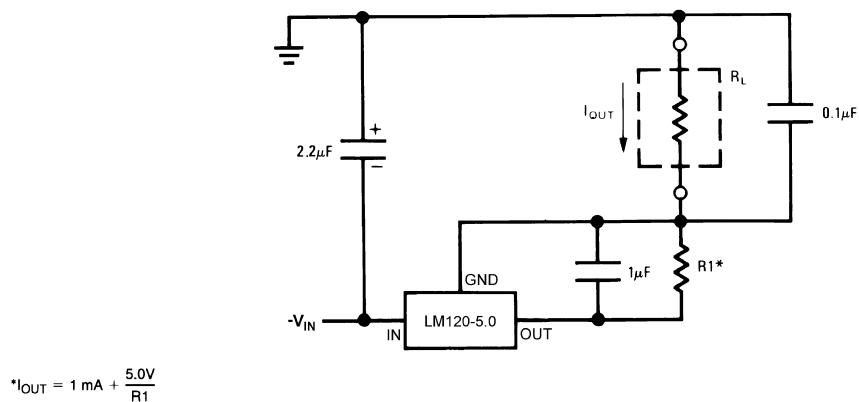
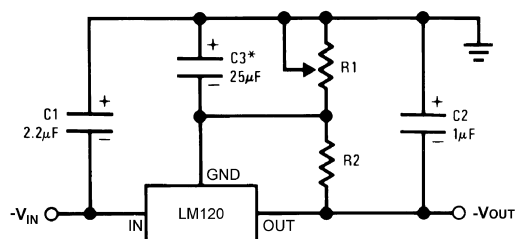


Figure 18. Current Source



SELECT R2 AS FOLLOWS:

LM120-5      300Ω

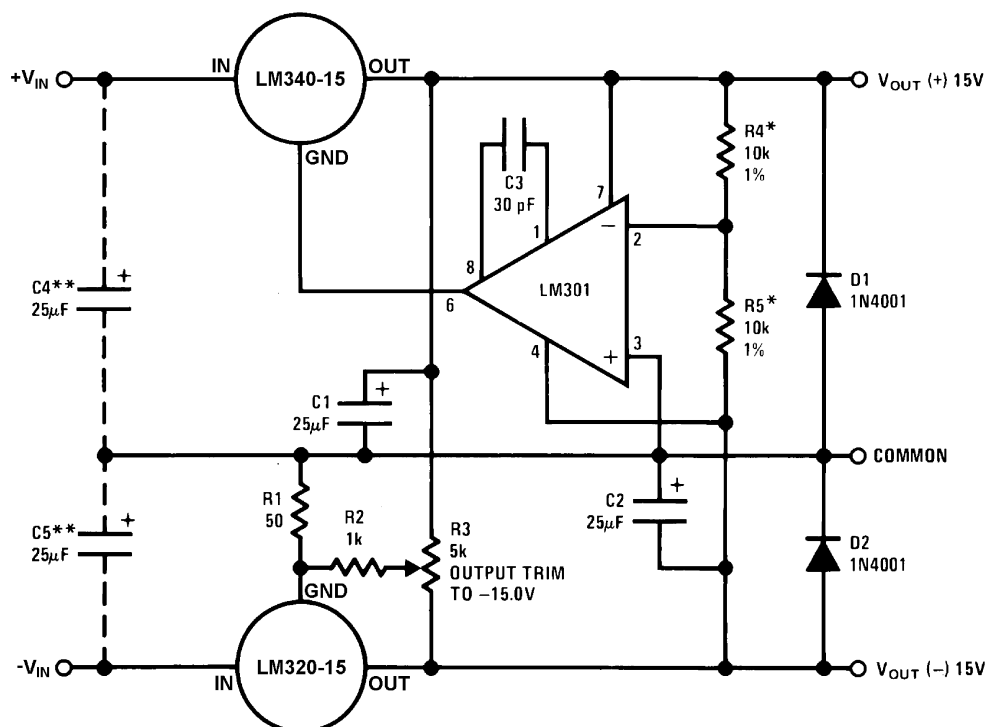
LM120-12    750Ω

LM120-15    1k

$$V_{OUT} = V_{SET} \frac{R_1 + R_2}{R_2}$$

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

Figure 19. Variable Output Current Source



See [Performance \(Typical\)](#)

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

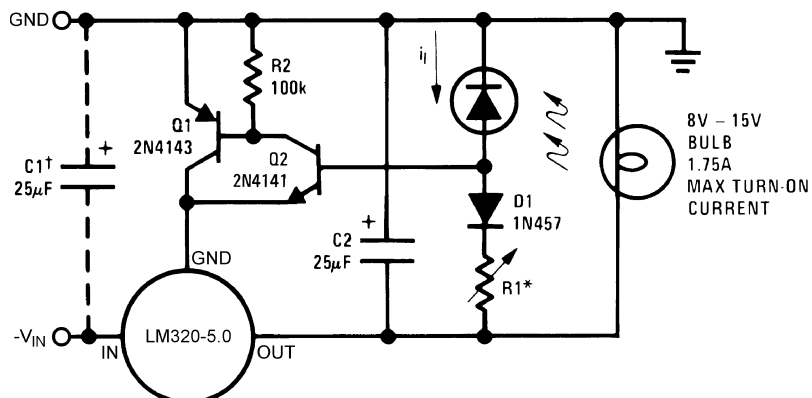
\*\*Necessary only if raw supply filter capacitors are more than 2 inches from regulators.

**Figure 20. ±15V, 1 Amp Tracking Regulators**

#### Performance (Typical)

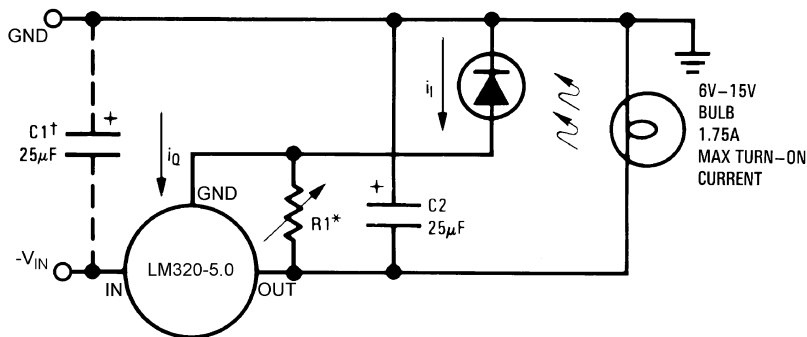
|                                                      |                   |                   |
|------------------------------------------------------|-------------------|-------------------|
| Load Regulation at $\Delta I_L = 1A$                 | 10 mV             | 1 mV              |
| Output Ripple, $C_{IN} = 3000 \mu F$ ,<br>$I_L = 1A$ | 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 $\mu V_{rms}$ |

#### Light Controllers Using Silicon Photo Cells



\*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.



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

†Necessary only if raw supply filter capacitor is more than 2 inches from LM320-N.

## Connection Diagram

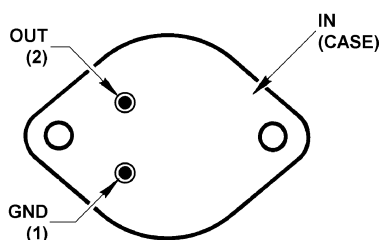


Figure 21. Steel Metal Can Package TO-3 (NDS)  
(Bottom View)

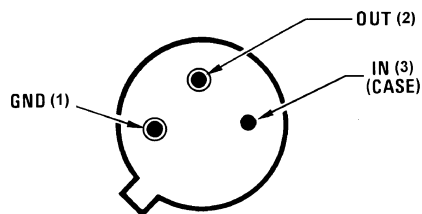


Figure 22. Metal Can Package TO (NDT)  
(Bottom View)

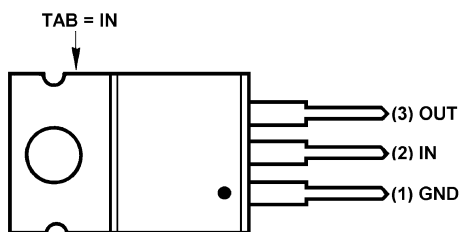


Figure 23. Power Package TO-220 (NDE)  
(Front View)

## Schematic Diagrams

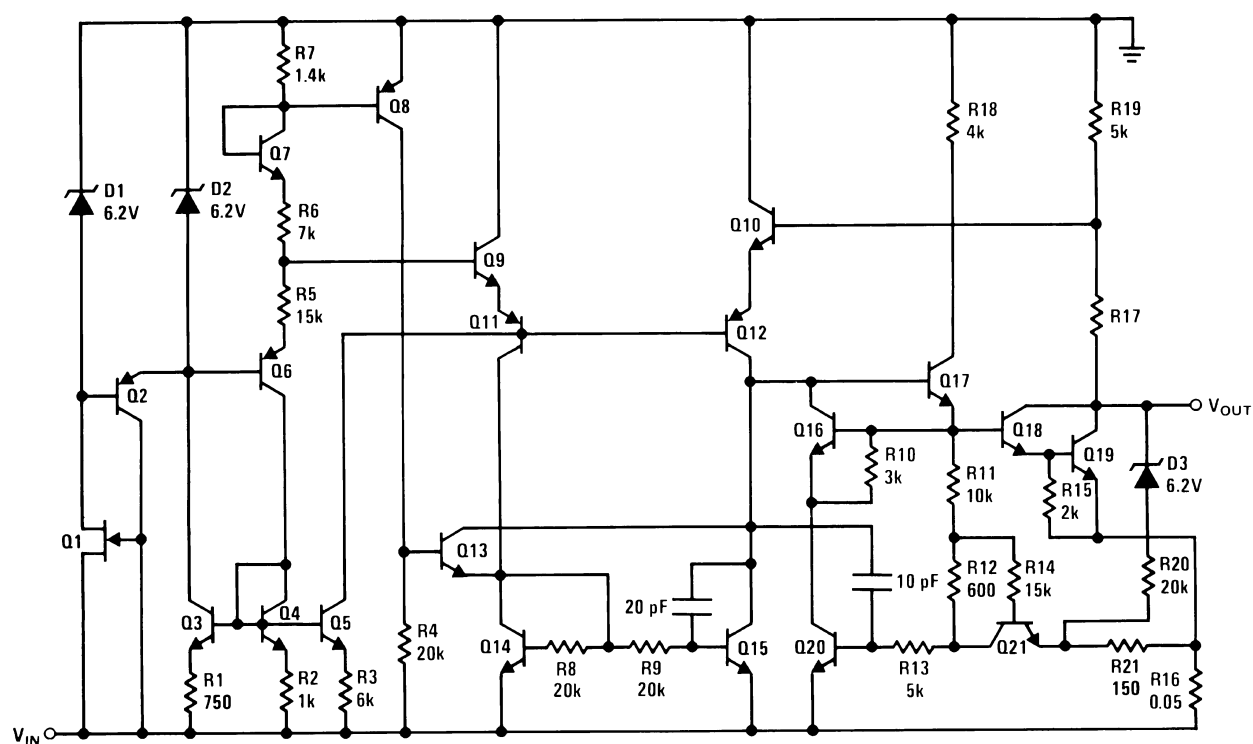


Figure 24. -5V

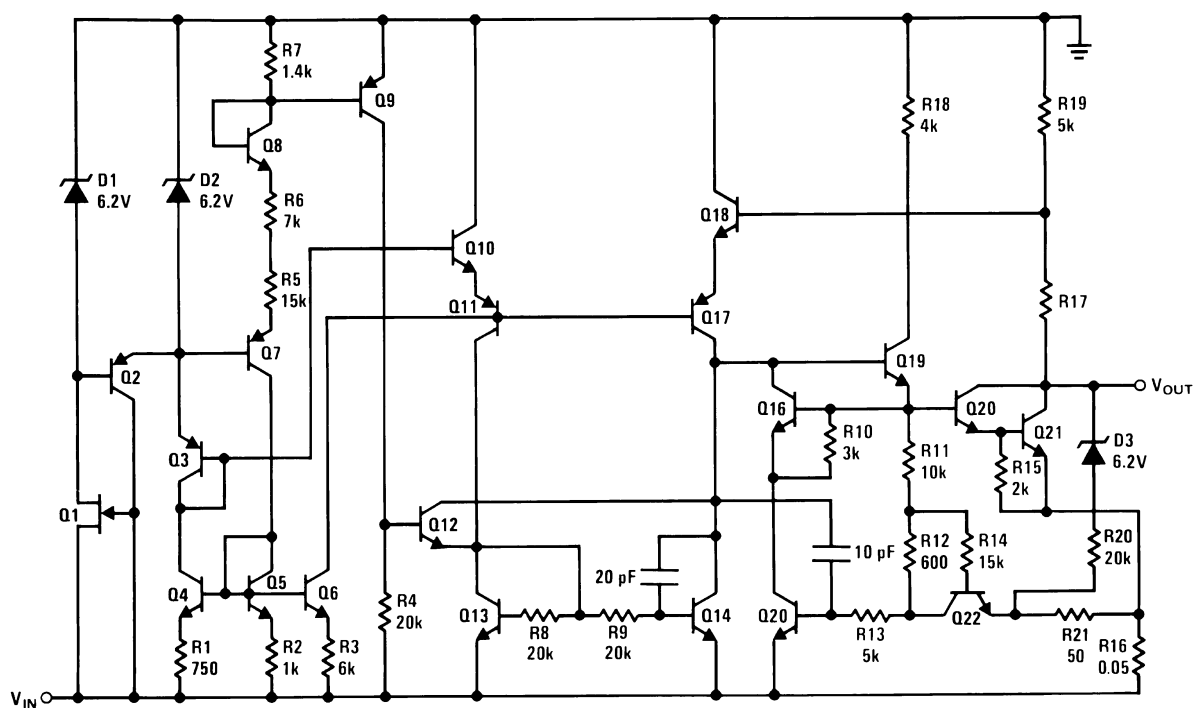


Figure 25. -12V and -15V

## REVISION HISTORY

| Changes from Revision B (April 2013) to Revision C         | Page               |
|------------------------------------------------------------|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">16</a> |

## PACKAGING INFORMATION

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6)           |
|---------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|-------------------------------|
| <a href="#">LM120H-12</a>       | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-12P+, LM120H-12P+)   |
| <a href="#">LM120H-12/NOPB</a>  | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-12P+, LM120H-12P+)   |
| <a href="#">LM120H-15</a>       | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-15P+, LM120H-15P+)   |
| <a href="#">LM120H-15/NOPB</a>  | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-15P+, LM120H-15P+)   |
| <a href="#">LM120H-5.0</a>      | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-5.0P+, LM120H-5.0P+) |
| <a href="#">LM120H-5.0/NOPB</a> | Active        | Production           | TO (NDT)   3     | 500   BULK            | Yes         | AU                                   | Level-1-NA-UNLIM                  | -55 to 150   | ( LM120H-5.0P+, LM120H-5.0P+) |
| <a href="#">LM320T-15/NOPB</a>  | Active        | Production           | TO-220 (NDE)   3 | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | 0 to 125     | LM320T-15 P+                  |
| LM320T-15/NOPB.B                | Active        | Production           | TO-220 (NDE)   3 | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | 0 to 125     | LM320T-15 P+                  |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## TUBE

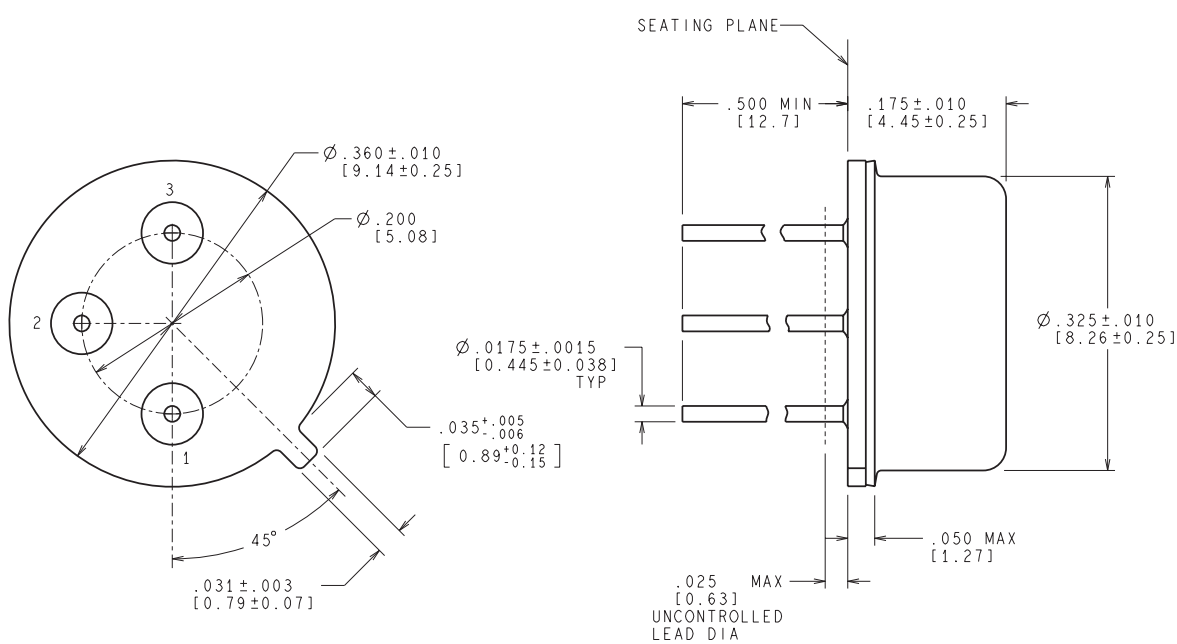


\*All dimensions are nominal

| Device           | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM320T-15/NOPB   | NDE          | TO-220       | 3    | 45  | 502    | 33     | 6985   | 4.06   |
| LM320T-15/NOPB.B | NDE          | TO-220       | 3    | 45  | 502    | 33     | 6985   | 4.06   |



NDT0003A



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

MIL-PRF-38535  
CONFIGURATION CONTROL

H03A (Rev D)

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