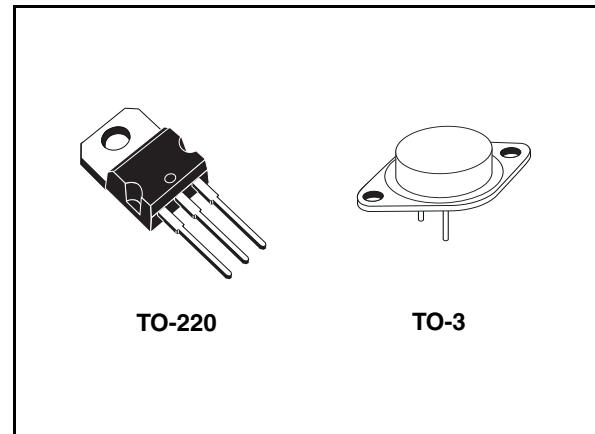


## Three-terminal adjustable negative voltage regulators

### Features

- Output voltage adjustable down to  $V_{REF}$
- 1.5 A guaranteed output current
- 0.3 %/V typical load regulation
- 0.01 %/V typical line regulation
- Current limit constant with temperature
- Ripple rejection: 77 dB
- Standard 3-lead transistor packages
- Excellent thermal regulation: 0.002 %/V
- 50 ppm/°C temperature coefficient



### Description

The LM137 series are adjustable 3-terminal negative voltage regulators capable of supplying in excess -1.5 A over a -1.2 to -37 V output voltage range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, LM137 regulators are supplied in standard transistor packages which are easily mounted and handled. In addition to higher performance than fixed regulators, the LM137 series offer full overload protection available only in integrated circuits.

Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

**Table 1. Device summary**

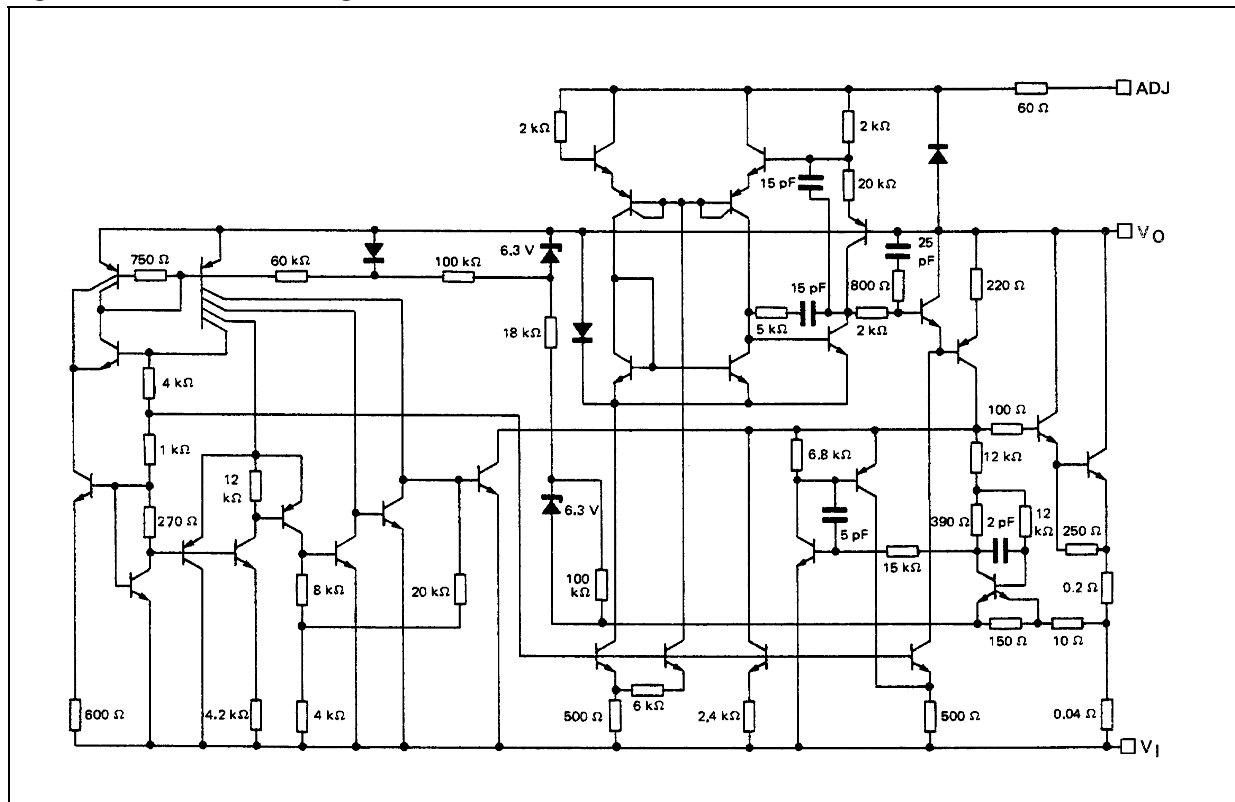
| Part numbers | Order codes | Temperature range |
|--------------|-------------|-------------------|
| LM137        | LM137K      | -55 °C to 150 °C  |
| LM337        | LM337K      | 0 °C to 125 °C    |

# Contents

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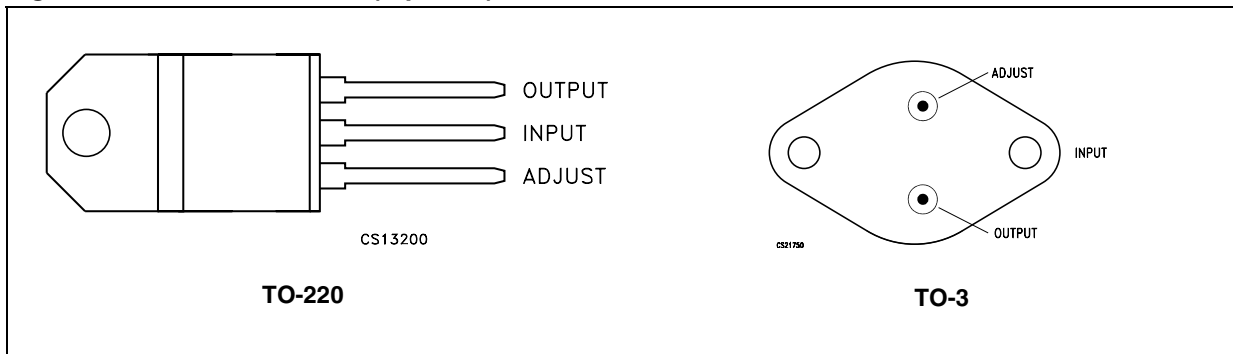
# 1 Diagram

Figure 1. Schematic diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)



### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol      | Parameter                            | Value              | Unit        |
|-------------|--------------------------------------|--------------------|-------------|
| $V_I - V_O$ | Input output voltage differential    | 40                 | V           |
| $I_O$       | Output current                       | 1.5                | A           |
| $P_D$       | Power dissipation                    | Internally limited |             |
| $T_{STG}$   | Storage temperature range            | - 65 to 150        | °C          |
| $T_{OP}$    | Operating junction temperature range | LM137              | - 55 to 150 |
|             |                                      | LM337              | 0 to 125    |

*Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.*

**Table 3. Thermal data**

| Symbol     | Parameter                                | TO-220 | TO-3 | Unit |
|------------|--|--------|------|------|
| $R_{thJC}$ | Thermal resistance junction-case max.    | 3      | 4    | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient max. | 70     | 35   | °C/W |

## 4 Electrical characteristics

**Table 4. Electrical characteristics of LM137** ( $T_J = -55$  to  $150$  °C,  $V_I - V_O = 5$  V,  $I_O = 0.5$  A unless otherwise specified) <sup>(1)</sup>

| Symbol           | Parameter                      | Test conditions   | Min.             | Typ.  | Max.   | Unit          |    |
|------------------|--------------------------------|---|------------------|-------|--------|---------------|----|
| $V_{REF}$        | Reference voltage              | $T_a = 25^\circ\text{C}$  | -1.225           | -1.25 | -1.275 | V             |    |
|                  |                                | $ V_I - V_O  = 3$ to $40$ V, $T_J = T_{min}$ to $T_{max}$<br>$ I_O  = 10\text{mA}$ to $ I_{O(max)} $ , $P \leq P_{max}$ | -1.2             | -1.25 | -1.3   |               |    |
| $K_{VI}$         | Line regulation <sup>(2)</sup> | $T_a = 25^\circ\text{C}$<br>$ V_I - V_O  = 3$ to $40$ V   | $I_O = 0.1$ A    |       | 0.01   | 0.02          | %V |
|                  |                                |   | $I_O = 20$ mA    |       | 0.01   | 0.02          |    |
| $K_{VO}$         | Load regulation <sup>(2)</sup> | $T_a = 25^\circ\text{C}$<br>$ I_O  = 10\text{mA}$ to $ I_{O(max)} $   | $ V_O  \leq 5$ V |       | 15     | 25            | mV |
|                  |                                |   | $ V_O  \geq 5$ V |       | 0.3    | 0.5           | %  |
|                  | Thermal regulation             | $T_a = 25^\circ\text{C}$ , pulse 10 ms  |                  | 0.002 | 0.02   | %/W           |    |
| $I_{ADJ}$        | Adjustment pin current         |   |                  | 65    | 100    | $\mu\text{A}$ |    |
| $\Delta I_{ADJ}$ | Adjustment pin current change  | $T_a = 25^\circ\text{C}$ , $ I_O  = 10$ mA to $ I_{O(max)} $<br>$ V_I - V_O  = 3$ to $40$ V                             |                  | 2     | 5      | $\mu\text{A}$ |    |
| $K_{VI}$         | Line regulation <sup>(2)</sup> | $ V_I - V_O  = 3$ to $40$ V   |                  | 0.02  | 0.05   | %V            |    |
| $K_{VO}$         | Load regulation <sup>(2)</sup> | $ I_O  = 10\text{mA}$ to $ I_{O(max)} $   | $ V_O  \leq 5$ V |       | 20     | 50            | mV |
|                  |                                |   | $ V_O  \geq 5$ V |       | 0.3    | 1             | %  |
| $ I_{O(min)} $   | Minimum load current           | $ V_I - V_O  \leq 40$ V   |                  | 2.5   | 5      | mA            |    |
|                  |                                | $ V_I - V_O  \leq 10$ V   |                  | 1.2   | 3      |               |    |
| $I_{OS}$         | Short circuit output current   | $ V_I - V_O  \leq 15$ V   | 1.5              | 2.2   |        | A             |    |
|                  |                                | $ V_I - V_O  = 40$ V, $T_J = 25^\circ\text{C}$  | 0.24             | 0.4   |        |               |    |
| $V_{NO}$         | RMS output noise (% of $V_O$ ) | $T_a = 25^\circ\text{C}$ , $f = 10$ Hz to $10$ kHz  |                  | 0.003 |        | %             |    |
| $R_{VF}$         | Ripple rejection ratio         | $V_O = -10$ V, $f = 120$ Hz   |                  | 60    |        | dB            |    |
|                  |                                | $C_{ADJ} = 10$ $\mu\text{F}$  | 66               | 77    |        |               |    |
| $K_{VT}$         | Temperature stability          |   |                  | 0.6   |        | %             |    |
| $K_{VH}$         | Long term stability            | $T_a = 125^\circ\text{C}$ , 1000 H  |                  | 0.3   | 1      | %             |    |

1. Although power dissipation is internally limited, these specifications are applicable for power dissipation of: 15 W for TO-220 and 20 W for TO-3 Package;  $I_{O(max)}$  is 1.5 A
2. Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.

**Table 5. Electrical characteristics of LM337** ( $T_J = 0$  to  $150$  °C unless otherwise specified). <sup>(1)</sup>

| Symbol           | Parameter                      | Test conditions   | Min.             | Typ.  | Max.   | Unit          |    |
|------------------|--------------------------------|---|------------------|-------|--------|---------------|----|
| $V_{REF}$        | Reference voltage              | $T_a = 25^\circ\text{C}$  | -1.213           | -1.25 | -1.287 | V             |    |
|                  |                                | $ V_I - V_O  = 3$ to $40$ V, $T_J = T_{min}$ to $T_{max}$<br>$ I_O  = 10\text{mA}$ to $ I_{O(max)} $ , $P \leq P_{max}$ | -1.2             | -1.25 | -1.3   |               |    |
| $K_{VI}$         | Line regulation <sup>(2)</sup> | $T_a = 25^\circ\text{C}$<br>$ V_I - V_O  = 3$ to $40$ V   | $I_O = 0.1$ A    |       | 0.01   | 0.04          | %V |
|                  |                                |   | $I_O = 20$ mA    |       | 0.01   | 0.04          |    |
| $K_{VO}$         | Load regulation <sup>(2)</sup> | $T_a = 25^\circ\text{C}$<br>$ I_O  = 10\text{mA}$ to $ I_{O(max)} $   | $ V_O  \leq 5$ V |       | 15     | 50            | mV |
|                  |                                |   | $ V_O  \geq 5$ V |       | 0.3    | 1             | %  |
|                  | Thermal regulation             | $T_a = 25^\circ\text{C}$ , pulse 10 ms  |                  | 0.003 | 0.04   | %/W           |    |
| $I_{ADJ}$        | Adjustment pin current         |   |                  | 65    | 100    | $\mu\text{A}$ |    |
| $\Delta I_{ADJ}$ | Adjustment pin current change  | $T_a = 25^\circ\text{C}$ , $ I_O  = 10$ mA to $ I_{O(max)} $<br>$ V_I - V_O  = 3$ to $40$ V                             |                  | 2     | 5      | $\mu\text{A}$ |    |
| $K_{VI}$         | Line regulation <sup>(2)</sup> | $ V_I - V_O  = 3$ to $40$ V   |                  | 0.02  | 0.07   | %V            |    |
| $K_{VO}$         | Load regulation <sup>(2)</sup> | $ I_O  = 10\text{mA}$ to $ I_{O(max)} $   | $ V_O  \leq 5$ V |       | 20     | 70            | mV |
|                  |                                |   | $ V_O  \geq 5$ V |       | 0.3    | 1.5           | %  |
| $ I_{O(min)} $   | Minimum load current           | $ V_I - V_O  \leq 40$ V   |                  | 2.5   | 10     | mA            |    |
|                  |                                | $ V_I - V_O  \leq 10$ V   |                  | 1.5   | 6      |               |    |
| $I_{OS}$         | Short circuit output current   | $ V_I - V_O  \leq 15$ V   | 1.5              | 2.2   |        | A             |    |
|                  |                                | $ V_I - V_O  = 40$ V, $T_J = 25^\circ\text{C}$  | 0.15             | 0.4   |        |               |    |
| $V_{NO}$         | RMS output noise (% of $V_O$ ) | $T_a = 25^\circ\text{C}$ , $f = 10$ Hz to $10$ kHz  |                  | 0.003 |        | %             |    |
| $R_{VF}$         | Ripple rejection ratio         | $V_O = -10$ V, $f = 120$ Hz   |                  | 60    |        | dB            |    |
|                  |                                | $C_{ADJ} = 10$ $\mu\text{F}$  | 66               | 77    |        |               |    |
| $K_{VT}$         | Temperature stability          |   |                  | 0.6   |        | %             |    |
| $K_{VH}$         | Long term stability            | $T_a = 125^\circ\text{C}$ , 1000 H  |                  | 0.3   | 1      | %             |    |

- Although power dissipation is internally limited, these specifications are applicable for power dissipation of: 15 W for TO-220 and 20 W for TO-3 package;  $I_{O(max)}$  is 1.5 A.
- Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.

# 5 Typical characteristics

Figure 3. Load regulation

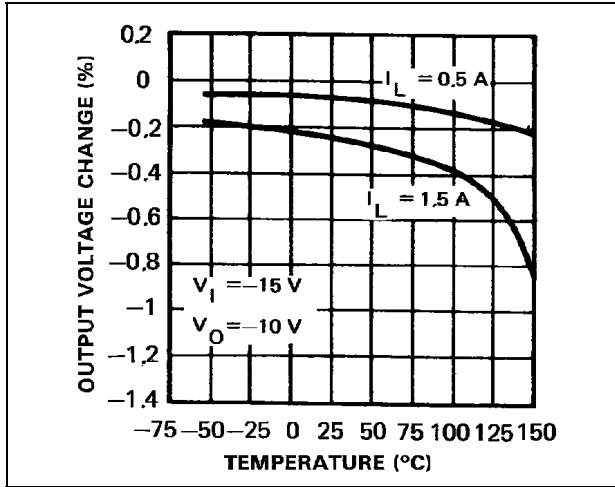


Figure 4. Current limit

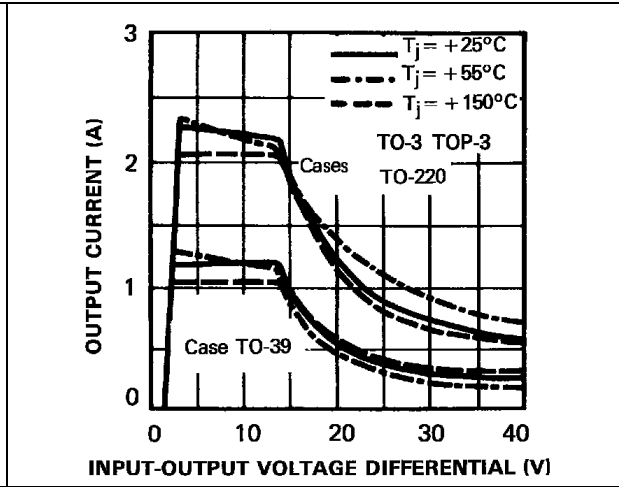


Figure 5. Adjustment current

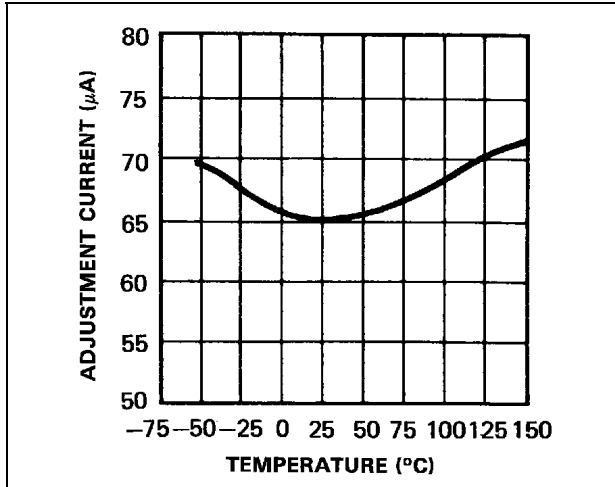


Figure 6. Dropout voltage

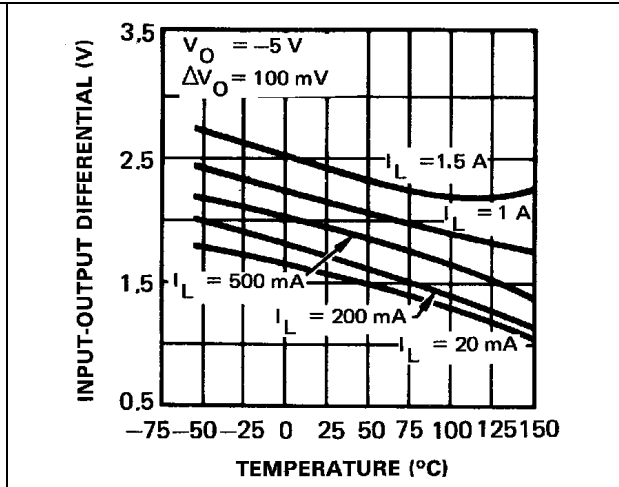


Figure 7. Temperature stability

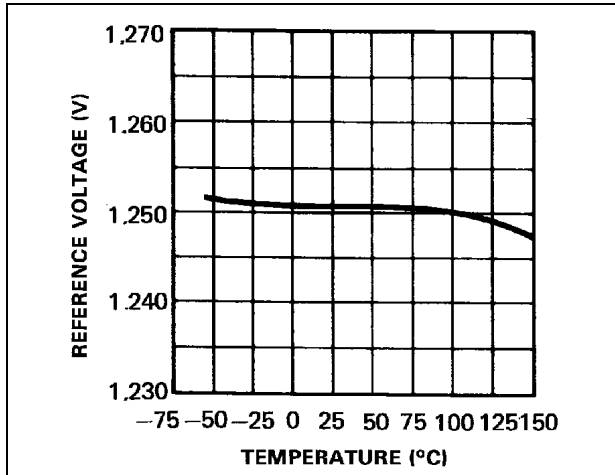


Figure 8. Minimum operating current

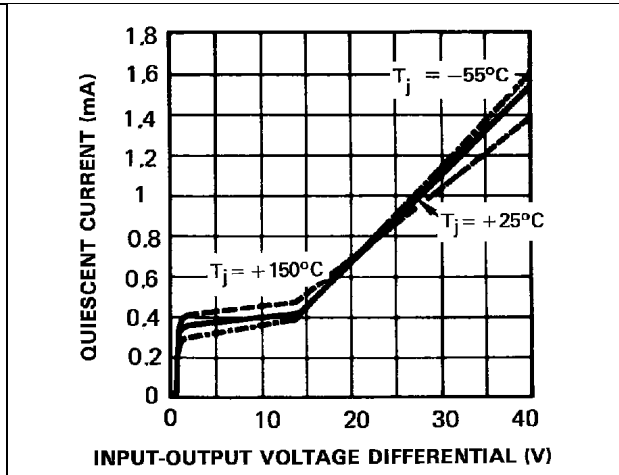




Figure 9. Ripple rejection vs output voltage

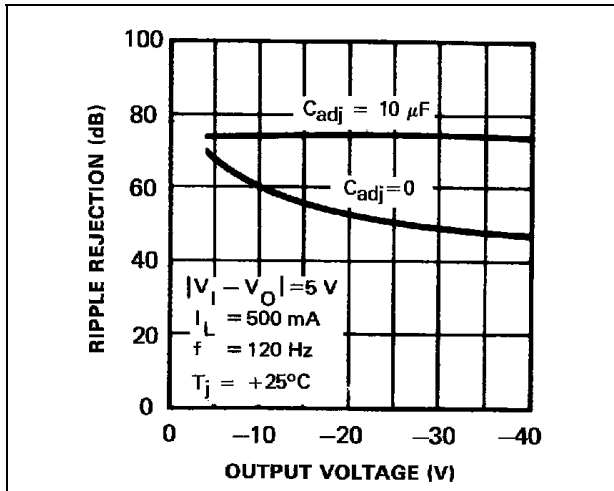


Figure 10. Ripple rejection vs frequency

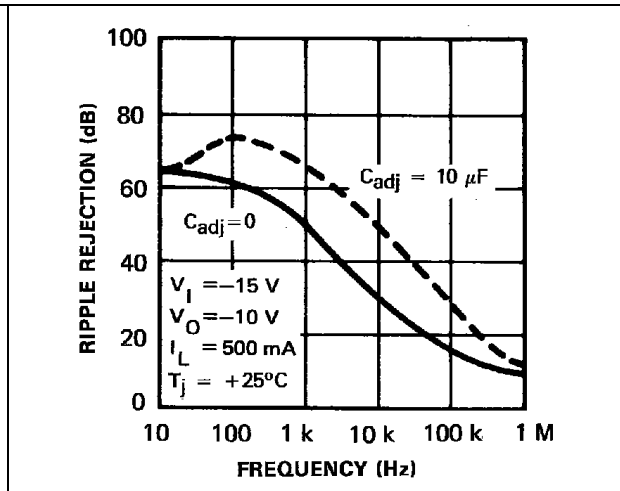


Figure 11. Ripple rejection vs output current

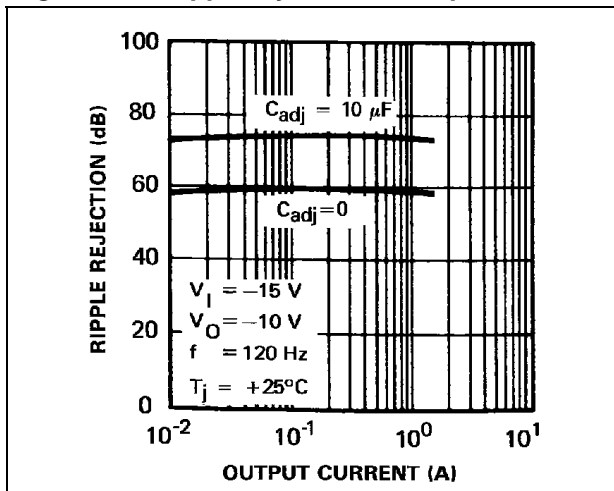


Figure 12. Output impedance

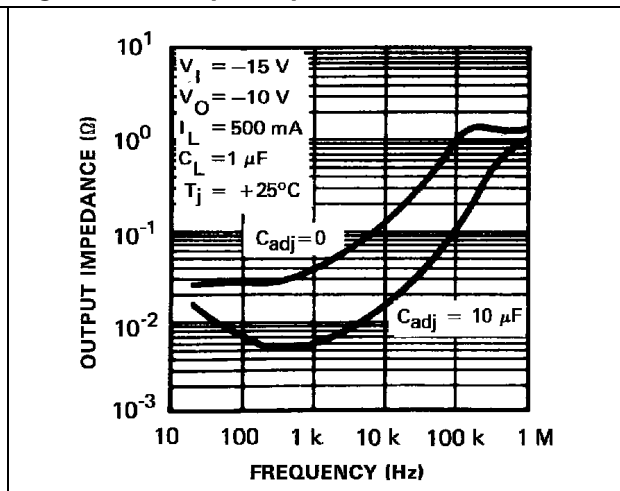


Figure 13. Line transient response

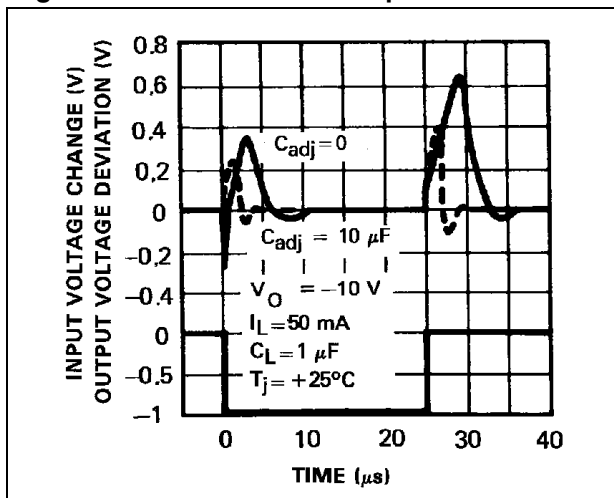
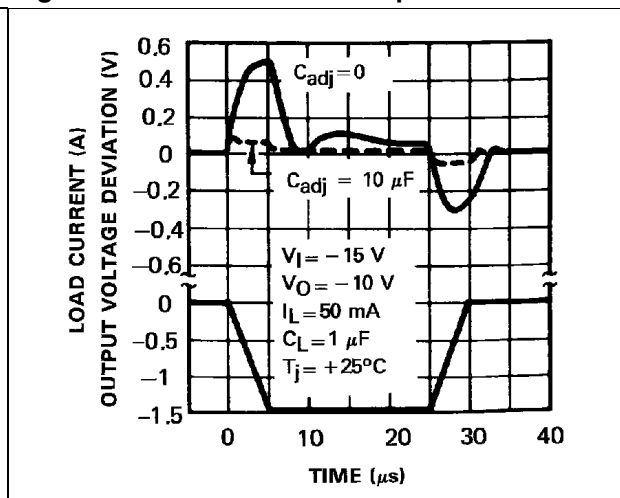


Figure 14. Load transient response



## 6 Thermal regulation

When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large.

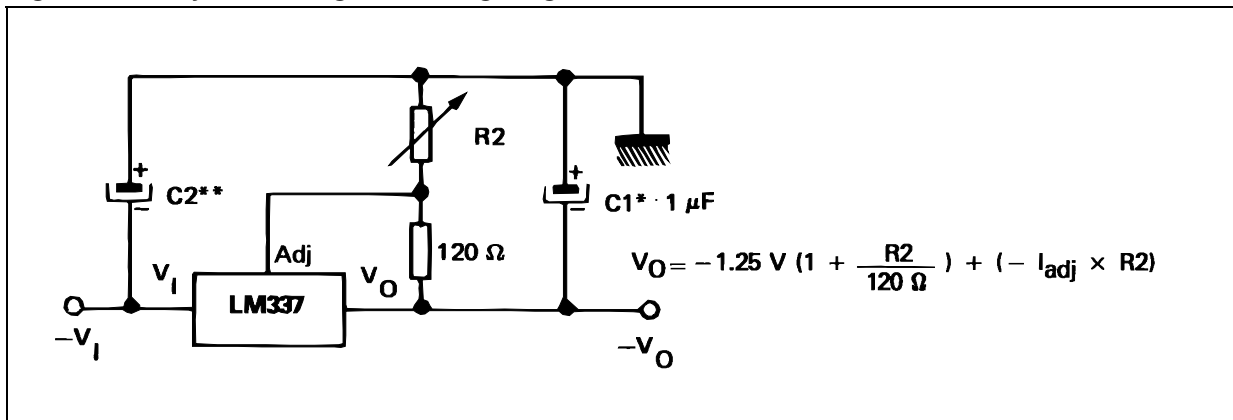
Thermal regulation is the effect of these temperature gradients on output voltage (in percentage output change) per watt of power change in a specified time. Thermal regulation error is independent of electrical regulation or temperature coefficient, and occurs within 5 ms to 50 ms after a change in power dissipation. Thermal regulation depends on IC layout as well as electrical design. The thermal regulation of a voltage regulator is defined as the percentage change of  $V_O$ , per watt, within the first 10ms after a step of power, is applied.

The LM137 specification is 0.02 %/W max. In [Figure 1](#), a typical LM337's output drifts only 3 mV for 0.03% of  $V_O = -10$  V) when a 10 W pulse is applied for 10 ms. This performance is thus well inside the specification limit of 0.02 %/W x 10 W = 0.2% max. When the 10 W pulse is ended the thermal regulation again shows a 3 mV step as the LM137 chip cools off. Note that the load regulation error of about 8 mV (0.08 %) is additional to the thermal regulation error.

In [Figure 2](#), when the 10 W pulse is applied for 100 ms, the output drifts only slightly beyond the drift in the first 10 ms and the thermal error stays well within 0.1% (10 mV).

## 7 Typical application

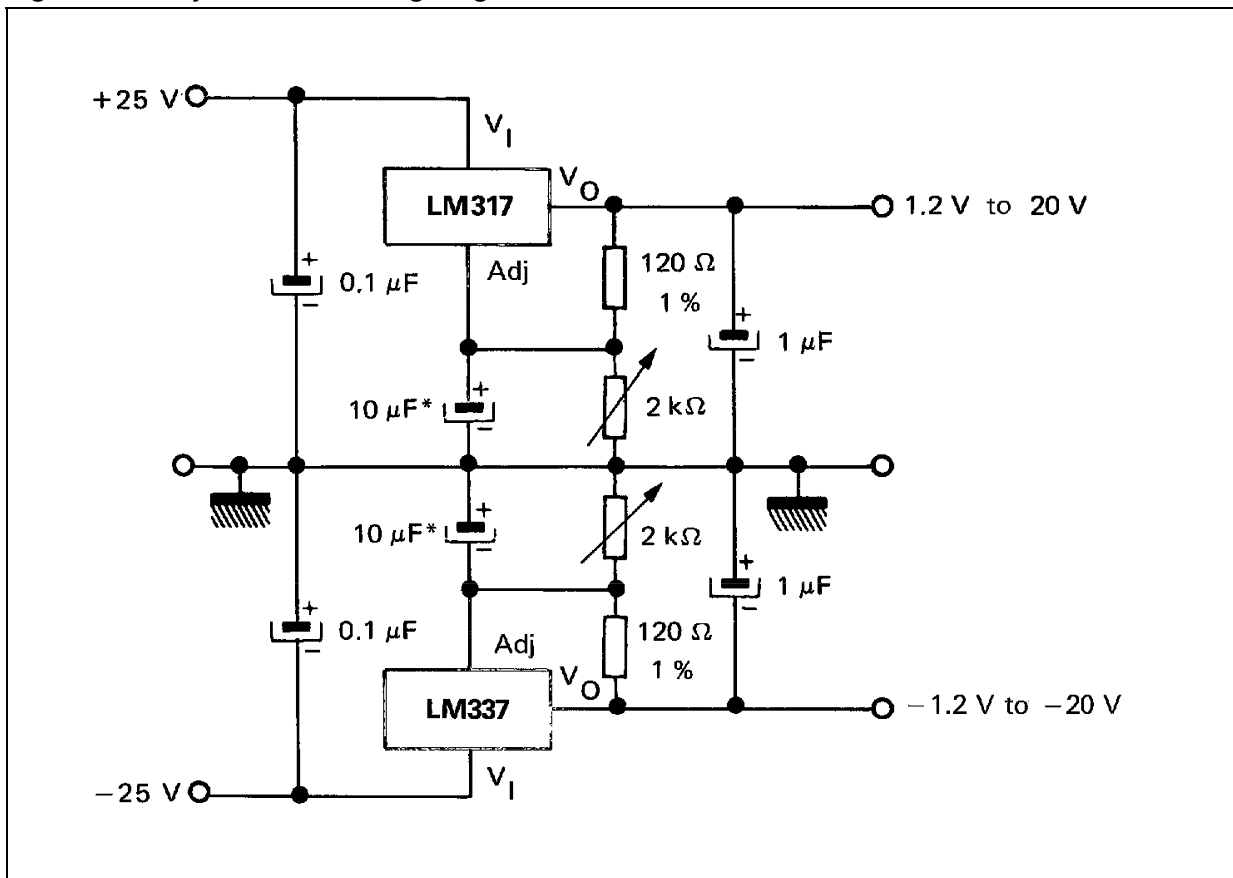
Figure 15. Adjustable negative voltage regulator



\* C1 = 1 μF solid tantalum or 10μF aluminium electrolytic required for stability.

\*\* C2 = 1 μF solid tantalum is required only if regulator is more than 10 cm from power supply filter capacitors

Figure 16. Adjustable lab voltage regulator



\* The 10 μF capacitors are optimal to improve ripple rejection.

Figure 17. Current regulator

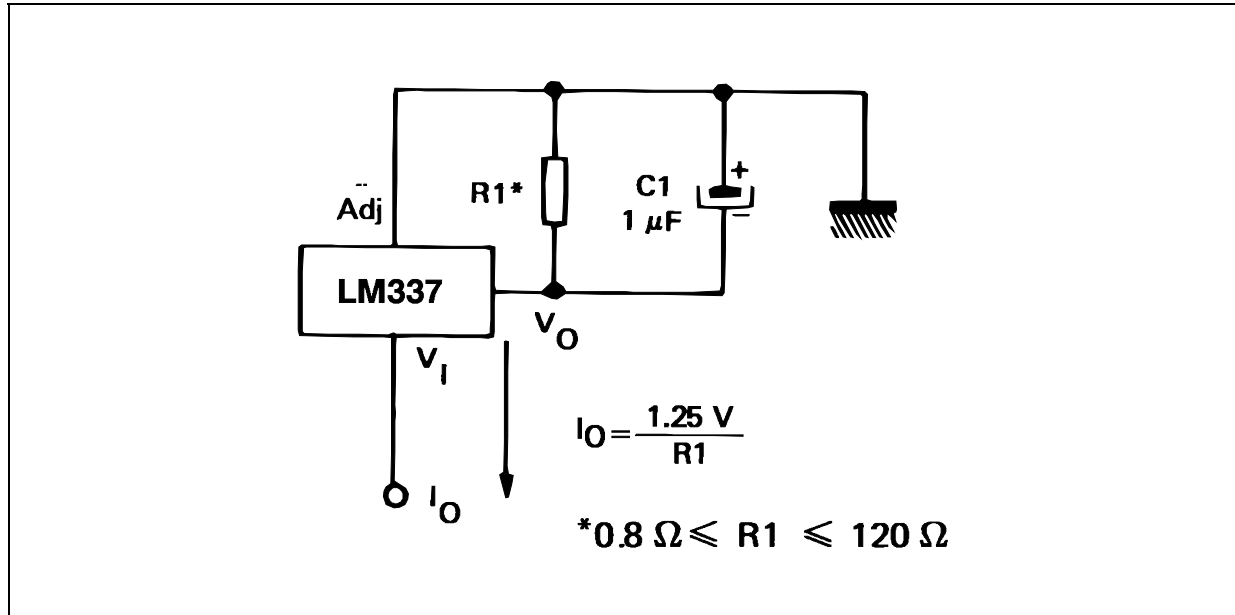
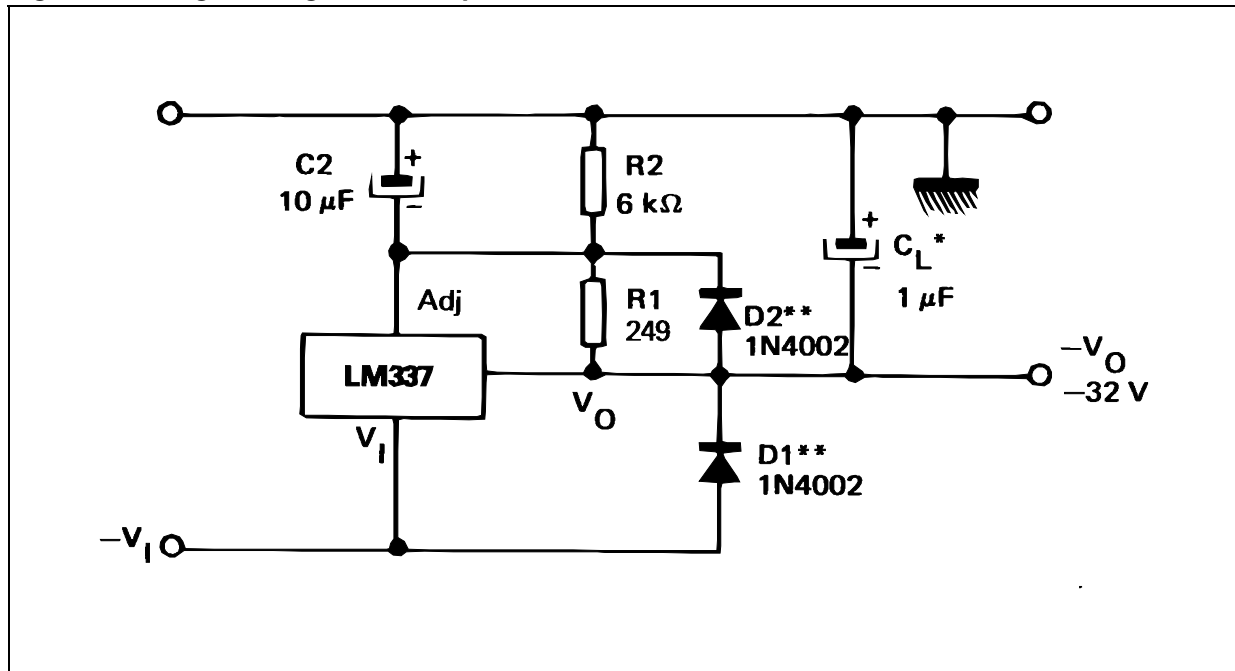


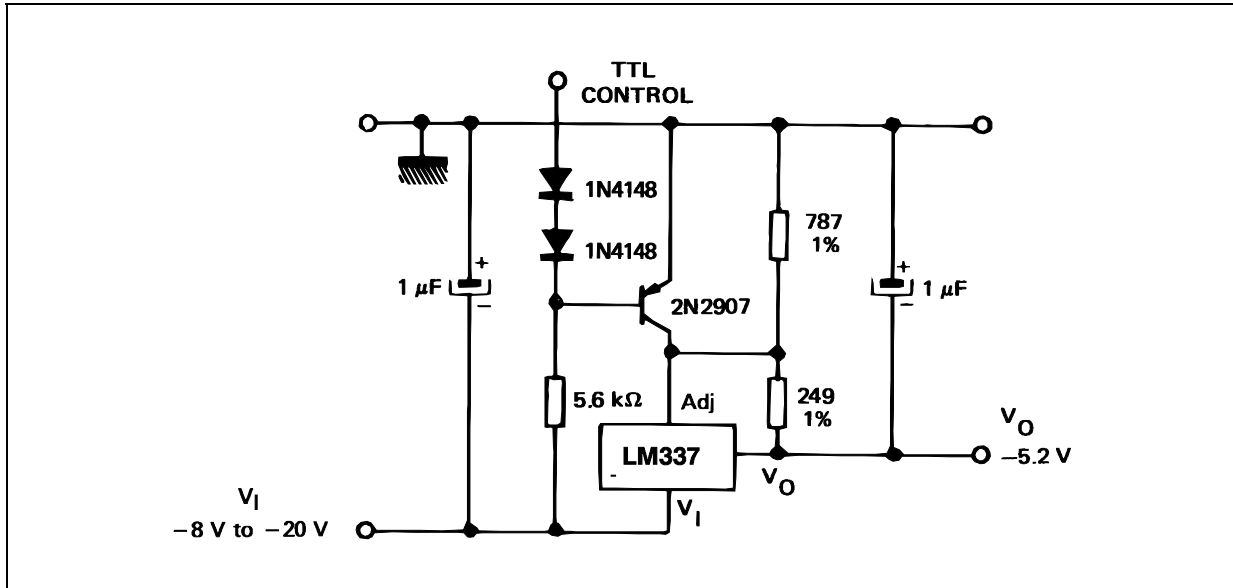
Figure 18. Negative regulator with protection diodes



\* When  $C_L$  is larger than  $20 \mu\text{F}$ ,  $D1$  protects the LM137 in case the input supply is shorted.

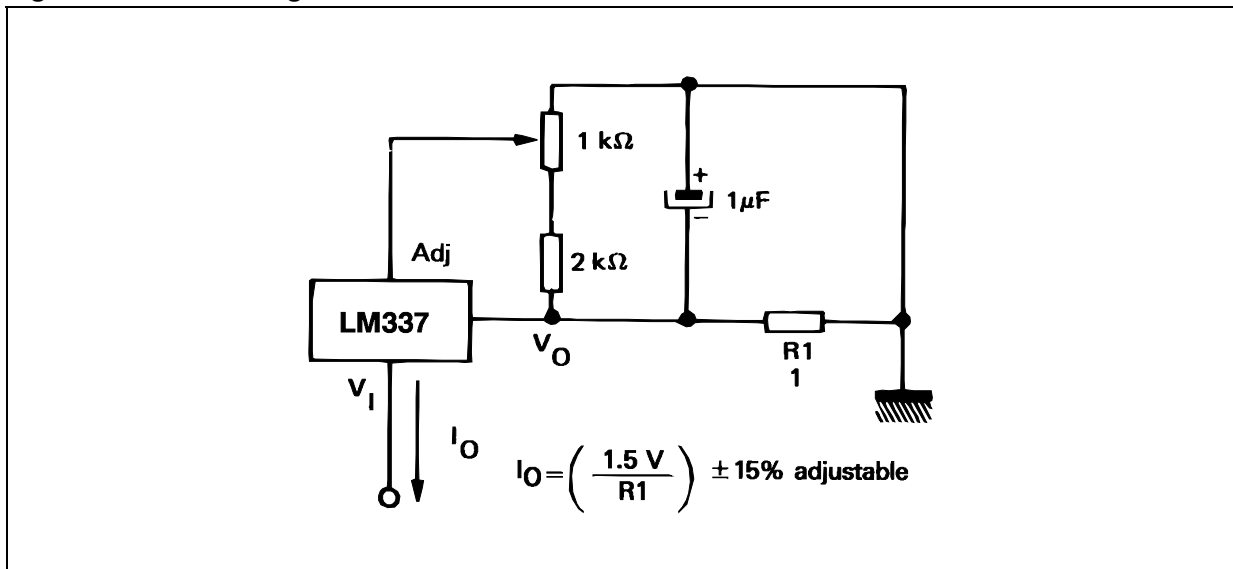
\*\* When  $C2$  is larger than  $10 \mu\text{F}$  and  $V_O$  is larger than  $-25 \text{ V}$ ,  $D2$  protects the LM137 in case the output is shorted.

Figure 19. - 5.2 V regulator with electronic shutdown (1)



1. Minimum output = - 1.3 V when control input is low.

Figure 20. Current regulator

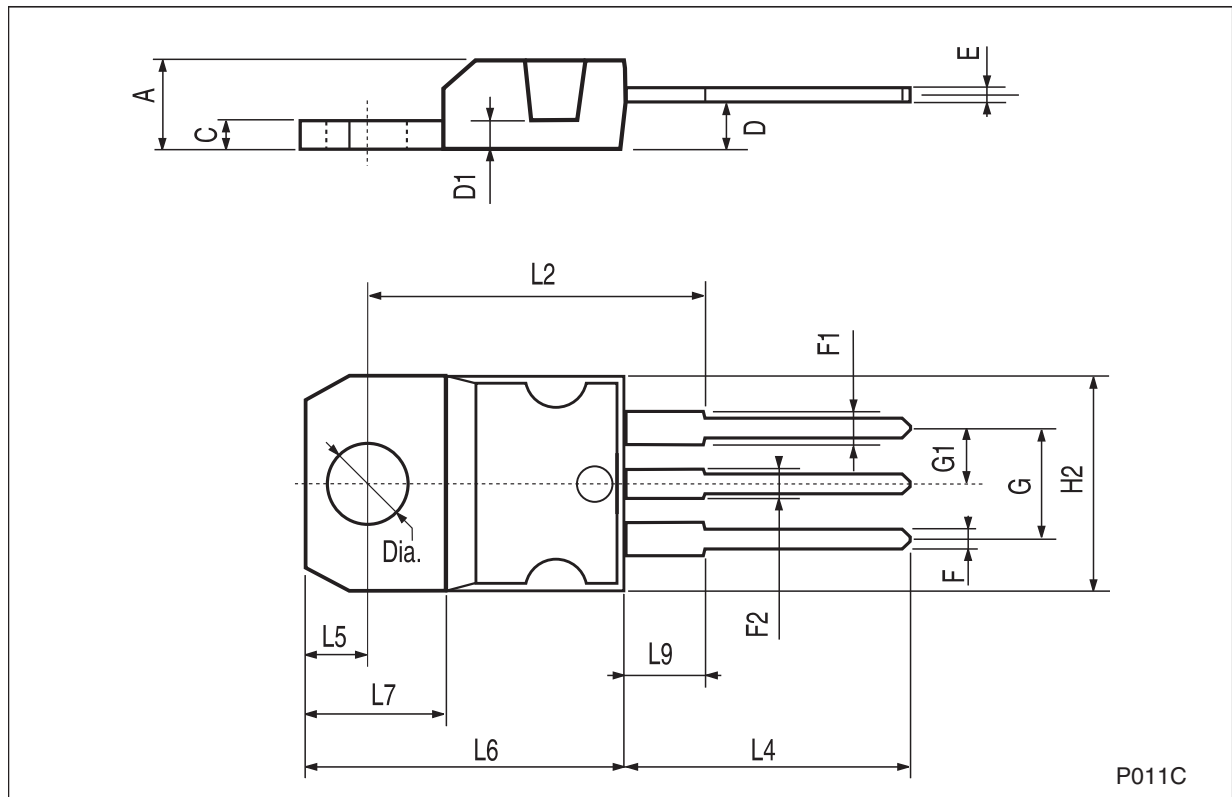


## 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

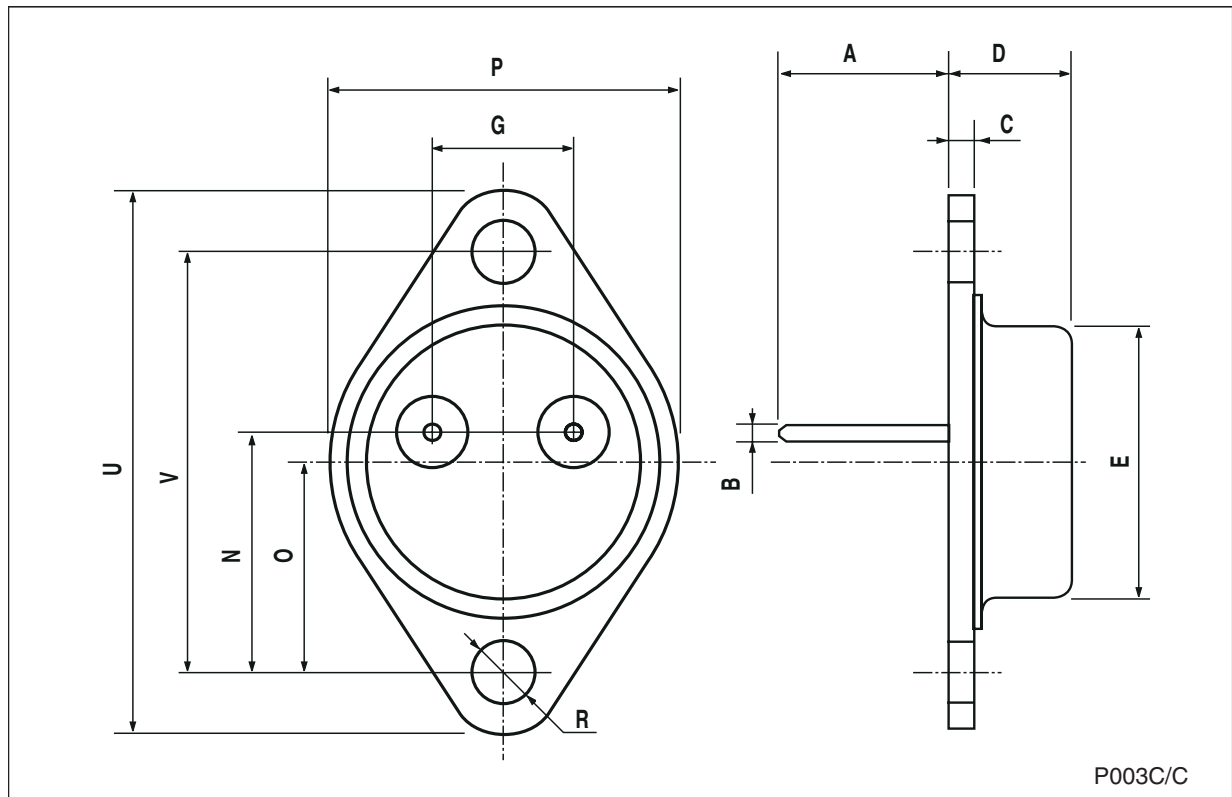
**TO-220 mechanical data**

| Dim. | mm.   |      |       | inch. |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | Min.  | Typ. | Max.  | Min.  | Typ.  | Max.  |
| A    | 4.40  |      | 4.60  | 0.173 |       | 0.181 |
| C    | 1.23  |      | 1.32  | 0.048 |       | 0.051 |
| D    | 2.40  |      | 2.72  | 0.094 |       | 0.107 |
| D1   |       | 1.27 |       |       | 0.050 |       |
| E    | 0.49  |      | 0.70  | 0.019 |       | 0.027 |
| F    | 0.61  |      | 0.88  | 0.024 |       | 0.034 |
| F1   | 1.14  |      | 1.70  | 0.044 |       | 0.067 |
| F2   | 1.14  |      | 1.70  | 0.044 |       | 0.067 |
| G    | 4.95  |      | 5.15  | 0.194 |       | 0.203 |
| G1   | 2.4   |      | 2.7   | 0.094 |       | 0.106 |
| H2   | 10.0  |      | 10.40 | 0.393 |       | 0.409 |
| L2   |       | 16.4 |       |       | 0.645 |       |
| L4   | 13.0  |      | 14.0  | 0.511 |       | 0.551 |
| L5   | 2.65  |      | 2.95  | 0.104 |       | 0.116 |
| L6   | 15.25 |      | 15.75 | 0.600 |       | 0.620 |
| L7   | 6.2   |      | 6.6   | 0.244 |       | 0.260 |
| L9   | 3.5   |      | 3.93  | 0.137 |       | 0.154 |
| DIA. | 3.75  |      | 3.85  | 0.147 |       | 0.151 |



**TO-3 mechanical data**

| Dim. | mm.  |       |      | inch. |       |       |
|------|------|-------|------|-------|-------|-------|
|      | Min. | Typ.  | Max. | Min.  | Typ.  | Max.  |
| A    |      | 11.85 |      |       | 0.466 |       |
| B    | 0.96 | 1.05  | 1.10 | 0.037 | 0.041 | 0.043 |
| C    |      |       | 1.70 |       |       | 0.066 |
| D    |      |       | 8.7  |       |       | 0.342 |
| E    |      |       | 20.0 |       |       | 0.787 |
| G    |      | 10.9  |      |       | 0.429 |       |
| N    |      | 16.9  |      |       | 0.665 |       |
| P    |      |       | 26.2 |       |       | 1.031 |
| R    | 3.88 |       | 4.09 | 0.152 |       | 0.161 |
| U    |      |       | 39.5 |       |       | 1.555 |
| V    |      | 30.10 |      |       | 1.185 |       |



P003C/C



## 9 Revision history

**Table 6. Document revision history**

| Date        | Revision | Changes                                    |
|-------------|----------|--|
| 19-Jul-2004 | 1        | First issue.                               |
| 10-Jan-2005 | 2        | Modified pin connection for TO-3.          |
| 17-Jul-2008 | 3        | Added: <a href="#">Table 1 on page 1</a> . |

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