

# Voltage Regulator - Adjustable Output, Negative

1.5 A

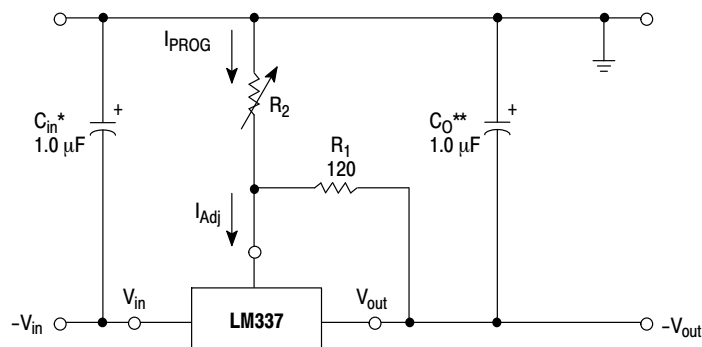
## LM337

The LM337 is an adjustable 3-terminal negative voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of -1.2 V to -37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow-out proof.

The LM337 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM337 can be used as a precision current regulator.

### Features

- Output Current in Excess of 1.5 A
- Output Adjustable between -1.2 V and -37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe-Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking many Fixed Voltages
- Available in Surface Mount D<sup>2</sup>PAK and Standard 3-Lead Transistor Package
- These Devices are Pb-Free and are RoHS Compliant



\*C<sub>in</sub> is required if regulator is located more than 4 inches from power supply filter. A 1.0 μF solid tantalum or 10 μF aluminum electrolytic is recommended.

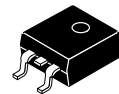
\*\*C<sub>O</sub> is necessary for stability. A 1.0 μF solid tantalum or 10 μF aluminum electrolytic is recommended.

$$V_{out} = -1.25 V \left( 1 + \frac{R_2}{R_1} \right)$$

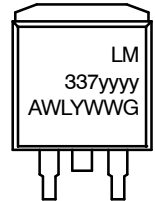
Figure 1. Standard Application

## THREE-TERMINAL ADJUSTABLE NEGATIVE VOLTAGE REGULATOR

### MARKING DIAGRAMS

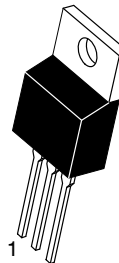


D<sup>2</sup>PAK  
D2T SUFFIX  
CASE 936



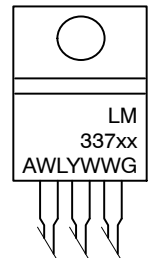
Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.

Pin 1. Adjust  
2. V<sub>in</sub>  
3. V<sub>out</sub>



TO-220AB  
T SUFFIX  
CASE 221AB

Heatsink surface  
connected to Pin 2.



xx = BT, T  
yyyy = BD2T, D2T  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 8 of this data sheet.

# LM337

## MAXIMUM RATINGS (T<sub>A</sub> = +25°C, unless otherwise noted)

| Rating                                                                                                                                                                                                                                                                                    | Symbol                                                                                                           | Value                                                                  | Unit                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------|
| Input–Output Voltage Differential                                                                                                                                                                                                                                                         | V <sub>I</sub> –V <sub>O</sub>                                                                                   | 40                                                                     | V <sub>dc</sub>                            |
| Power Dissipation<br>Case 221A<br>T <sub>A</sub> = +25°C<br>Thermal Resistance, Junction–to–Ambient<br>Thermal Resistance, Junction–to–Case<br>Case 936 (D <sup>2</sup> PAK)<br>T <sub>A</sub> = +25°C<br>Thermal Resistance, Junction–to–Ambient<br>Thermal Resistance, Junction–to–Case | P <sub>D</sub><br>θ <sub>JA</sub><br>θ <sub>JC</sub><br><br>P <sub>D</sub><br>θ <sub>JA</sub><br>θ <sub>JC</sub> | Internally Limited<br>65<br>5.0<br><br>Internally Limited<br>70<br>5.0 | W<br>°C/W<br>°C/W<br><br>W<br>°C/W<br>°C/W |
| Operating Junction Temperature Range                                                                                                                                                                                                                                                      | T <sub>J</sub>                                                                                                   | –40 to +125                                                            | °C                                         |
| Storage Temperature Range                                                                                                                                                                                                                                                                 | T <sub>stg</sub>                                                                                                 | –65 to +150                                                            | °C                                         |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## ELECTRICAL CHARACTERISTICS (|V<sub>I</sub>–V<sub>O</sub>| = 5.0 V; I<sub>O</sub> = 0.5 A for T package; T<sub>J</sub> = T<sub>low</sub> to T<sub>high</sub> [Note 1]; I<sub>max</sub> and P<sub>max</sub> [Note 2].)

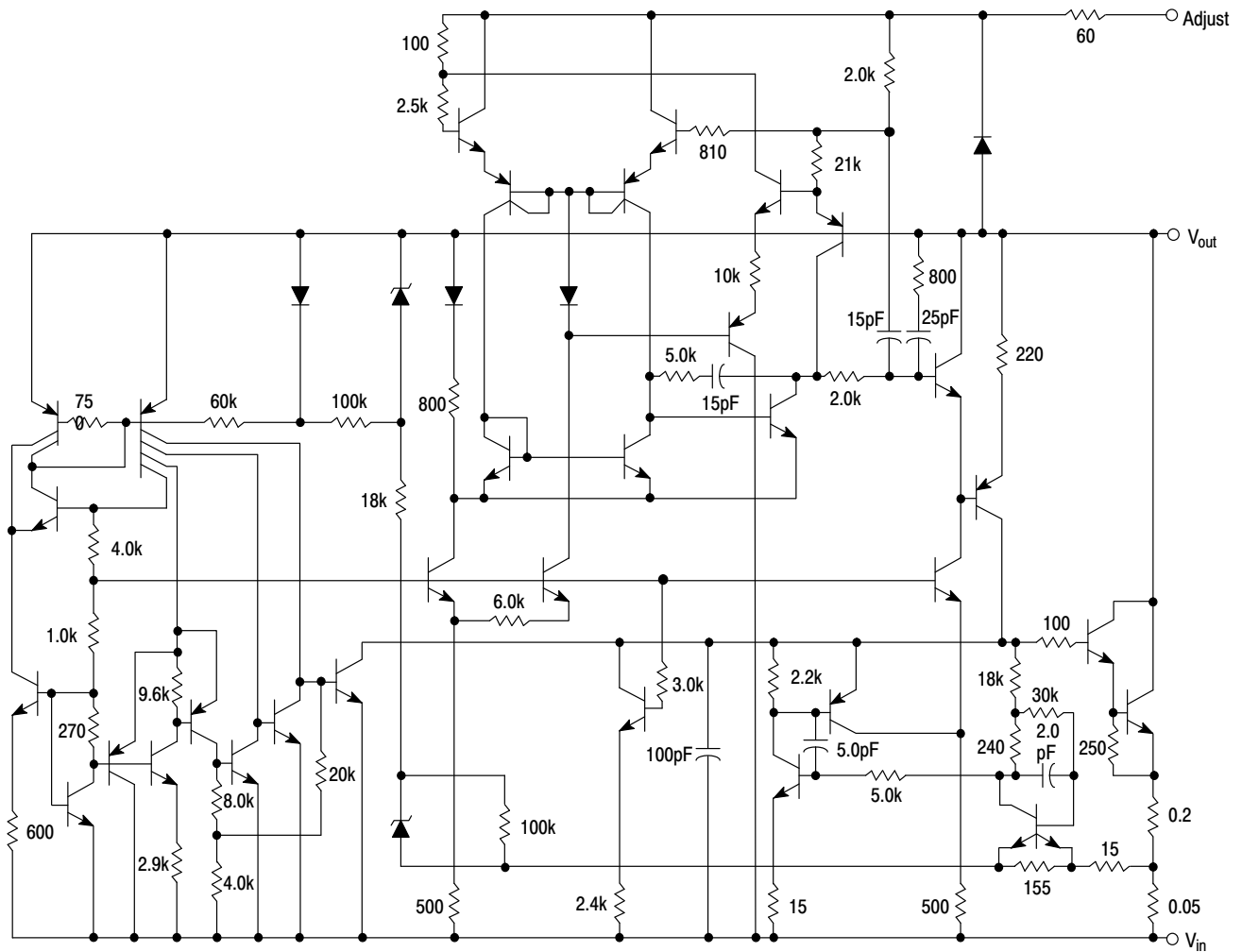
| Characteristics                                                                                                                                                                                                                        | Figure | Symbol               | Min             | Typ             | Max             | Unit                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------|-----------------|-----------------|-----------------|------------------------|
| Line Regulation (Note 3), T <sub>A</sub> = +25°C, 3.0 V ≤  V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V                                                                                                                                     | 1      | Reg <sub>line</sub>  | –               | 0.01            | 0.04            | %/V                    |
| Load Regulation (Note 3), T <sub>A</sub> = +25°C, 10 mA ≤ I <sub>O</sub> ≤ I <sub>max</sub><br> V <sub>O</sub>   ≤ 5.0 V<br> V <sub>O</sub>   ≥ 5.0 V                                                                                  | 2      | Reg <sub>load</sub>  | –<br>–          | 15<br>0.3       | 50<br>1.0       | mV<br>% V <sub>O</sub> |
| Thermal Regulation, T <sub>A</sub> = +25°C (Note 5), 10 ms Pulse                                                                                                                                                                       |        | Reg <sub>therm</sub> | –               | 0.003           | 0.04            | % V <sub>O</sub> /W    |
| Adjustment Pin Current                                                                                                                                                                                                                 | 3      | I <sub>Adj</sub>     | –               | 65              | 100             | μA                     |
| Adjustment Pin Current Change, 2.5 V ≤  V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V,<br>10 mA ≤ I <sub>L</sub> ≤ I <sub>max</sub> , P <sub>D</sub> ≤ P <sub>max</sub> , T <sub>A</sub> = +25°C                                             | 1, 2   | ΔI <sub>Adj</sub>    | –               | 2.0             | 5.0             | μA                     |
| Reference Voltage, T <sub>A</sub> = +25°C, 3.0 V ≤  V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V,<br>10 mA ≤ I <sub>O</sub> ≤ I <sub>max</sub> , P <sub>D</sub> ≤ P <sub>max</sub> , T <sub>J</sub> = T <sub>low</sub> to T <sub>high</sub> | 3      | V <sub>ref</sub>     | –1.213<br>–1.20 | –1.250<br>–1.25 | –1.287<br>–1.30 | V                      |
| Line Regulation (Note 3), 3.0 V ≤  V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V                                                                                                                                                             | 1      | Reg <sub>line</sub>  | –               | 0.02            | 0.07            | %/V                    |
| Load Regulation (Note 3), 10 mA ≤ I <sub>O</sub> ≤ I <sub>max</sub><br> V <sub>O</sub>   ≤ 5.0 V<br> V <sub>O</sub>   ≥ 5.0 V                                                                                                          | 2      | Reg <sub>load</sub>  | –<br>–          | 20<br>0.3       | 70<br>1.5       | mV<br>% V <sub>O</sub> |
| Temperature Stability (T <sub>low</sub> ≤ T <sub>J</sub> ≤ T <sub>high</sub> )                                                                                                                                                         | 3      | T <sub>S</sub>       | –               | 0.6             | –               | % V <sub>O</sub>       |
| Minimum Load Current to Maintain Regulation<br>( V <sub>I</sub> –V <sub>O</sub>   ≤ 10 V)<br>( V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V)                                                                                                | 3      | I <sub>Lmin</sub>    | –<br>–          | 1.5<br>2.5      | 6.0<br>10       | mA                     |
| Maximum Output Current<br> V <sub>I</sub> –V <sub>O</sub>   ≤ 15 V, P <sub>D</sub> ≤ P <sub>max</sub> , T Package<br> V <sub>I</sub> –V <sub>O</sub>   ≤ 40 V, P <sub>D</sub> ≤ P <sub>max</sub> , T <sub>J</sub> = +25°C, T Package   | 3      | I <sub>max</sub>     | –<br>–          | 1.5<br>0.15     | 2.2<br>0.4      | A                      |
| RMS Noise, % of V <sub>O</sub> , T <sub>A</sub> = +25°C, 10 Hz ≤ f ≤ 10 kHz                                                                                                                                                            |        | N                    | –               | 0.003           | –               | % V <sub>O</sub>       |
| Ripple Rejection, V <sub>O</sub> = –10 V, f = 120 Hz (Note 4)<br>Without C <sub>Adj</sub><br>C <sub>Adj</sub> = 10 μF                                                                                                                  | 4      | RR                   | –<br>66         | 60<br>77        | –<br>–          | dB                     |
| Long–Term Stability, T <sub>J</sub> = T <sub>high</sub> (Note 6), T <sub>A</sub> = +25°C for<br>Endpoint Measurements                                                                                                                  | 3      | S                    | –               | 0.3             | 1.0             | %/1.0 k<br>Hrs.        |
| Thermal Resistance, Junction–to–Case, T Package                                                                                                                                                                                        |        | R <sub>θJC</sub>     | –               | 4.0             | –               | °C/W                   |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. T<sub>low</sub> to T<sub>high</sub> = 0° to +125°C, for LM337T, D2T. T<sub>low</sub> to T<sub>high</sub> = –40° to +125°C, for LM337BT, BD2T.
2. I<sub>max</sub> = 1.5 A, P<sub>max</sub> = 20 W
3. Load and line regulation are specified at constant junction temperature. Change in V<sub>O</sub> because of heating effects is covered under the Thermal Regulation specification. Pulse testing with a low duty cycle is used.
4. C<sub>Adj</sub>, when used, is connected between the adjustment pin and ground.
5. Power dissipation within an IC voltage regulator produces a temperature gradient on the die, affecting individual IC components on the die. These effects can be minimized by proper integrated circuit design and layout techniques. Thermal Regulation is the effect of these temperature gradients on the output voltage and is expressed in percentage of output change per watt of power change in a specified time.
6. Since Long Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.

# LM337

## Representative Schematic Diagram



This device contains 39 active transistors.

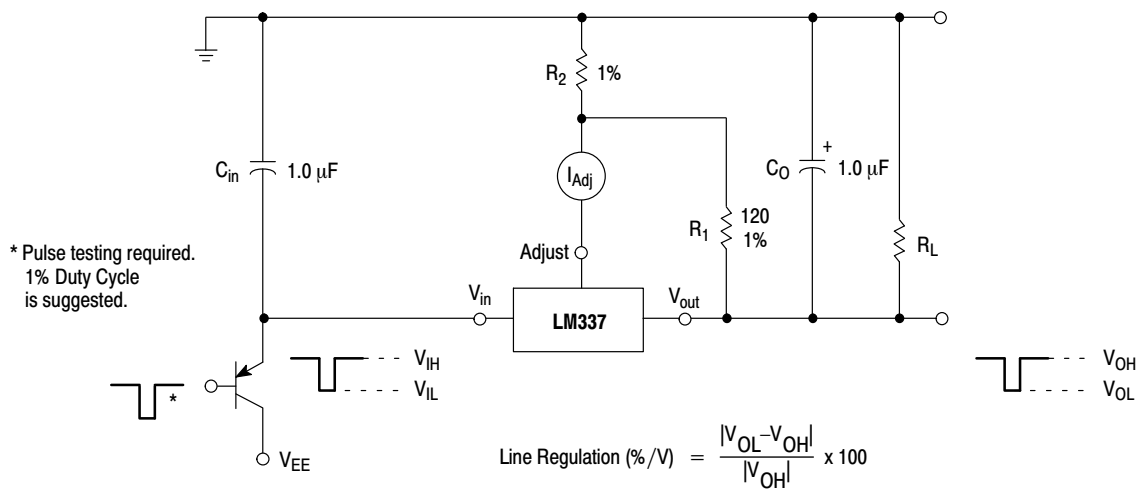
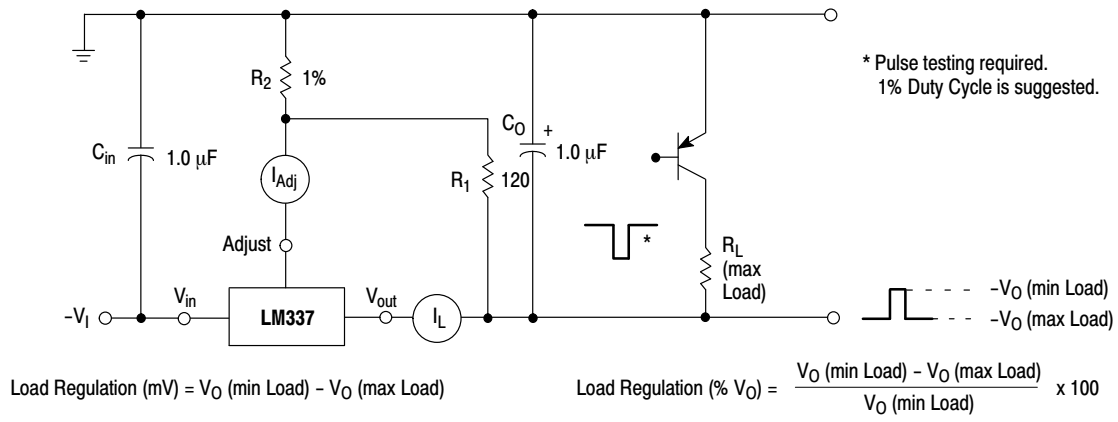
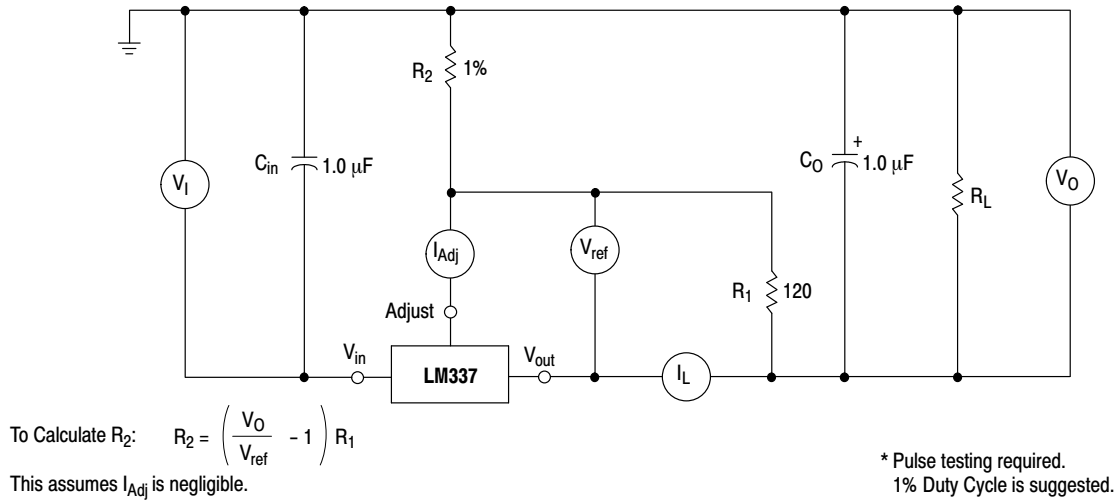


Figure 1. Line Regulation and  $\Delta I_{Adi}$ /Line Test Circuit

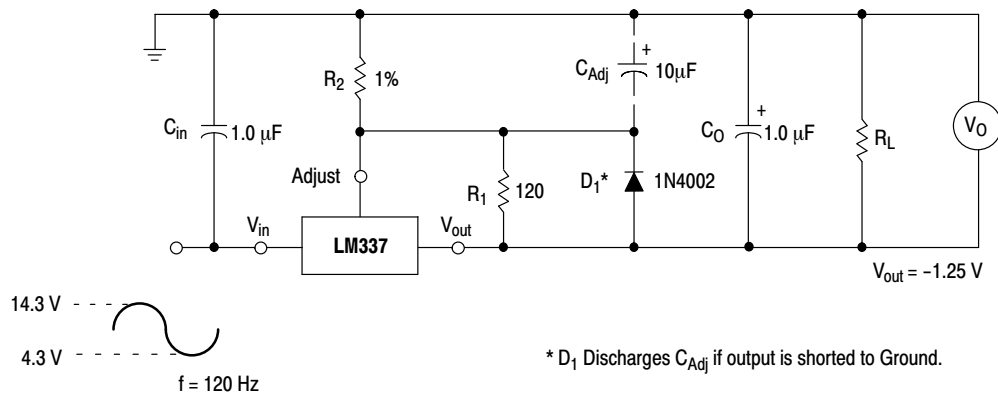
## LM337



**Figure 2. Load Regulation and  $\Delta I_{Adj}$ /Load Test Circuit**



**Figure 3. Standard Test Circuit**



**Figure 4. Ripple Rejection Test Circuit**

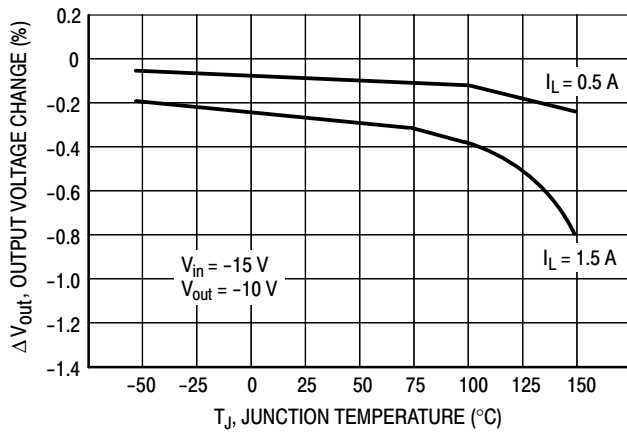


Figure 5. Load Regulation

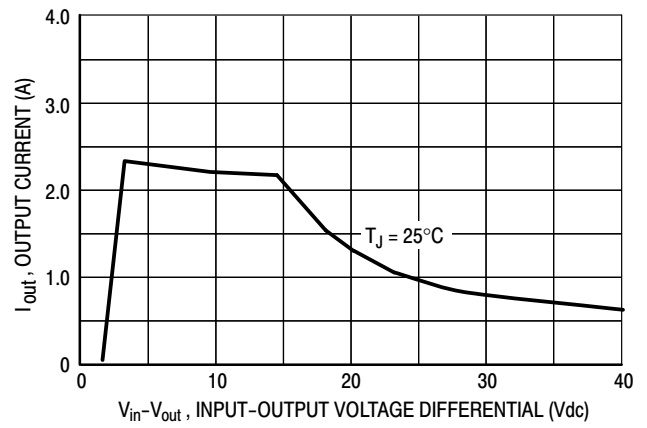


Figure 6. Current Limit

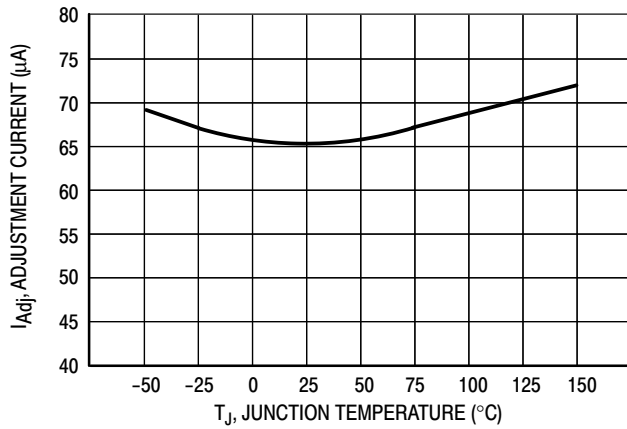


Figure 7. Adjustment Pin Current

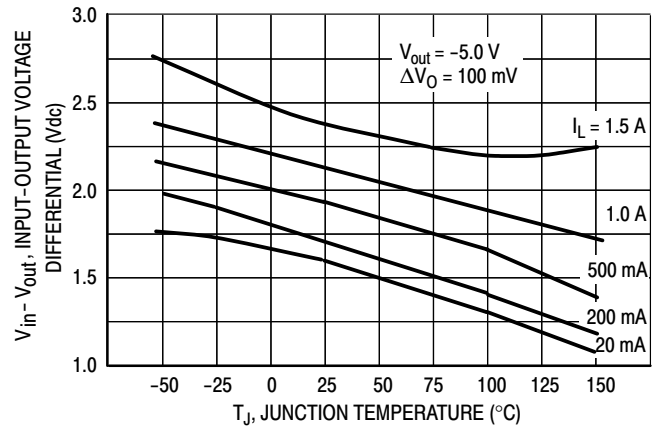


Figure 8. Dropout Voltage

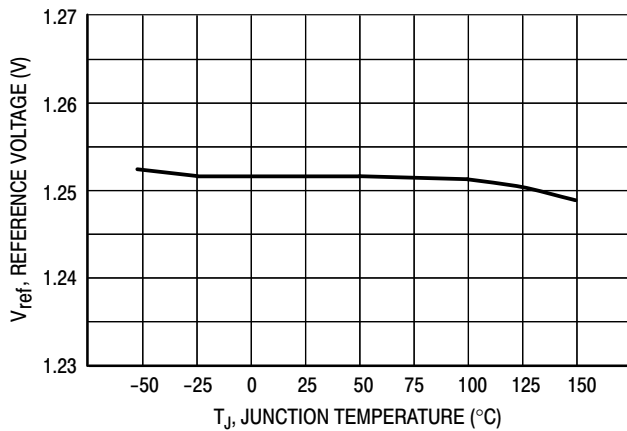


Figure 9. Temperature Stability

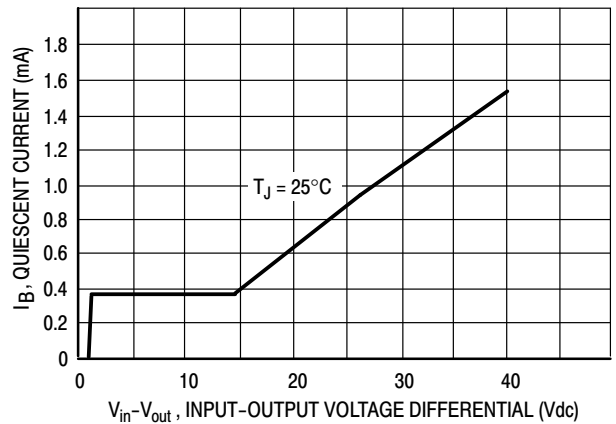


Figure 10. Minimum Operating Current

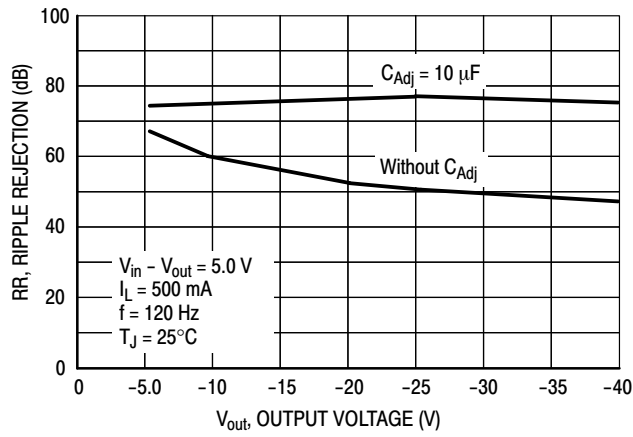


Figure 11. Ripple Rejection versus Output Voltage

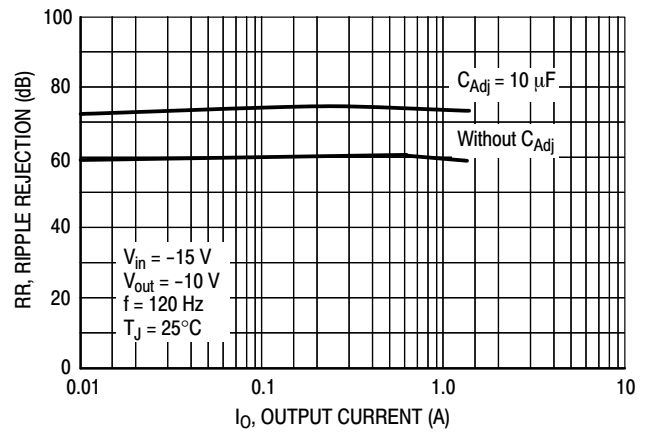


Figure 12. Ripple Rejection versus Output Current

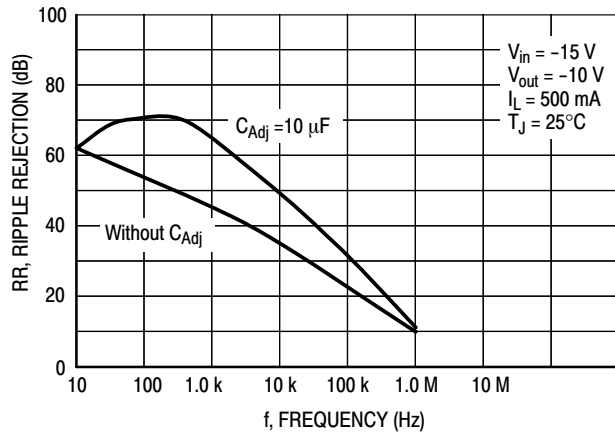


Figure 13. Ripple Rejection versus Frequency

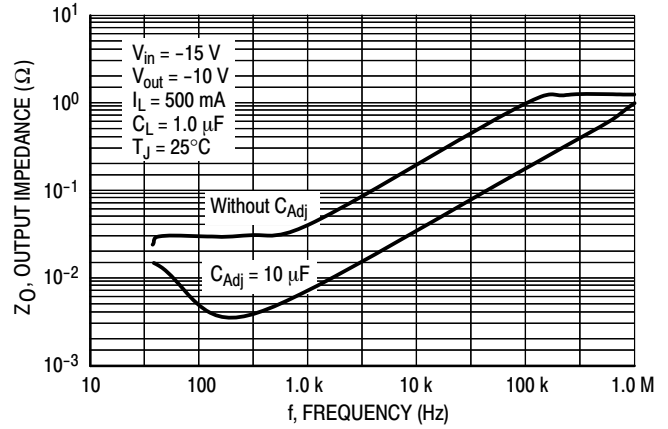


Figure 14. Output Impedance

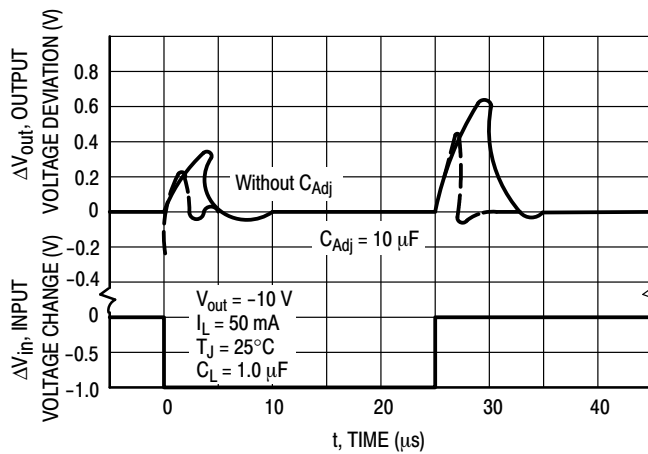


Figure 15. Line Transient Response

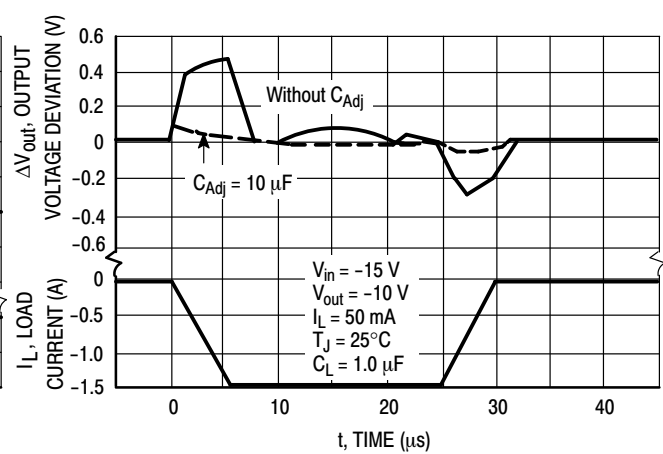


Figure 16. Load Transient Response

## APPLICATIONS INFORMATION

## Basic Circuit Operation

The LM337 is a 3-terminal floating regulator. In operation, the LM337 develops and maintains a nominal  $-1.25\text{ V}$  reference ( $V_{\text{ref}}$ ) between its output and adjustment terminals. This reference voltage is converted to a programming current ( $I_{\text{PROG}}$ ) by  $R_1$  (see Figure 17), and this constant current flows through  $R_2$  from ground.

The regulated output voltage is given by:

$$V_{\text{out}} = V_{\text{ref}} \left( 1 + \frac{R_2}{R_1} \right) + I_{\text{Adj}} R_2$$

Since the current into the adjustment terminal ( $I_{\text{Adj}}$ ) represents an error term in the equation, the LM337 was designed to control  $I_{\text{Adj}}$  to less than  $100\text{ }\mu\text{A}$  and keep it constant. To do this, all quiescent operating current is returned to the output terminal. This imposes the requirement for a minimum load current. If the load current is less than this minimum, the output voltage will rise.

Since the LM337 is a floating regulator, it is only the voltage differential across the circuit which is important to performance, and operation at high voltages with respect to ground is possible.

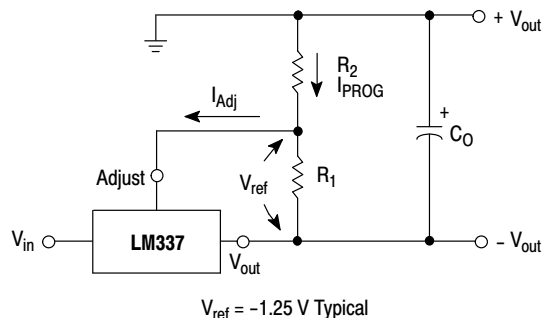


Figure 17. Basic Circuit Configuration

## Load Regulation

The LM337 is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor ( $R_1$ ) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of  $R_2$  can be returned near the load ground to provide remote ground sensing and improve load regulation.

## External Capacitors

A  $1.0\text{ }\mu\text{F}$  tantalum input bypass capacitor ( $C_{\text{in}}$ ) is recommended to reduce the sensitivity to input line impedance.

The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor ( $C_{\text{Adj}}$ ) prevents ripple from being amplified as the output voltage is increased. A  $10\text{ }\mu\text{F}$  capacitor should improve ripple rejection about  $15\text{ dB}$  at  $120\text{ Hz}$  in a  $10\text{ V}$  application.

An output capacitance ( $C_O$ ) in the form of a  $1.0\text{ }\mu\text{F}$  tantalum or  $10\text{ }\mu\text{F}$  aluminum electrolytic capacitor is required for stability. Using the classical tantalum or aluminum electrolytic capacitor types with non-reduced ESR (Equivalent Series Resistance) value is necessary. Low-ESR or similar capacitor types with reduced ESR value and ceramic capacitors can cause instability or continuous oscillations in the application.

## Protection Diodes

When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator.

Figure 18 shows the LM337 with the recommended protection diodes for output voltages in excess of  $-25\text{ V}$  or high capacitance values ( $C_O > 25\text{ }\mu\text{F}$ ,  $C_{\text{Adj}} > 10\text{ }\mu\text{F}$ ). Diode  $D_1$  prevents  $C_O$  from discharging thru the IC during an input short circuit. Diode  $D_2$  protects against capacitor  $C_{\text{Adj}}$  discharging through the IC during an output short circuit. The combination of diodes  $D_1$  and  $D_2$  prevents  $C_{\text{Adj}}$  from the discharging through the IC during an input short circuit.

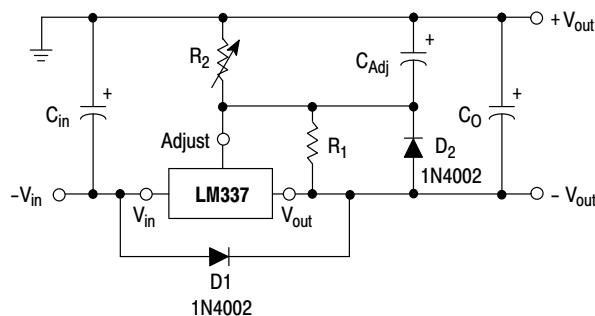
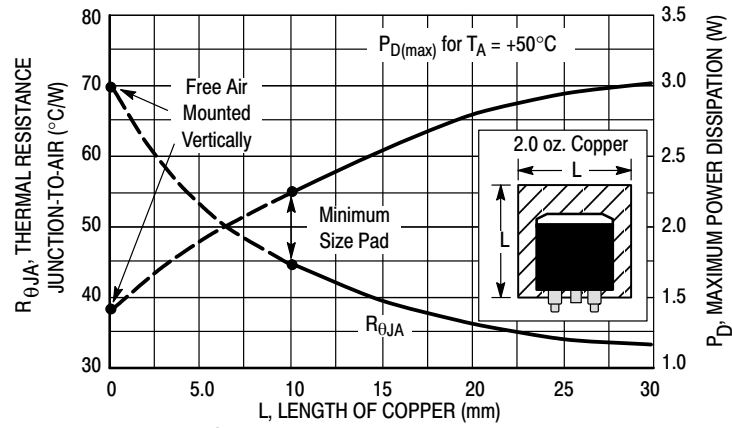


Figure 18. Voltage Regulator with Protection Diodes

# LM337



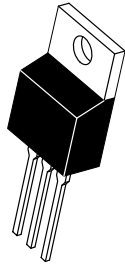
**Figure 19. D²PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length**

## ORDERING INFORMATION

| Device       | Operating Temperature Range               | Package            | Shipping <sup>†</sup> |
|--------------|-------------------------------------------|--------------------|-----------------------|
| LM337BD2TR4G | $T_J = -40^\circ$ to $+125^\circ\text{C}$ | D²PAK (Pb-Free)    | 800 / Tape & Reel     |
| LM337BTG     |                                           | TO-220AB (Pb-Free) | 50 Units / Rail       |
| LM337D2TR4G  | $T_J = 0^\circ$ to $+125^\circ\text{C}$   | D²PAK (Pb-Free)    | 800 / Tape & Reel     |
| LM337TG      |                                           | TO-220AB (Pb-Free) | 50 Units / Rail       |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

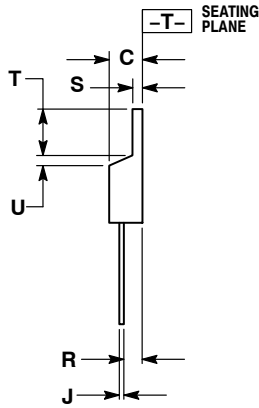
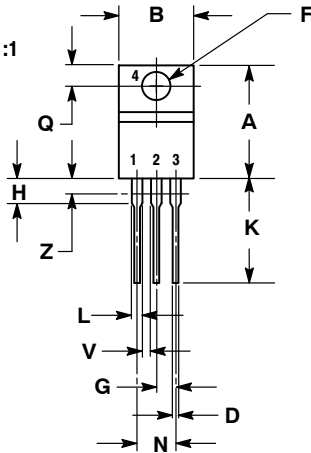




TO-220, SINGLE GAUGE  
CASE 221AB  
ISSUE A

DATE 16 NOV 2010

SCALE 1:1



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
4. PRODUCT SHIPPED PRIOR TO 2008 HAD DIMENSIONS  
S = 0.045 - 0.055 INCHES (1.143 - 1.397 MM)

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.570  | 0.620 | 14.48       | 15.75 |
| B   | 0.380  | 0.405 | 9.66        | 10.28 |
| C   | 0.160  | 0.190 | 4.07        | 4.82  |
| D   | 0.025  | 0.035 | 0.64        | 0.88  |
| F   | 0.142  | 0.147 | 3.61        | 3.73  |
| G   | 0.095  | 0.105 | 2.42        | 2.66  |
| H   | 0.110  | 0.155 | 2.80        | 3.93  |
| J   | 0.018  | 0.025 | 0.46        | 0.64  |
| K   | 0.500  | 0.562 | 12.70       | 14.27 |
| L   | 0.045  | 0.060 | 1.15        | 1.52  |
| N   | 0.190  | 0.210 | 4.83        | 5.33  |
| Q   | 0.100  | 0.120 | 2.54        | 3.04  |
| R   | 0.080  | 0.110 | 2.04        | 2.79  |
| S   | 0.020  | 0.024 | 0.508       | 0.61  |
| T   | 0.235  | 0.255 | 5.97        | 6.47  |
| U   | 0.000  | 0.050 | 0.00        | 1.27  |
| V   | 0.045  | ---   | 1.15        | ---   |
| Z   | ---    | 0.080 | ---         | 2.04  |

STYLE 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

STYLE 2:  
PIN 1. BASE  
2. EMITTER  
3. COLLECTOR  
4. EMITTER

STYLE 3:  
PIN 1. CATHODE  
2. ANODE  
3. GATE  
4. ANODE

STYLE 4:  
PIN 1. MAIN TERMINAL 1  
2. MAIN TERMINAL 2  
3. GATE  
4. MAIN TERMINAL 2

STYLE 5:  
PIN 1. GATE  
2. DRAIN  
3. SOURCE  
4. DRAIN

STYLE 6:  
PIN 1. ANODE  
2. CATHODE  
3. ANODE  
4. CATHODE

STYLE 7:  
PIN 1. CATHODE  
2. ANODE  
3. CATHODE  
4. ANODE

STYLE 8:  
PIN 1. CATHODE  
2. ANODE  
3. EXTERNAL TRIP/DELAY  
4. ANODE

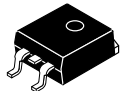
STYLE 9:  
PIN 1. GATE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

STYLE 10:  
PIN 1. GATE  
2. SOURCE  
3. DRAIN  
4. SOURCE

STYLE 11:  
PIN 1. DRAIN  
2. SOURCE  
3. GATE  
4. SOURCE

|                  |                      |                                                                                                                                                                                     |
|------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| DESCRIPTION:     | TO-220, SINGLE GAUGE | PAGE 1 OF 1                                                                                                                                                                         |

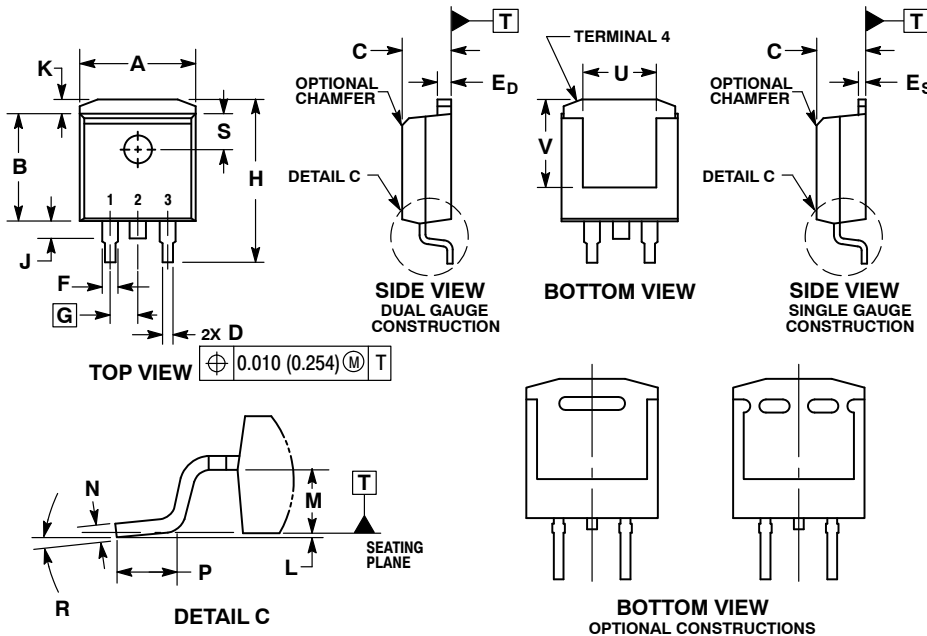
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SCALE 1:1

**D<sup>2</sup>PAK**  
CASE 936-03  
ISSUE E

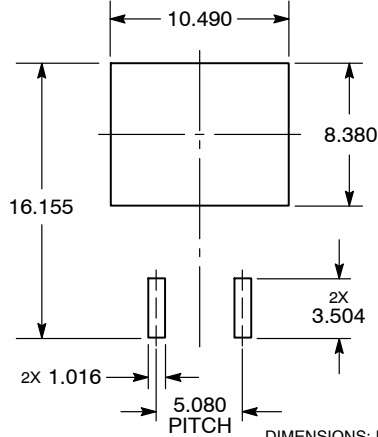
DATE 29 SEP 2015



## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCHES.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.
6. SINGLE GAUGE DESIGN WILL BE SHIPPED AFTER FPCN EXPIRATION IN OCTOBER 2011.

| DIM            | INCHES    |       | MILLIMETERS |        |
|----------------|-----------|-------|-------------|--------|
|                | MIN       | MAX   | MIN         | MAX    |
| A              | 0.386     | 0.403 | 9.804       | 10.236 |
| B              | 0.356     | 0.368 | 9.042       | 9.347  |
| C              | 0.170     | 0.180 | 4.318       | 4.572  |
| D              | 0.026     | 0.036 | 0.660       | 0.914  |
| E <sub>D</sub> | 0.045     | 0.055 | 1.143       | 1.397  |
| E <sub>S</sub> | 0.018     | 0.026 | 0.457       | 0.660  |
| F              | 0.051 REF |       | 1.295 REF   |        |
| G              | 0.100 BSC |       | 2.540 BSC   |        |
| H              | 0.539     | 0.579 | 13.691      | 14.707 |
| J              | 0.125 MAX |       | 3.175 MAX   |        |
| K              | 0.050 REF |       | 1.270 REF   |        |
| L              | 0.000     | 0.010 | 0.000       | 0.254  |
| M              | 0.088     | 0.102 | 2.235       | 2.591  |
| N              | 0.018     | 0.026 | 0.457       | 0.660  |
| P              | 0.058     | 0.078 | 1.473       | 1.981  |
| R              | 0°        | 8°    | 0°          | 8°     |
| S              | 0.116 REF |       | 2.946 REF   |        |
| U              | 0.200 MIN |       | 5.080 MIN   |        |
| V              | 0.250 MIN |       | 6.350 MIN   |        |

**RECOMMENDED  
SOLDERING FOOTPRINT\***


DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the **onsemi** Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

**GENERIC  
MARKING DIAGRAM\***


XXXXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

|                         |                         |                                                                                                                                                                                     |
|-------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>D<sup>2</sup>PAK</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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