

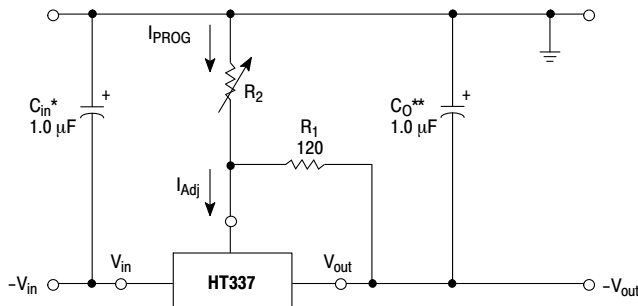
1.5 A, Adjustable Output, Negative Voltage Regulator

The HT337 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 HT337 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 HT337 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 D²PAK and Standard 3-Lead Transistor Package
- These Devices are Pb-Free and are RoHS Compliant



*C_{in} 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_O 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

PIN CONNECTIONS

- Pin 1. V_{in}
 2. V_{out}
 3. V_{out}
 4. Adjust
 5. N.C.
 6. V_{out}
 7. V_{out}
 8. N.C.



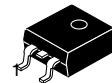
ESOP8 E
SUFFIX
HT337AREZ



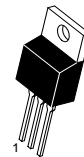
SOT223 D
SUFFIX
HT337ARDZ



TO252 M
SUFFIX
HT337ARMZ



TO263 S
SUFFIX
HT337ARSZ



TO220 T
SUFFIX
HT337ATZ

- Pin 1. Adjust
 2. V_{in}
 3. V_{out}

Heatsink tab is connected to Pin 2.

T_A = -40° to 125°C for all packages

MAXIMUM RATINGS ($T_A = +25^\circ\text{C}$, unless otherwise noted)

| Rating | Symbol | Value | Unit |
|---|--|--|--|
| Input–Output Voltage Differential | $V_I - V_O$ | 40 | Vdc |
| Power Dissipation Case 221A $T_A = +25^\circ\text{C}$ Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case Case 936 (D ² PAK) $T_A = +25^\circ\text{C}$ Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case | P_D θ_{JA} θ_{JC} P_D θ_{JA} θ_{JC} | Internally Limited 65 5.0 Internally Limited 70 5.0 | W $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ W $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ |
| Operating Junction Temperature Range | T_J | –40 to +125 | $^\circ\text{C}$ |
| Storage Temperature Range | T_{stg} | –65 to +150 | $^\circ\text{C}$ |

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 ($|V_I - V_O| = 5.0\text{ V}$; $I_O = 0.5\text{ A}$ for T package;; I_{max} and P_{max} [Note 1].)

| Characteristics | Figure | Symbol | Min | Typ | Max | Unit |
|--|--------|----------------------|-----------------|-----------------|-----------------|---------------------------|
| Line Regulation (Note 3), $T_A = +25^\circ\text{C}$, $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$ | 1 | Reg_{line} | – | 0.01 | 0.04 | %/V |
| Load Regulation (Note 3), $T_A = +25^\circ\text{C}$, $10\text{ mA} \leq I_O \leq I_{max}$ $ V_O \leq 5.0\text{ V}$ $ V_O \geq 5.0\text{ V}$ | 2 | Reg_{load} | – – | 15 0.3 | 50 1.0 | mV % V_O |
| Thermal Regulation, $T_A = +25^\circ\text{C}$ (Note 5), 10 ms Pulse | | Reg_{therm} | – | 0.003 | 0.04 | % V_O/W |
| Adjustment Pin Current | 3 | I_{Adj} | – | 65 | 100 | μA |
| Adjustment Pin Current Change, $2.5\text{ V} \leq V_I - V_O \leq 40\text{ V}$, $10\text{ mA} \leq I_L \leq I_{max}$, $P_D \leq P_{max}$, $T_A = +25^\circ\text{C}$ | 1, 2 | ΔI_{Adj} | – | 2.0 | 5.0 | μA |
| Reference Voltage, $T_A = +25^\circ\text{C}$, $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$, $10\text{ mA} \leq I_O \leq I_{max}$, $P_D \leq P_{max}$, $T_J = T_{low}$ to T_{high} | 3 | V_{ref} | –1.213 –1.20 | –1.250 –1.25 | –1.287 –1.30 | V |
| Line Regulation (Note 3), $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$ | 1 | Reg_{line} | – | 0.02 | 0.07 | %/V |
| Load Regulation (Note 3), $10\text{ mA} \leq I_O \leq I_{max}$ $ V_O \leq 5.0\text{ V}$ $ V_O \geq 5.0\text{ V}$ | 2 | Reg_{load} | – – | 20 0.3 | 70 1.5 | mV % V_O |
| Temperature Stability ($T_{low} \leq T_J \leq T_{high}$) | 3 | T_S | – | 0.6 | – | % V_O |
| Minimum Load Current to Maintain Regulation ($ V_I - V_O \leq 10\text{ V}$) ($ V_I - V_O \leq 40\text{ V}$) | 3 | I_{Lmin} | – – | 1.5 2.5 | 6.0 10 | mA |
| Maximum Output Current $ V_I - V_O \leq 15\text{ V}$, $P_D \leq P_{max}$, T Package $ V_I - V_O \leq 40\text{ V}$, $P_D \leq P_{max}$, $T_J = +25^\circ\text{C}$, T Package | 3 | I_{max} | – – | 1.5 0.15 | 2.2 0.4 | A |
| RMS Noise, % of V_O , $T_A = +25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$ | | N | – | 0.003 | – | % V_O |
| Ripple Rejection, $V_O = -10\text{ V}$, $f = 120\text{ Hz}$ (Note 4) Without C_{Adj} $C_{Adj} = 10\text{ }\mu\text{F}$ | 4 | RR | – 66 | 60 77 | – – | dB |
| Long–Term Stability, $T_J = T_{high}$ (Note 6), $T_A = +25^\circ\text{C}$ for Endpoint Measurements | 3 | S | – | 0.3 | 1.0 | %/1.0 k Hrs. |
| Thermal Resistance, Junction–to–Case, T Package | | $R_{\theta JC}$ | – | 4.0 | – | $^\circ\text{C}/\text{W}$ |

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.

- $I_{max} = 1.5\text{ A}$, $P_{max} = 20\text{ W}$
- Load and line regulation are specified at constant junction temperature. Change in V_O because of heating effects is covered under the Thermal Regulation specification. Pulse testing with a low duty cycle is used.
- C_{Adj} , when used, is connected between the adjustment pin and ground.
- 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.
- 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.

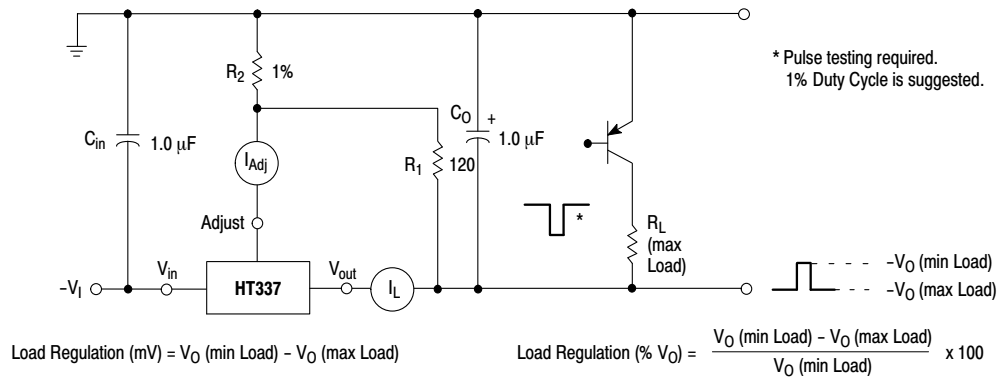


Figure 2. Load Regulation and ΔI_{Adj} /Load Test Circuit

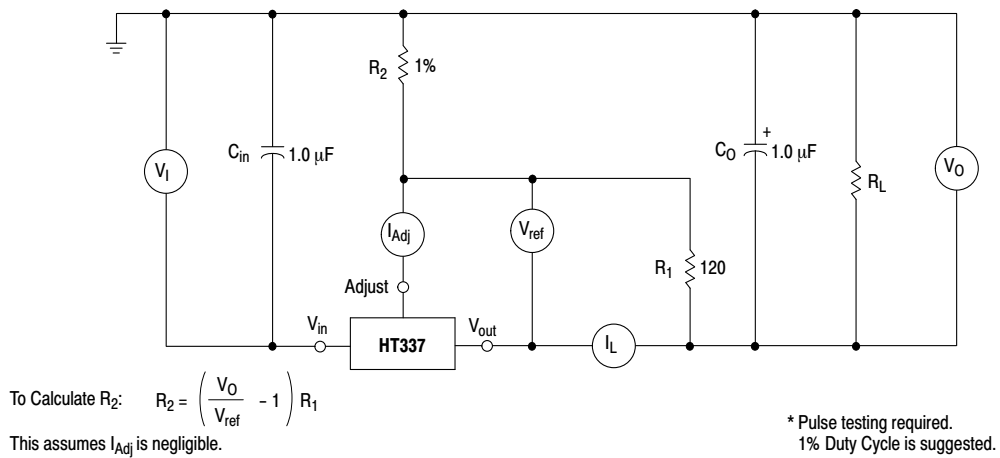


Figure 3. Standard Test Circuit

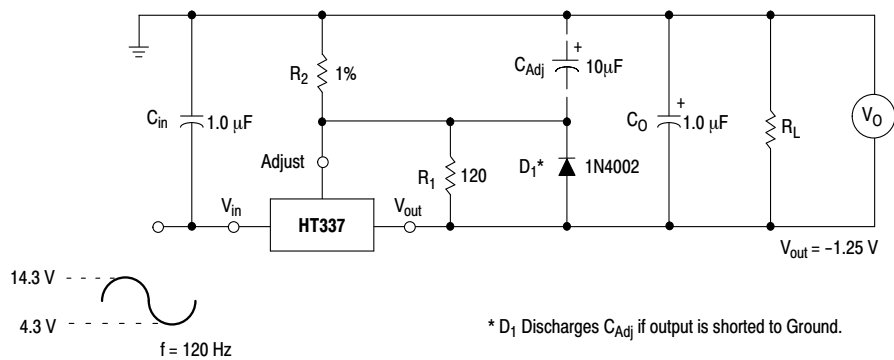


Figure 4. Ripple Rejection Test Circuit

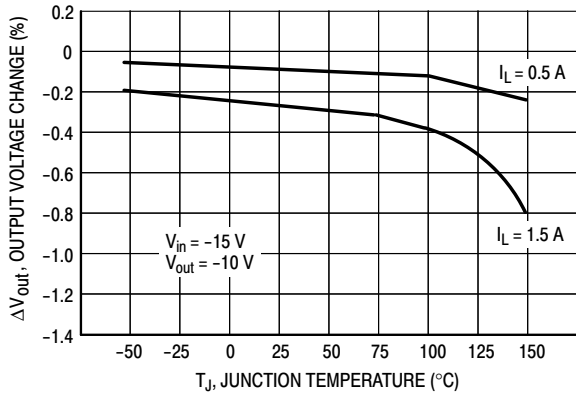


Figure 5. Load Regulation

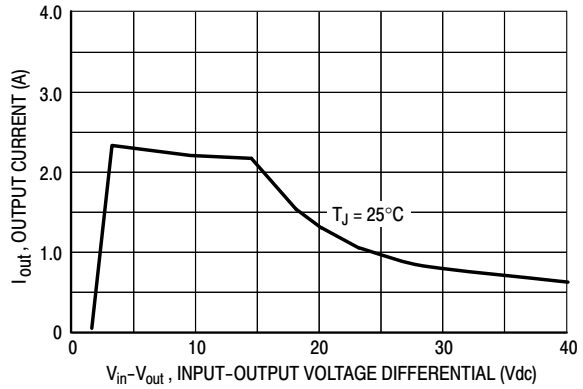


Figure 6. Current Limit

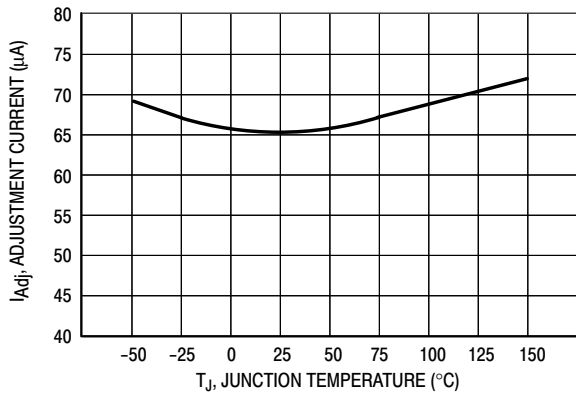


Figure 7. Adjustment Pin Current

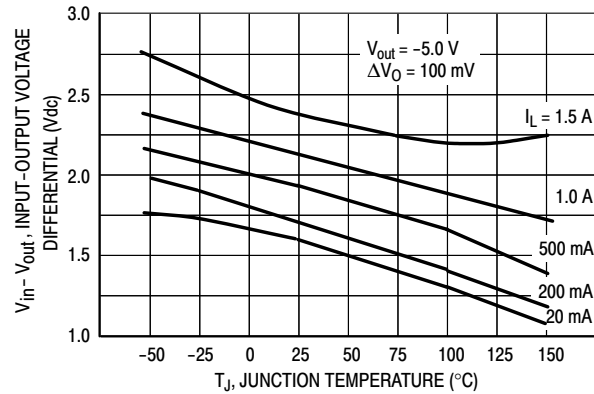


Figure 8. Dropout Voltage

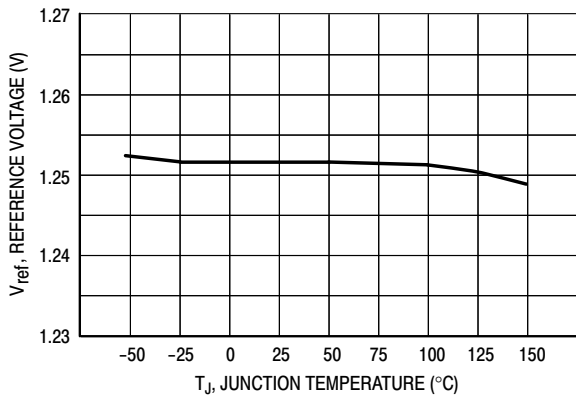


Figure 9. Temperature Stability

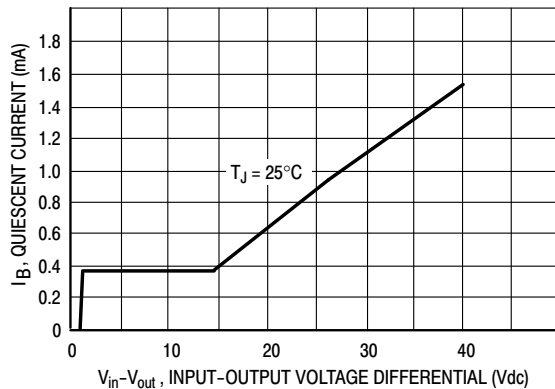
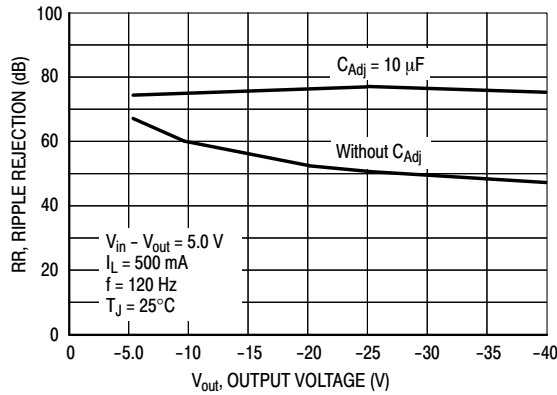
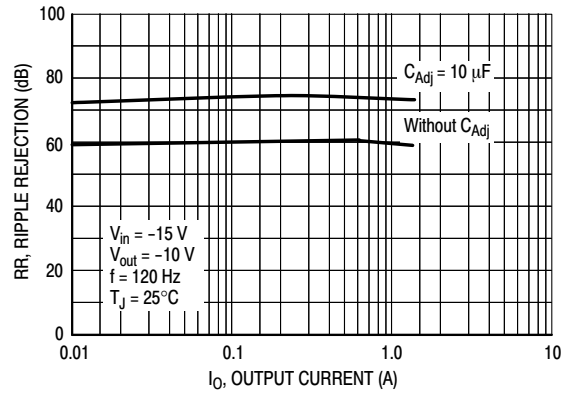
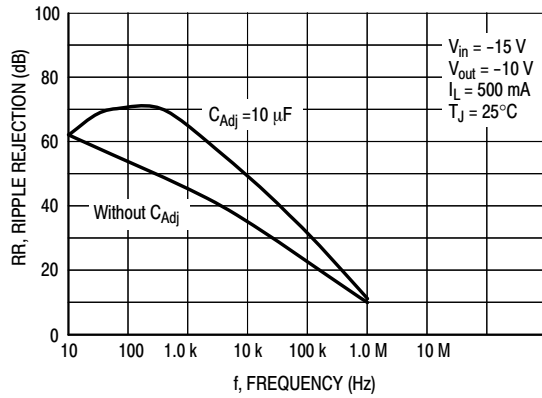
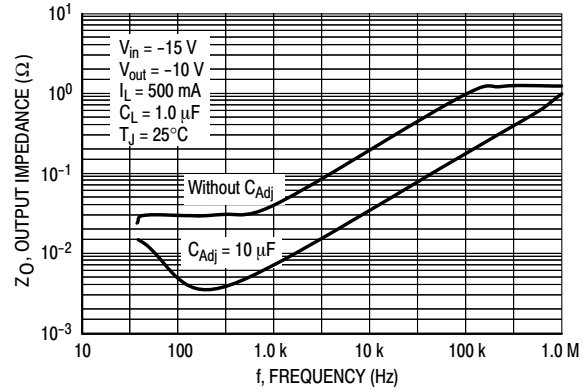
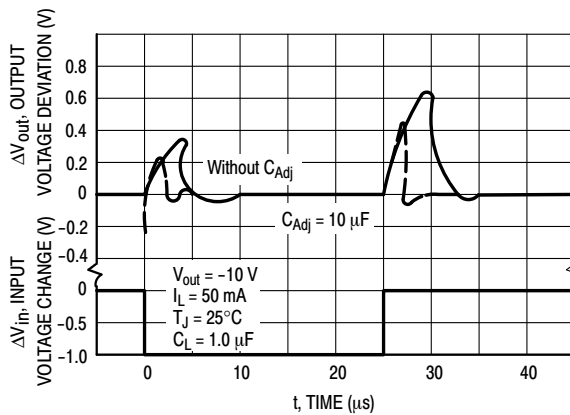
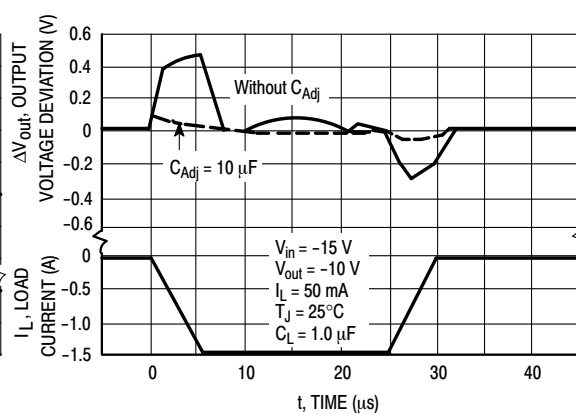


Figure 10. Minimum Operating Current


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 HT337 is a 3-terminal floating regulator. In operation, the HT337 develops and maintains a nominal -1.25 V reference (V_{ref}) between its output and adjustment terminals. This reference voltage is converted to a programming current (I_{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_{Adj}) represents an error term in the equation, the HT337 was designed to control I_{Adj} to less than $100\ \mu\text{A}$ 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 HT337 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.

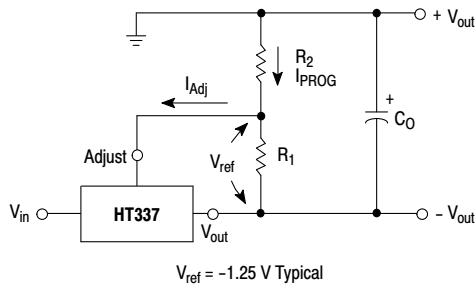


Figure 17. Basic Circuit Configuration

Load Regulation

The HT337 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 $1.0\ \mu\text{F}$ tantalum input bypass capacitor (C_{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_{Adj}) prevents ripple from being amplified as the output voltage is increased. A $10\ \mu\text{F}$ 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 $1.0\ \mu\text{F}$ tantalum or $10\ \mu\text{F}$ 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 HT337 with the recommended protection diodes for output voltages in excess of $-25\ \text{V}$ or high capacitance values ($C_O > 25\ \mu\text{F}$, $C_{\text{Adj}} > 10\ \mu\text{F}$). Diode D_1 prevents C_O from discharging thru the IC during an input short circuit. Diode D_2 protects against capacitor C_{Adj} discharging through the IC during an output short circuit. The combination of diodes D_1 and D_2 prevents C_{Adj} from the discharging through the IC during an input short circuit.

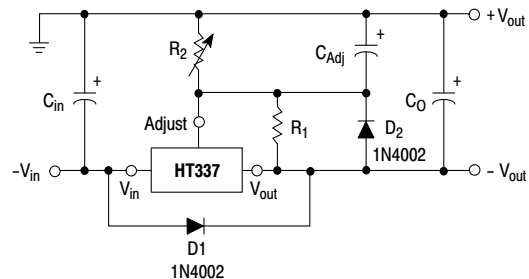


Figure 18. Voltage Regulator with Protection Diodes

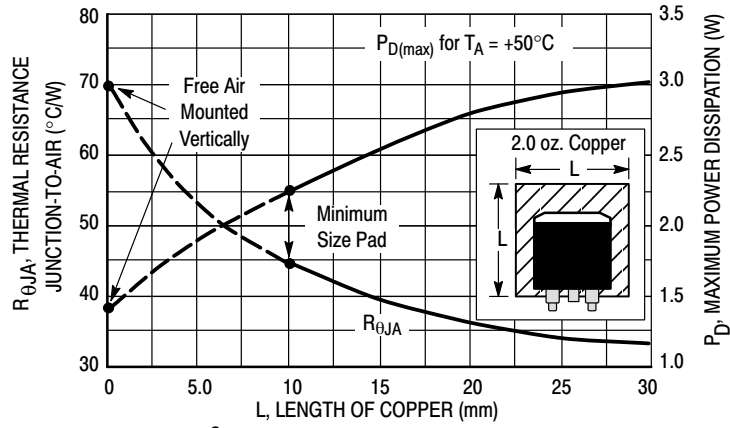
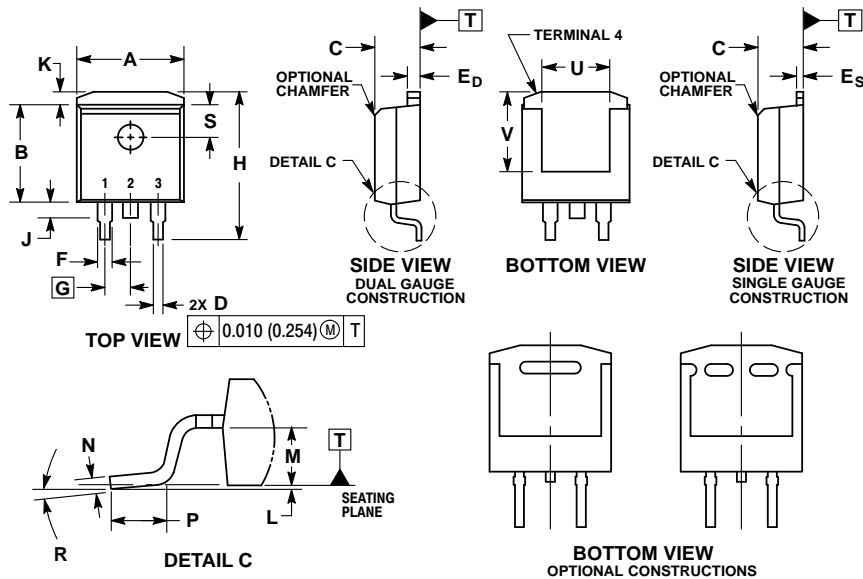
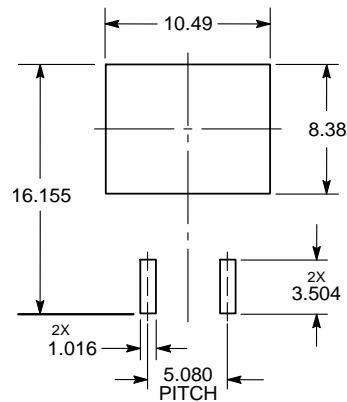


Figure 19. D²PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

TO263


- 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.

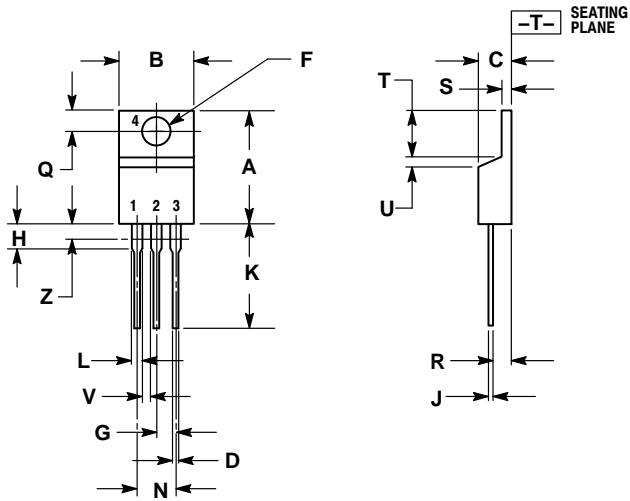
| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|--------|
| | MIN | MAX | MIN | MAX |
| A | 0.386 | 0.403 | 9.804 | 10.236 |
| B | 0.356 | 0.368 | 9.042 | 9.347 |
| C | 0.170 | 0.180 | 4.318 | 4.572 |
| D | 0.026 | 0.036 | 0.660 | 0.914 |
| Ed | 0.045 | 0.055 | 1.143 | 1.397 |
| Es | 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 | 5° REF | | 5° REF | |
| S | 0.116 REF | | 2.946 REF | |
| U | 0.200 MIN | | 5.080 MIN | |
| V | 0.250 MIN | | 6.350 MIN | |

SOLDERING FOOTPRINT*


DIMENSIONS: MILLIMETERS

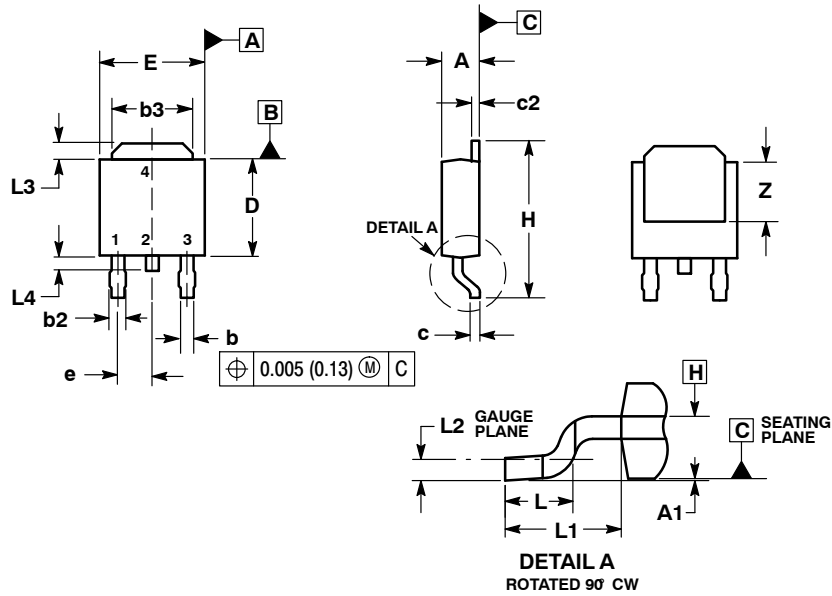
*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

TO220



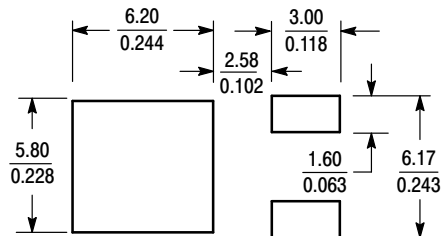
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: INCHES.
 3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
 4. PRODUCT SHIPPED PRIOR TO 2008 HAD DIMENSIONS S = 0.045 - 0.055 INCHES (1.143 - 1.397 MM)

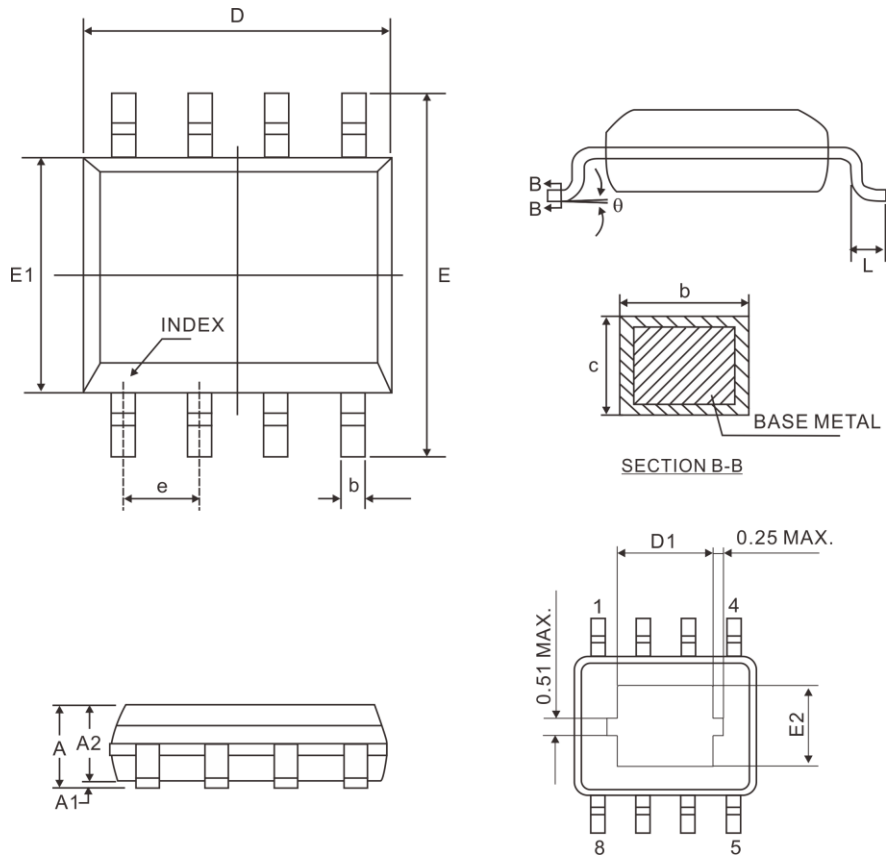
| DIM | INCHES | | MILLIMETERS | |
|-----|--------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.570 | 0.620 | 14.48 | 15.75 |
| B | 0.380 | 0.405 | 9.66 | 10.28 |
| C | 0.160 | 0.190 | 4.07 | 4.82 |
| D | 0.025 | 0.035 | 0.64 | 0.88 |
| F | 0.142 | 0.147 | 3.61 | 3.73 |
| G | 0.095 | 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 |

TO252

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3 and Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. DIMENSIONS D AND E ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
6. DATUMS A AND B ARE DETERMINED AT DATUM PLANE H.

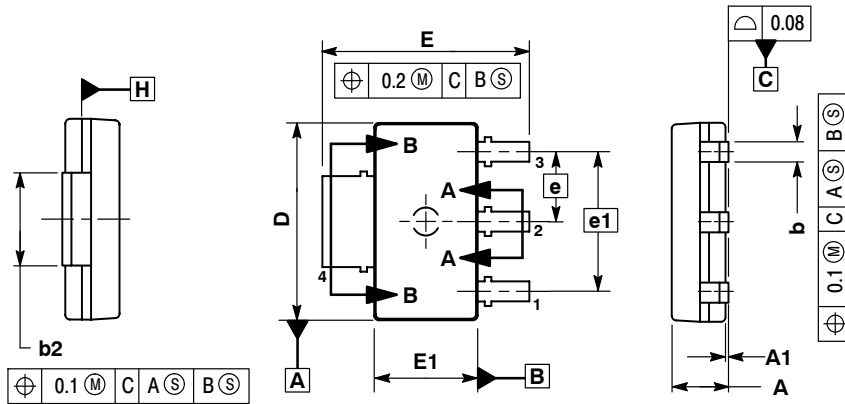
| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.086 | 0.094 | 2.18 | 2.38 |
| A1 | 0.000 | 0.005 | 0.00 | 0.13 |
| b | 0.025 | 0.035 | 0.63 | 0.89 |
| b2 | 0.030 | 0.045 | 0.76 | 1.14 |
| b3 | 0.180 | 0.215 | 4.57 | 5.46 |
| c | 0.018 | 0.024 | 0.46 | 0.61 |
| c2 | 0.018 | 0.024 | 0.46 | 0.61 |
| D | 0.235 | 0.245 | 5.97 | 6.22 |
| E | 0.250 | 0.265 | 6.35 | 6.73 |
| e | 0.090 BSC | | 2.29 BSC | |
| H | 0.370 | 0.410 | 9.40 | 10.41 |
| L | 0.055 | 0.070 | 1.40 | 1.78 |
| L1 | 0.108 REF | | 2.74 REF | |
| L2 | 0.020 BSC | | 0.51 BSC | |
| L3 | 0.035 | 0.050 | 0.89 | 1.27 |
| L4 | --- | 0.040 | --- | 1.01 |
| Z | 0.155 | --- | 3.93 | --- |

SOLDERING FOOTPRINT*


ESOP8


| Symbol | Dimensions(mm) | | |
|----------|----------------|------|------|
| | Min. | Nom. | Max. |
| A | - | - | 1.70 |
| A1 | 0.00 | - | 0.15 |
| A2 | 1.25 | - | - |
| b | 0.31 | - | 0.51 |
| c | 0.10 | - | 0.25 |
| e | 1.27 BSC | | |
| D | 4.90 BSC | | |
| D1 | 2.81 | - | 3.30 |
| E | 6.00 BSC | | |
| E1 | 3.90 BSC | | |
| E2 | 2.05 | - | 2.41 |
| L | 0.40 | 0.60 | 1.27 |
| θ | 0° | - | 8° |

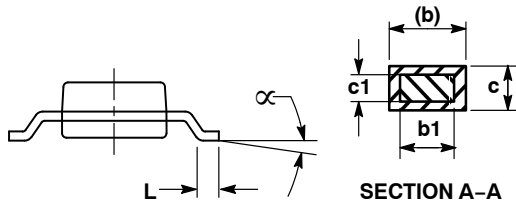
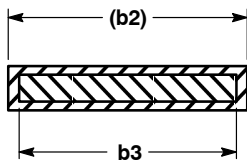
SOT-223



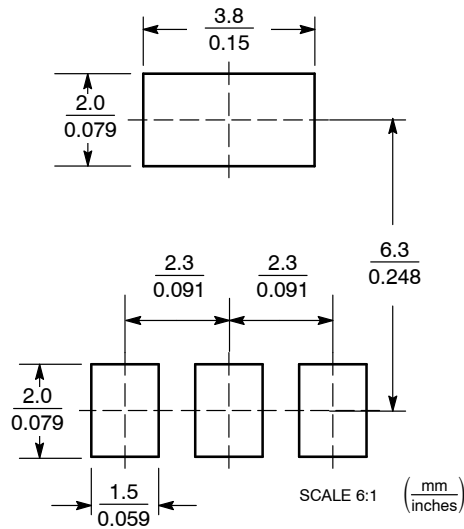
NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.23 PER SIDE.
4. DIMENSIONS b AND b2 DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 TOTAL IN EXCESS OF THE b AND b2 DIMENSIONS AT MAXIMUM MATERIAL CONDITION.
5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
6. DIMENSIONS D AND E1 ARE TO BE DETERMINED AT DATUM PLANE H.

| MILLIMETERS | | |
|-------------|------|------|
| DIM | MIN | MAX |
| A | --- | 1.80 |
| A1 | 0.02 | 0.11 |
| b | 0.60 | 0.88 |
| b1 | 0.60 | 0.80 |
| b2 | 2.90 | 3.10 |
| b3 | 2.90 | 3.05 |
| c | 0.24 | 0.35 |
| c1 | 0.24 | 0.30 |
| D | 6.30 | 6.70 |
| E | 6.70 | 7.30 |
| E1 | 3.30 | 3.70 |
| e | 2.30 | |
| e1 | 4.60 | |
| L | 0.25 | --- |
| α | 0° | 10° |



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