

LM117HVQML 3-Terminal Adjustable Regulator

Check for Samples: [LM117HVQML](#), [LM117HVQML-SP](#)

FEATURES

- Available with Radiation Ensured
 - Total Ionizing Dose 100 krad(Si)
 - Low Dose Rate Qualified 100 krad(Si)
- Adjustable Output down to 1.2V
- Specified 0.5A or 1.5A Output Current
- Line Regulation Typically 0.01%/V
- Load Regulation Typically 0.1%
- Current Limit Constant with Temperature
- Eliminates the Need to Stock Many Voltages
- 80 dB Ripple Rejection
- Output is Short-Circuit Protected

DESCRIPTION

The LM117HV are adjustable 3-terminal positive voltage regulators capable of supplying either 0.5A or 1.5A over a 1.2V to 57V output 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.

In addition to higher performance than fixed regulators, the LM117HV series offers full overload protection available only in IC's. 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.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejections ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117HV is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e. do not short the output to ground.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM117HV can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

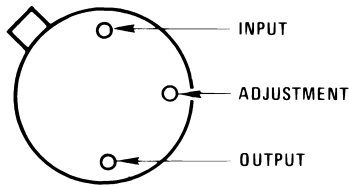


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

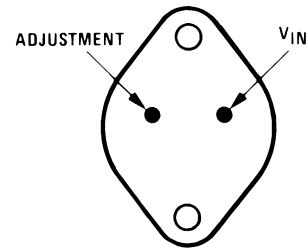
CONNECTION DIAGRAMS

(See Physical Dimension section for further information)



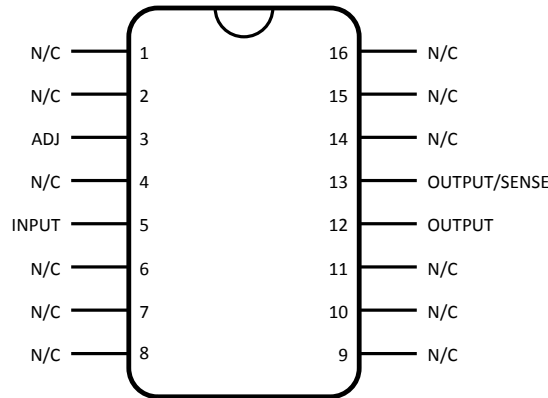
CASE IS OUTPUT

**Figure 1. 3-Pin TO Metal Can Package
Bottom View
See NDT003A Package**



CASE IS OUTPUT

**Figure 2. 2-Pin TO Metal Can Package
Bottom View
See K0002C Package**



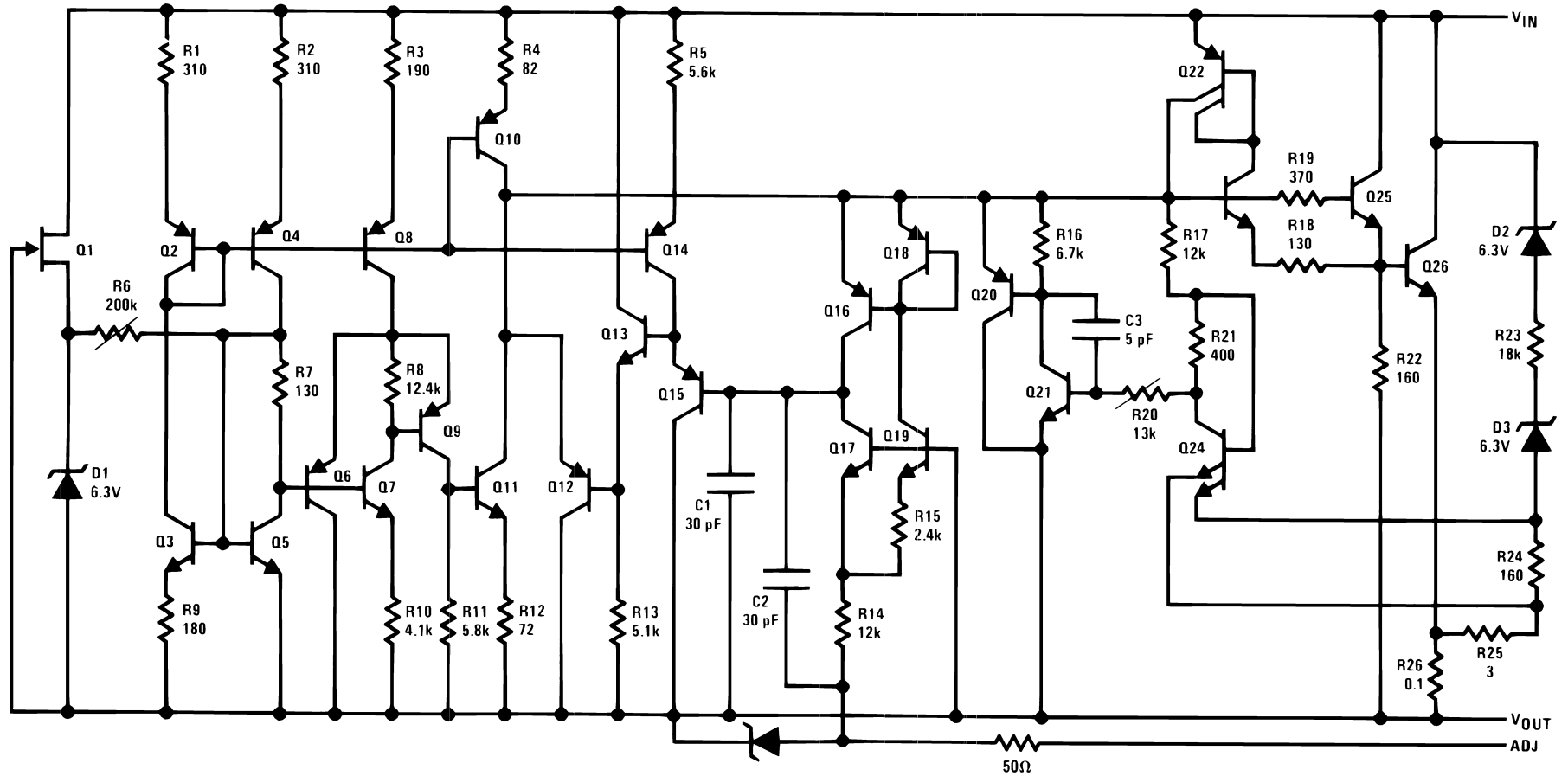
For the CFP device to function properly, the “Output” and “Output/Sense” pins must be connected on the users printed circuit board.

**Figure 3. 16-Pin CFP
Top View**

Table 1. LM117HV Series Packages

| Part Number Suffix | Package | Design Load Current |
|--------------------|---------|---------------------|
| H | TO | 0.5A |
| K | TO | 1.5A |
| WG, GW | CFP | 0.5A |

Schematic Diagram





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⁽¹⁾

| | | | |
|---------------------------------------|---------------------------------|---|---------|
| Power Dissipation ⁽²⁾ | Internally limited | | |
| Input - Output Voltage Differential | +60V, -0.3V | | |
| Maximum Junction Temperature | +150°C | | |
| Storage Temperature | -65°C ≤ T _A ≤ +150°C | | |
| Lead Temperature (Soldering, 10 sec.) | 300°C | | |
| Thermal Resistance | θ _{JA} | TO Metal Can - Still Air | 39°C/W |
| | | TO Metal Can - 500LF/Min Air flow | 14°C/W |
| | | TO Metal Can - Still Air | 186°C/W |
| | | TO Metal Can - 500LF/Min Air flow | 64°C/W |
| | | CFP "WG" (device 01, 61) - Still Air | 115°C/W |
| | | CFP "WG" (device 01, 61) - 500LF/Min Air flow | 66°C/W |
| | | CFP "GW" (device 02, 62) - Still Air | 130°C/W |
| | | CFP "GW" (device 02, 62) - 500LF/Min Air flow | 80°C/W |
| | θ _{JC} | TO Metal Can | 1.9°C/W |
| | | TO Metal Can | 21°C/W |
| | | CFP "WG" (device 01, 61) ⁽³⁾ | 3.4°C/W |
| | | CFP "GW" (device 02, 62) | 7°C/W |
| ESD Tolerance ⁽⁴⁾ | 2000V | | |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is P_{Dmax} = (T_{Jmax} - T_A) / θ_{JA} or the number given in the Absolute Maximum Ratings, whichever is lower. "Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the PFM package and 20W for the TO package."
- (3) The package material for these devices allows much improved heat transfer over our standard ceramic packages. In order to take full advantage of this improved heat transfer, heat sinking must be provided between the package base (directly beneath the die), and either metal traces on, or thermal vias through, the printed circuit board. Without this additional heat sinking, device power dissipation must be calculated using θ_{JA}, rather than θ_{JC}, thermal resistance. It must not be assumed that the device leads will provide substantial heat transfer out the package, since the thermal resistance of the lead frame material is very poor, relative to the material of the package base. The stated θ_{JC} thermal resistance is for the package material only, and does not account for the additional thermal resistance between the package base and the printed circuit board. The user must determine the value of the additional thermal resistance and must combine this with the stated value for the package, to calculate the total allowed power dissipation for the device.
- (4) Human body model, 1.5 kΩ in series with 100 pF.

Recommended Operating Conditions

| | |
|-----------------------------|---------------------------------|
| Operating Temperature Range | -55°C ≤ T _A ≤ +125°C |
|-----------------------------|---------------------------------|

Table 2. Quality Conformance Inspection

| Mil-Std-883, Method 5005 - Group A | | |
|------------------------------------|---------------------|---------|
| Subgroup | Description | Temp °C |
| 1 | Static tests at | 25 |
| 2 | Static tests at | 125 |
| 3 | Static tests at | -55 |
| 4 | Dynamic tests at | 25 |
| 5 | Dynamic tests at | 125 |
| 6 | Dynamic tests at | -55 |
| 7 | Functional tests at | 25 |
| 8A | Functional tests at | 125 |

Table 2. Quality Conformance Inspection (continued)

| Mil-Std-883, Method 5005 - Group A | | |
|------------------------------------|---------------------|---------|
| Subgroup | Description | Temp °C |
| 8B | Functional tests at | -55 |
| 9 | Switching tests at | 25 |
| 10 | Switching tests at | 125 |
| 11 | Switching tests at | -55 |
| 12 | Settling time at | 25 |
| 13 | Settling time at | 125 |
| 14 | Settling time at | -55 |

LM117HVH, HVWG Electrical Characteristics DC Parameters

 The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 8mA$, $V_{OUT} = 1.25V$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|------------------------|-------------------------------|---|-------|-------|------|---------|------------|
| I_{Adj} | Adjustment Pin Current | $V_{Diff} = 3V$ | | | 100 | μA | 1 |
| | | $V_{Diff} = 3.3V$ | | | 100 | μA | 2, 3 |
| | | $V_{Diff} = 40V$ | | | 100 | μA | 1, 2, 3 |
| I_Q | Minimum Load Current | $V_{Diff} = 3V, V_O = 1.7V$ | | | 5.0 | mA | 1 |
| | | $V_{Diff} = 3.3V, V_O = 1.7V$ | | | 5.0 | mA | 2, 3 |
| | | $V_I = 40V, V_O = 1.7V$ | | | 5.0 | mA | 1, 2, 3 |
| | | $V_I = 60V, V_O = 1.7V$ | | | 8.2 | mA | 1 |
| V_{Ref} | Reference Voltage | $V_{Diff} = 3V$ | | 1.2 | 1.3 | V | 1 |
| | | $V_{Diff} = 3.3V$ | | 1.2 | 1.3 | V | 2, 3 |
| | | $V_{Diff} = 40V$ | | 1.2 | 1.3 | V | 1, 2, 3 |
| V_{RLine} | Line Regulation | $3V \leq V_{Diff} \leq 40V,$ $V_O = V_{Ref}$ | | -8.64 | 8.64 | mV | 1 |
| | | $3.3V \leq V_{Diff} \leq 40V,$ $V_O = V_{Ref}$ | | -18 | 18 | mV | 2, 3 |
| | | $40V \leq V_{Diff} \leq 60V,$ $I_L = 60mA$ | | -25 | 25 | mV | 1 |
| V_{RLoad} | Load Regulation | $V_{Diff} = 3V,$ $I_L = 10mA$ to 500mA | | -15 | 15 | mV | 1 |
| | | $V_{Diff} = 3.3V,$ $I_L = 10mA$ to 500mA | | -15 | 15 | mV | 2, 3 |
| | | $V_{Diff} = 40V,$ $I_L = 10mA$ to 150mA | | -15 | 15 | mV | 1 |
| | | $V_{Diff} = 40V,$ $I_L = 10mA$ to 100mA | | -15 | 15 | mV | 2, 3 |
| Delta I_{Adj} / Load | Adjustment Pin Current Change | $V_{Diff} = 3V,$ $I_L = 10mA$ to 500mA | | -5.0 | 5.0 | μA | 1 |
| | | $V_{Diff} = 3.3V,$ $I_L = 10mA$ to 500mA | | -5.0 | 5.0 | μA | 2, 3 |
| | | $V_{Diff} = 40V,$ $I_L = 10mA$ to 150mA | | -5.0 | 5.0 | μA | 1 |
| | | $V_{Diff} = 40V,$ $I_L = 10mA$ to 100mA | | -5.0 | 5.0 | μA | 2, 3 |

LM117HVH, HVWG Electrical Characteristics DC Parameters (continued)

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 8\text{mA}$, $V_{OUT} = 1.25\text{V}$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|------------------------|-------------------------------|---|-------|------|-----|---------------|------------|
| Delta I_{Adj} / Line | Adjustment Pin Current Change | $3\text{V} \leq V_{Diff} \leq 40\text{V}$ | | -5.0 | 5.0 | μA | 1 |
| | | $3.3\text{V} \leq V_{Diff} \leq 40\text{V}$ | | -5.0 | 5.0 | μA | 2, 3 |
| I_{OS} | Short Circuit Current | $V_{Diff} = 60\text{V}$ | | 0.0 | 0.4 | A | 1 |
| | | $V_{Diff} = 4.25\text{V}$ | | 0.5 | 1.8 | A | 1 |
| θ_R | Thermal Regulation | $V_{Diff} = 40\text{V}$, $I_L = 150\text{mA}$, $t = 20\text{mS}$ | | | 6.0 | mV | 1 |

LM117HVH, HVWG Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 8\text{mA}$, $V_{OUT} = 1.25\text{V}$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|--------|------------------|--|--------------------|-----|-----|------|------------|
| RR | Ripple Rejection | $V_I = +6.25\text{V}$, $f = 120\text{Hz}$, $e_i = 1V_{RMS}$, $I_L = 125\text{mA}$, $V_O = V_{Ref}$ | See ⁽¹⁾ | 66 | | dB | 4, 5, 6 |

(1) Tested @ 25°C; specified, but not tested @ 125°C & -55°C

LM117HVH, HVWG Delta Electrical Characteristics DC Delta Parameters

The following conditions apply, unless otherwise specified.

Deltas performed on QMLV devices at Group B, Subgroup 5, only.

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|-------------|--------------------|---|-------|-------|------|---------------|------------|
| I_{Adj} | Adjust Pin Current | $V_{Diff} = 3\text{V}$ | | -10 | 10 | μA | 1 |
| | | $V_{Diff} = 40\text{V}$ | | -10 | 10 | μA | 1 |
| V_{Ref} | Reference Voltage | $V_{Diff} = 3\text{V}$ | | -0.01 | 0.01 | V | 1 |
| | | $V_{Diff} = 40\text{V}$ | | -0.01 | 0.01 | V | 1 |
| V_{RLine} | Line Regulation | $3\text{V} \leq V_{Diff} \leq 40\text{V}$, $V_O = V_{Ref}$ | | -4.0 | 4.0 | mV | 1 |
| | | $40\text{V} \leq V_{Diff} \leq 60\text{V}$, $I_L = 60\text{mA}$ | | -6.0 | 6.0 | mV | 1 |

LM117HVH, HVWG Post Radiation Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 8\text{mA}$, $V_{OUT} = 1.25\text{V}$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|-------------|-------------------|--|-------|-----|------|------|------------|
| V_{Ref} | Reference Voltage | $V_{Diff} = 3\text{V}$ | | 1.2 | 1.45 | V | 1 |
| | | $V_{Diff} = 40\text{V}$ | | 1.2 | 1.45 | V | 1 |
| V_{RLine} | Line Regulation | $3\text{V} \leq V_{Diff} \leq 40\text{V}$, $V_O = V_{Ref}$ | | -40 | 40 | mV | 1 |
| V_{RLoad} | Load Regulation | $V_{Diff} = 3\text{V}$, $I_L = 10\text{mA}$ to 500mA | | -27 | 27 | mV | 1 |

LM117HVH, HVWG Post Radiation Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 8\text{mA}$, $V_{OUT} = 1.25\text{V}$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|--------|------------------|--|-------|-----|-----|------|------------|
| RR | Ripple Rejection | $V_I = +6.25\text{V}$, $f = 120\text{Hz}$, $e_i = 1V_{RMS}$, $I_L = 125\text{mA}$, $V_O = V_{Ref}$ | | 55 | | dB | 4 |

LM117HVK Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 10\text{mA}$, $V_{OUT} = 1.25\text{V}$ (Nominal)

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|---------------------------|-------------------------------|---|-------|-------|------|---------------|------------|
| I_{Adj} | Adjustment Pin Current | $V_{Diff} = 3\text{V}$ | | | 100 | μA | 1 |
| | | $V_{Diff} = 3.3\text{V}$ | | | 100 | μA | 2, 3 |
| | | $V_{Diff} = 40\text{V}$ | | | 100 | μA | 1, 2, 3 |
| I_Q | Minimum Load Current | $V_{Diff} = 3\text{V}$, $V_O = 1.7\text{V}$ | | | 5.0 | mA | 1 |
| | | $V_{Diff} = 3.3\text{V}$, $V_O = 1.7\text{V}$ | | | 5.0 | mA | 2, 3 |
| | | $V_I = 40\text{V}$, $V_O = 1.7\text{V}$ | | | 5.0 | mA | 1, 2, 3 |
| | | $V_I = 60\text{V}$, $V_O = 1.7\text{V}$ | | 0.25 | 8.2 | mA | 1 |
| V_{Ref} | Reference Voltage | $V_{Diff} = 3\text{V}$ | | 1.2 | 1.3 | V | 1 |
| | | $V_{Diff} = 3.3\text{V}$ | | 1.2 | 1.3 | V | 2, 3 |
| | | $V_{Diff} = 40\text{V}$ | | 1.2 | 1.3 | V | 1, 2, 3 |
| V_{RLine} | Line Regulation | $3\text{V} \leq V_{Diff} \leq 40\text{V}$, $V_O = V_{Ref}$ | | -8.64 | 8.64 | mV | 1 |
| | | $3.3\text{V} \leq V_{Diff} \leq 40\text{V}$, $V_O = V_{Ref}$ | | -18 | 18 | mV | 2, 3 |
| | | $40\text{V} \leq V_{Diff} \leq 60\text{V}$, $I_L = 60\text{mA}$ | | -25 | 25 | mV | 1 |
| V_{RLoad} | Load Regulation | $V_{Diff} = 3\text{V}$, $I_L = 10\text{mA}$ to 1.5A | | -15 | 15 | mV | 1 |
| | | $V_{Diff} = 3.3\text{V}$, $I_L = 10\text{mA}$ to 1.5A | | -15 | 15 | mV | 2, 3 |
| | | $V_{Diff} = 40\text{V}$, $I_L = 10\text{mA}$ to 300mA | | -15 | 15 | mV | 1 |
| | | $V_{Diff} = 40\text{V}$, $I_L = 10\text{mA}$ to 195mA | | -15 | 15 | mV | 2, 3 |
| Delta I_{Adj} / Load | Adjustment Pin Current Change | $V_{Diff} = 3\text{V}$, $I_L = 10\text{mA}$ to 1.5A | | -5.0 | 5.0 | μA | 1 |
| | | $V_{Diff} = 3.3\text{V}$, $I_L = 10\text{mA}$ to 1.5A | | -5.0 | 5.0 | μA | 2, 3 |
| | | $V_{Diff} = 40\text{V}$, $I_L = 10\text{mA}$ to 300mA | | -5.0 | 5.0 | μA | 1 |
| | | $V_{Diff} = 40\text{V}$, $I_L = 10\text{mA}$ to 195mA | | -5.0 | 5.0 | μA | 2, 3 |
| Delta I_{Adj} / Line | Adjustment Pin Current Change | $3\text{V} \leq V_{Diff} \leq 40\text{V}$ | | -5.0 | 5.0 | μA | 1 |
| | | $3.3\text{V} \leq V_{Diff} \leq 40\text{V}$ | | -5.0 | 5.0 | μA | 2, 3 |
| I_{OS} | Short Circuit Current | $V_{Diff} = 60\text{V}$ | | 0.0 | 0.4 | A | 1 |
| | | $V_{Diff} = 3\text{V}$ | | 1.5 | 3.5 | A | 1 |
| θ_R | Thermal Regulation | $V_{Diff} = 40\text{V}$, $I_L = 300\text{mA}$, $t = 20\text{mS}$ | | | 10.5 | mV | 1 |

LM117HVK Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, $I_L = 10\text{mA}$.

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-groups |
|--------|------------------|--|--------------------|-----|-----|-------------|------------|
| RR | Ripple Rejection | $V_I = +6.25\text{V}$, $f = 120\text{Hz}$, $e_I = 1\text{V}_{RMS}$, $I_L = 0.5\text{A}$, $V_O = V_{Ref}$ | See ⁽¹⁾ | 66 | | dB | 4, 5, 6 |

(1) Tested @ 25°C; specified, but not tested @ 125°C & -55°C

Typical Performance Characteristics

Output capacitor = 0 μ F unless otherwise noted.

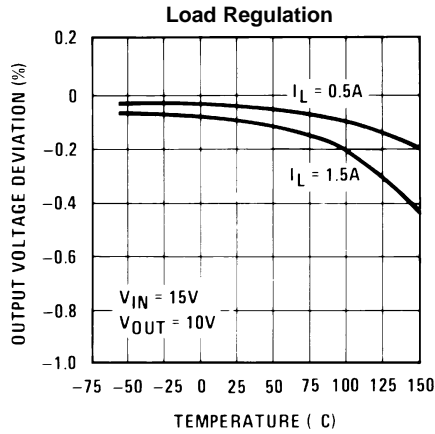


Figure 4.

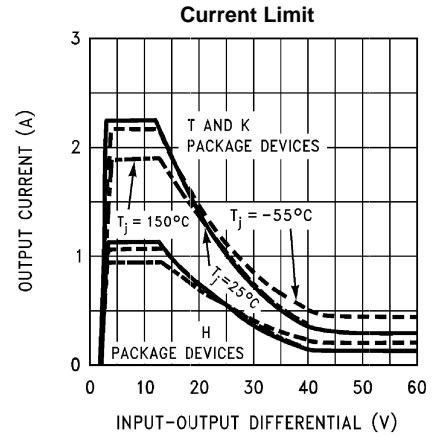


Figure 5.

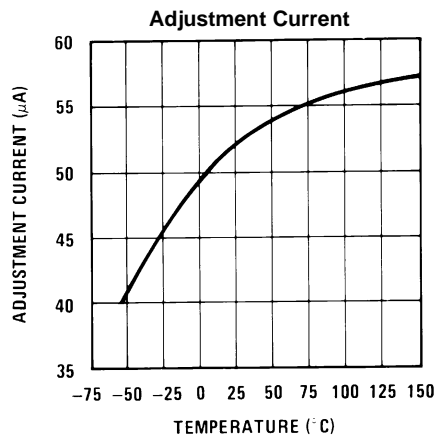


Figure 6.

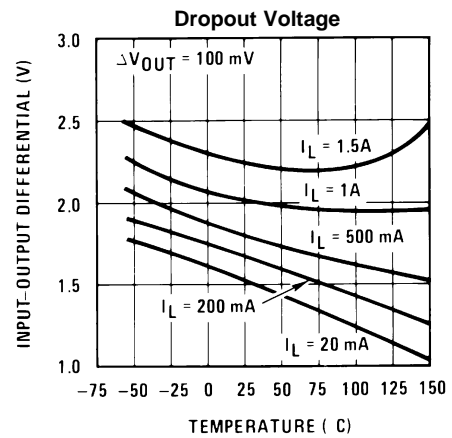


Figure 7.

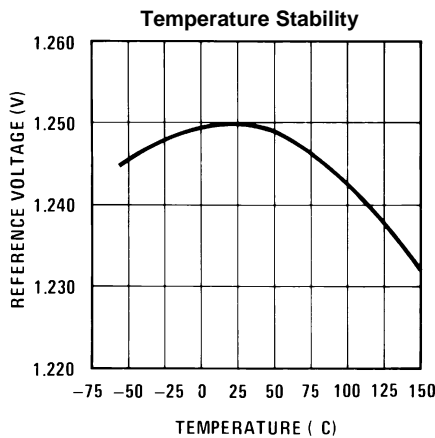


Figure 8.

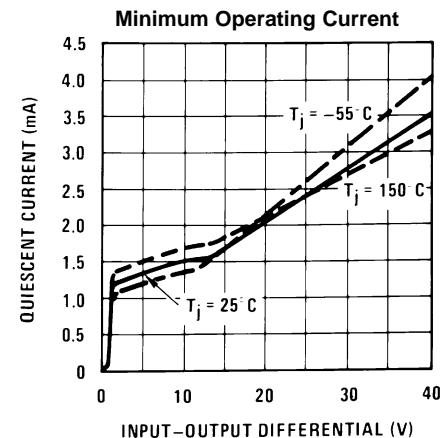


Figure 9.

Typical Performance Characteristics (continued)

Output capacitor = 0 μ F unless otherwise noted.

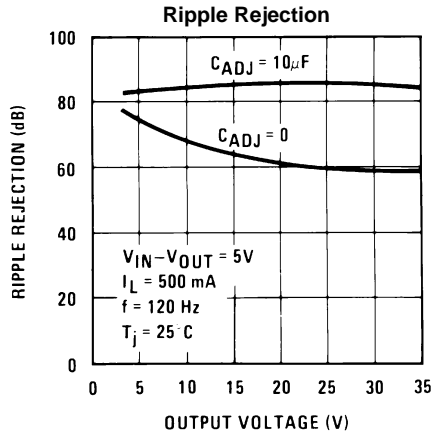


Figure 10.

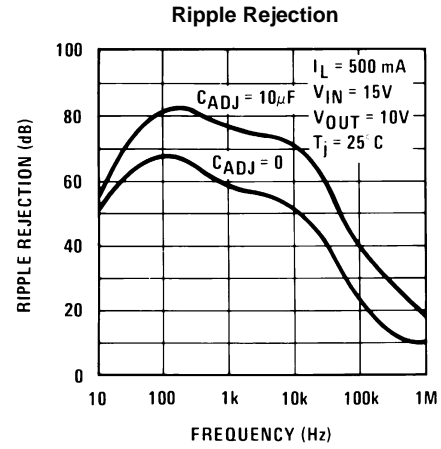


Figure 11.

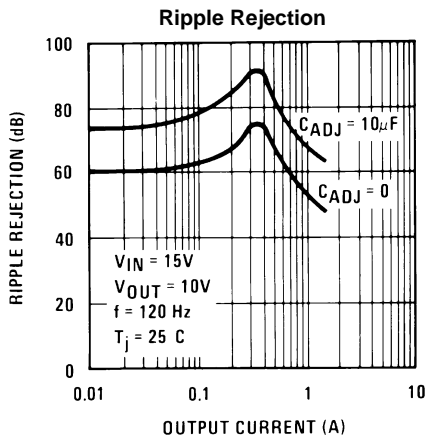


Figure 12.

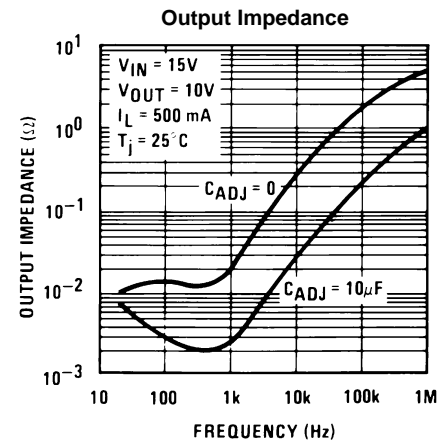


Figure 13.

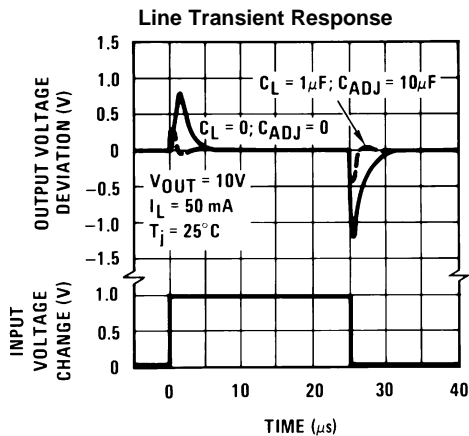


Figure 14.

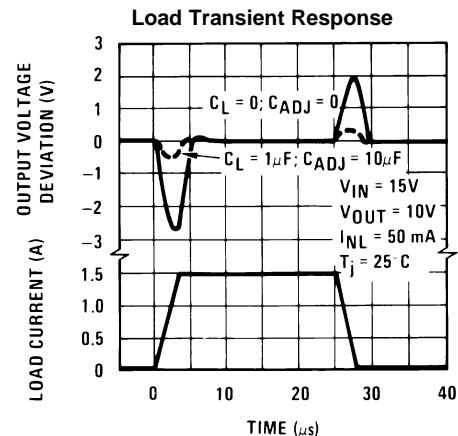


Figure 15.

Typical Radiation Characteristics

Irradiation conditions: $V_I = 60V$; low dose rate = 10 mrad(Si)/s

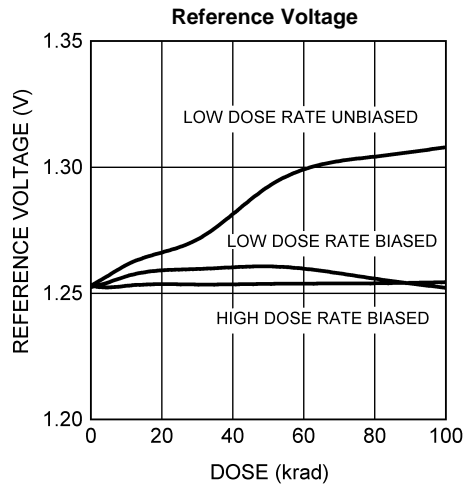


Figure 16.

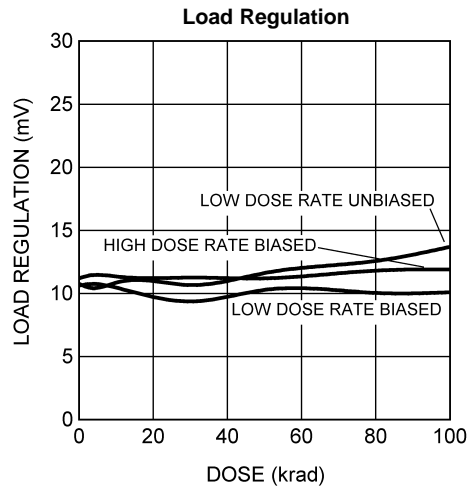


Figure 17.

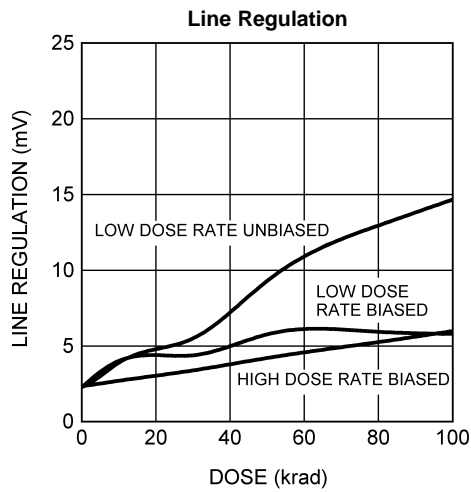


Figure 18.

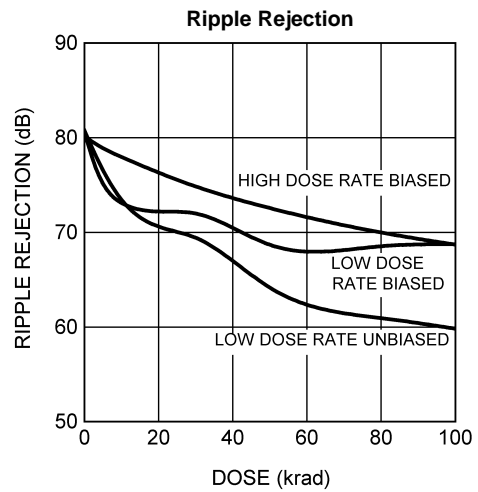


Figure 19.

APPLICATION HINTS

In operation, the LM117HV develops a nominal 1.25V reference voltage, V_{REF} , between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF} \left(1 + \frac{R2}{R1} \right) + I_{ADJ}R2 \quad (1)$$

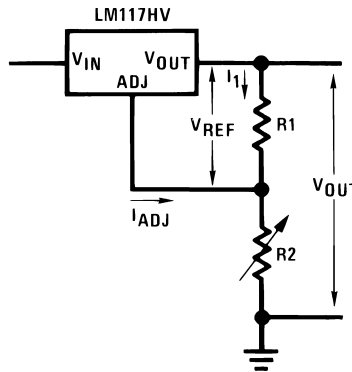


Figure 20.

Since the 100 μ A current from the adjustment terminal represents an error term, the LM117HV was designed to minimize I_{ADJ} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

EXTERNAL CAPACITORS

An input bypass capacitor is recommended. A 0.1 μ F disc or 1 μ F solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM117HV to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 μ F bypass capacitor 80 dB ripple rejection is obtainable at any output level. Increases over 10 μ F do not appreciably improve the ripple rejection at frequencies above 120 Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 μ F in aluminum electrolytic to equal 1 μ F solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5 MHz. For this reason, 0.01 μ F disc may seem to work better than a 0.1 μ F disc as a bypass.

Although the LM117HV is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1 μ F solid tantalum (or 25 μ F aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of load capacitance larger than 10 μ F will merely improve the loop stability and output impedance.

LOAD REGULATION

The LM117HV is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240 Ω) should be tied directly to the output of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05 Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05 Ω \times I_L . If the set resistor is connected near the load the effective line resistance will be 0.05 Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 21 shows the effect of resistance between the regulator and 240Ω set resistor.

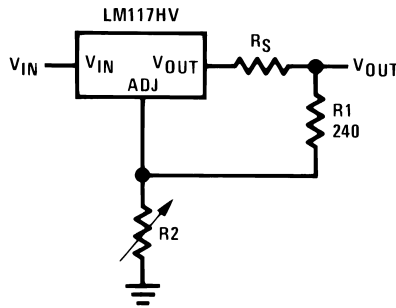


Figure 21. Regulator with Line Resistance in Output Lead

With the TO package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

PROTECTION DIODES

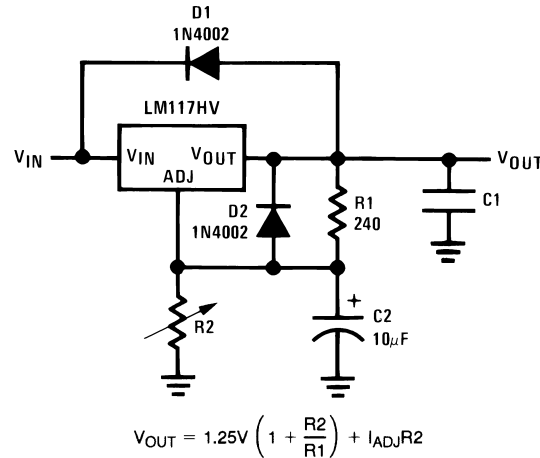
When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10 μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN} . In the LM117HV, this discharge path is through a large junction that is able to sustain 15A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25 μF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when *either* the input or output is shorted. Internal to the LM117HV is a 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10 μF capacitance. Figure 22 shows an LM117HV with protection diodes included for use with outputs greater than 25V and high values of output capacitance.

CURRENT LIMIT

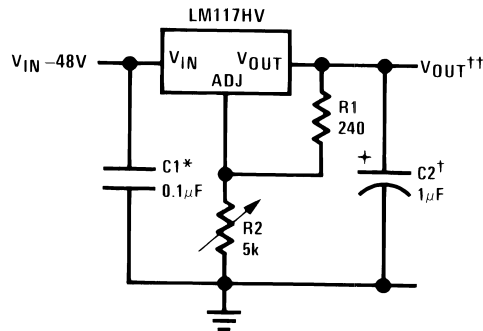
Internal current limit will be activated whenever the output current exceeds the limit indicated in the Typical Performance Characteristics. However, if during a short circuit condition the regulator's differential voltage exceeds the Absolute Maximum Rating of 60V (e.g. $V_{IN} \geq 60V$, $V_{OUT} = 0V$), internal junctions in the regulator may break down and the device may be damaged or fail. Failure modes range from an apparent open or short from input to output of the regulator, to a destroyed package (most common with the TO-220 package). To protect the regulator, the user is advised to be aware of voltages that may be applied to the regulator during fault conditions, and to avoid violating the Absolute Maximum Ratings.



D1 protects against C1
D2 protects against C2

Figure 22. Regulator with Protection Diodes

Typical Applications



Full output current not available at high input-output voltages

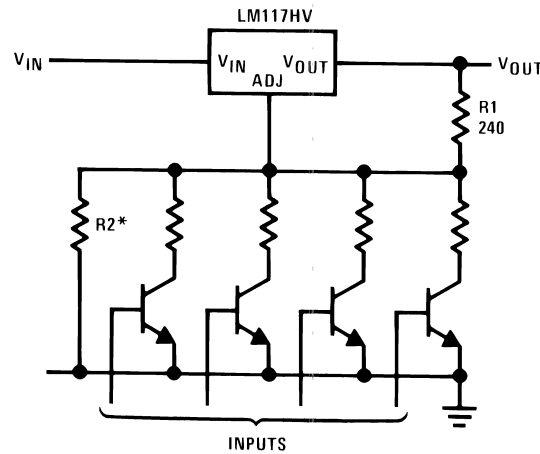
†Optional—improves transient response. Output capacitors in the range of 1 μ F to 1000 μ F of aluminum or tantalum electrolytic

are commonly used to provide improved output impedance and rejection of transients.

*Needed if device is more than 6 inches from filter capacitors.

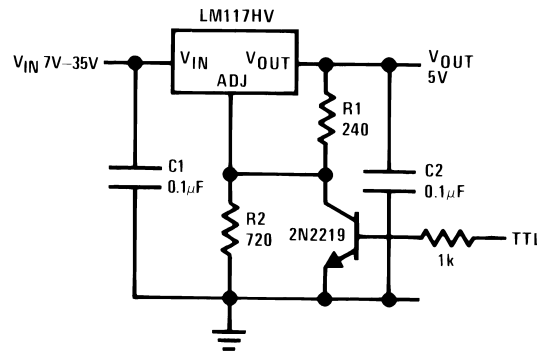
$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ} R_2$$

Figure 23. 1.2V-45V Adjustable Regulator



*Sets maximum V_{OUT}

Figure 24. Digitally Selected Outputs



*Min. output $\approx 1.2V$

Figure 25. 5V Logic Regulator with Electronic Shutdown*

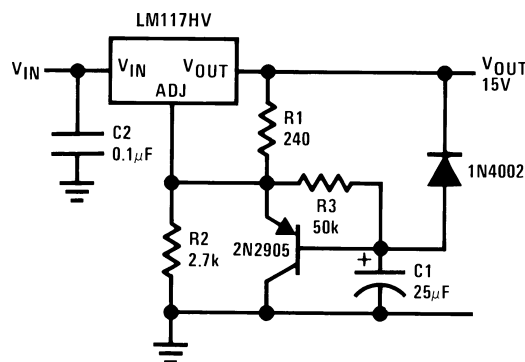
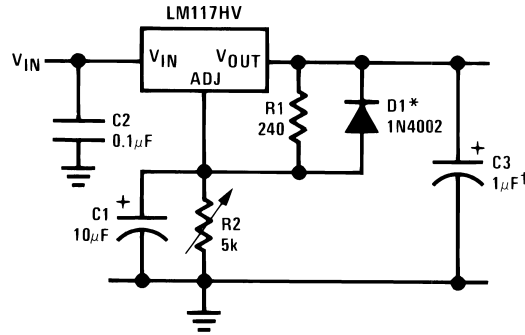


Figure 26. Slow Turn-On 15V Regulator



†Solid tantalum

*Discharges C1 if output is shorted to ground

Figure 27. Adjustable Regulator with Improved Ripple Rejection

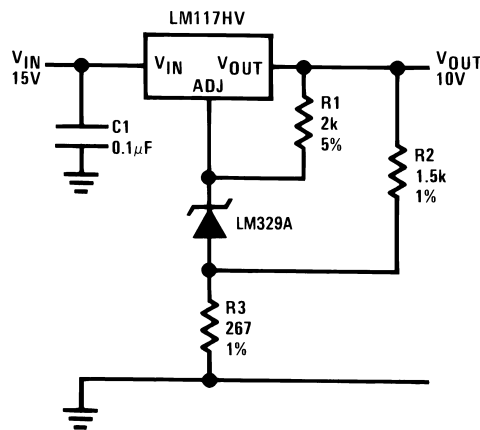
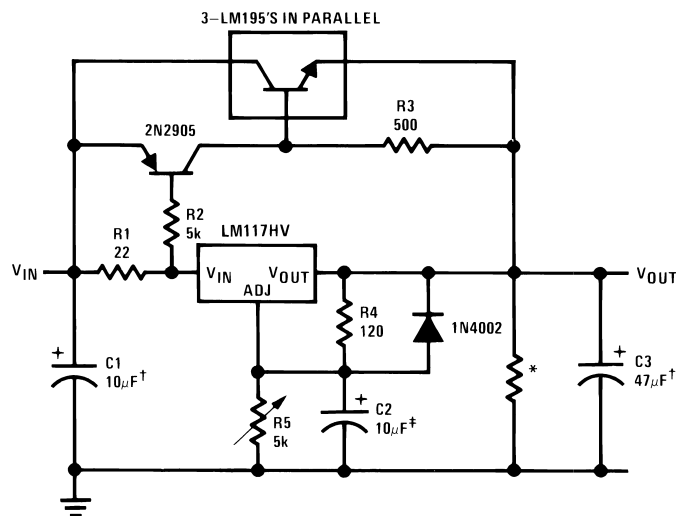


Figure 28. High Stability 10V Regulator

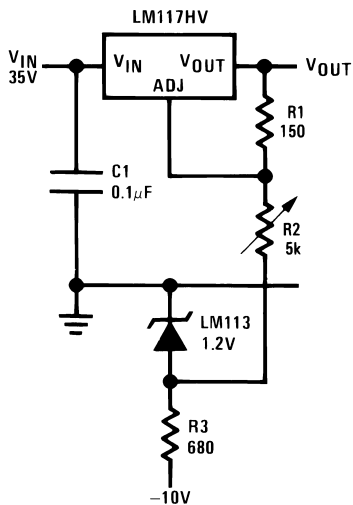


†Solid tantalum

*Minimum load current = 30 mA

‡Optional—improves ripple rejection

Figure 29. High Current Adjustable Regulator



Full output current not available at high input-output voltages

Figure 30. 0 to 30V Regulator

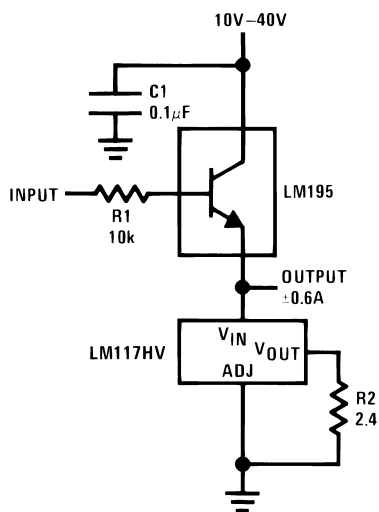
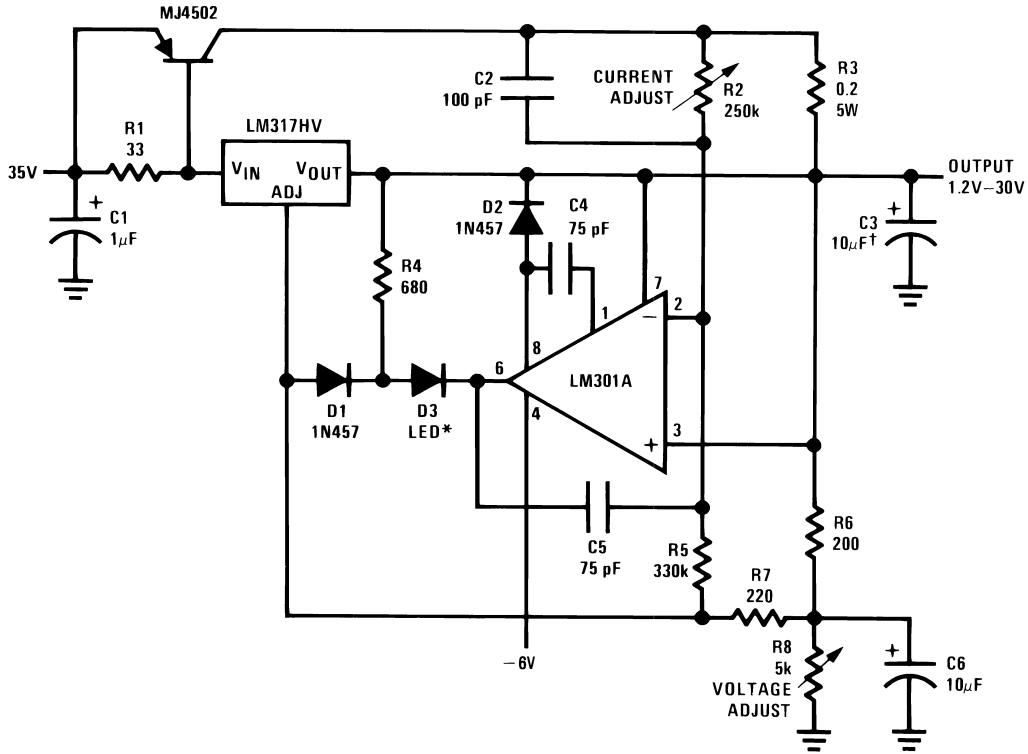


Figure 31. Power Follower



†Solid tantalum

*Lights in constant current mode

Figure 32. 5A Constant Voltage/Constant Current Regulator

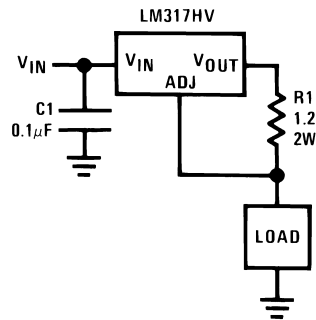
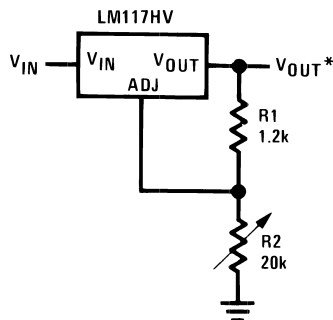
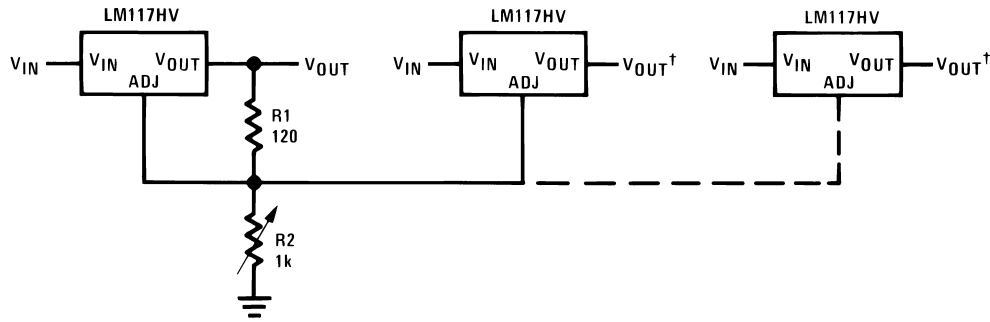


Figure 33. 1A Current Regulator



*Minimum load current \approx 4 mA

Figure 34. 1.2V–20V Regulator with Minimum Program Current



*All outputs within ± 100 mV
 †Minimum load—10 mA

Figure 40. Adjustable Multiple On-Card Regulators with Single Control*

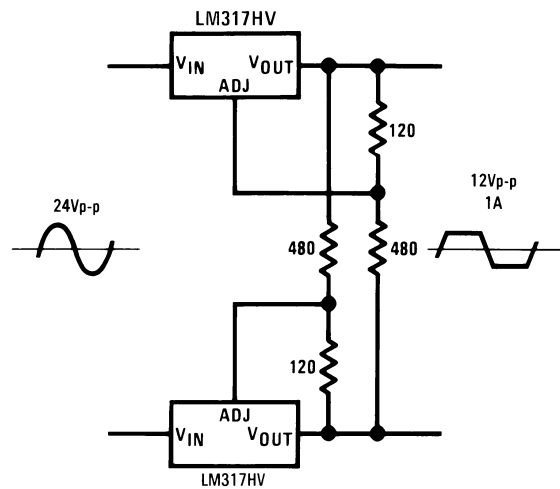
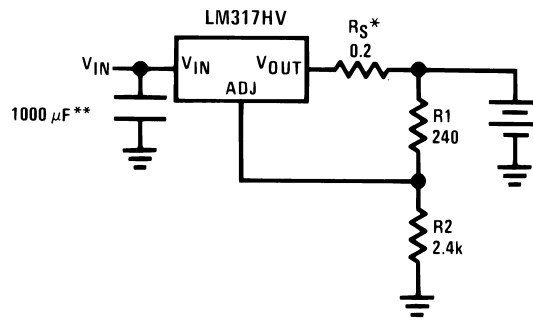


Figure 41. AC Voltage Regulator



$$*R_S \text{—sets output impedance of charger } Z_{OUT} = R_S \left(1 + \frac{R_2}{R_1} \right)$$

Use of R_S allows low charging rates with fully charged battery.
 **The 1000 μ F is recommended to filter out input transients

Figure 42. 12V Battery Charger

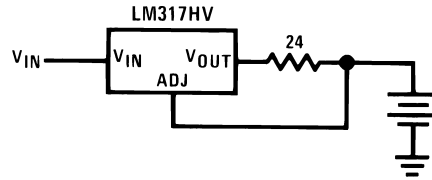


Figure 43. 50 mA Constant Current Battery Charger

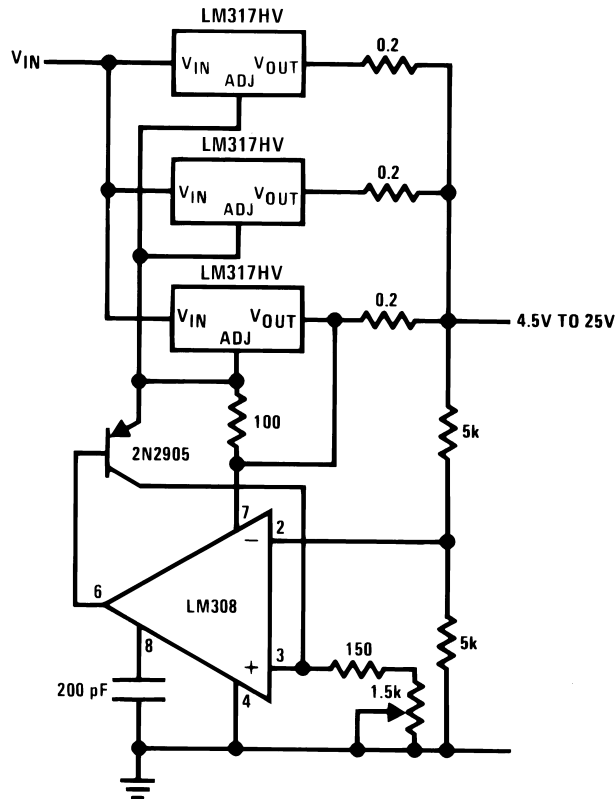
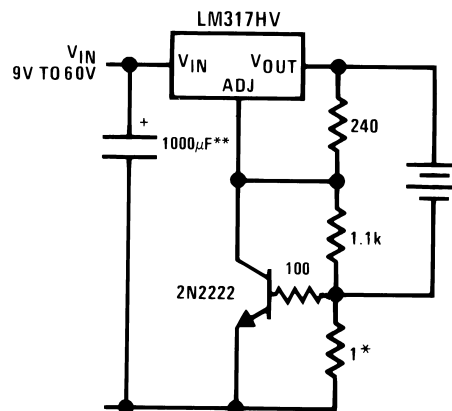


Figure 44. Adjustable 4A Regulator



*Sets peak current (0.6A for 1Ω)

**The 1000 μF is recommended to filter out input transients

Figure 45. Current Limited 6V Charger

REVISION HISTORY

| Date Released | Revision | Section | Originator | Changes |
|---------------|----------|---|-------------|--|
| 03/14/06 | A | New Release, Corporate format | L. Lytle | 2 MDS datasheets converted into one Corporate datasheet format. Corrected I_L from 60mA to 8mA for R_{Line} . Separated Delta I_{Adj} / Line from Delta I_{Adj} / Load for both the H & K devices. Removed drift from MNLM117HV-H electrical characteristics since not performed on 883 product. MNLM117HV-K Rev 0C1 & MNLM117HV-H Rev 2A1 will be archived. |
| 07/06/07 | B | Features, Ordering Information, Connection Diagram, Absolute Maximum Ratings, Electrical's, Notes and Physical Dimensions | Larry McGee | Added Radiation information and WG information to data sheet. Revision A to be Archived. |
| 02/13/08 | C | Features, Ordering Information, Electrical's, Notes and Typical Radiation Characteristics, Physical Dimensions Drawing | Larry McGee | Added ELDRS NSID information, HVH & HVWG Delta and Post Radiation Table, Typical Radiation Characteristics Plots, Note 8, 9 and WG Market Drawing. Revision B to be Archived. |
| 09/02/11 | D | Ordering Information, Absolute Maximum Ratings | Larry McGee | Added 'GW' NSIDS & SMD numbers. Added Theta JA and Theta JC for 'GW' devices. Revision C to be Archived. Deleted Ordering Information table. |
| 04/17/2013 | D | | | Changed layout of National Data Sheet to TI format. |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|---|-------------------------|
| 5962-0722901QXA | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVH-QML 5962-0722901QXA Q ACO 5962-0722901QXA Q >T | Samples |
| 5962-0722902QZA | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGW QML Q 5962-07229 02QZA ACO 02QZA >T | Samples |
| 5962R0722901V9A | ACTIVE | DIESALE | Y | 0 | 42 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |
| 5962R0722901VXA | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVHRQMLV 5962R0722901VXA Q ACO 5962R0722901VXA Q >T | Samples |
| 5962R0722902VXA | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T | Samples |
| 5962R0722902VZA | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGWR QMLV Q 5962R07229 02VZA ACO 02VZA >T | Samples |
| 5962R0722961V9A | ACTIVE | DIESALE | Y | 0 | 42 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |
| 5962R0722961VXA | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T | Samples |
| 5962R0722962VZA | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGWRL QMLV Q 5962R07229 | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|----------------------------|-------------------------|----------------------|--------------|---|-------------------------|
| | | | | | | | | | | 62VZA ACO 62VZA >T | |
| LM117HVGW-QML | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGW QML Q 5962-07229 02QZA ACO 02QZA >T | Samples |
| LM117HVGWRLQMLV | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGWRL QMLV Q 5962R07229 62VZA ACO 62VZA >T | Samples |
| LM117HVGWRQMLV | ACTIVE | CFP | NAC | 16 | 42 | TBD | Call TI | Call TI | -55 to 125 | LM117HVGWR QMLV Q 5962R07229 02VZA ACO 02VZA >T | Samples |
| LM117HVH MDE | ACTIVE | DIESALE | Y | 0 | 42 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |
| LM117HVH MDR | ACTIVE | DIESALE | Y | 0 | 42 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |
| LM117HVH MDS | ACTIVE | DIESALE | Y | 0 | 42 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |
| LM117HVH-QML | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVH-QML 5962-0722901QXA Q ACO 5962-0722901QXA Q >T | Samples |
| LM117HVH/883 | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVH/883 Q ACO LM117HVH/883 Q >T | Samples |
| LM117HVHRLQMLV | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T | Samples |
| LM117HVHRQMLV | ACTIVE | TO | NDT | 3 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM117HVHRQMLV 5962R0722901VXA Q ACO 5962R0722901VXA Q | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|----------------------------|-------------------------|----------------------|--------------|-------------------------------------|----------------|
| | | | | | | | | | | >T | |
| LM117HVK/883 | ACTIVE | TO | K | 2 | 50 | TBD | Call TI | Call TI | -55 to 125 | LM117HVK /883 Q ACO /883 Q >T | Samples |
| LM117HVKG MD8 | ACTIVE | DIESALE | Y | 0 | 196 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | -55 to 125 | | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

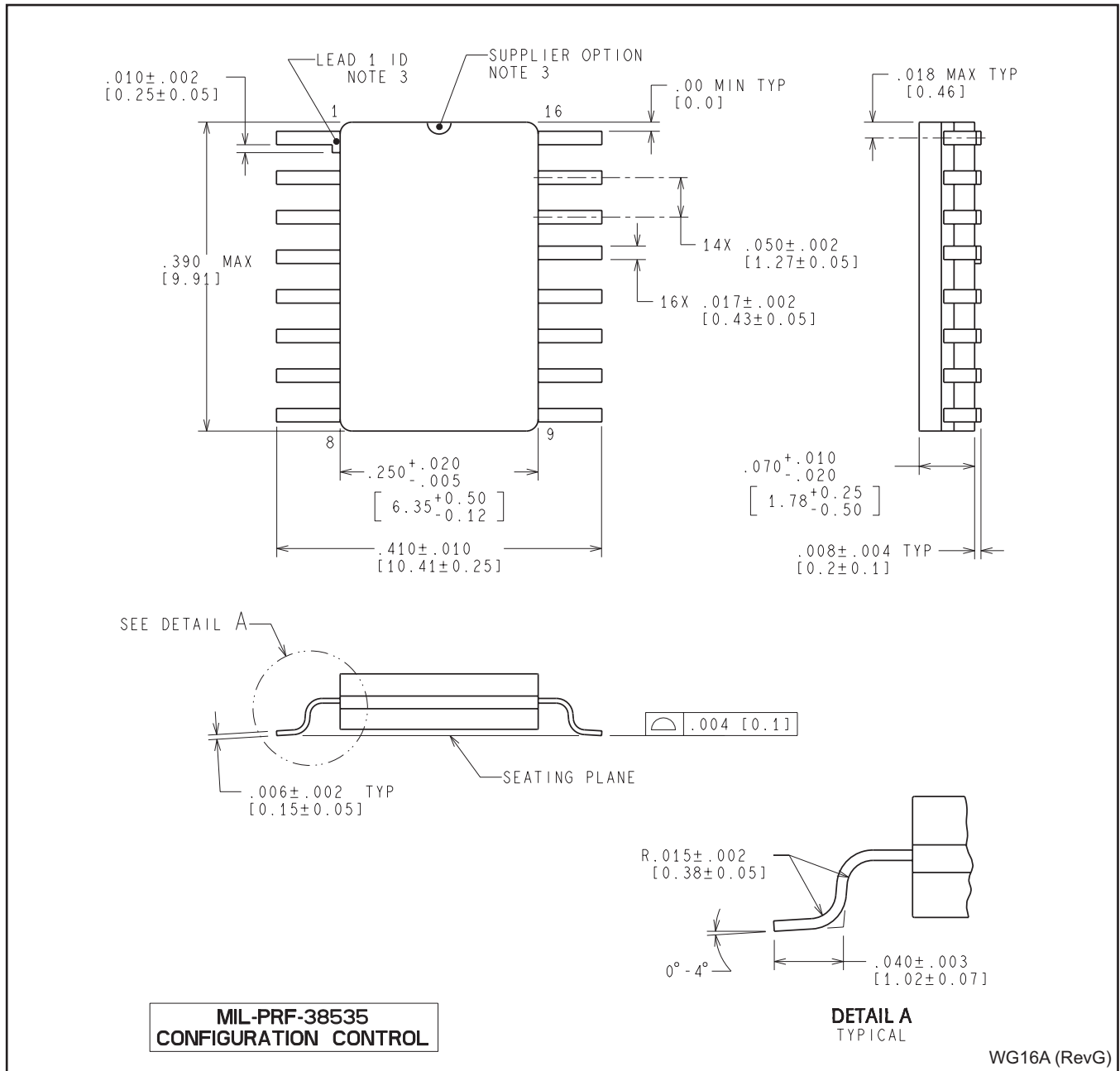
OTHER QUALIFIED VERSIONS OF LM117HVQML, LM117HVQML-SP :

- Military: [LM117HVQML](#)
- Space: [LM117HVQML-SP](#)

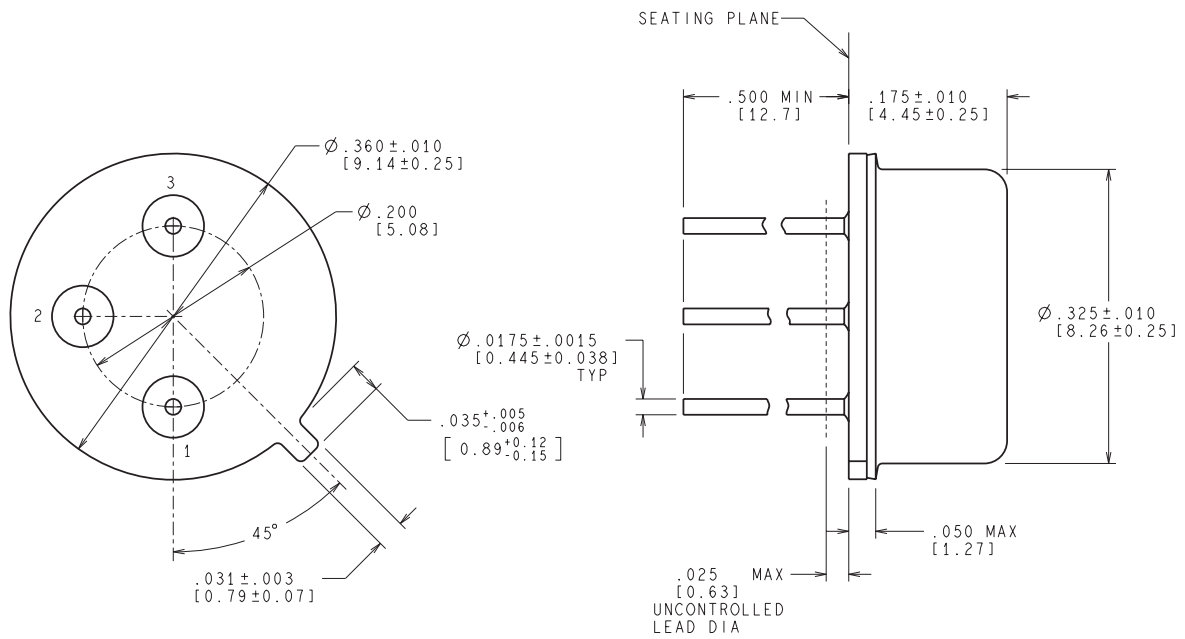
NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

NAC0016A



NDT0003A

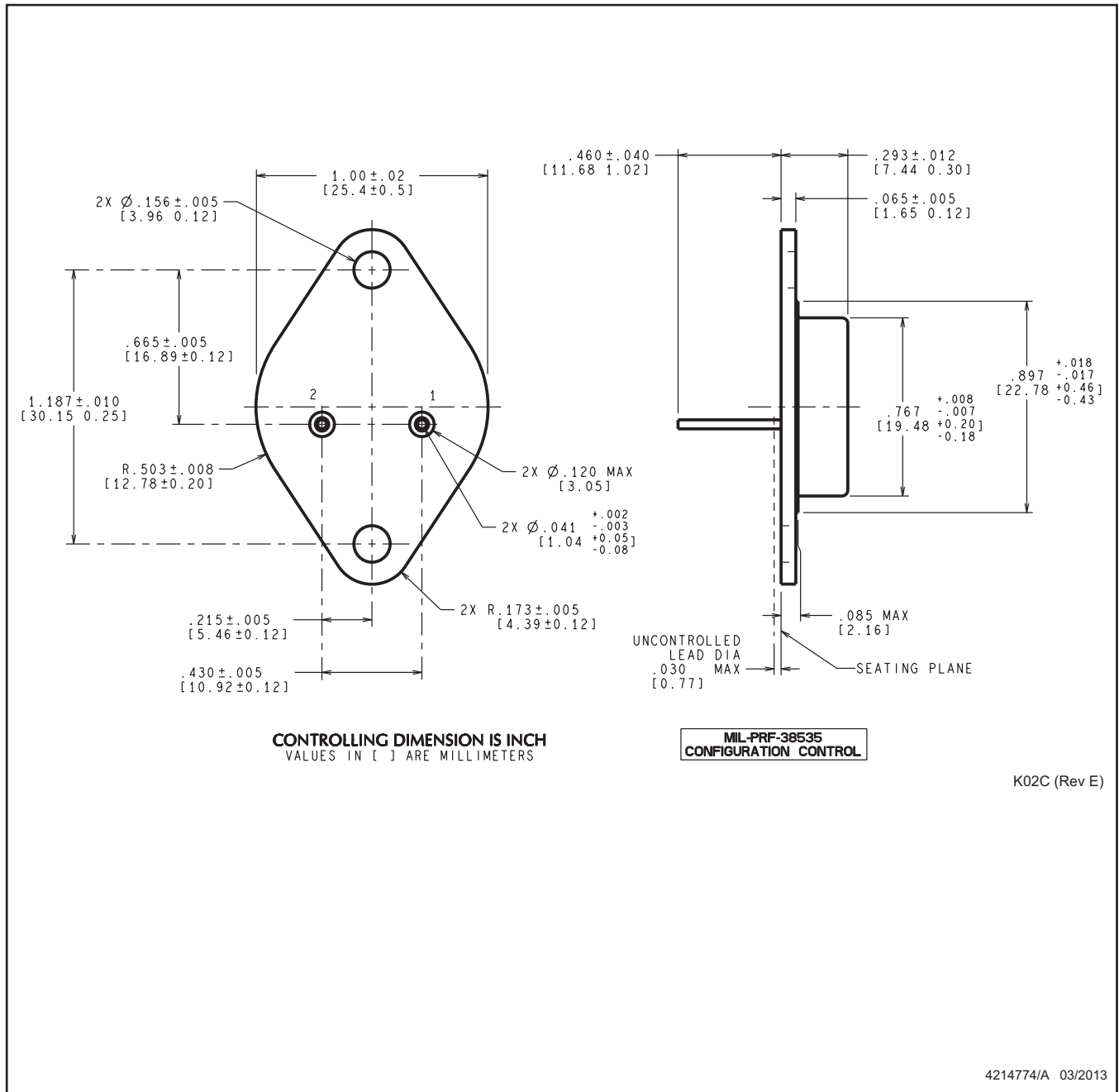


CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

K0002C



NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Leads not to be bent greater than 15°

IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.