# LM117HVQML-SP RHA 4.25-V to 60-V 3-Terminal Adjustable Regulator

## 1 Features

- Radiation hardness assured (RHA) up to a total ionizing dose (TID) of 100 krad(Si)
  - High dose rate (HDR) option at 50–300 rad(Si)/s
  - Low dose rate (LDR) option at 10 mrad(Si)/s
- Specified 0.5-A output current
- Adjustable output down to 1.2 V
- Current limit constant with temperature
- Output is short-circuit protected

## 2 Applications

- Satellite electrical power system (EPS)

## 3 Description

The LM117HVQML-SP adjustable 3-terminal positive voltage linear regulator is capable of supplying 0.5 A over a 1.2-V to 57-V output range. It is simple to use and requires only two external resistors to set the output voltage.

The regulator is "floating" and sees only the input-to-output differential voltage, thus enabling supplies of several hundred volts to be regulated as long as the maximum input-to-output differential is not exceeded.

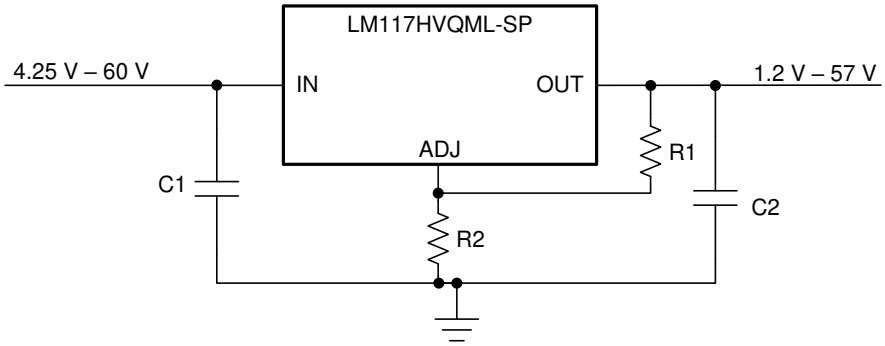
The flight-proven LM117HVQML-SP offers full overload protection such as current limit, thermal overload protection, and safe area protection. It is exceptionally versatile and can also be used as an adjustable switching regulator, a programmable output regulator, a precision current regulator, and more.

For lower voltage applications, the LM117QML-SP is a pin-to-pin drop-in replacement suitable for up to 41.25 V. For the negative complement, see the LM137QML-SP data sheet.

**Device Information**

| PART NUMBER(1) | GRADE(2) | PACKAGE(3) |
|---|---|---|
| LM117HVGWRLQMLV | Flight grade QMLV, RHA 100 krad(Si) at LDR (10 mrad/s) | CFP SOIC (NAC) 16 pin 6.35 mm × 9.91 mm Mass = 0.467 g(5) |
| 5962R0722962VZA | | |
| LM117HVGWRQMLV | Flight grade QMLV, RHA 100 krad(Si) at HDR (50–300 rad/s) | |
| 5962R0722902VZA | | |
| LM117HVNAC/EM | Engineering samples(4) | |
| LM117HVHRLQMLV | Flight grade QMLV, RHA 100 krad(Si) at LDR (10 mrad/s) | TO-39 (NDT) 3 pin 8.26 mm × 8.26 mm Mass = 1.036 g(5) |
| 5962R0722961VXA | | |
| LM117HVHRQMLV | Flight grade QMLV, RHA 100 krad(Si) at HDR (50–300 rad/s) | |
| 5962R0722901VXA | | |
| LM117HVH MDE | Flight grade QMLV, RHA 100 krad(Si) at LDR (10 mrad/s) | Die 2.18 mm × 2.36 mm |
| 5962R0722961V9A | | |
| LM117HVH MDR | Flight grade QMLV, RHA 100 krad(Si) at HDR (50–300 rad/s) | |
| 5962R0722901V9A | | |

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) For additional information about part grade, view SLYB235.
(3) The TI Packaging page can be referenced for additional packing details.
(4) These units are intended for engineering evaluation only and are processed to a noncompliant flow. Not suitable for qualification, production, radiation testing, or flight use. Not warranted for performance over full MIL specified temperature range (–55°C to 125°C) or operating life.
(5) Mass is accurate to ±10%.




**Simplified Schematic**

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE | REVISION | NOTES |
|---|---|---|
| October 2021 | * | Initial release. Device split from shared data sheet (SNVS357). |


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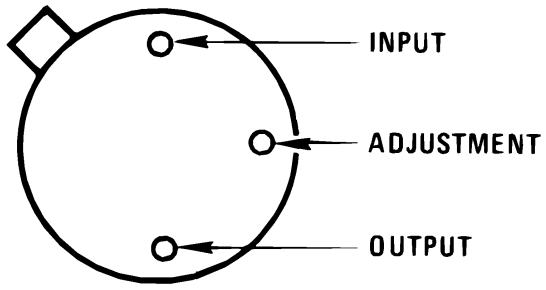
## 5 Related Products

| PART NUMBER | INPUT VOLTAGE RANGE | $I_{OUT}$ | PART NUMBER SUFFIX | PACKAGE | RADIATION TESTING (1) |
|---|---|---|---|---|---|
| LM117QML-SP | 4.25 V to 41.25 V | 1.5 A | K | TO-3 (K) 2 pin | HDR 100 krad(Si) |
| | | 0.5 A | H | TO-39 (NDT) 3 pin | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| | | | | Die | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| | | | GW | CFP SOIC (NAC) 16 pin | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| LM117HVQML-SP | 4.25 V to 60 V | 0.5 A | H | TO-39 (NDT) 3 pin | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| | | | | Die | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| | | | GW | CFP SOIC (NAC) 16 pin | LDR 100 krad(Si) |
| | | | | | HDR 100 krad(Si) |
| LM137QML-SP | –41.25 V to –4.25 V | 1.5 A | H | TO-39 (NDT) 3 pin | HDR 30 krad(Si) |

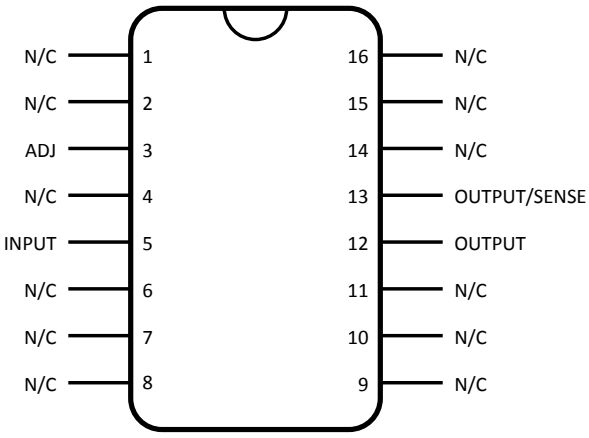
(1) The Device Information table can be referenced for information on which part numbers correspond to LDR or HDR options.

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## 6 Pin Configurations and Functions




**LM117H, LM117NDTTO-39 (NDT) 3-Pin Metal Can Package (Bottom View)**




**LM117GW CFP SOIC (NAC) 16-Pin Ceramic Package (Top View)**

**Table 6-1. Pin Functions**

| PIN | | | I/O[1] | DESCRIPTION |
|---|---|---|---|---|
| NAME | TO-39 (NDT) | CFP SOIC (NAC) | | |
| ADJ | 2 | 3 | – | Adjust pin. |
| $V_{IN}$ | 1 | 5 | I | Input voltage pin for the regulator. |
| $V_{OUT}$ | 3, CASE | 12 | O | Output voltage pin for the regulator. |
| OUTPUT/SENSE | – | 13 | – | Used to sense the output voltage. Must be connected to VOUT for proper operation. |
| N/C | – | 1, 2, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16 | – | No connection. These pins have no internal connections and may be grounded or left floating. They may also be connected to the board heatsink and used for thermal dissipation. |

(1) I = input, O = output, P = power, FB = feedback, GND = ground, NC = no connect


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# 7 Specifications

## 7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)(1)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| | Power dissipation(2) | Internally Limited | | |
| | Input-output voltage differential | –0.3 | 60 | V |
| $T_{stg}$ | Storage temperature | –65 | 150 | °C |
| $T_{jmax}$ | Maximum junction temperature | | 150 | °C |
| | Lead temperature metal package | | 300 | °C |

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{Jmax}$ (maximum junction temperature), $\theta_{JA}$ (package junction to ambient thermal resistance), and $T_A$ (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} – T_A) / \theta_{JA}$ 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 2 W for the TO-39 and CFP packages, and 20 W for the TO-3 package.

## 7.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1) (2) | ±2000 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) Human-body model, 100 pF discharged through a 1.5-kΩ resistor.

## 7.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $T_A$ | Operating temperature | –55 | 125 | °C |
| $V_{IN}$ | Input voltage | 4.25 | 60 | V |

## 7.4 Thermal Information

| THERMAL METRIC(1) | | | LM117HVQML-SP | | UNIT |
|---|---|---|---|---|---|
| | | | TO-39 (NDT) | CFP (NAC) | |
| | | | 3 PINS (LM117H) | 16 PINS (LM117GW) | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | Still air | 186 | 130 | °C/W |
| | | 500 LF/min air flow | 64 | 80 | |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | 21 | 7 | °C/W |

(1) For more information, see the *Semiconductor and IC package thermal metrics* application report.

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## 7.5 Electrical Characteristics

The following conditions apply, unless otherwise specified. $V_{Diff}$ = ($V_I$ − $V_O$), $I_L$ = 8 mA, $V_O$ = 1.25 V (nominal), over operating temperature range (T = –55°C to 125°C).

| PARAMETER | | TEST CONDITIONS (1) | | SUBGROUP (2) | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{Ref}$ | Reference voltage | $V_{Diff}$ = 3 V | | 1 | 1.2 | 1.3 | V |
| | | | 25°C, Post-radiation | 1 | | 1.45 | |
| | | $V_{Diff}$ = 3.3 V | | 2, 3 | 1.2 | 1.3 | |
| | | $V_{Diff}$ = 40 V | | 1, 2, 3 | 1.2 | 1.3 | |
| | | | 25°C, Post-radiation | 1 | | 1.45 | |
| $V_{RLine}$ | Line regulation | 3 V ≤ $V_{Diff}$ ≤ 40 V, $V_O$ = $V_{Ref}$ | 25°C | 1 | –8.64 | 8.64 | mV |
| | | | 25°C, Post-radiation | 1 | –40 | 40 | |
| | | 3.3 V ≤ $V_{Diff}$ ≤ 40 V, $V_O$ = $V_{Ref}$ | 125°C, –55°C | 2, 3 | –18 | 18 | |
| | | 40 V ≤ $V_{Diff}$ ≤ 60 V, $I_L$ = 60 mA | 25°C | 1 | –25 | 25 | |
| $V_{RLoad}$ | Load regulation | $V_{Diff}$ = 3 V, 10 mA ≤ $I_L$ ≤ 500 mA | 25°C | 1 | –15 | 15 | mV |
| | | | 25°C, Post-radiation | 1 | –27 | 27 | |
| | | $V_{Diff}$ = 3.3 V, 10 mA ≤ $I_L$ ≤ 500 mA | 125°C, –55°C | 2, 3 | –15 | 15 | |
| | | $V_{Diff}$ = 40 V, 10 mA ≤ $I_L$ ≤ 150 mA | 25°C | 1 | –15 | 15 | |
| | | $V_{Diff}$ = 40 V, 10 mA ≤ $I_L$ ≤ 100 mA | 125°C, –55°C | 2, 3 | –15 | 15 | |
| $V_{RTh}$ | Thermal regulation | $V_{Diff}$ = 40 V, $I_L$ = 150 mA, t = 20 ms | 25°C | 1 | | 6 | mV |
| $I_{Adj}$ | Adjust pin current | $V_{Diff}$ = 3 V | 25°C | 1 | | 100 | µA |
| | | $V_{Diff}$ = 3.3 V | 125°C, –55°C | 2, 3 | | 100 | |
| | | $V_{Diff}$ = 40 V | | 1, 2, 3 | | 100 | |
| $\Delta I_{Adj}$/ Line | Adjust pin current change | 3 V ≤ $V_{Diff}$ ≤ 40 V | 25°C | 1 | –5 | 5 | µA |
| | | 3.3 V ≤ $V_{Diff}$ ≤ 40 V | 125°C, –55°C | 2, 3 | –5 | 5 | |
| $\Delta I_{Adj}$ / Load | Adjust pin current change | $V_{Diff}$ = 3 V, 10 mA ≤ $I_L$ ≤ 500 mA | 25°C | 1 | –5 | 5 | µA |
| | | $V_{Diff}$ = 3.3 V, 10 mA ≤ $I_L$ ≤ 500 mA | 125°C, –55°C | 2, 3 | –5 | 5 | |
| | | $V_{Diff}$ = 40 V, 10 mA ≤ $I_L$ ≤ 150 mA | 25°C | 1 | –5 | 5 | |
| | | $V_{Diff}$ = 40 V, 10 mA ≤ $I_L$ ≤ 100 mA | 125°C, –55°C | 2, 3 | –5 | 5 | |
| $I_Q$ | Minimum load current | $V_{Diff}$ = 3 V $V_O$ = 1.7 V | 25°C | 1 | | 5 | mA |
| | | $V_{Diff}$ = 3.3 V $V_O$ = 1.7 V | 125°C, –55°C | 2, 3 | | 5 | |
| | | $V_{Diff}$ = 40 V $V_O$ = 1.7 V | | 1, 2, 3 | | 5 | |
| | | $V_{Diff}$ = 60 V $V_O$ = 1.7 V | 25°C | 1 | | 8.2 | |


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| PARAMETER | | TEST CONDITIONS (1) | | SUBGROUP (2) | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $I_{OS}$ | Output short circuit current | $V_I$ = 4.25 V | 25°C | 1 | 0.5 | 1.8 | A |
| | | $V_I$ = 60 V | 25°C | 1 | 0 | 0.4 | |
| $\Delta V_I$ / $\Delta V_O$ | Ripple rejection | $V_I$ = 6.25 V, $I_L$ = 125 mA, $e_I$ = 1 $V_{RMS}$, $f$ = 120 Hz | 25°C | 4 | 66 | | dB |
| | | | 25°C Post-radiation | 4 | 55 | | |

(1) Pre- and post-irradiation limits are identical for the parameters above unless specified by the test conditions.
(2) For subgroup definitions, see Quality Conformance Inspection table.

## 7.6 Parameter Drift

The following deltas are for Group C (Life Test). Data is measured at 25°C.

| PARAMETER | | TEST CONDITIONS | SUBGROUP (1) | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{Ref}$ | Reference voltage | $V_{Diff}$ = 3 V | 1 | –0.01 | 0.01 | V |
| | | $V_{Diff}$ = 40 V | 1 | –0.01 | 0.01 | V |
| $V_{RLine}$ | Line regulation | 3 V ≤ $V_{Diff}$ ≤ 40 V, $V_O$ = $V_{Ref}$ | 1 | –4 | 4 | mV |
| | | 40 V ≤ $V_{Diff}$ ≤ 60 V, $I_L$ = 60 mA | 1 | –6 | 6 | |
| $I_{Adj}$ | Adjust pin current | $V_{Diff}$ = 3 V | 1 | –10 | 10 | µA |
| | | $V_{Diff}$ = 40 V | 1 | –10 | 10 | µA |

(1) For subgroup definitions, see Qualirt Conformance Inspection table.

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## 7.7 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 |
| 8B | Functional tests at | –55 |
| 9 | Switching tests at | 25 |
| 10 | Switching tests at | 125 |
| 11 | Switching tests at | –55 |


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## 7.8 Typical Characteristics

Output capacitor = 0 µF unless otherwise noted

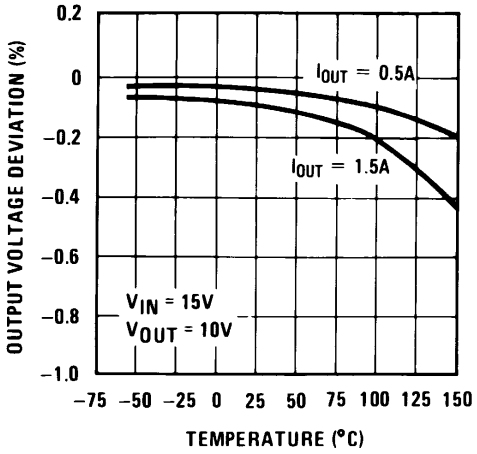



Figure 7-1. Load Regulation

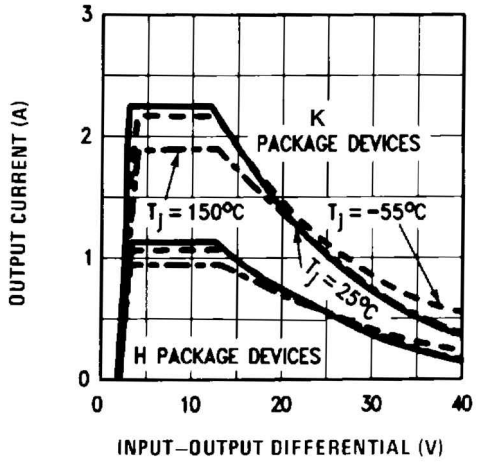



Figure 7-2. Current Limit

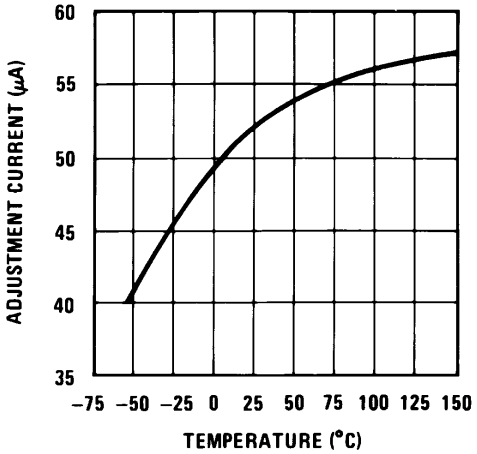



Figure 7-3. Adjustment Current

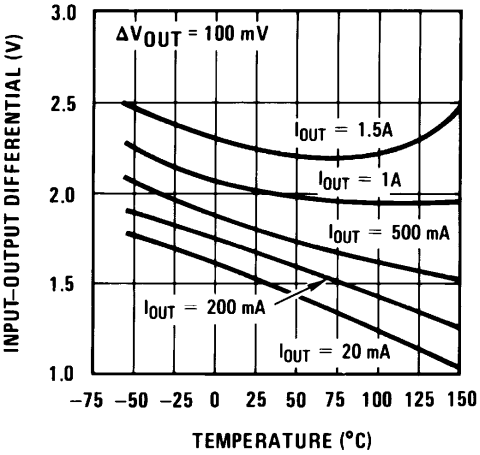



Figure 7-4. Dropout Voltage

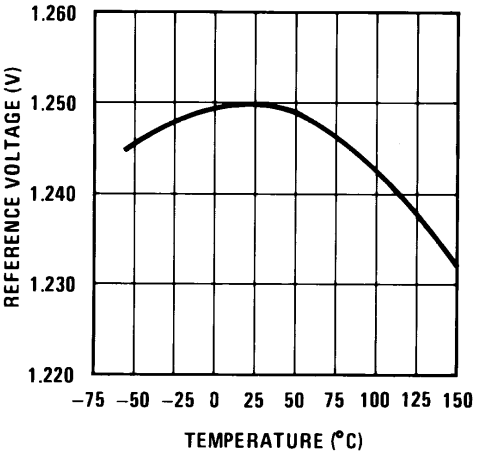



Figure 7-5. Temperature Stability

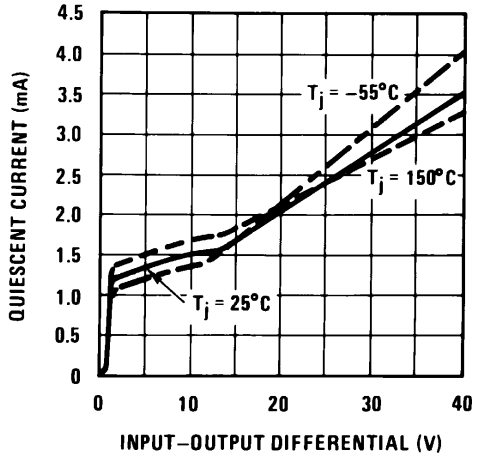



Figure 7-6. Minimum Operating Current

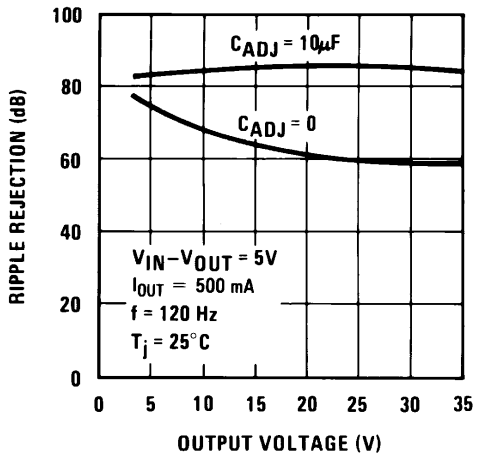



Figure 7-7. Ripple Rejection

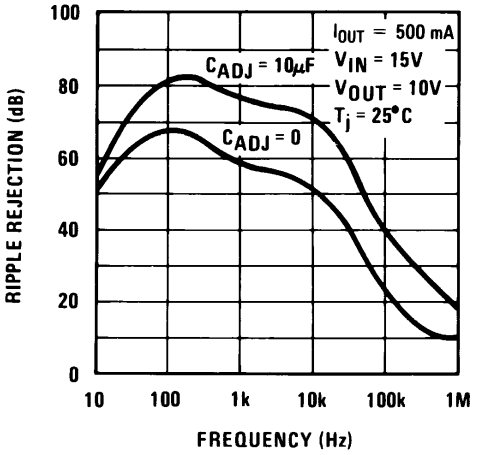



Figure 7-8. Ripple Rejection

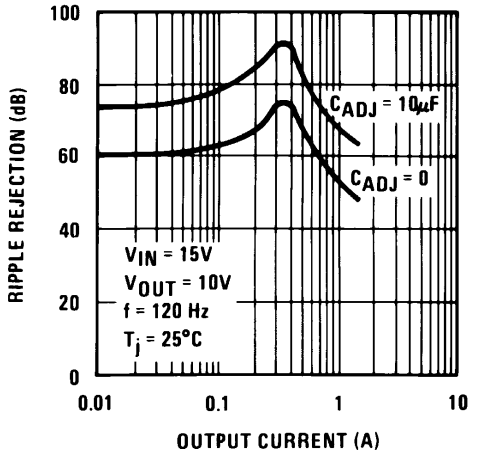



Figure 7-9. Ripple Rejection

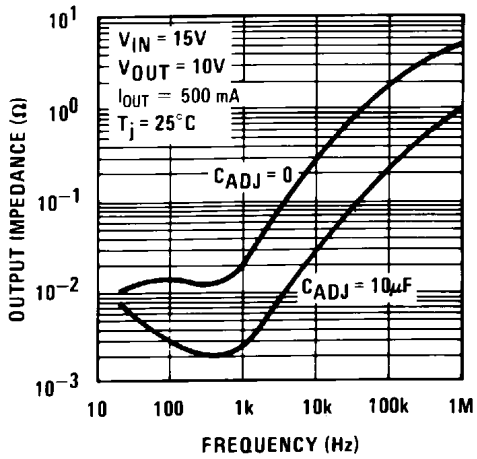



Figure 7-10. Output Impedance

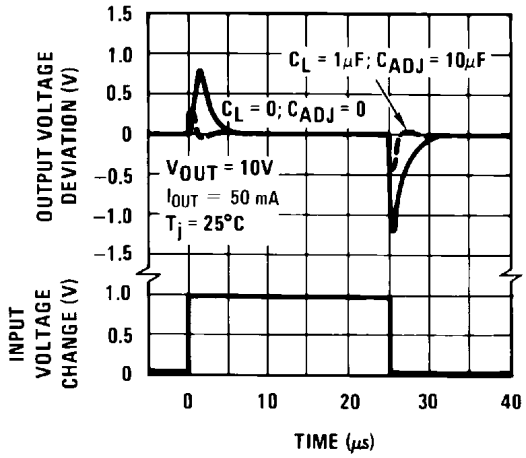



Figure 7-11. Line Transient Response

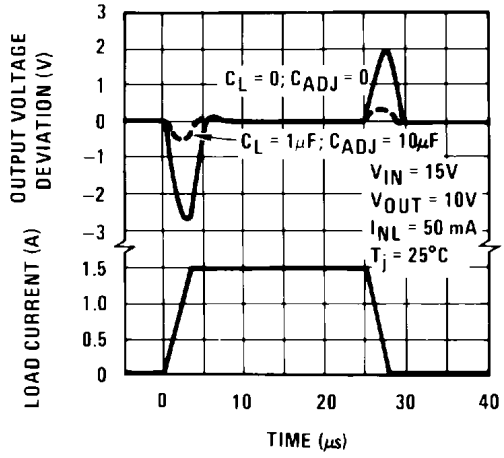



Figure 7-12. Load Transient Response


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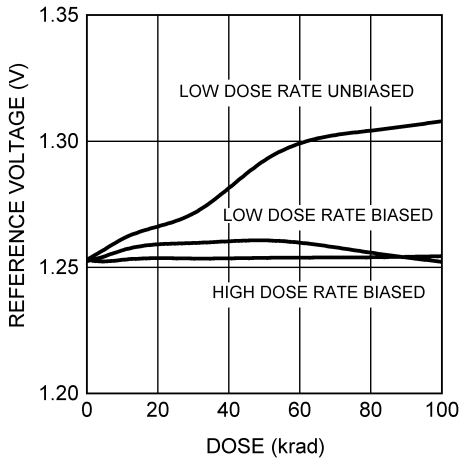



**Figure 7-13. Reference Voltage**

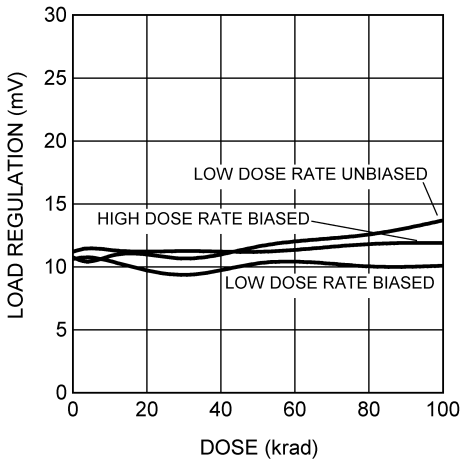



**Figure 7-14. Load Regulation**

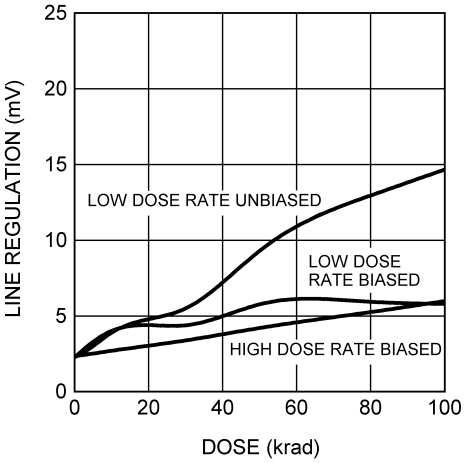



**Figure 7-15. Line Regulation**

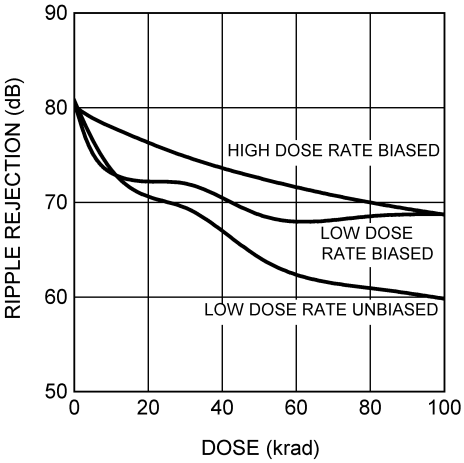



**Figure 7-16. Ripple Rejection**

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# 8 Detailed Description

## 8.1 Overview

The LM117HVQML-SP 3-terminal positive voltage linear regulator is capable of supplying 0.5 A over a 1.2-V to 57-V output range. It is simple to use and requires only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators.

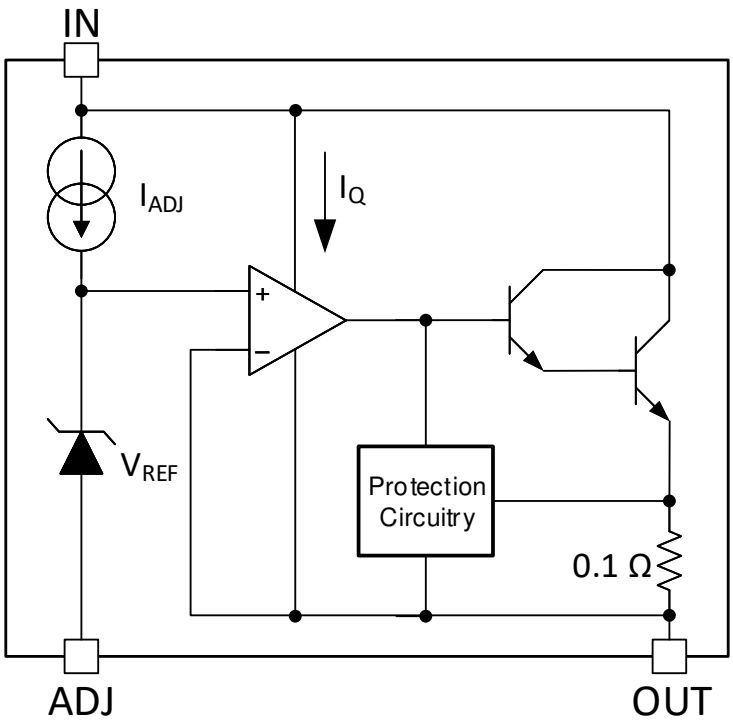
The regulator is "floating" and sees only the input-to-output differential voltage, thus enabling supplies of several hundred volts to be regulated as long as the maximum input-to-output differential is not exceeded (i.e. don't short circuit the output).

The LM117HVQML-SP offers full overload protection such as current limit, thermal overload protection, and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Typically, no capacitors are needed unless the device is situated more than 6 in 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 rejection ratios which are difficult to achieve with standard 3-terminal regulators.

This device makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output it 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 1.2 V where most loads draw little current.

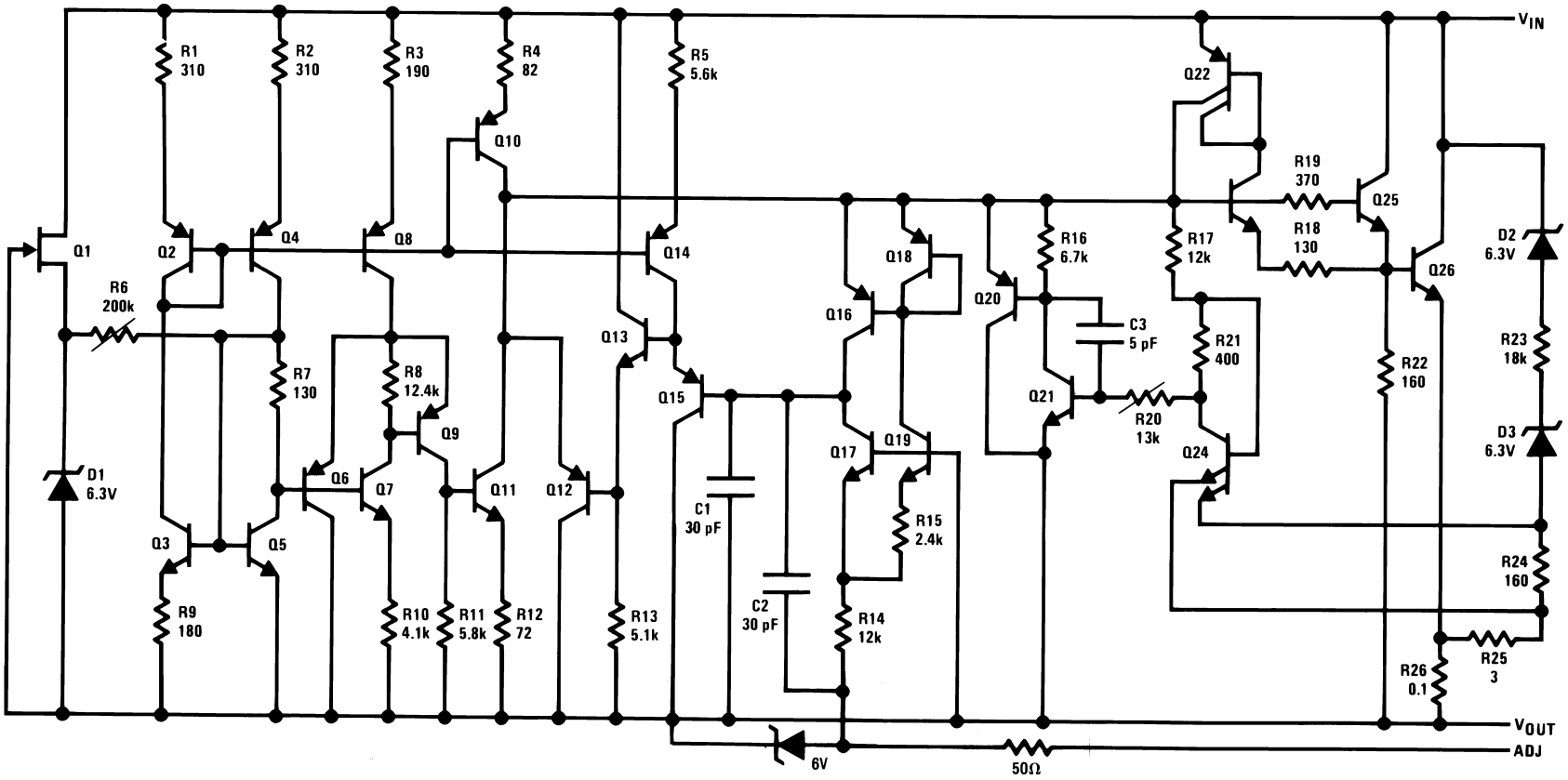
## 8.2 Functional Block Diagram





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### 8.2.1 Simplified Device Schematic

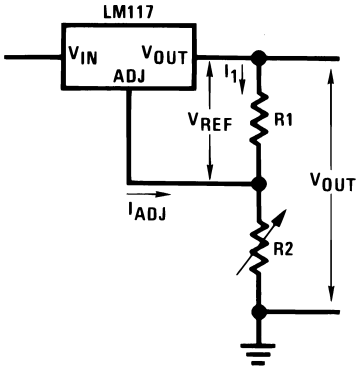


## 8.3 Feature Description

### 8.3.1 Setting Output Voltage

In operation, the LM117HVQML-SP develops a nominal 1.25-V reference voltage, $V_{REF}$, between the output and adjustment terminal. The reference voltage is expressed across R1 and, since the voltage is constant, a constant current $I_1$ then flows through R2, giving an output voltage of:

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




Since the 100-µA current from the adjustment terminal represents an error term, the LM117HVQML-SP 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.

To mitigate the requirement for an added load to sink the required output current, the resistor divider may be selected so that it alone can sink the largest specified output load current of 5 mA (nominal). This has the additional benefit of minimizing the $I_{ADJ}$ error term (which varies over temperature).

### 8.3.2 Load Regulation

The LM117HVQML-SP 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 (case) 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 15-V regulator with 0.05-Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05 Ω × $I_L$. 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 8-1 shows the effect of resistance between the regulator and 240-Ω set resistor.

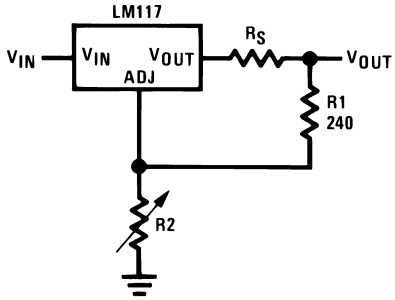



**Figure 8-1. Regulator With Line Resistance in Output Lead**

With the TO-39 package, 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.


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### 8.3.3 External Capacitors

An input bypass capacitor is recommended. A 0.1-µF disc or 1-µF 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 LM117HVQML-SP to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10-µF bypass capacitor 80-dB ripple rejection is obtainable at any output level. Increases over 10-µF 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 (see Section 8.3.4).

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-µF in aluminum electrolytic to equal 1-µF 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-µF disc may seem to work better than a 0.1-µF disc as a bypass.

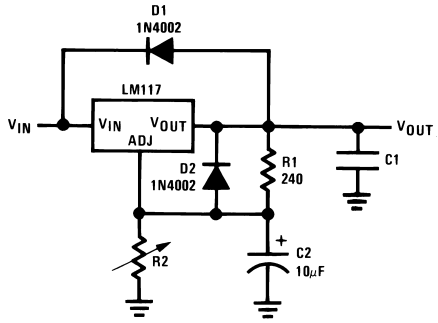
Although the LM117HVQML-SP is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1-µF solid tantalum (or 25-µF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10 µF will merely improve the loop stability and output impedance.

### 8.3.4 Protection Diodes

When external capacitors are used with an 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 20-A 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 LM117HVQML-SP, this discharge path is through a large junction that is able to sustain 15-A surge. 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 LM117HVQML-SP is a 50-Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25 V or less and 10-µF capacitance. Figure 8-2 shows an LM117HVQML-SP with protection diodes included for use with outputs greater than 25 V and high values of output capacitance.




$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

D1 protects against C1 (such as due to a VIN short),
D2 protects against C2 (Such as due to a VOUT short).

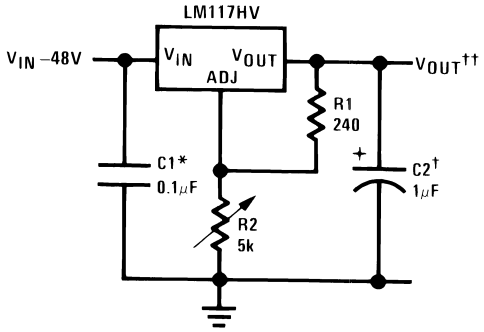
**Figure 8-2. Regulator With Protection Diodes**

# 9 Application and Implementation

**Note**

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

## 9.1 Typical Applications



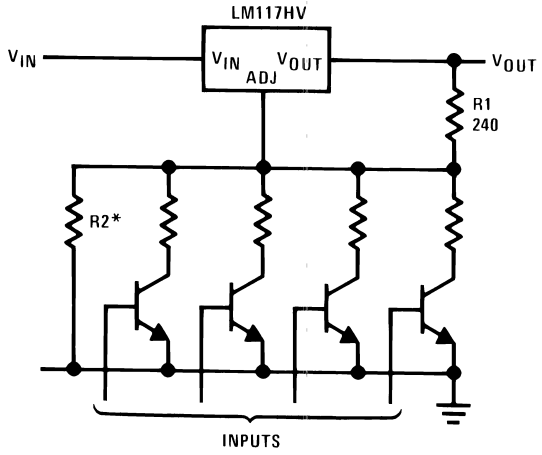

Full output current not available at high input-output voltages

†Optional—improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

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

$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R2}{R1}\right) + I_{ADJ} R_2$$

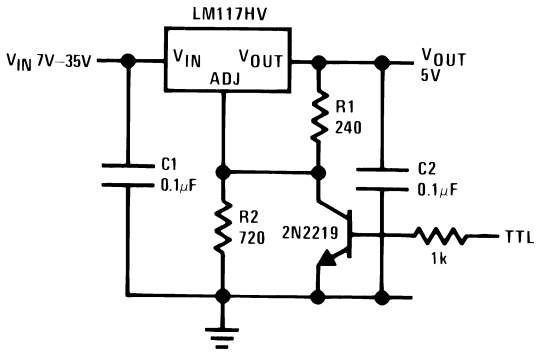
**Figure 9-1. 1.2-V–45-V Adjustable Regulator**




*Sets maximum $V_{OUT}$

**Figure 9-2. Digitally Selected Outputs**


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*Min. output ≈ 1.2 V

**Figure 9-3. 5-V Logic Regulator With Electronic Shutdown***

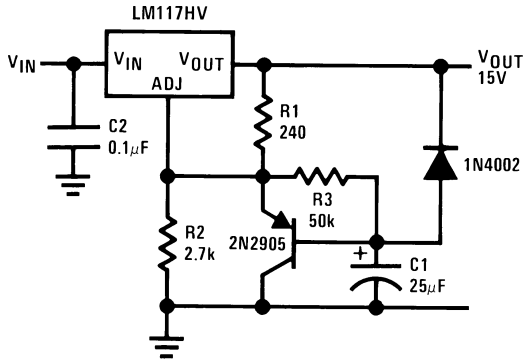
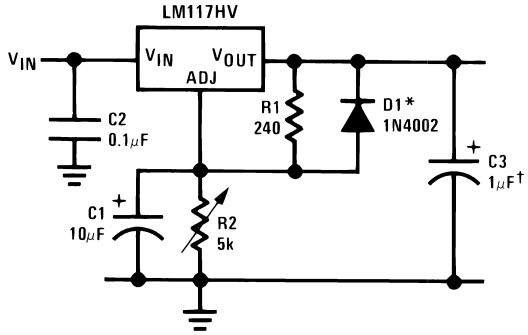



**Figure 9-4. Slow Turn-On 15-V Regulator**




†Solid tantalum

*Discharges C1 if output is shorted to ground

**Figure 9-5. Adjustable Regulator With Improved Ripple Rejection**

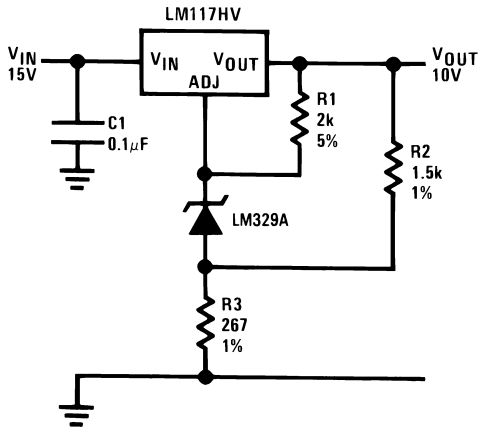
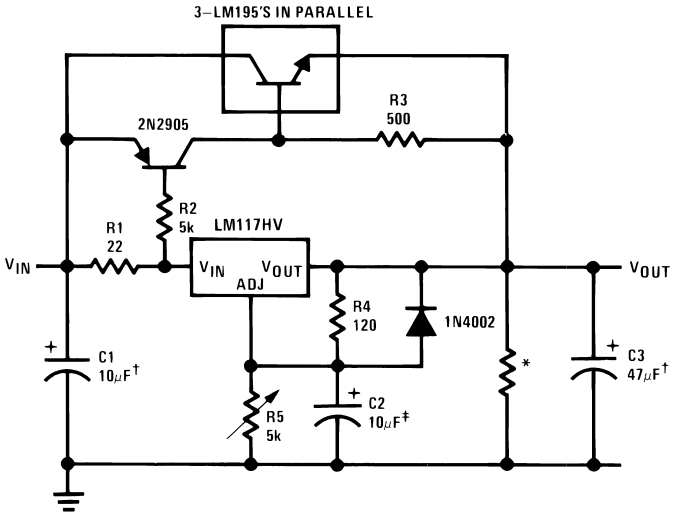



**Figure 9-6. High Stability 10-V Regulator**



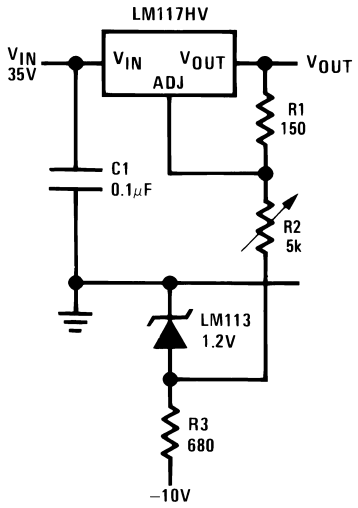

†Solid tantalum

*Minimum load current = 30 mA

‡Optional—improves ripple rejection

**Figure 9-7. High Current Adjustable Regulator**


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Full output current not available at high input-output voltages

**Figure 9-8. 0-V to 30-V Regulator**

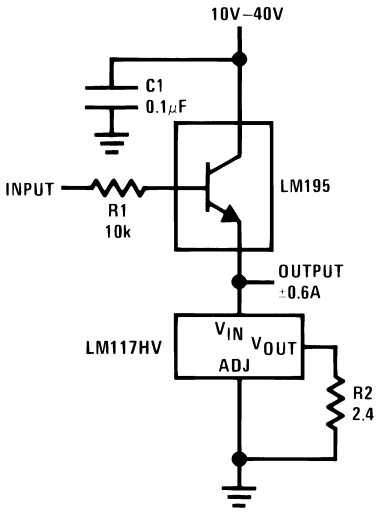
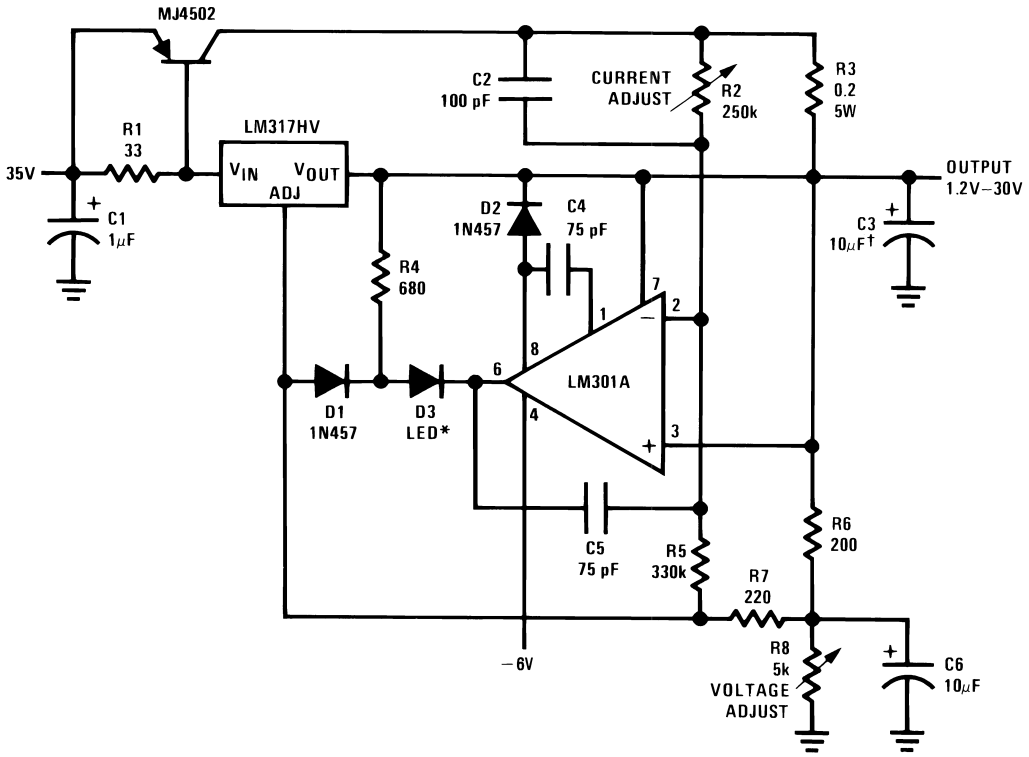



**Figure 9-9. Power Follower**




†Solid tantalum

*Lights in constant current mode

**Figure 9-10. 5-A Constant Voltage/Constant Current Regulator**

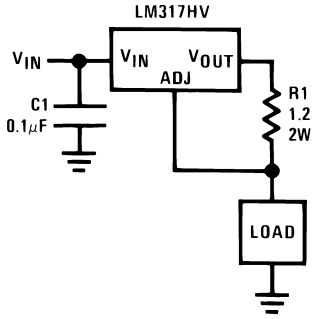
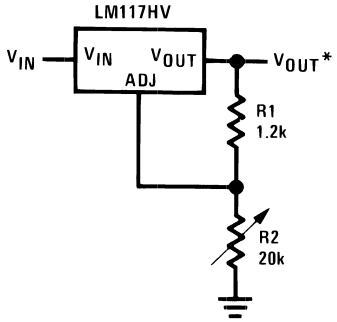



**Figure 9-11. 1-A Current Regulator**




*Minimum load current ≈ 5 mA

**Figure 9-12. 1.2-V–20-V Regulator With Minimum Program Current**


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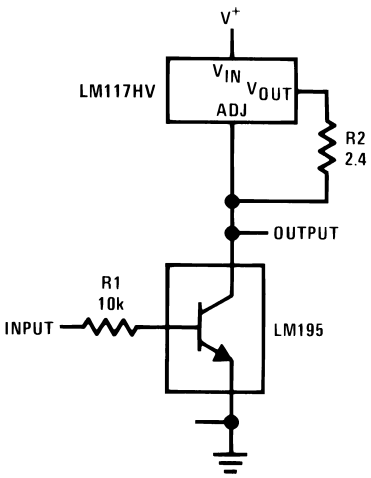
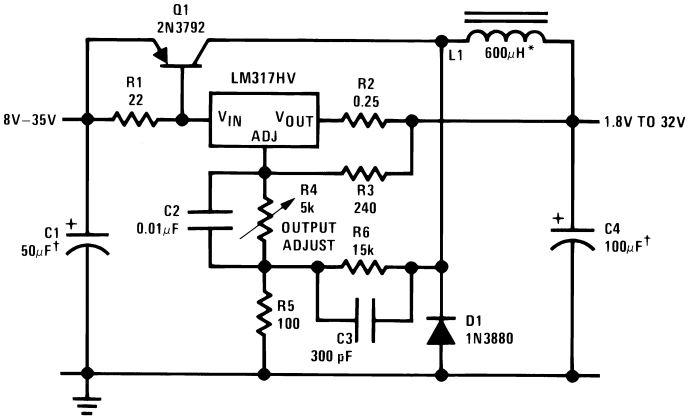


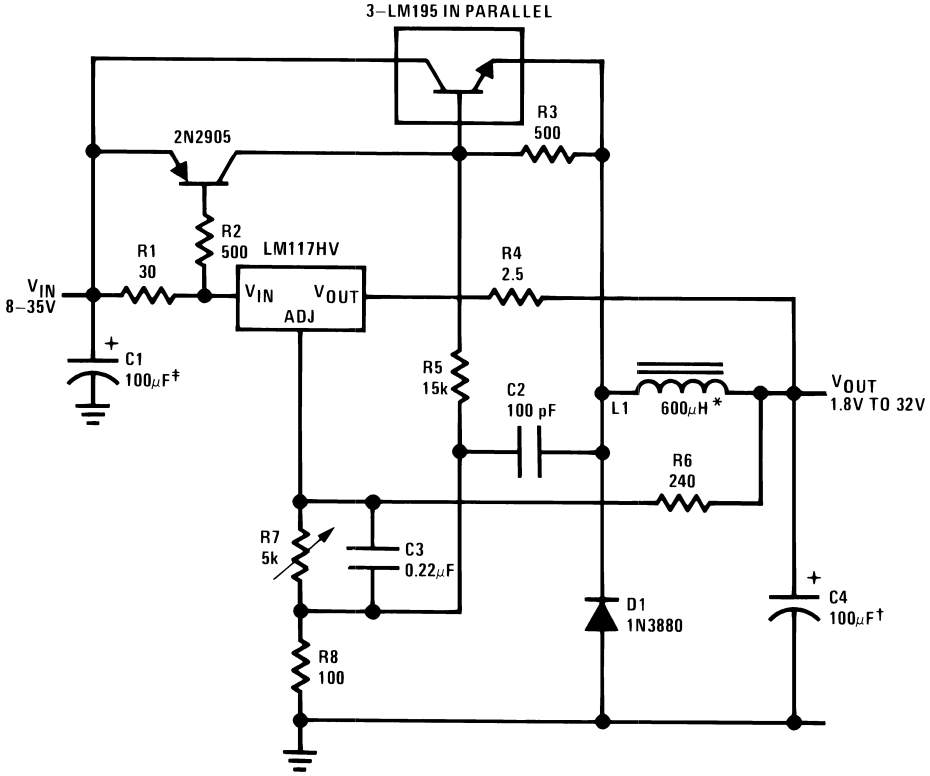

**Figure 9-13. High Gain Amplifier**




†Solid tantalum

*Core—Arnold A-254168-2 60 turns

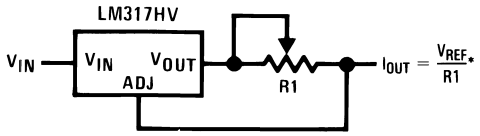
**Figure 9-14. Low Cost 3-A Switching Regulator**




†Solid tantalum

*Core—Arnold A-254168-2 60 turns

**Figure 9-15. 4-A Switching Regulator With Overload Protection**




* 0.8 Ω ≤ R1 ≤ 120 Ω

**Figure 9-16. Precision Current Limiter**

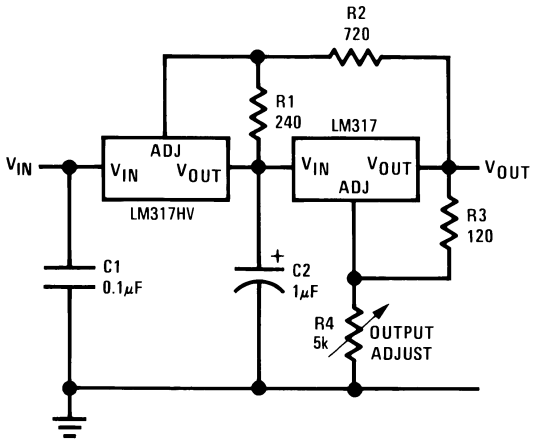
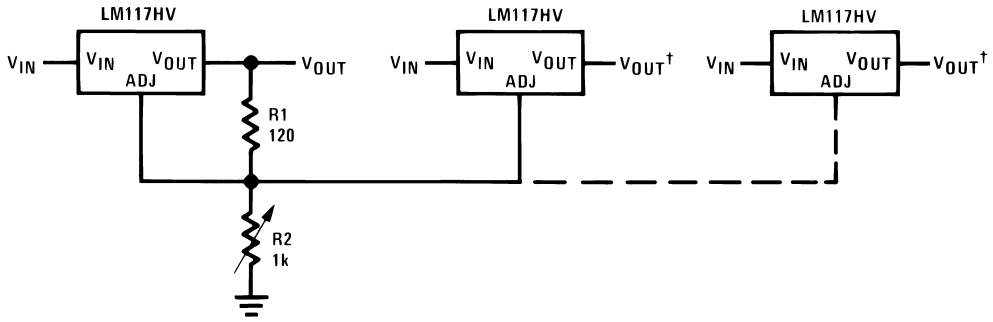



**Figure 9-17. Tracking Preregulator**


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*All outputs within ±100 mV

†Minimum load = 10 mA

**Figure 9-18. Adjustable Multiple On-card Regulators With Single Control***

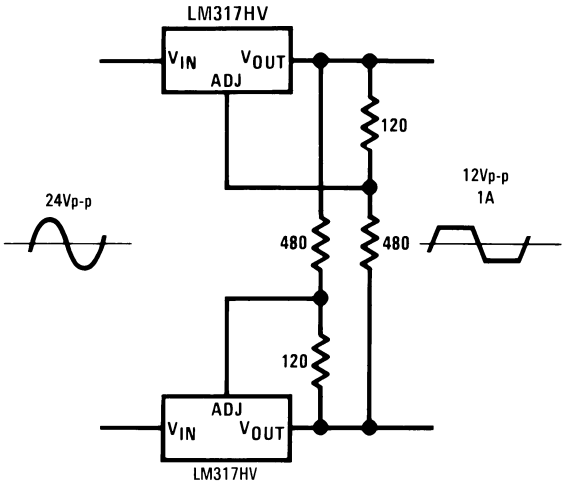
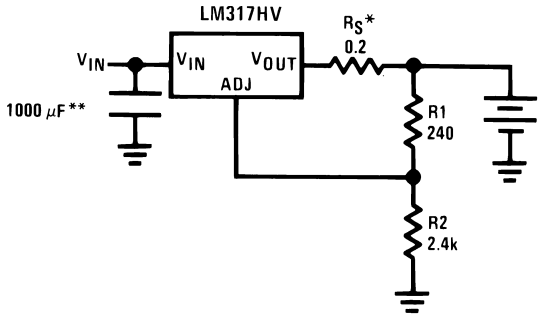



**Figure 9-19. AC Voltage Regulator**




*$R_S$—sets output impedance of charger $Z_{OUT} = R_S\left(1 + \frac{R2}{R1}\right)$

Use of $R_S$ allows low charging rates with fully charged battery.

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

**Figure 9-20. 12-V Battery Charger**

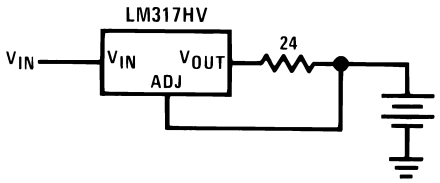



**Figure 9-21. 50-mA Constant Current Battery Charger**

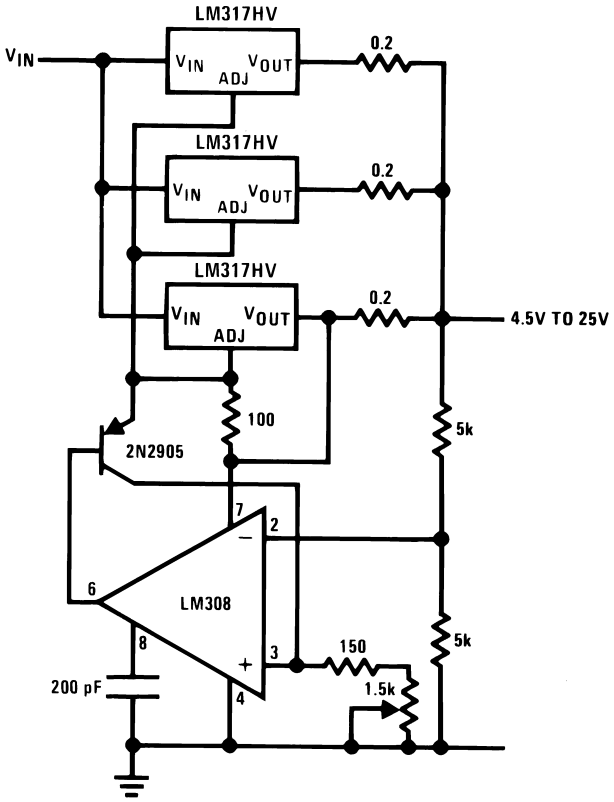
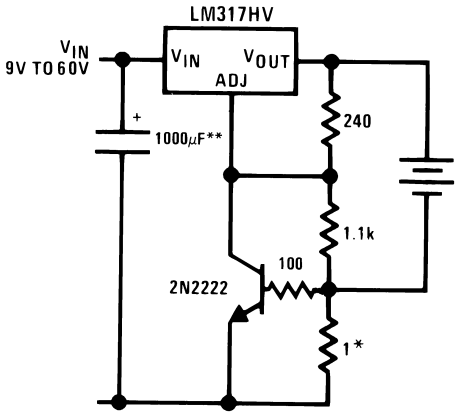



**Figure 9-22. Adjustable 4-A Regulator**




*Sets peak current (0.6 A for 1 Ω)

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

**Figure 9-23. Current Limited 6-V Charger**


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## 10 Power Supply Recommendations

The input supply to the LM117HVQML-SP must be kept at a voltage level such that its maximum input to output differential voltage is not exceeded. The minimum dropout voltage must also be met with extra headroom when possible to keep the LM117HVQML-SP in regulation. An input capacitor is recommended, especially when the input pin is located more than 6 in away from the power supply source. For more information regarding capacitor selection, refer to External Capacitors.

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# 11 Layout

## 11.1 Layout Guidelines

Ensure wide enough traces for those carrying the load current in order to reduce the amount of parasitic trace inductance. Keep the feedback loop from VOUT to ADJ as short as possible. To improve PSRR, a bypass capacitor can be placed at the ADJ pin and must be located as close as possible to the IC. In cases when VIN shorts to ground, an external diode must be placed from VOUT to VIN to divert the surge current from the output capacitor and protect the IC. Similarly, in cases when a large bypass capacitor is placed at the ADJ pin and VOUT shorts to ground, an external diode must be placed from ADJ to VOUT to provide a path for the bypass capacitor to discharge. These diodes must be placed close to the corresponding LM117HVQML-SP pins to increase their effectiveness.


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# 12 Device and Documentation Support

## 12.1 Device Support

### 12.1.1 Third-Party Products Disclaimer

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## 12.2 Documentation Support

### 12.2.1 Related Documentation

1. LM117HVQML-SP NDD (Neutron Displacement Damage) Characterization
2. LM117HVQML-SP SMD 5962R0722961V9A
3. Die Datasheet LM117HVKG MD8 3-Terminal Adj Regulator
4. High Reliability Part Numbering System
5. Applications for an Adjustable IC Power Regulator
6. Improving Power Supply Reliability with IC Power Regulators
7. A New Production Technique for Trimming Voltage Regulators
8. LDO basics: capacitor vs. capacitance
9. LDO Basics: Preventing reverse current

## 12.3 Receiving Notification of Documentation Updates

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## 12.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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## 12.6 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 12.7 Glossary

| | |
|---|---|
| TI Glossary | This glossary lists and explains terms, acronyms, and definitions. |

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## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.


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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| 5962R0722901V9A | Active | Production | DIESALE (Y) \| 0 | 42 \| NOT REQUIRED | Yes | Call TI | Level-1-NA-UNLIM | -55 to 125 | |
| 5962R0722901VXA | Active | Production | TO (NDT) \| 3 | 20 \| JEDEC TRAY (5+1) | - | Call TI | Call TI | -55 to 125 | LM117HVHRQMLV 5962R0722901VXA Q ACO 5962R0722901VXA Q >T |
| 5962R0722902VXA | Active | Production | TO (NDT) \| 3 | 20 \| JEDEC TRAY (5+1) | - | Call TI | Call TI | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T |
| 5962R0722902VZA | Active | Production | CFP (NAC) \| 16 | 88 \| JEDEC TRAY (5+1) | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | LM117HVGWR QMLV Q 5962R07229 02VZA ACO 02VZA >T |
| 5962R0722961V9A | Active | Production | DIESALE (Y) \| 0 | 42 \| NOT REQUIRED | - | Call TI | Call TI | -55 to 125 | |
| 5962R0722961VXA | Active | Production | TO (NDT) \| 3 | 20 \| JEDEC TRAY (5+1) | - | Call TI | Call TI | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T |
| 5962R0722962VZA | Active | Production | CFP (NAC) \| 16 | 88 \| JEDEC TRAY (5+1) | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | LM117HVGWRL QMLV Q 5962R07229 62VZA ACO 62VZA >T |
| LM117HVGWRLQMLV | Active | Production | CFP (NAC) \| 16 | 88 \| JEDEC TRAY (5+1) | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | LM117HVGWRL QMLV Q 5962R07229 62VZA ACO 62VZA >T |

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM117HVGWRQMLV | Active | Production | CFP (NAC) \| 16 | 88 \| JEDEC TRAY (5+1) | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | LM117HVGWR QMLV Q 5962R07229 02VZA ACO 02VZA >T |
| LM117HVH MDE | Active | Production | DIESALE (Y) \| 0 | 42 \| NOT REQUIRED | - | Call TI | Call TI | -55 to 125 | |
| LM117HVH MDR | Active | Production | DIESALE (Y) \| 0 | 42 \| NOT REQUIRED | Yes | Call TI | Level-1-NA-UNLIM | -55 to 125 | |
| LM117HVHRLQMLV | Active | Production | TO (NDT) \| 3 | 20 \| JEDEC TRAY (5+1) | No | Call TI | Level-1-NA-UNLIM | -55 to 125 | LM117HVHRLQMLV 5962R0722961VXA Q ACO 5962R0722961VXA Q >T |
| LM117HVHRQMLV | Active | Production | TO (NDT) \| 3 | 20 \| JEDEC TRAY (5+1) | No | Call TI | Level-1-NA-UNLIM | -55 to 125 | LM117HVHRQMLV 5962R0722901VXA Q ACO 5962R0722901VXA Q >T |
| LM117HVNAC/EM | Active | Production | CFP (NAC) \| 16 | 88 \| JEDEC TRAY (5+1) | No | SNPB | Level-1-NA-UNLIM | 25 to 25 | LM117HVNAC/EM EVAL ONLY T |

(1) **Status:** For more details on status, see our product life cycle.

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

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

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

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

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

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

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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.

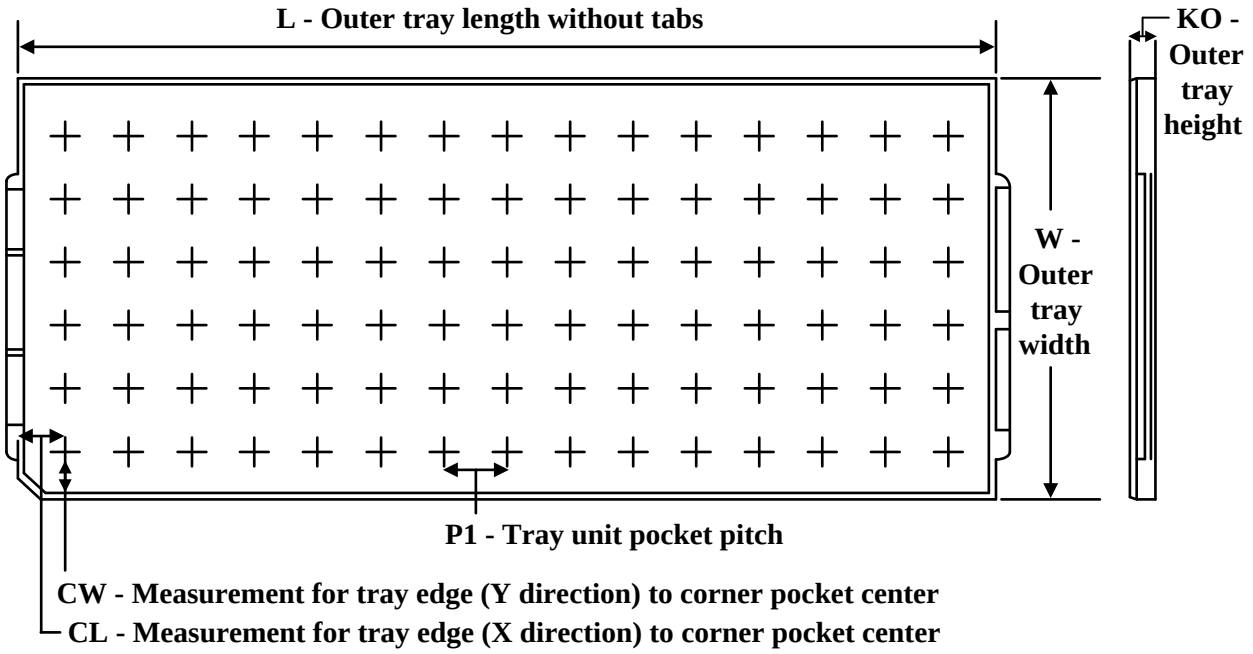
**OTHER QUALIFIED VERSIONS OF LM117HVQML-SP :**

- Military : LM117HVQML

NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications

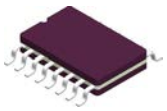
## TRAY




Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5962R0722901VXA | NDT | TO-CAN | 3 | 20 | 2 X 10 | 150 | 126.49 | 61.98 | 8890 | 11.18 | 12.95 | 18.54 |
| 5962R0722902VXA | NDT | TO-CAN | 3 | 20 | 2 X 10 | 150 | 126.49 | 61.98 | 8890 | 11.18 | 12.95 | 18.54 |
| 5962R0722961VXA | NDT | TO-CAN | 3 | 20 | 2 X 10 | 150 | 126.49 | 61.98 | 8890 | 11.18 | 12.95 | 18.54 |
| LM117HVHRLQMLV | NDT | TO-CAN | 3 | 20 | 2 X 10 | 150 | 126.49 | 61.98 | 8890 | 11.18 | 12.95 | 18.54 |
| LM117HVHRQMLV | NDT | TO-CAN | 3 | 20 | 2 X 10 | 150 | 126.49 | 61.98 | 8890 | 11.18 | 12.95 | 18.54 |

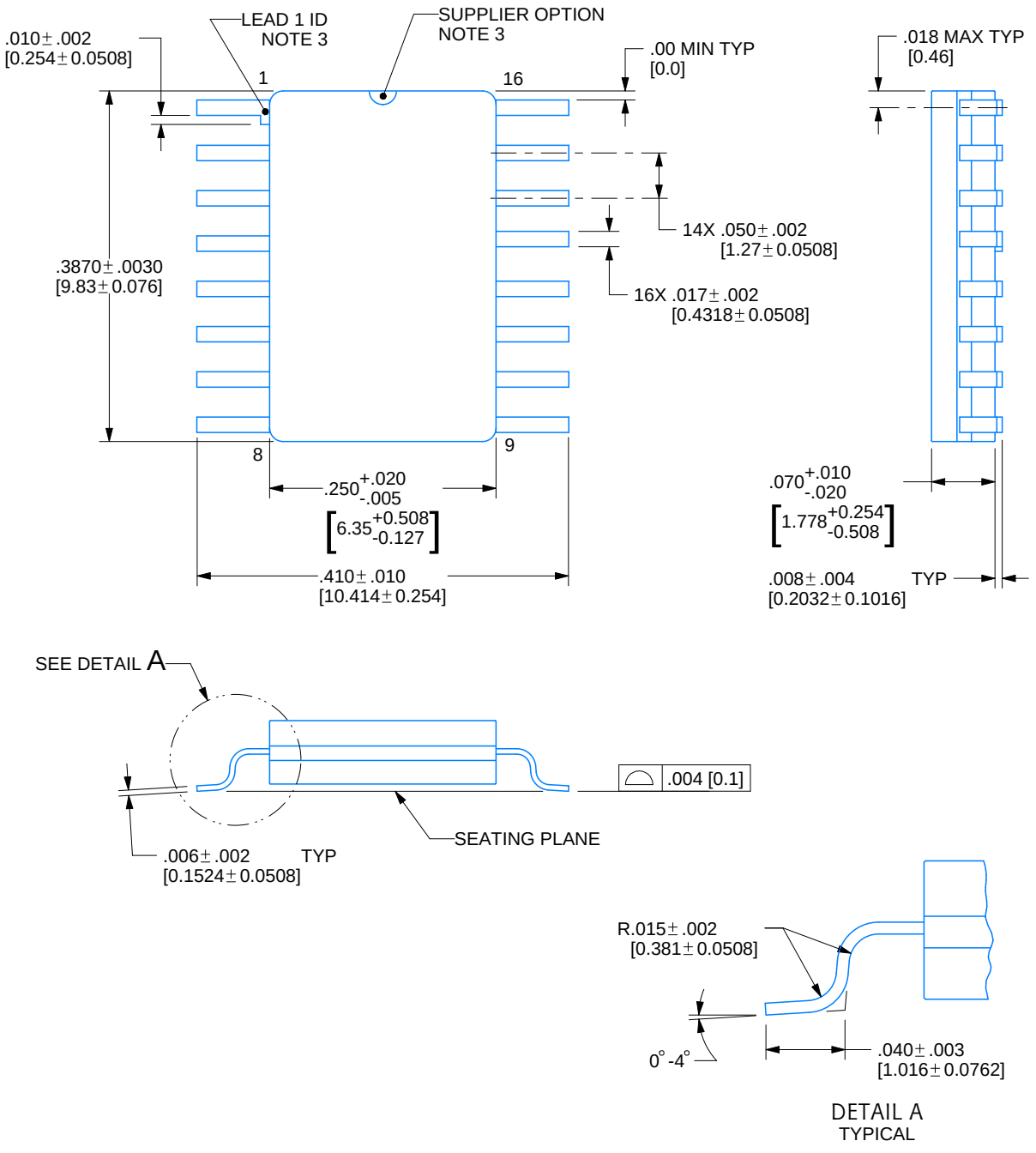


# PACKAGE OUTLINE

## NAC0016A

## CFP - 2.33mm max height

CERAMIC FLATPACK




4215198/C 08/2022

NOTES:

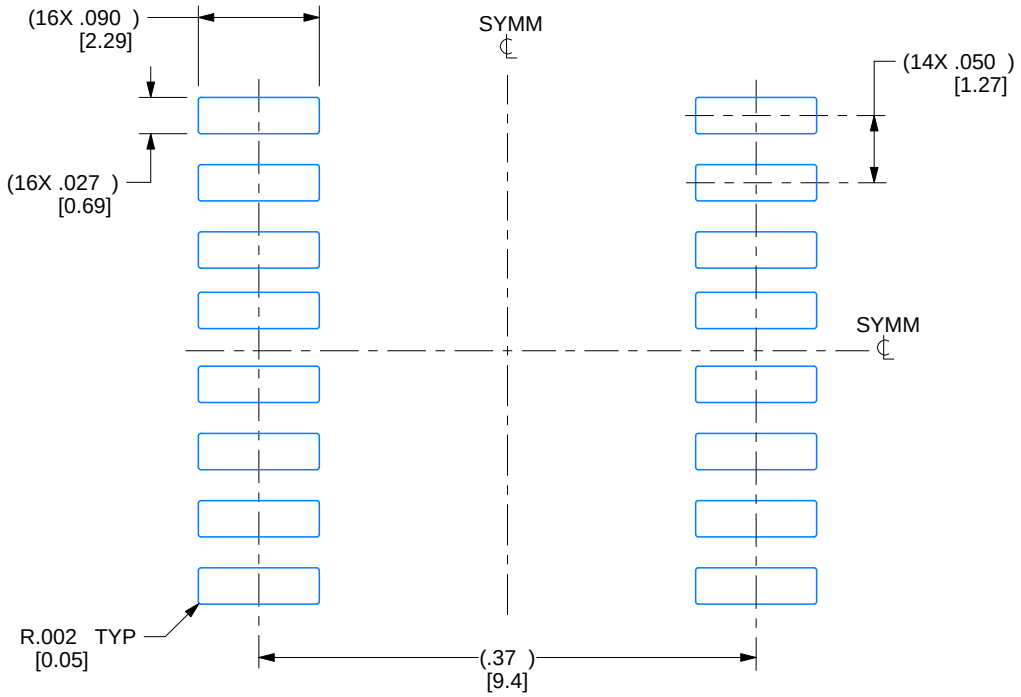
1. Controlling dimension is Inch. Values in [ ] are milimeters. Dimensions in ( ) for reference only.
2. For solder thickness and composition, see the "Lead Finish Composition/Thickness" link in the packaging section of the Texas Instruments website
3. Lead 1 identification shall be:
   a) A notch or other mark within this area
   b) A tab on lead 1, either side
4. No JEDEC registration as of December 2021

# EXAMPLE BOARD LAYOUT

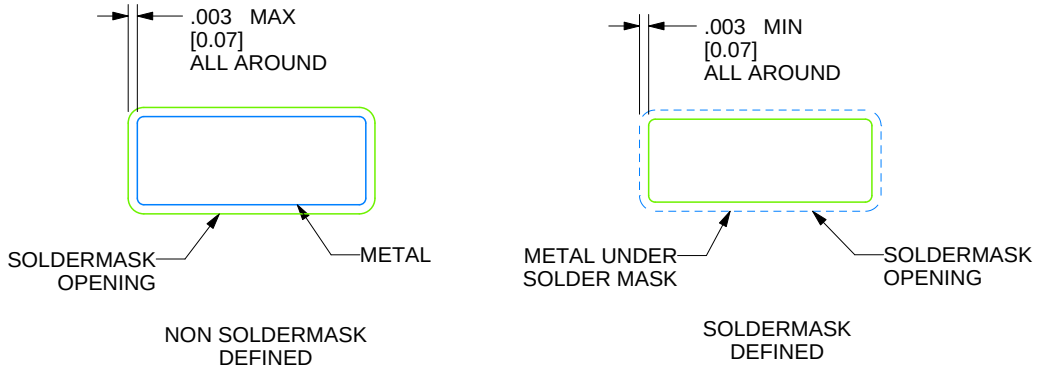
## NAC0016A

### CFP - 2.33mm max height

CERAMIC FLATPACK




RECOMMENDED LAND PATTERN

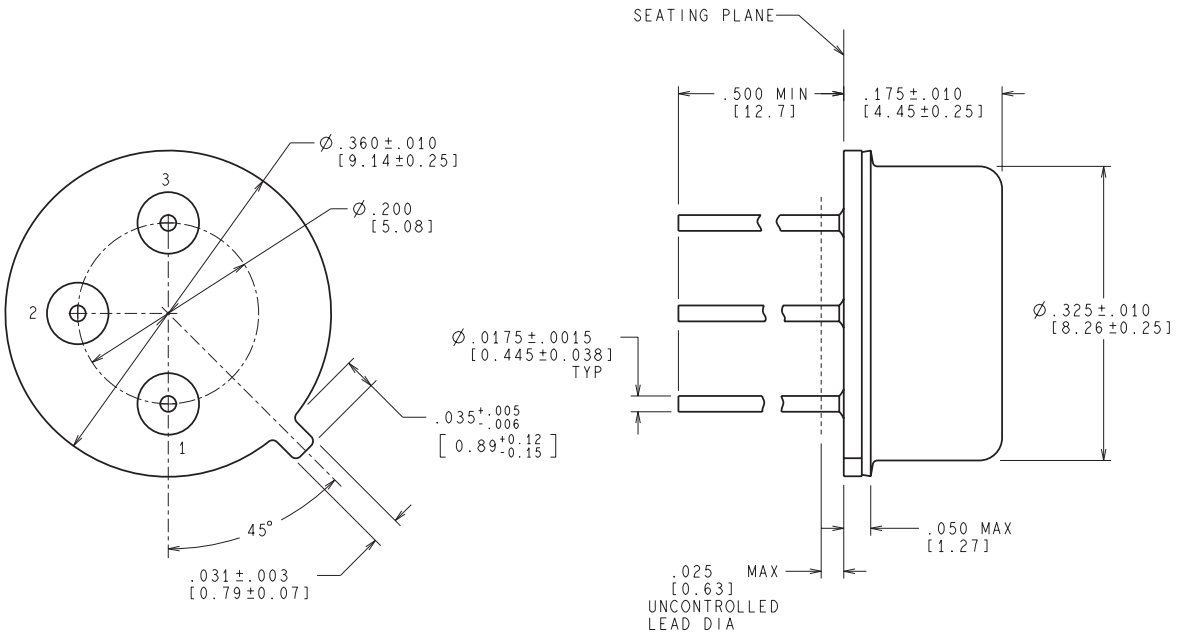



4215198/C 08/2022

## REVISIONS

| REV | DESCRIPTION | E.C.N. | DATE | BY/APP'D |
|---|---|---|---|---|
| A | RELEASE TO DOCUMENT CONTROL | 2197879 | 12/30/2021 | TINA TRAN / ANIS FAUZI |
| B | NO CHANGE TO DRAWING; REVISION FOR YODA RELEASE; | 2198832 | 02/15/2022 | K. SINCERBOX |
| C | .387± .003 WAS .39000± .00012; | 2200917 | 08/08/2022 | D. CHIN / K. SINCERBOX |

# NDT0003A




CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

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