



**THE DATASHEET OF  
FT2705P**



## 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.

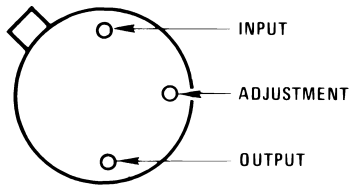


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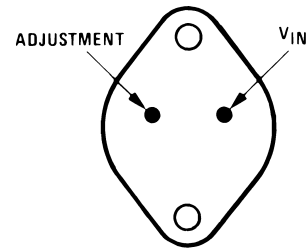
**CONNECTION DIAGRAMS**

(See Physical Dimension section for further information)



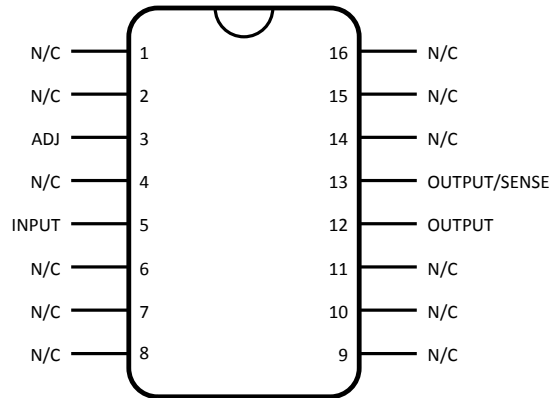
CASE IS OUTPUT

**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**



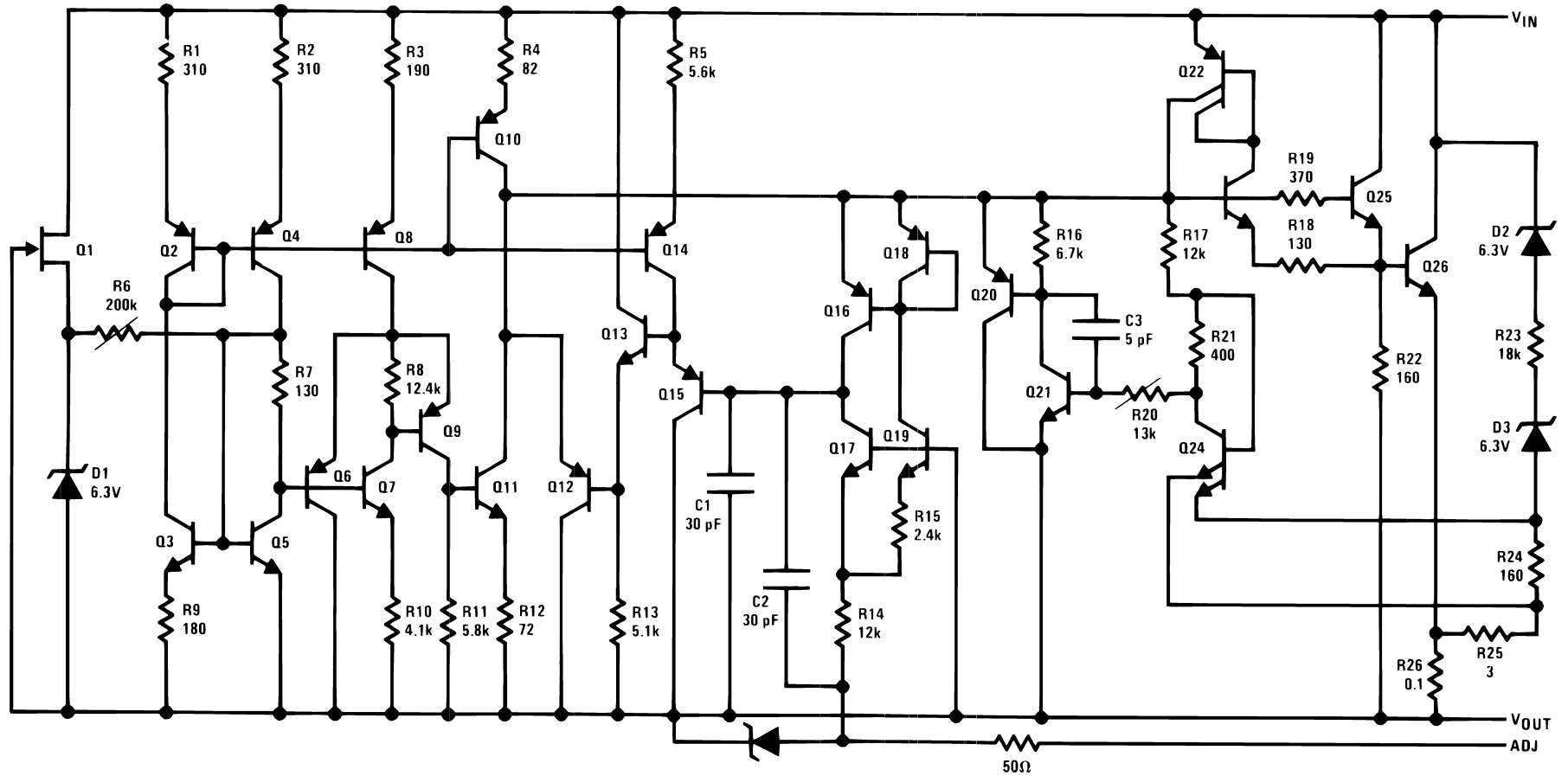
For the CFP device to function properly, the “Output” and “Output/Sense” pins must be connected on the users printed circuit board.

**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<sup>(1)</sup>

Power Dissipation <sup>(2)</sup>	Internally limited		
Input - Output Voltage Differential	+60V, -0.3V		
Maximum Junction Temperature	+150°C		
Storage Temperature	-65°C ≤ T <sub>A</sub> ≤ +150°C		
Lead Temperature (Soldering, 10 sec.)	300°C		
Thermal Resistance	θ <sub>JA</sub>	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 <sub>JC</sub>	TO Metal Can	1.9°C/W
		TO Metal Can	21°C/W
		CFP "WG" (device 01, 61) <sup>(3)</sup>	3.4°C/W
		CFP "GW" (device 02, 62)	7°C/W
ESD Tolerance <sup>(4)</sup>	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<sub>Jmax</sub> (maximum junction temperature), θ<sub>JA</sub> (package junction to ambient thermal resistance), and T<sub>A</sub> (ambient temperature). The maximum allowable power dissipation at any temperature is P<sub>Dmax</sub> = (T<sub>Jmax</sub> - T<sub>A</sub>) / θ<sub>JA</sub> 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<sub>JA</sub>, rather than θ<sub>JC</sub>, 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<sub>JC</sub> 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 <sub>A</sub> ≤ +125°C
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**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	$\mu A$	1
		$V_{Diff} = 3.3V$			100	$\mu A$	2, 3
		$V_{Diff} = 40V$			100	$\mu A$	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	$\mu A$	1
		$V_{Diff} = 3.3V,$ $I_L = 10mA$ to 500mA		-5.0	5.0	$\mu A$	2, 3
		$V_{Diff} = 40V,$ $I_L = 10mA$ to 150mA		-5.0	5.0	$\mu A$	1
		$V_{Diff} = 40V,$ $I_L = 10mA$ to 100mA		-5.0	5.0	$\mu A$	2, 3

**LM117HVH, HVWG Electrical Characteristics DC Parameters (continued)**

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
Delta $I_{Adj}$ / Line	Adjustment Pin Current Change	$3V \leq V_{Diff} \leq 40V$		-5.0	5.0	$\mu A$	1
		$3.3V \leq V_{Diff} \leq 40V$		-5.0	5.0	$\mu A$	2, 3
$I_{OS}$	Short Circuit Current	$V_{Diff} = 60V$		0.0	0.4	A	1
		$V_{Diff} = 4.25V$		0.5	1.8	A	1
$\theta_R$	Thermal Regulation	$V_{Diff} = 40V$ , $I_L = 150mA$ , $t = 20mS$			6.0	mV	1

**LM117HVH, HVWG Electrical Characteristics AC Parameters**

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

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	$V_I = +6.25V$ , $f = 120Hz$ , $e_i = 1V_{RMS}$ , $I_L = 125mA$ , $V_O = V_{Ref}$	See <sup>(1)</sup>	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	$V_{Diff} = 3V$		-10	10	$\mu A$	1
		$V_{Diff} = 40V$		-10	10	$\mu A$	1
$V_{Ref}$	Reference Voltage	$V_{Diff} = 3V$		-0.01	0.01	V	1
		$V_{Diff} = 40V$		-0.01	0.01	V	1
$V_{RLine}$	Line Regulation	$3V \leq V_{Diff} \leq 40V$ , $V_O = V_{Ref}$		-4.0	4.0	mV	1
		$40V \leq V_{Diff} \leq 60V$ , $I_L = 60mA$		-6.0	6.0	mV	1

**LM117HVH, HVWG Post Radiation Electrical Characteristics DC Parameters**

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

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

**LM117HVH, HVWG Post Radiation Electrical Characteristics AC Parameters**

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

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	$V_I = +6.25V$ , $f = 120Hz$ , $e_i = 1V_{RMS}$ , $I_L = 125mA$ , $V_O = V_{Ref}$		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	$\mu\text{A}$	1
		$V_{Diff} = 3.3\text{V}$			100	$\mu\text{A}$	2, 3
		$V_{Diff} = 40\text{V}$			100	$\mu\text{A}$	1, 2, 3
$I_Q$	Minimum Load Current	$V_{Diff} = 3\text{V}$ , $V_O = 1.7\text{V}$			5.0	$\text{mA}$	1
		$V_{Diff} = 3.3\text{V}$ , $V_O = 1.7\text{V}$			5.0	$\text{mA}$	2, 3
		$V_I = 40\text{V}$ , $V_O = 1.7\text{V}$			5.0	$\text{mA}$	1, 2, 3
		$V_I = 60\text{V}$ , $V_O = 1.7\text{V}$		0.25	8.2	$\text{mA}$	1
$V_{Ref}$	Reference Voltage	$V_{Diff} = 3\text{V}$		1.2	1.3	$\text{V}$	1
		$V_{Diff} = 3.3\text{V}$		1.2	1.3	$\text{V}$	2, 3
		$V_{Diff} = 40\text{V}$		1.2	1.3	$\text{V}$	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	$\text{mV}$	1
		$3.3\text{V} \leq V_{Diff} \leq 40\text{V}$ , $V_O = V_{Ref}$		-18	18	$\text{mV}$	2, 3
		$40\text{V} \leq V_{Diff} \leq 60\text{V}$ , $I_L = 60\text{mA}$		-25	25	$\text{mV}$	1
$V_{RLoad}$	Load Regulation	$V_{Diff} = 3\text{V}$ , $I_L = 10\text{mA}$ to $1.5\text{A}$		-15	15	$\text{mV}$	1
		$V_{Diff} = 3.3\text{V}$ , $I_L = 10\text{mA}$ to $1.5\text{A}$		-15	15	$\text{mV}$	2, 3
		$V_{Diff} = 40\text{V}$ , $I_L = 10\text{mA}$ to $300\text{mA}$		-15	15	$\text{mV}$	1
		$V_{Diff} = 40\text{V}$ , $I_L = 10\text{mA}$ to $195\text{mA}$		-15	15	$\text{mV}$	2, 3
Delta $I_{Adj}$ / Load	Adjustment Pin Current Change	$V_{Diff} = 3\text{V}$ , $I_L = 10\text{mA}$ to $1.5\text{A}$		-5.0	5.0	$\mu\text{A}$	1
		$V_{Diff} = 3.3\text{V}$ , $I_L = 10\text{mA}$ to $1.5\text{A}$		-5.0	5.0	$\mu\text{A}$	2, 3
		$V_{Diff} = 40\text{V}$ , $I_L = 10\text{mA}$ to $300\text{mA}$		-5.0	5.0	$\mu\text{A}$	1
		$V_{Diff} = 40\text{V}$ , $I_L = 10\text{mA}$ to $195\text{mA}$		-5.0	5.0	$\mu\text{A}$	2, 3
Delta $I_{Adj}$ / Line	Adjustment Pin Current Change	$3\text{V} \leq V_{Diff} \leq 40\text{V}$		-5.0	5.0	$\mu\text{A}$	1
		$3.3\text{V} \leq V_{Diff} \leq 40\text{V}$		-5.0	5.0	$\mu\text{A}$	2, 3
$I_{OS}$	Short Circuit Current	$V_{Diff} = 60\text{V}$		0.0	0.4	$\text{A}$	1
		$V_{Diff} = 3\text{V}$		1.5	3.5	$\text{A}$	1
$\theta_R$	Thermal Regulation	$V_{Diff} = 40\text{V}$ , $I_L = 300\text{mA}$ , $t = 20\text{mS}$			10.5	$\text{mV}$	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	$V_I = +6.25\text{V}$ , $f = 120\text{Hz}$ , $e_I = 1\text{V}_{\text{RMS}}$ , $I_L = 0.5\text{A}$ , $V_O = V_{Ref}$	See <sup>(1)</sup>	66		$\text{dB}$	4, 5, 6

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

### Typical Performance Characteristics

Output capacitor = 0  $\mu$ F unless otherwise noted.

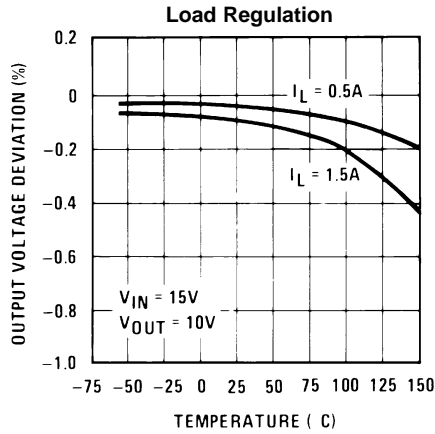


Figure 4.

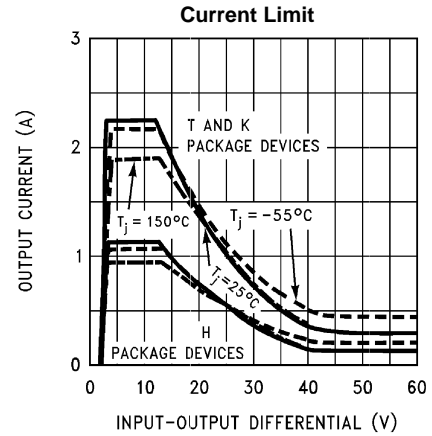


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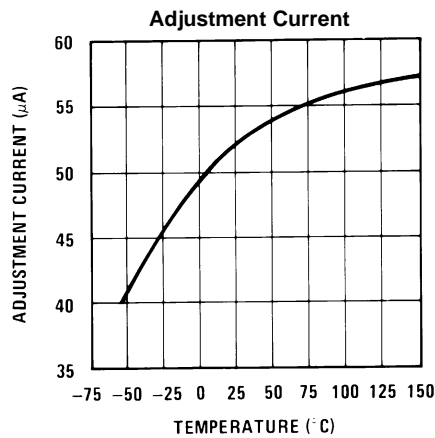


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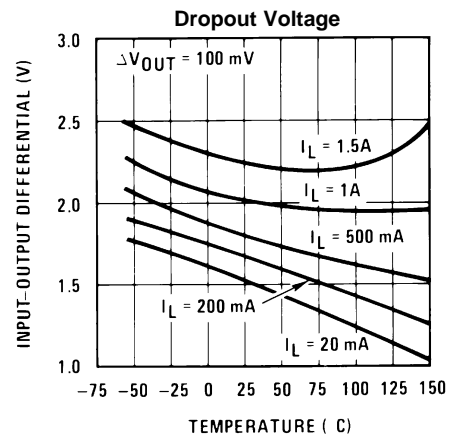


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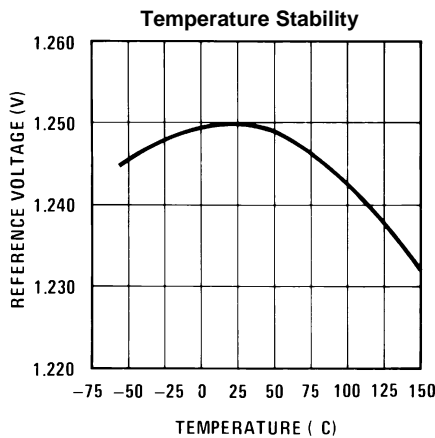


Figure 8.

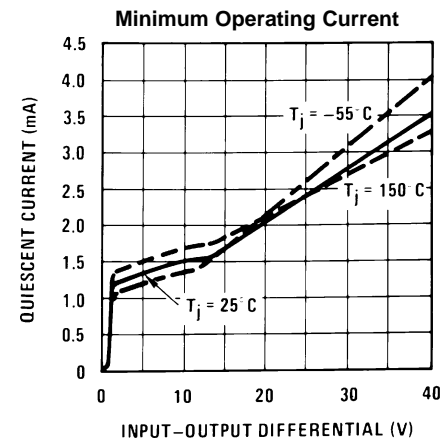


Figure 9.

Typical Performance Characteristics (continued)

Output capacitor = 0  $\mu$ F unless otherwise noted.

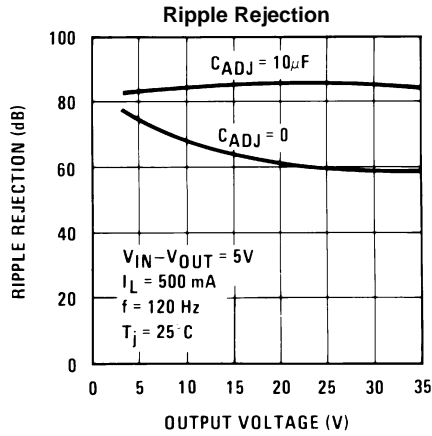


Figure 10.

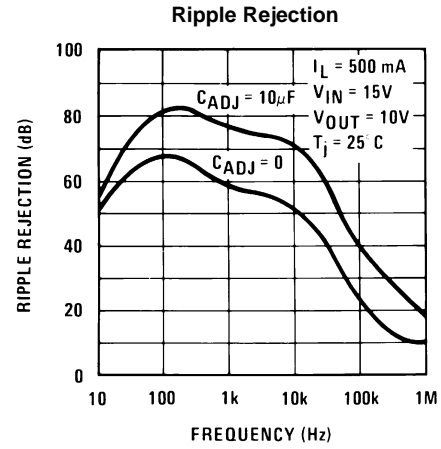


Figure 11.

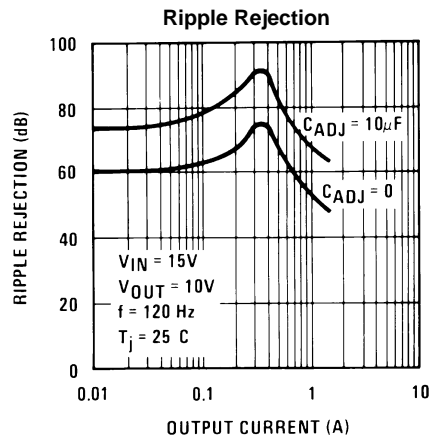


Figure 12.

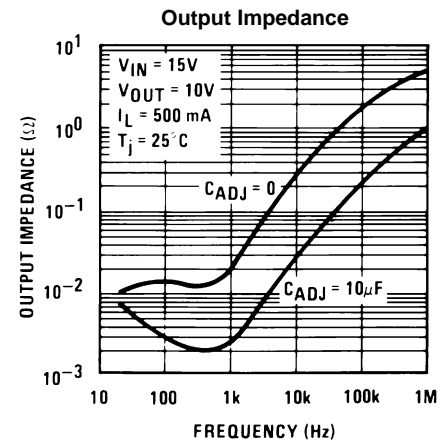


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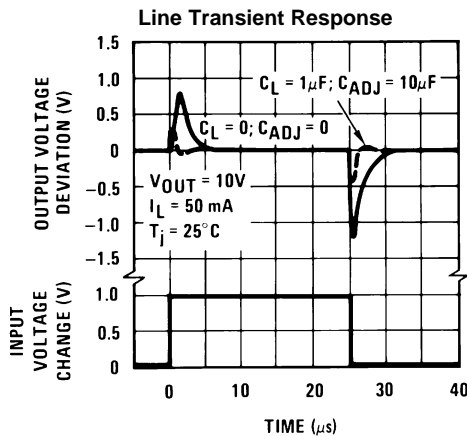


Figure 14.

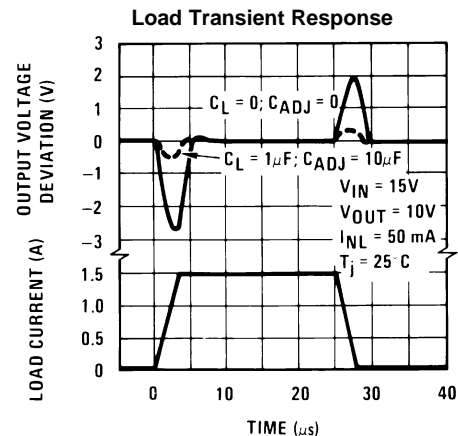


Figure 15.

### Typical Radiation Characteristics

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

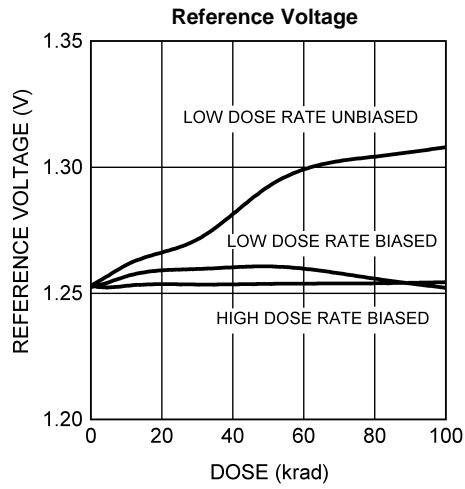


Figure 16.

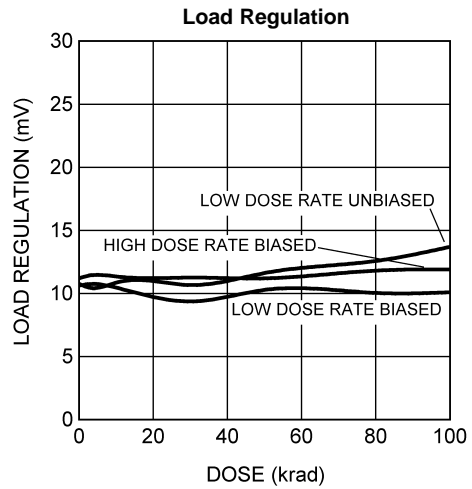


Figure 17.

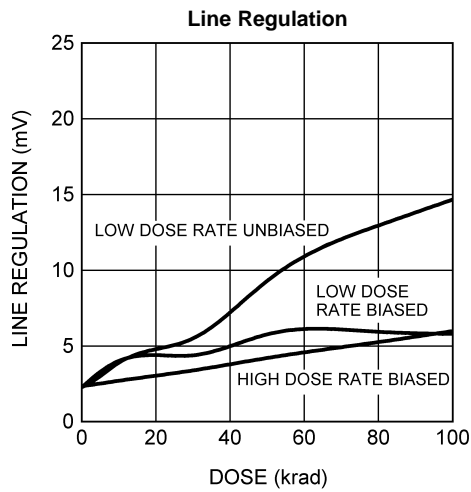


Figure 18.

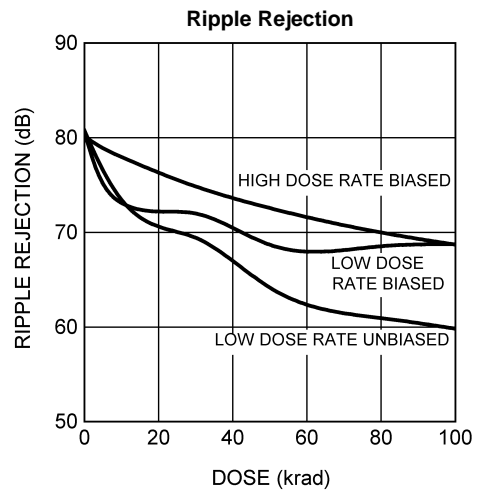


Figure 19.

## 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

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

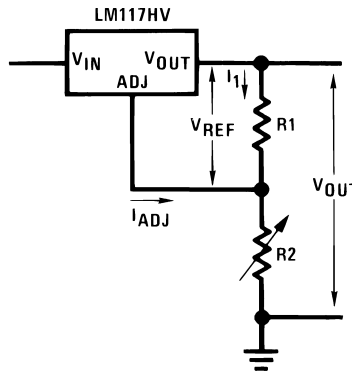


Figure 20.

Since the 100  $\mu$ 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  $\mu$ F disc or 1  $\mu$ 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  $\mu$ F bypass capacitor 80 dB ripple rejection is obtainable at any output level. Increases over 10  $\mu$ 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.

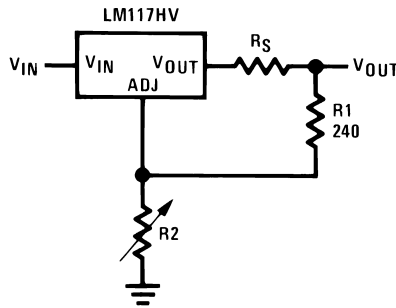
In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25  $\mu$ F in aluminum electrolytic to equal 1  $\mu$ F solid tantalum at high frequencies. Ceramic capacitors 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  $\mu$ F disc may seem to work better than a 0.1  $\mu$ 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  $\mu$ F solid tantalum (or 25  $\mu$ F aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of load capacitance larger than 10  $\mu$ 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 $\Omega$ ) 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 $\Omega$  resistance between the regulator and load will have a load regulation due to line resistance of 0.05 $\Omega$   $\times$   $I_L$ . If the set resistor is connected near the load the effective line resistance will be 0.05 $\Omega$  (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

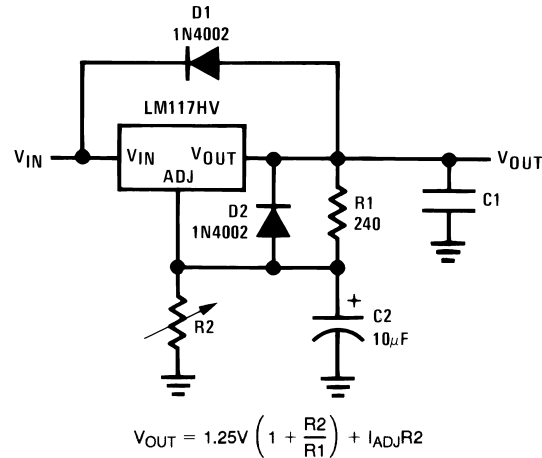
When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10 μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although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

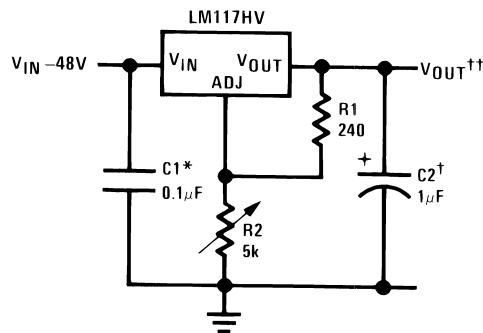
Internal current limit will be activated whenever the output current exceeds the limit indicated in the Typical Performance Characteristics. However, if during a short circuit condition the regulator's differential voltage exceeds the Absolute Maximum Rating of 60V (e.g.  $V_{IN} \geq 60V$ ,  $V_{OUT} = 0V$ ), 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

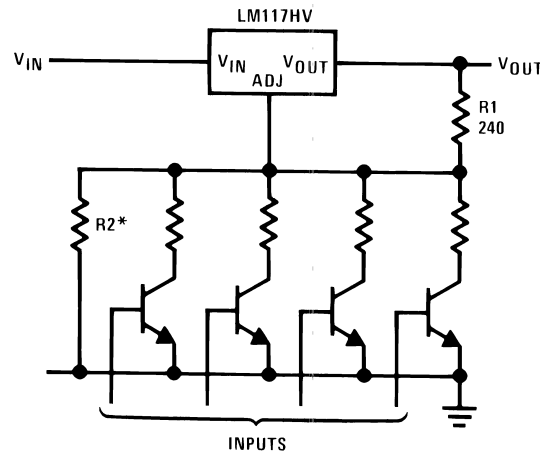
†Optional—improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic

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

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

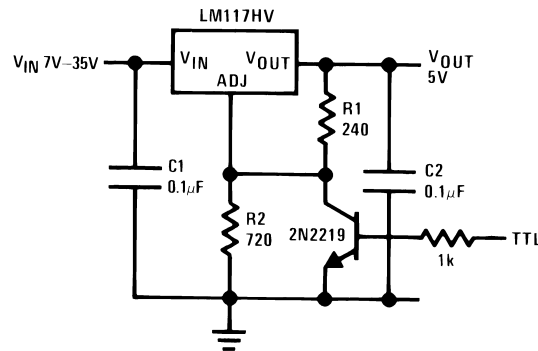
$$\dagger\dagger V_{OUT} = 1.25V \left( 1 + \frac{R2}{R1} \right) + I_{ADJ} R2$$

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\*

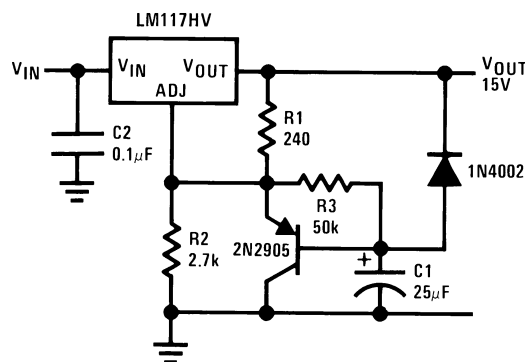
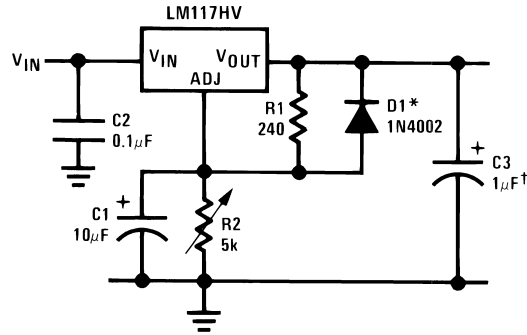


Figure 26. Slow Turn-On 15V Regulator



†Solid tantalum

\*Discharges C1 if output is shorted to ground

Figure 27. Adjustable Regulator with Improved Ripple Rejection

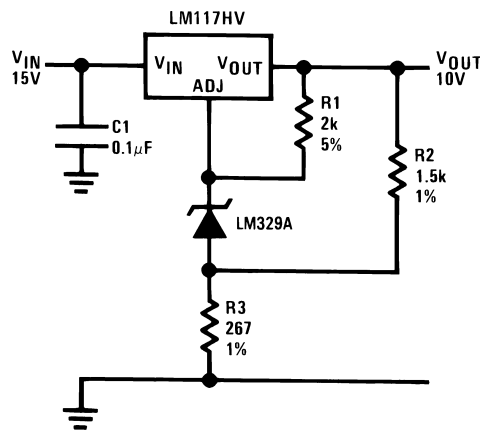
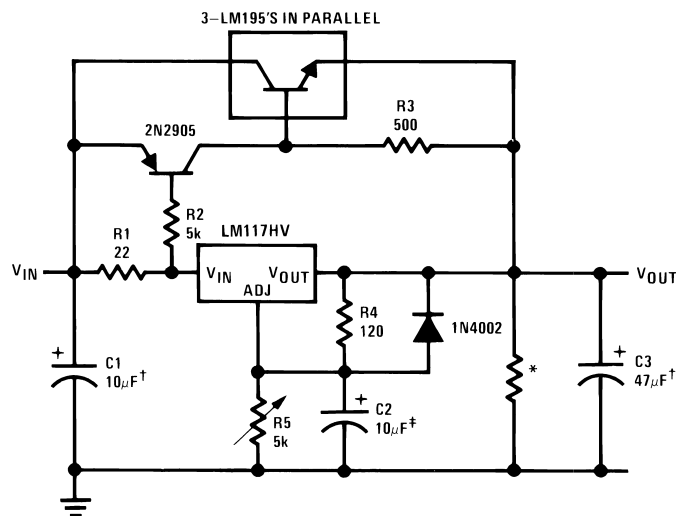


Figure 28. High Stability 10V Regulator

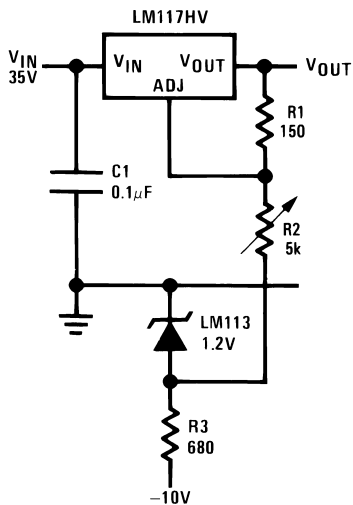


†Solid tantalum

\*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

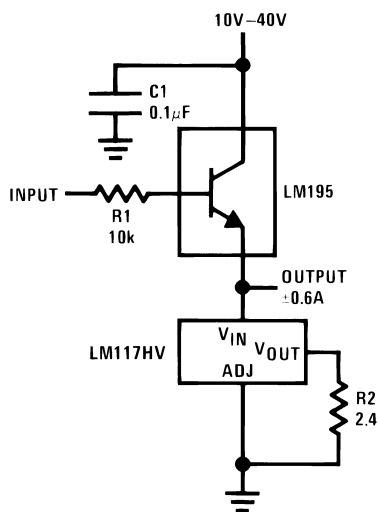
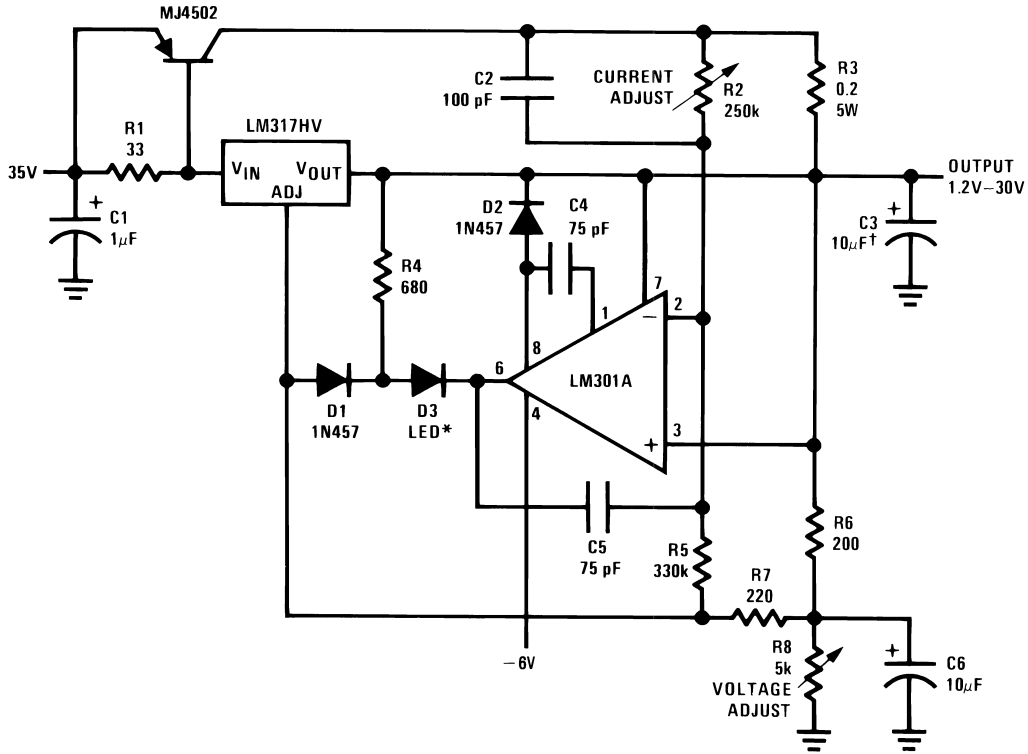


Figure 31. Power Follower



†Solid tantalum

\*Lights in constant current mode

Figure 32. 5A Constant Voltage/Constant Current Regulator

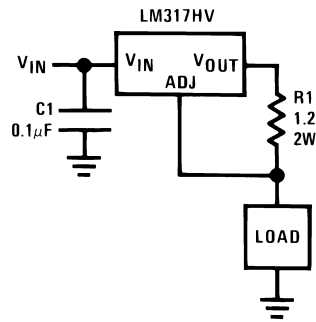
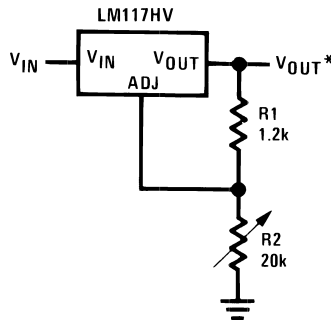


Figure 33. 1A Current Regulator



\*Minimum load current  $\approx$  4 mA

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

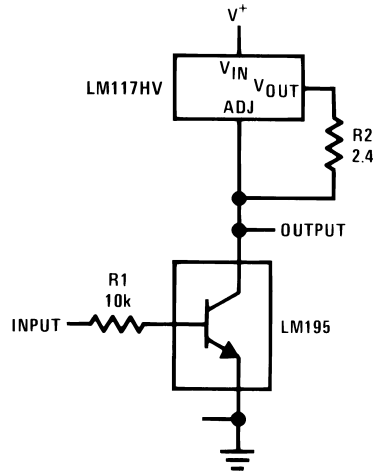
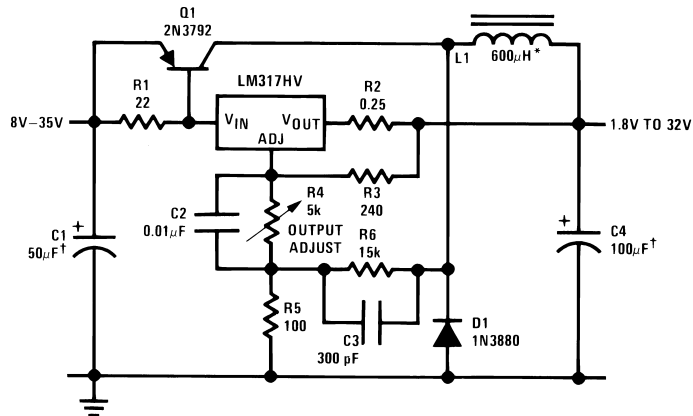


Figure 35. High Gain Amplifier

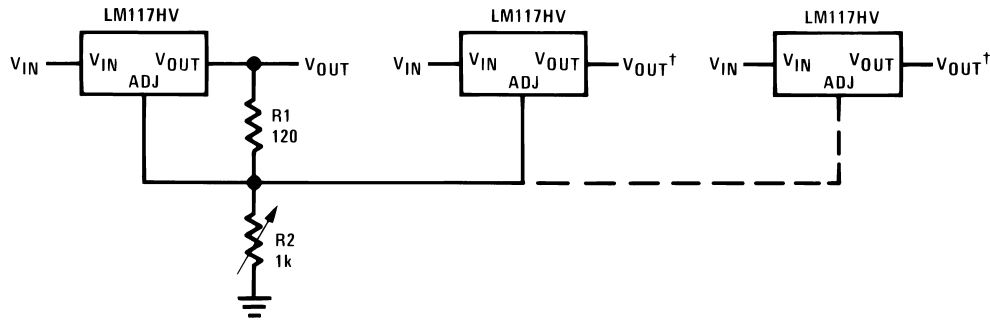


†Solid tantalum

\*Core—Arnold A-254168-2 60 turns

Figure 36. Low Cost 3A Switching Regulator





\*All outputs within  $\pm 100$  mV  
 †Minimum load—10 mA

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

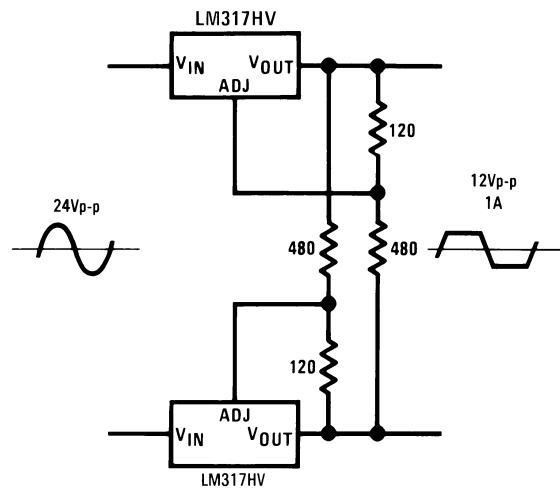
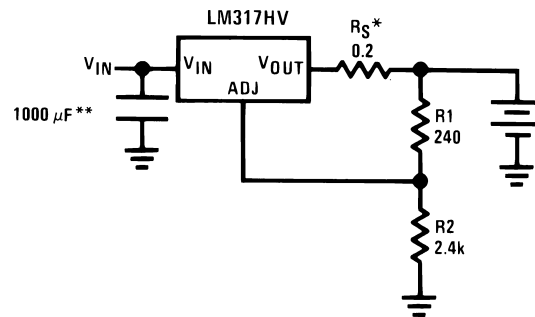


Figure 41. AC Voltage Regulator



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

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

Figure 42. 12V Battery Charger

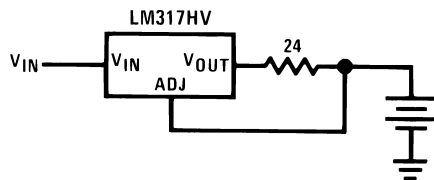


Figure 43. 50 mA Constant Current Battery Charger

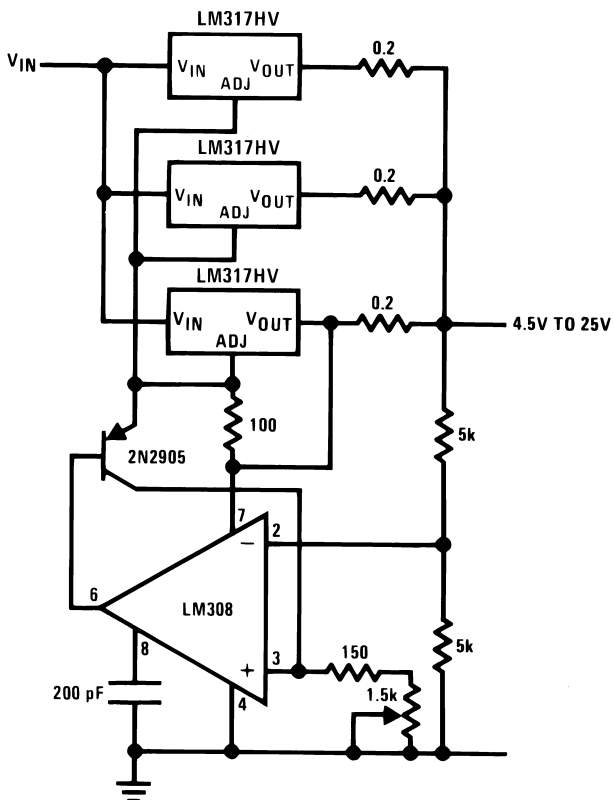
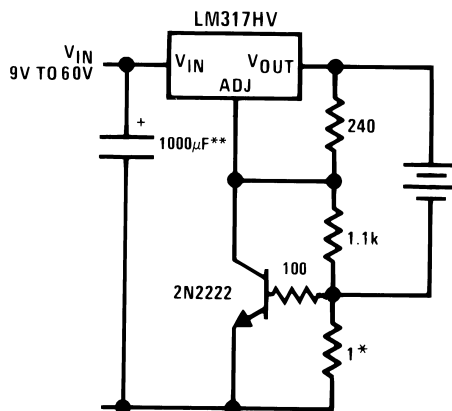


Figure 44. Adjustable 4A Regulator



\*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 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)
<a href="#">5962-0722901QXA</a>	Active	Production	TO (NDT)   3	20   JEDEC TRAY (5+1)	No	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HVH-QML 5962-0722901QXA Q ACO 5962-0722901QXA Q >T
<a href="#">5962-0722902QZA</a>	Active	Production	CFP (NAC)   16	88   TUBE	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM117HVGW QML Q 5962-07229 02QZA ACO 02QZA >T
<a href="#">LM117HVGW-QML</a>	Active	Production	CFP (NAC)   16	88   TUBE	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM117HVGW QML Q 5962-07229 02QZA ACO 02QZA >T
<a href="#">LM117HVH-QML</a>	Active	Production	TO (NDT)   3	20   JEDEC TRAY (5+1)	No	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HVH-QML 5962-0722901QXA Q ACO 5962-0722901QXA Q >T
<a href="#">LM117HVH/883</a>	Active	Production	TO (NDT)   3	20   JEDEC TRAY (5+1)	No	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HVH/883 Q ACO LM117HVH/883 Q >T
<a href="#">LM117HVK/883</a>	Active	Production	TO (K)   2	50   TRAY NON-STD	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HVK /883 Q ACO /883 Q >T
LM117HVKG MD8	Active	Production	DIESALE (Y)   0	196   JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	

(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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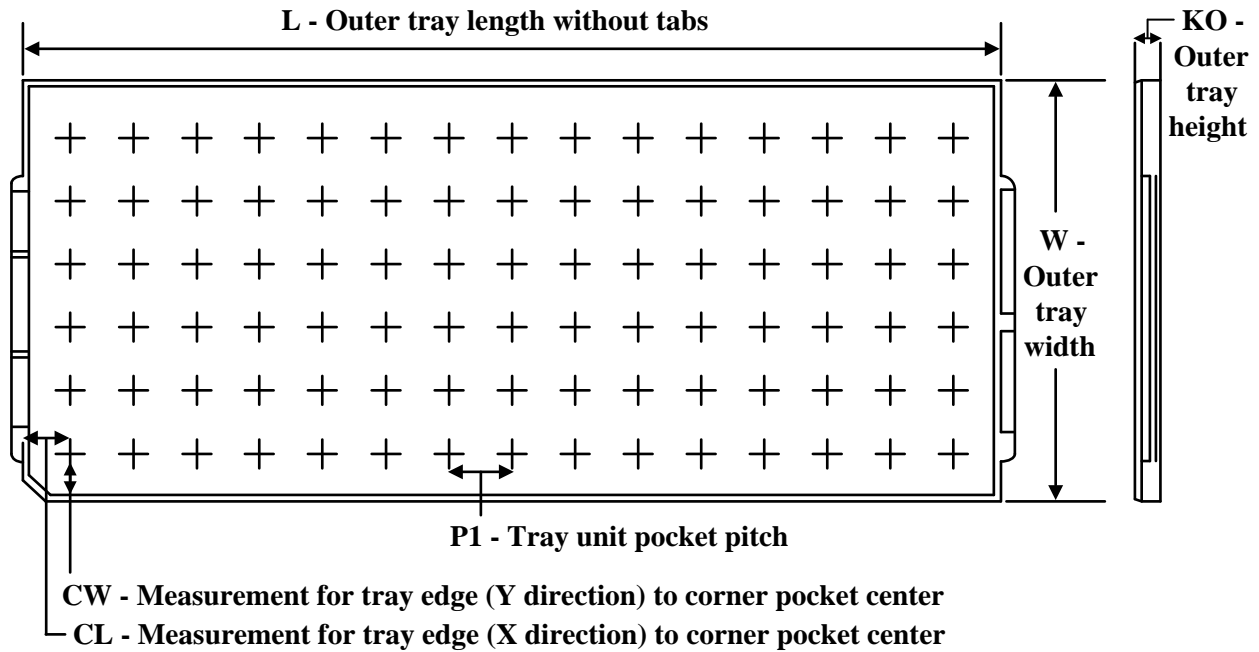
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**OTHER QUALIFIED VERSIONS OF LM117HVQML :**

- Space : [LM117HVQML-SP](#)

NOTE: Qualified Version Definitions:

- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

**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)
5962-0722901QXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117HVH-QML	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117HVH/883	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117HVK/883	K	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4

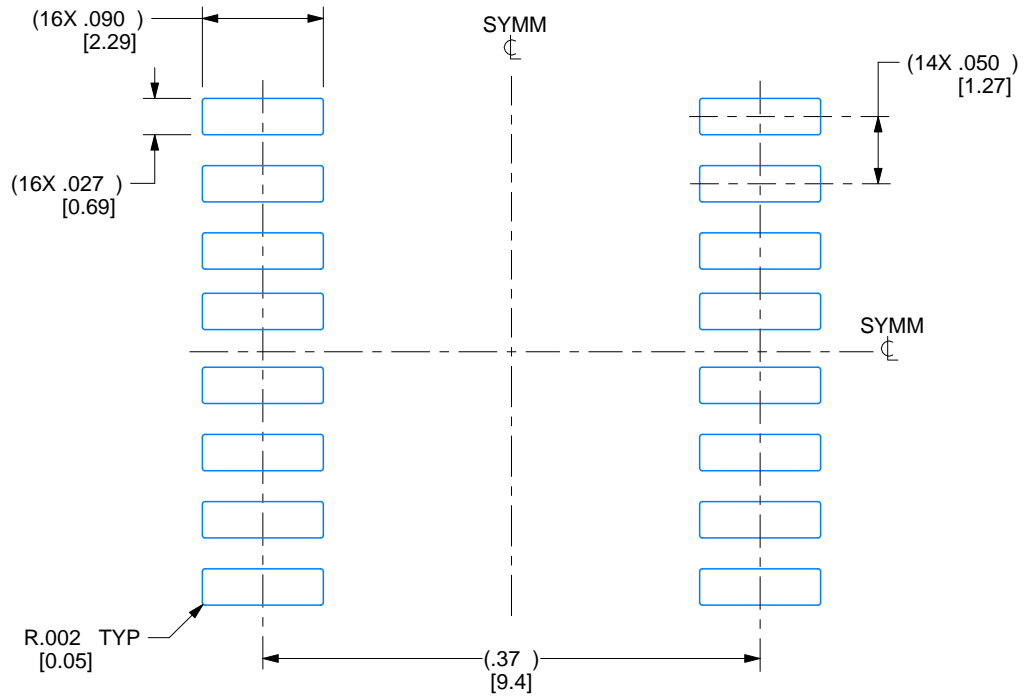


# EXAMPLE BOARD LAYOUT

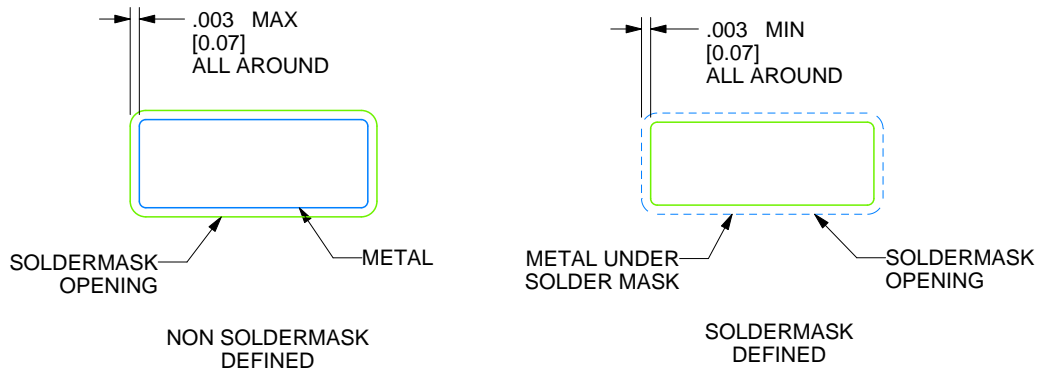
NAC0016A

CFP - 2.33mm max height

CERAMIC FLATPACK



RECOMMENDED LAND PATTERN

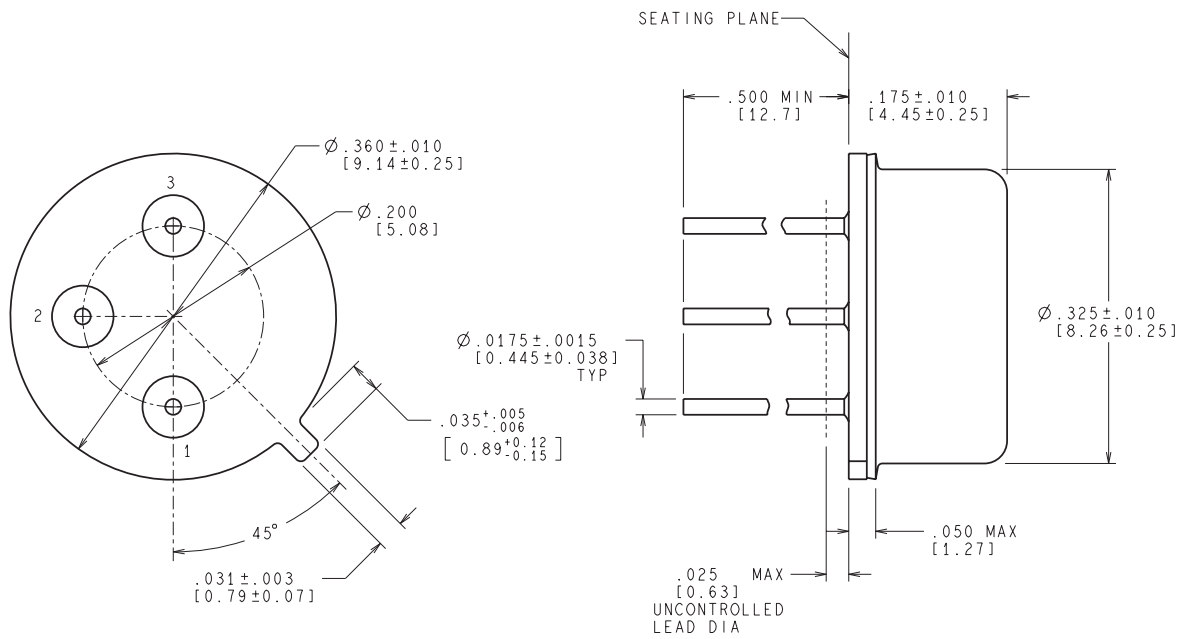


4215198/C 08/2022

# 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)

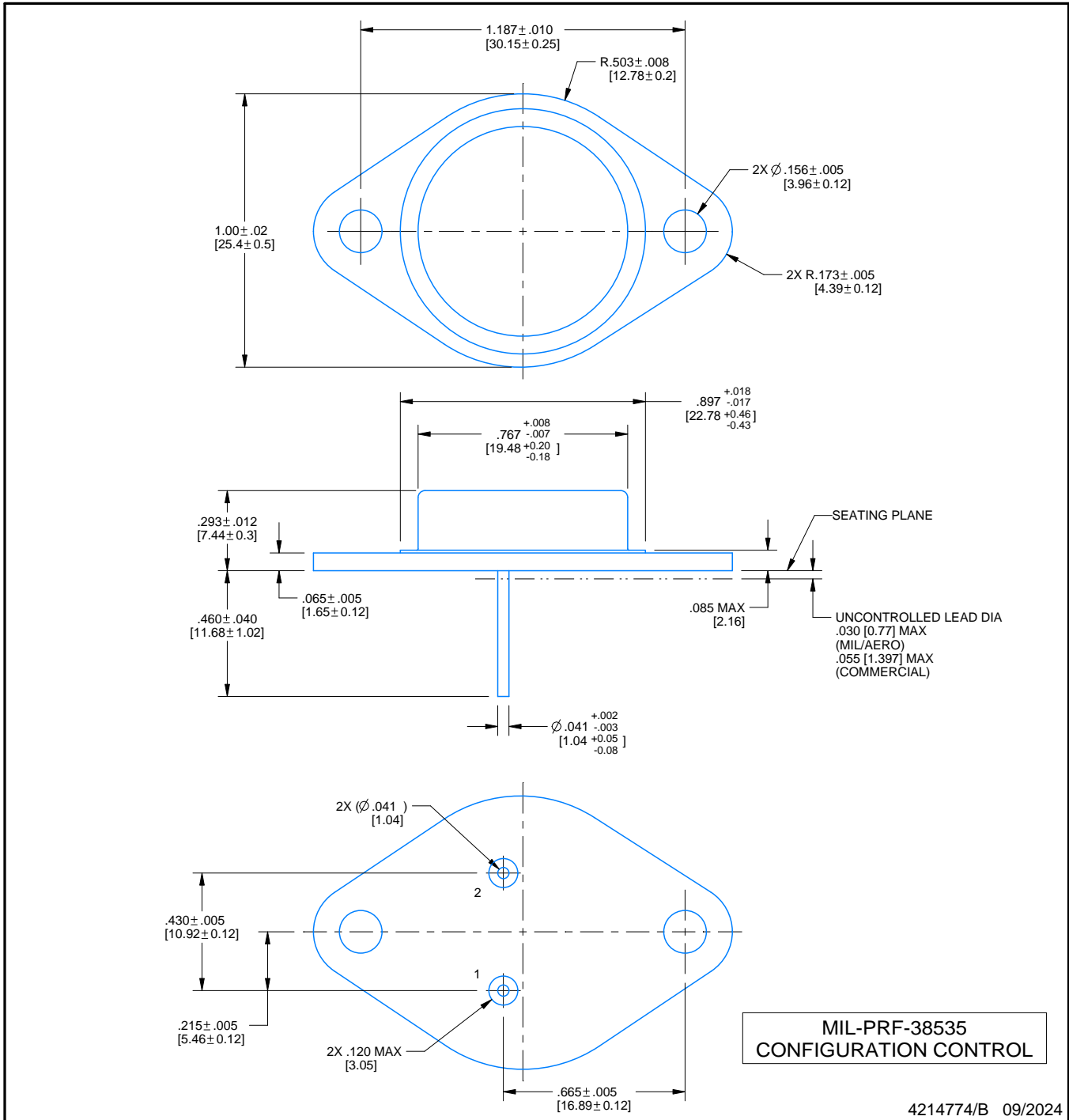
K0002A



# PACKAGE OUTLINE

TO-CAN - 7.747 mm max height

TRANSISTOR OUTLINE



4214774/B 09/2024

**NOTES:**

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. 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°.

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