LM117HV/LM317HV 3-Terminal Adjustable Regulator

Check for Samples: LM117HV, LM317HV

FEATURES

- **Adjustable Output Down to 1.2V**
- **Specified 1.5A Output Current**
- **Line Regulation Typically 0.01%/V**
- **Load Regulation Typically 0.1%**
- **Current Limit Constant with Temperature**
- **100% Electrical Burn-in**
- **Eliminates the Need to Stock Many Voltages**
- **Standard 3-lead Transistor Package**
- **80 dB Ripple Rejection**
- **Output is Short-circuit Protected**
- **P^+ Product Enhancement Tested**

DESCRIPTION

The LM117HV/LM317HV are adjustable 3-terminal positive voltage regulators capable of supplying in excess of 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. Also, the LM117HV is packaged in standard transistor packages which are easily mounted and handled.

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.

The LM117HVK STEEL and LM317HVK STEEL are packaged in standard TO-3 transistor packages, while the LM117HVH and LM317HVH are packaged in a solid Kovar base TO transistor package. The LM317HVT uses a TO-220 plastic package. The LM117HV is rated for operation from −55°C to +150°C, and the LM317HV from 0°C to +125°C.

Connection Diagrams

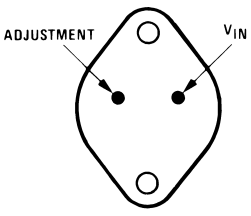

Figure 1. (TO-3)
Metal Can Package
Case is Output
Bottom View
See Package Number NDS0002A

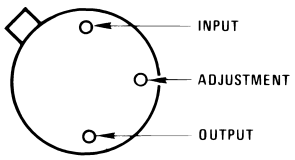

Figure 2. (TO)
Metal Can Package
Case is Output
Bottom View
See Package Number NDT0003A

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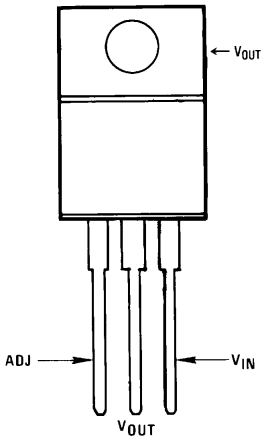
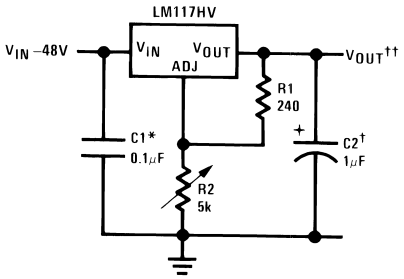


Figure 3. (TO-220)
Plastic Package
Front View
See Package Number NDE0003B

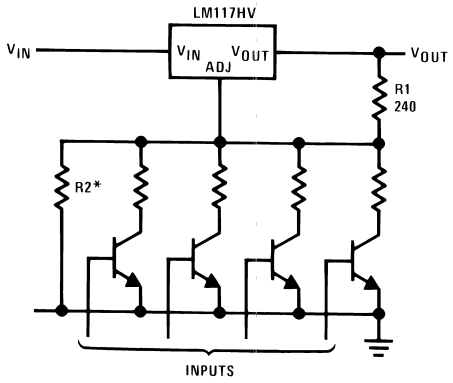
Typical Applications



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.

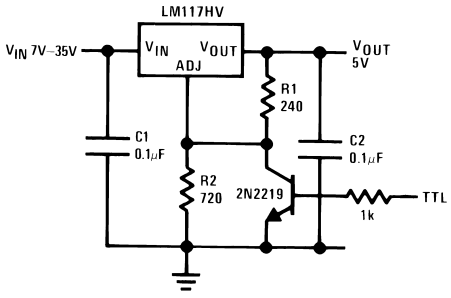
$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R2}{R1}\right) + I_{ADJ} R_2$$

Figure 4. 1.2V-45V Adjustable Regulator



*Sets maximum V_{OUT}

Figure 5. Digitally Selected Outputs



*Min. output ≈ 1.2V

Figure 6. 5V Logic Regulator with Electronic Shutdown*

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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)(2)

Power Dissipation		Internally limited
Input—Output Voltage Differential		+60V, −0.3V
Operating Junction Temperature Range	LM117HV	−55°C to +150°C
	LM317HV	0°C to +125°C
Storage Temperature		−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)		300°C
ESD Tolerance(3)		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.
(2) Refer to RETS117HVH for LM117HVH or RETS117HVK for LM117HVK military specifications.
(3) Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS(1)

Parameter	Conditions	LM117HV			LM317HV			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	T_J = 25°C, 3V ≤ V_{IN} − V_{OUT} ≤ 60V I_L = 10 mA(2)		0.01	0.02		0.01	0.04	%/V
Load Regulation	T_J = 25°C, 10 mA ≤ I_{OUT} ≤ I_{MAX}		0.1	0.3		0.1	0.5	%
Thermal Regulation	T_J = 25°C, 20 ms Pulse		0.03	0.07		0.04	0.07	%/W
Adjustment Pin Current			50	100		50	100	µA
Adjustment Pin Current Change	10 mA ≤ I_L ≤ I_{MAX} 3.0 V ≤ (V_{IN} − V_{OUT}) ≤ 60V		0.2	5		0.2	5	µA
Reference Voltage	3.0 V ≤ (V_{IN} − V_{OUT}) ≤ 60V(3) 10 mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}	1.20	1.25	1.30	1.20	1.25	1.30	V
Line Regulation	3.0V ≤ (V_{IN} − V_{OUT}) ≤ 60V, I_L = 10 mA, (2)		0.02	0.05		0.02	0.07	%/V
Load Regulation	10 mA ≤ I_{OUT} ≤ I_{MAX}(2)		0.3	1		0.3	1.5	%
Temperature Stability	T_{MIN} ≤ T_J ≤ T_{MAX}		1			1		%
Minimum Load Current	(V_{IN} − V_{OUT}) = 60V		3.5	7		3.5	12	mA
Current Limit	(V_{IN} − V_{OUT}) ≤ 15V							
	K, NDE Packages	1.5	2.2	3.5	1.5	2.2	3.7	A
	NDT Package	0.5	0.8	1.8	0.5	0.8	1.9	A
	(V_{IN} − V_{OUT}) ≤ 60V							
	K, NDE Packages		0.3			0.3		A
	NDT Package		0.03			0.03		A
RMS Output Noise, % of V_{OUT}	T_J = 25°C, 10 Hz ≤ f ≤ 10 kHz		0.003			0.003		%
Ripple Rejection Ratio	V_{OUT} = 10V, f = 120 Hz		65			65		dB
	C_{ADJ} = 10 µF	66	80		66	80		dB
Long-Term Stability	T_J = 125°C		0.3	1		0.3	1	%

(1) Unless otherwise specified, these specifications apply: −55°C ≤ T_J ≤ +150°C for the LM117HV, and 0°C ≤ T_J ≤ +125°C for the LM317HV; V_{IN} − V_{OUT} = 5V and I_{OUT} = 0.1A for the TO package and I_{OUT} = 0.5A for the TO-3 and TO-220 packages. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO and 20W for the TO-3 and TO-220. I_{MAX} is 1.5A for the TO-3 and TO-220 and 0.5A for the TO package.
(2) Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
(3) Refer to RETS117HVH for LM117HVH or RETS117HVK for LM117HVK military specifications.

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ELECTRICAL CHARACTERISTICS[1] (continued)

Parameter	Conditions	LM117HV			LM317HV			Units
		Min	Typ	Max	Min	Typ	Max	
Thermal Resistance, Junction to Case	NDT Package		12	15		12	15	°C/W
	NDE Package					4	5	°C/W
	NDS Package		2.3	3		2.3	3	°C/W
Thermal Resistance, Junction to Ambient (no heat sink)	NDT Package		140			140		°C/W
	NDE Package					50		°C/W
	NDS Package		35			35		°C/W

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TYPICAL PERFORMANCE CHARACTERISTICS

Output capacitor = 0 µF unless otherwise noted.

Load Regulation

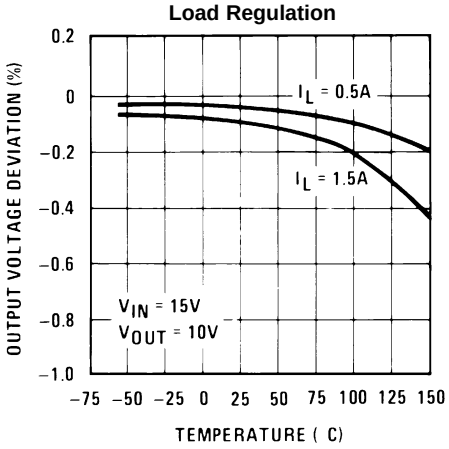

Figure 7.

Current Limit

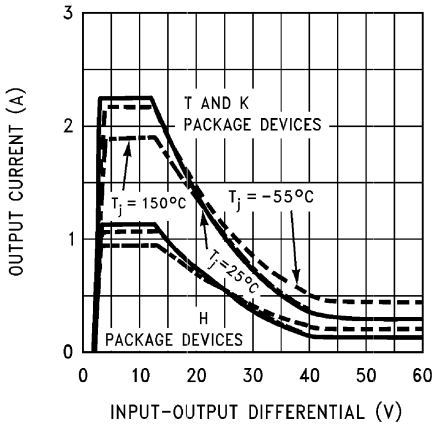

Figure 8.

Adjustment Current

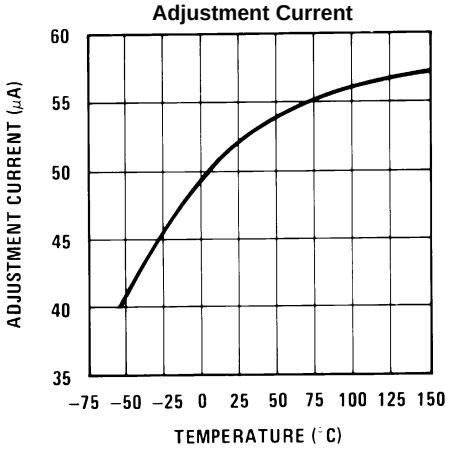

Figure 9.

Dropout Voltage

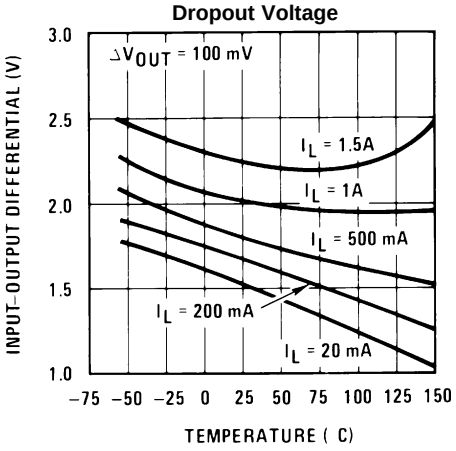

Figure 10.

Temperature Stability

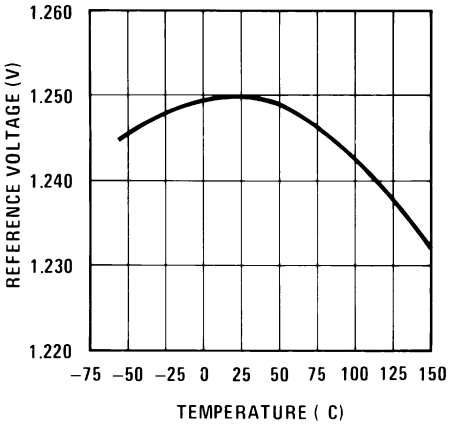

Figure 11.

Minimum Operating Current

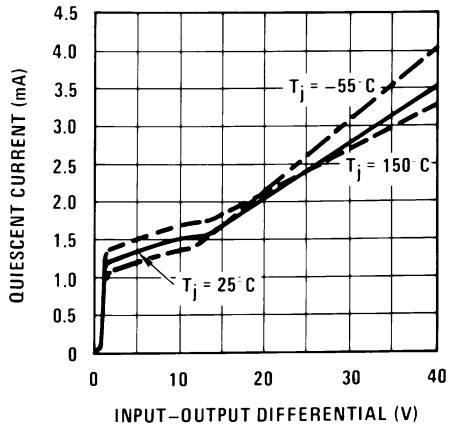

Figure 12.

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TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output capacitor = 0 µF unless otherwise noted.

Ripple Rejection

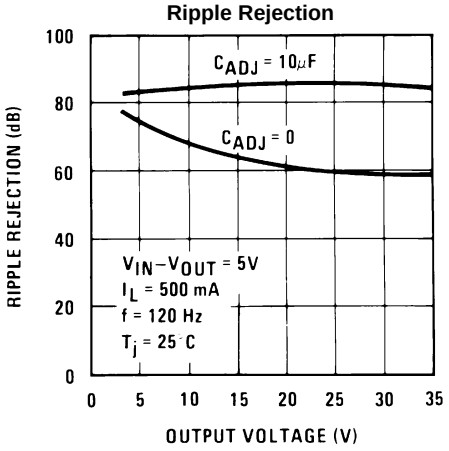

Figure 13.

Ripple Rejection

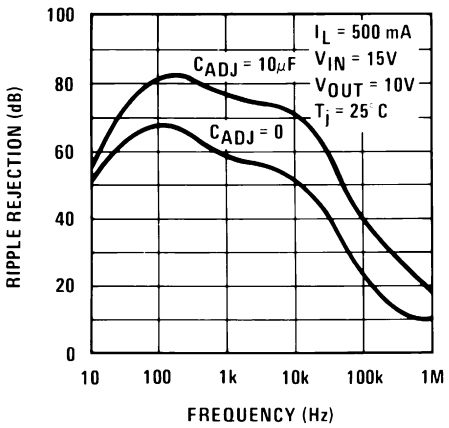

Figure 14.

Ripple Rejection

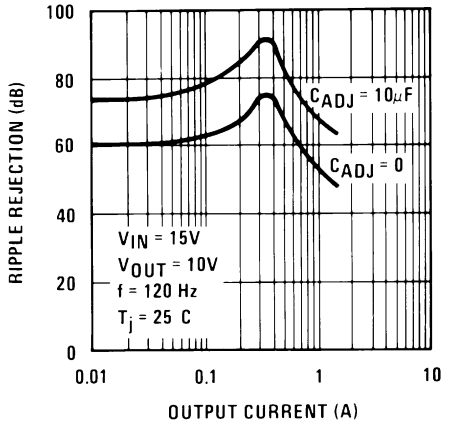

Figure 15.

Output Impedance

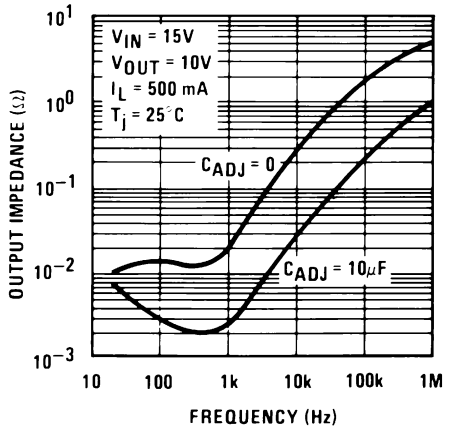

Figure 16.

Line Transient Response

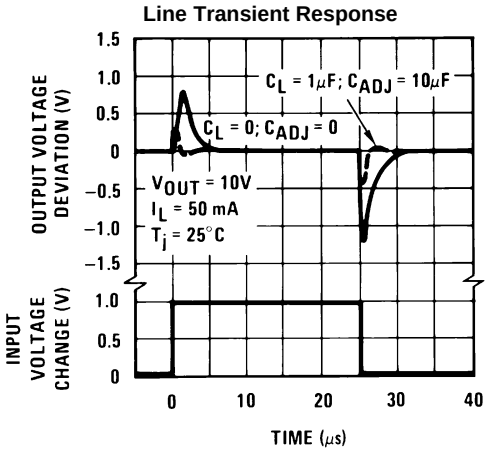

Figure 17.

Load Transient Response

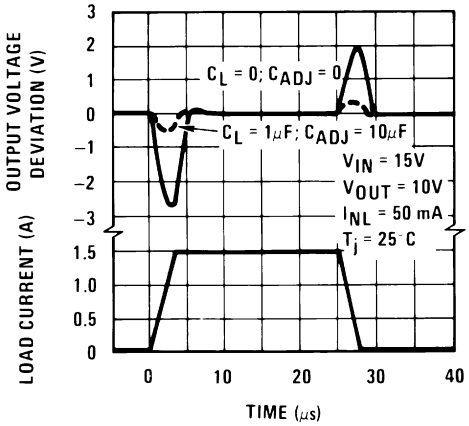

Figure 18.

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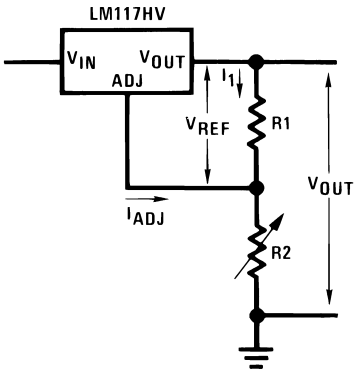
APPLICATION HINTS

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

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



Since the 100 µA 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 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 possiblity 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 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.

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 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 µF solid tantalum (or 25 µF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of load capacitance larger than 10 µF will merely improve the loop stability and output impedance.

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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 240Ω) 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 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05Ω × I_L. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 19 shows the effect of resistance between the regulator and 240Ω set resistor.

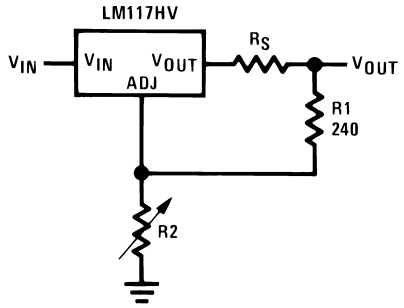

Figure 19. Regulator with Line Resistance in Output Lead

With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO-5 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.

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 20 shows an LM117HV with protection diodes included for use with outputs greater than 25V and high values of output capacitance.

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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.

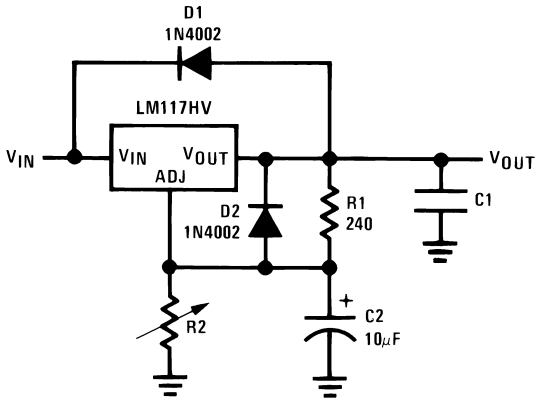
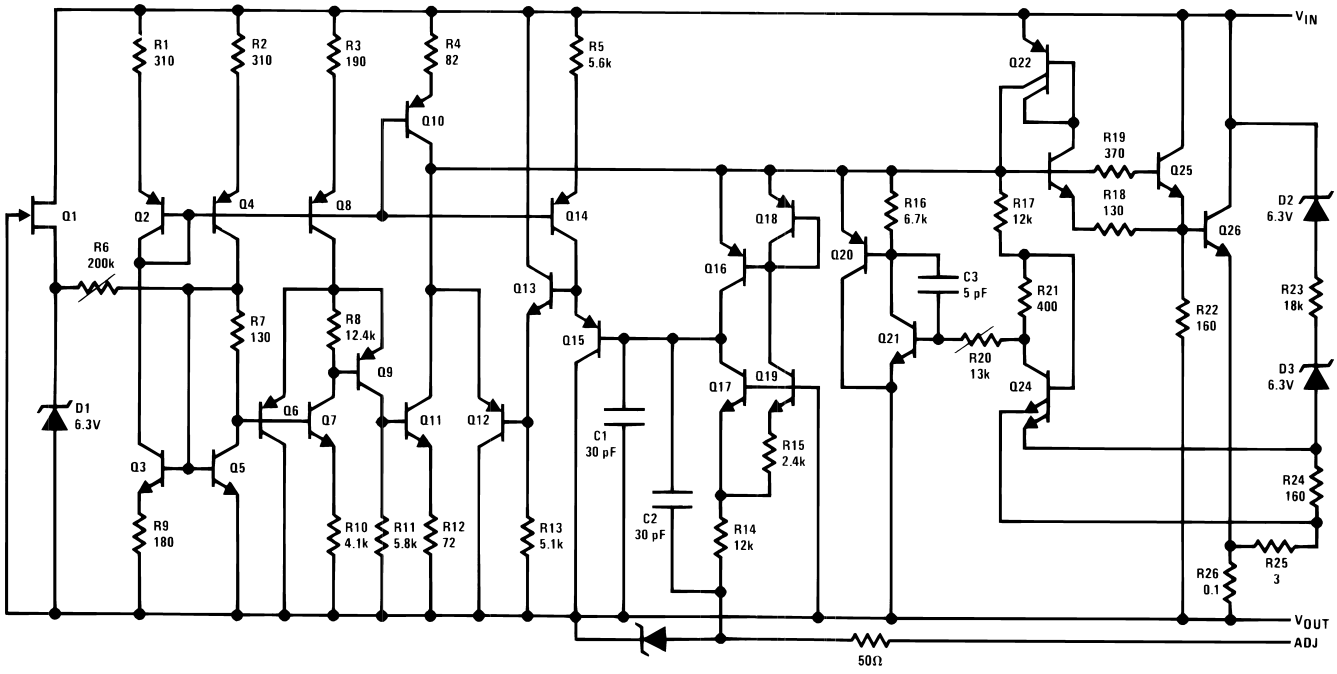


Figure 20. Regulator with Protection Diodes

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

D1 protects against C1
D2 protects against C2

Schematic Diagram



Typical Applications

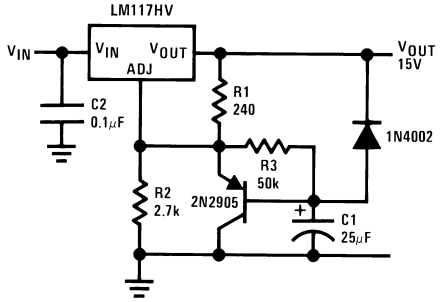
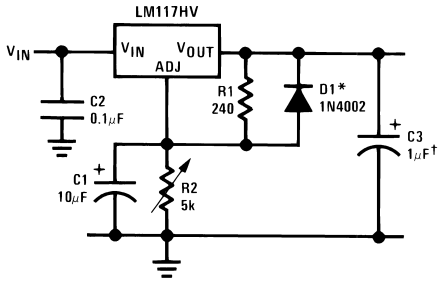


Figure 21. Slow Turn-On 15V Regulator



†Solid tantalum
*Discharges C1 if output is shorted to ground

Figure 22. Adjustable Regulator with Improved Ripple Rejection

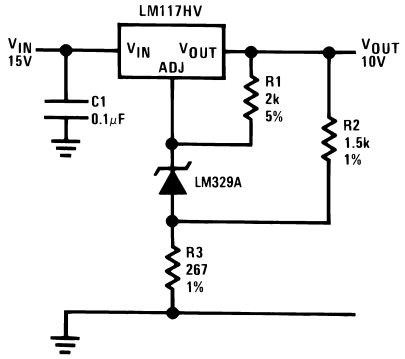


Figure 23. High Stability 10V Regulator

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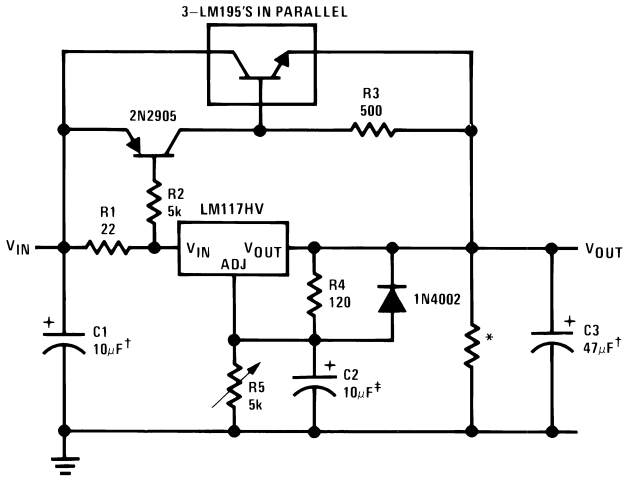
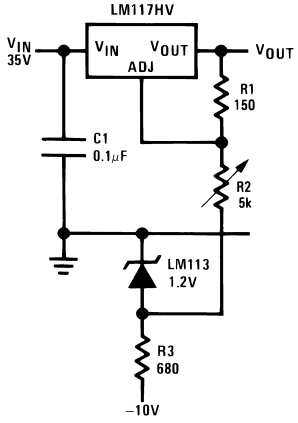


†Solid tantalum
*Minimum load current = 30 mA
‡Optional—improves ripple rejection

Figure 24. High Current Adjustable Regulator



Full output current not available at high input-output voltages

Figure 25. 0 to 30V Regulator

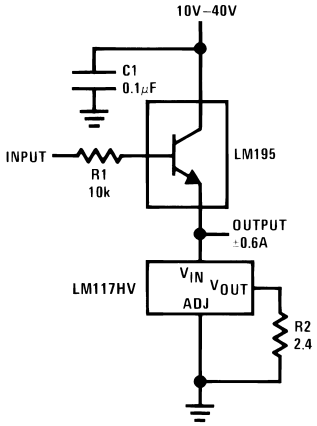
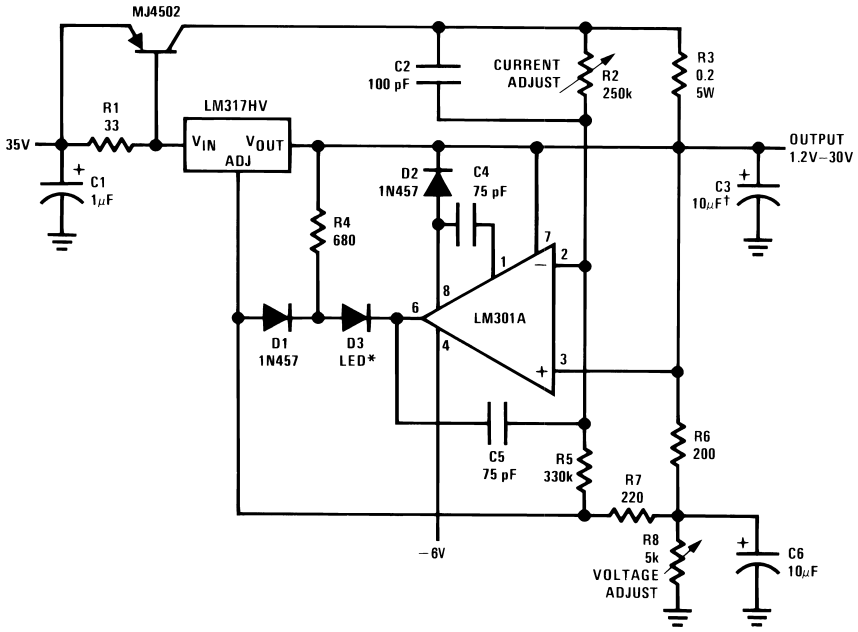


Figure 26. Power Follower



†Solid tantalum

*Lights in constant current mode

Figure 27. 5A Constant Voltage/Constant Current Regulator

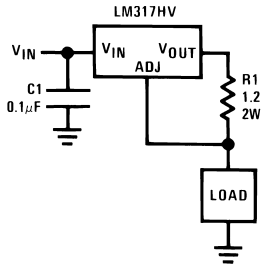
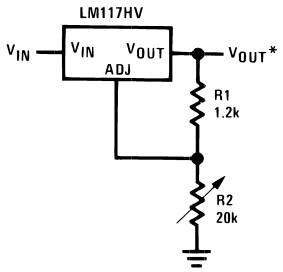


Figure 28. 1A Current Regulator



*Minimum load current ≈ 4 mA

Figure 29. 1.2V–20V Regulator with Minimum Program Current

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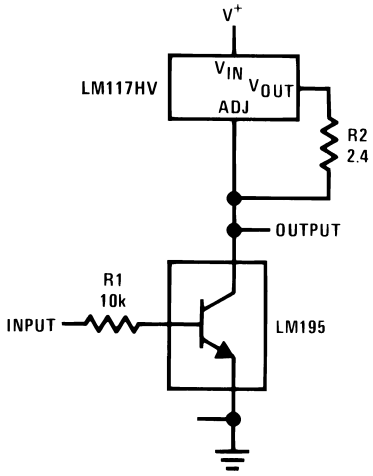
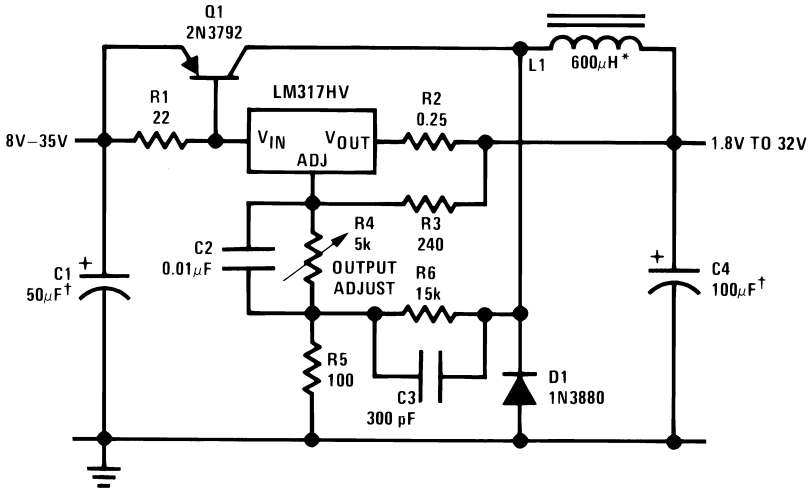
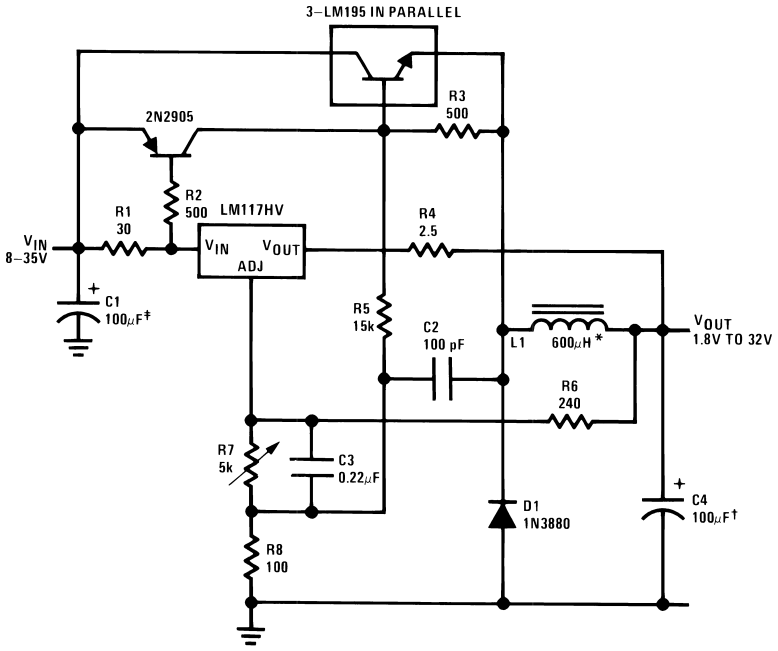


Figure 30. High Gain Amplifier



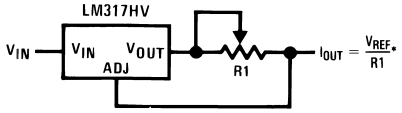
†Solid tantalum
*Core—Arnold A-254168-2 60 turns

Figure 31. Low Cost 3A Switching Regulator



†Solid tantalum
*Core—Arnold A-254168-2 60 turns

Figure 32. 4A Switching Regulator with Overload Protection



* 0.8Ω ≤ R1 ≤ 120Ω

Figure 33. Precision Current Limiter

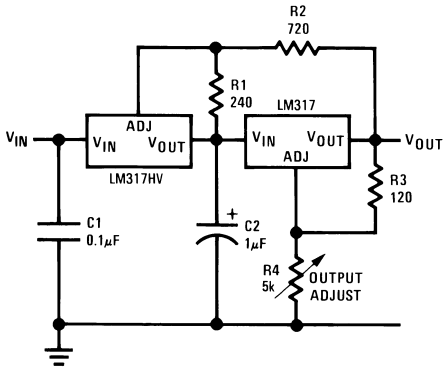


Figure 34. Tracking Preregulator

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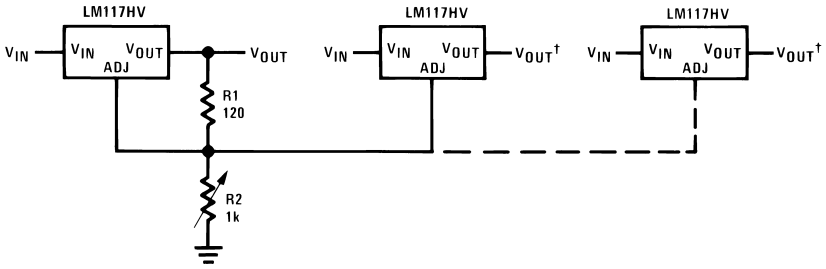


*All outputs within ±100 mV
†Minimum load—10 mA

Figure 35. Adjustable Multiple On-Card Regulators with Single Control*

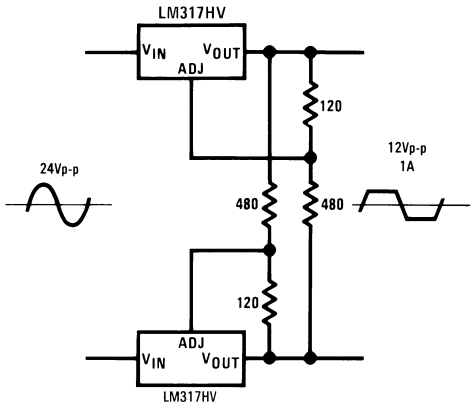
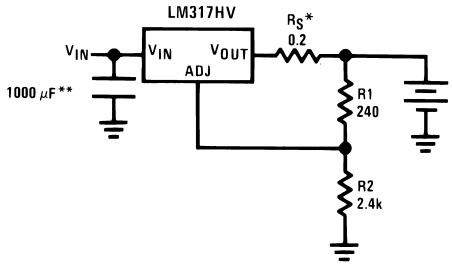


Figure 36. AC Voltage Regulator



*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 37. 12V Battery Charger

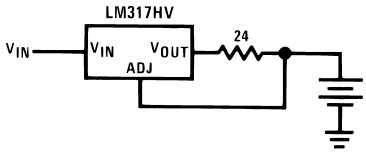


Figure 38. 50 mA Constant Current Battery Charger

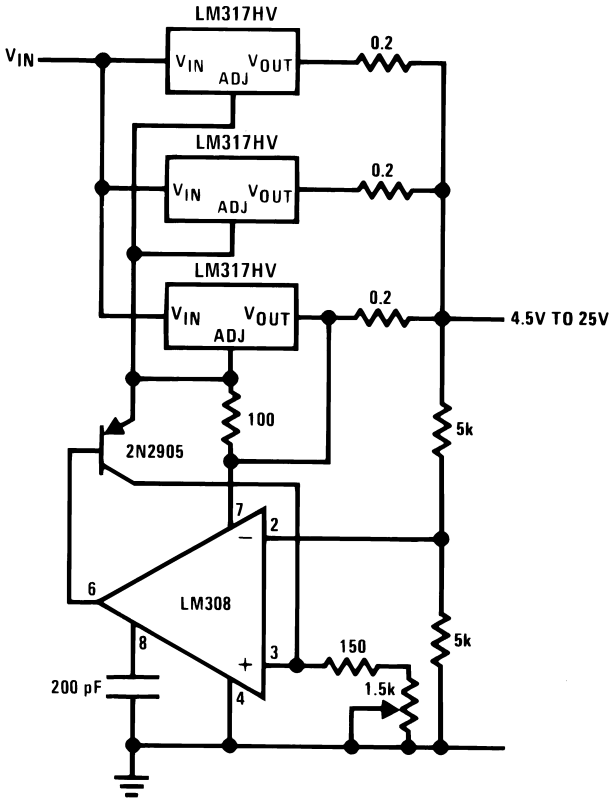
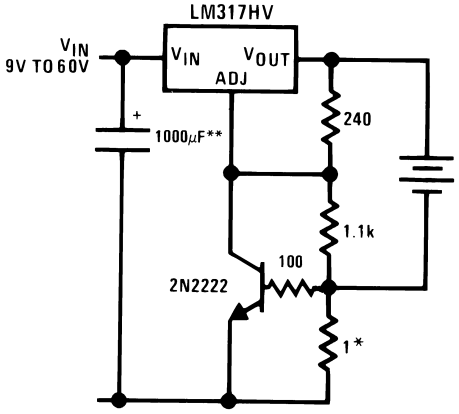


Figure 39. Adjustable 4A Regulator



*Sets peak current (0.6A for 1Ω)
**The 1000 µF is recommended to filter out input transients

Figure 40. Current Limited 6V Charger

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REVISION HISTORY

Changes from Revision B (April 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format	16

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM117HVH	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	AU	Level-1-NA-UNLIM	-55 to 125	LM117HVHP+	Samples
LM117HVH/NOPB	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	AU	Level-1-NA-UNLIM	-55 to 125	LM117HVHP+	Samples
LM317HVH	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	AU	Level-1-NA-UNLIM	0 to 125	LM317HVHP+	Samples
LM317HVH/NOPB	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	AU	Level-1-NA-UNLIM	0 to 125	LM317HVHP+	Samples
LM317HVK STEEL	ACTIVE	TO-3	NDS	2	50	TBD	Call TI	Call TI	0 to 125	LM317HVK STEELP+	Samples
LM317HVK STEEL/NOPB	ACTIVE	TO-3	NDS	2	50	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	0 to 125	LM317HVK STEELP+	Samples
LM317HVT/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 125	LM317 HVT P+	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.
OBSOLETE: 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.

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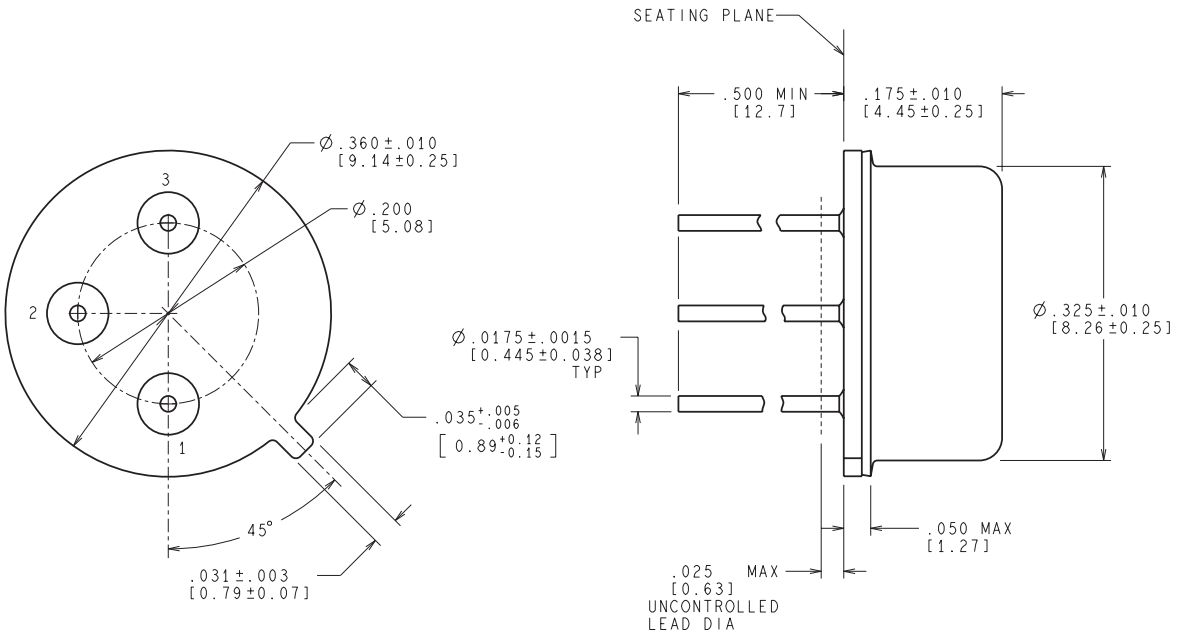

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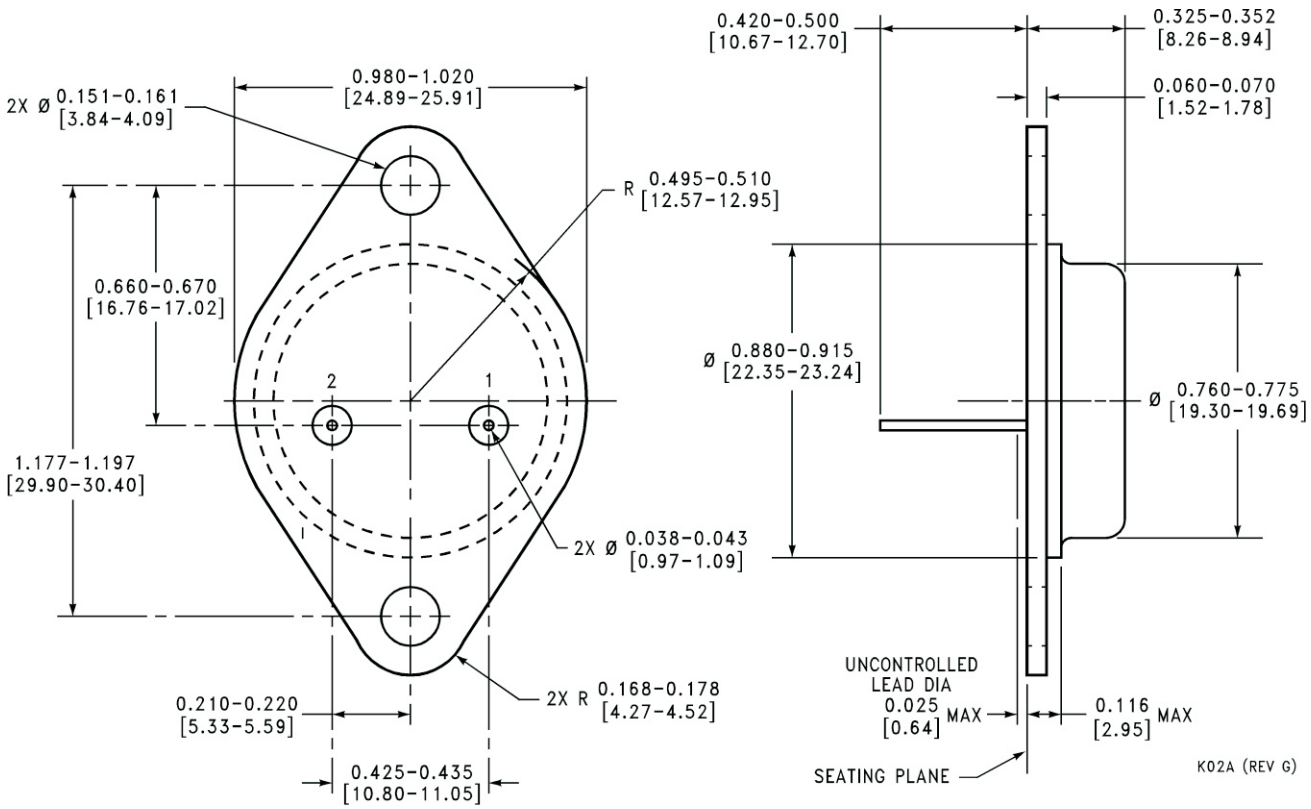
VALUES IN [ ] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

NDS0002A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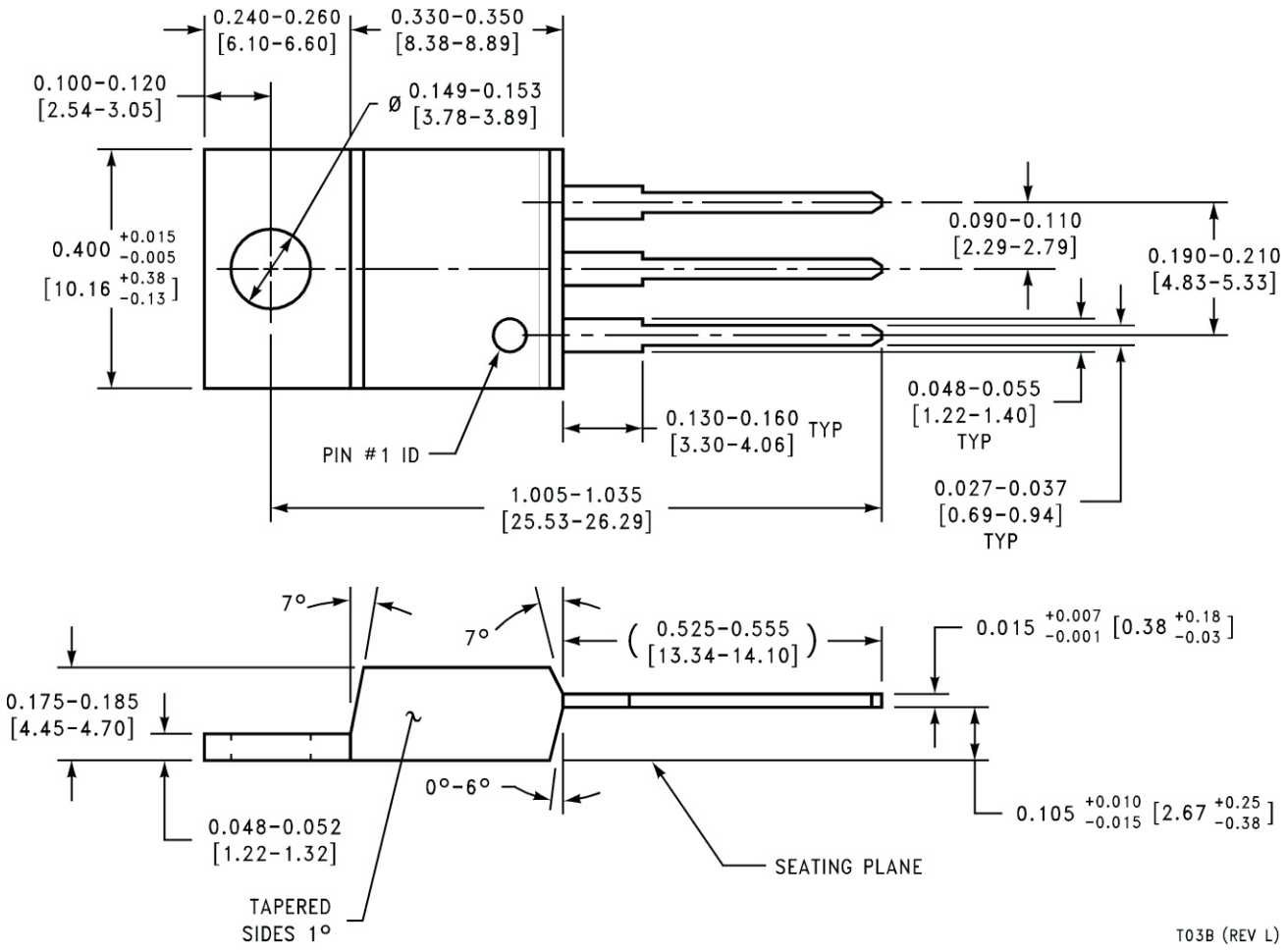
0.325-0.352
[8.26-8.94]
0.060-0.070
[1.52-1.78]
0.980-1.020
[24.89-25.91]
2X Ø 0.151-0.161
[3.84-4.09]
R 0.495-0.510
[12.57-12.95]
0.660-0.670
[16.76-17.02]
Ø 0.880-0.915
[22.35-23.24]
Ø 0.760-0.775
[19.30-19.69]
2
1
1.177-1.197
[29.90-30.40]
2X Ø 0.038-0.043
[0.97-1.09]
2X R 0.168-0.178
[4.27-4.52]
0.210-0.220
[5.33-5.59]
0.425-0.435
[10.80-11.05]
UNCONTROLLED
LEAD DIA
0.025
[0.64] MAX
0.116
[2.95] MAX
SEATING PLANE
K02A (REV G)

NDE0003B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0.330-0.350
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0.100-0.120
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Ø 0.149-0.153
[3.78-3.89]
0.400 +0.015 -0.005
[10.16 +0.38 -0.13]
0.090-0.110
[2.29-2.79]
0.190-0.210
[4.83-5.33]
PIN #1 ID
0.130-0.160 TYP
[3.30-4.06]
0.048-0.055
[1.22-1.40]
TYP
1.005-1.035
[25.53-26.29]
0.027-0.037
[0.69-0.94]
TYP
7°
7°
(0.525-0.555
[13.34-14.10])
0.015 +0.007 -0.001 [0.38 +0.18 -0.03]
0.175-0.185
[4.45-4.70]
0°-6°
0.105 +0.010 -0.015 [2.67 +0.25 -0.38]
0.048-0.052
[1.22-1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

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