

# LM117,LM137,LM138,LM150,LM317,LM337

*A New Production Technique for Trimming Voltage Regulators*



Literature Number: SNVA582

# A New Production Technique for Trimming Voltage Regulators

Three-terminal adjustable voltage regulators such as the LM317 and LM337 are becoming popular for making regulated supplies in instruments and various other OEM applications. Because the regulated output voltage is easily programmed by two resistors, the designer can choose any voltage in a wide range such as 1.2V to 37V. In a typical example (Figure 1) the output voltage will be:

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

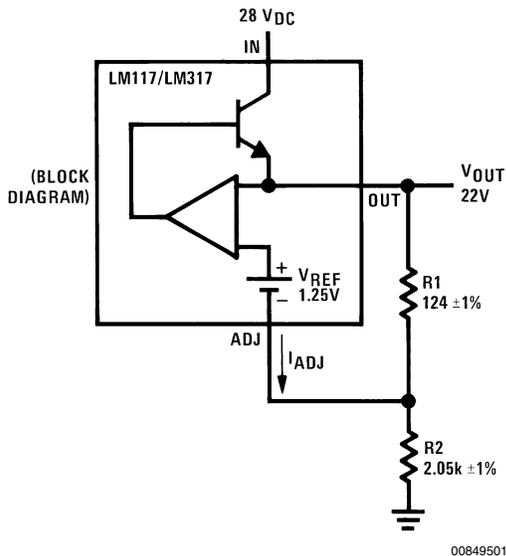


FIGURE 1. Basic Regulator

In many applications, when R1 and R2 are inexpensive  $\pm 1\%$  film resistors, and the room temperature accuracy of the LM117 is better than  $\pm 3\%$ , the overall accuracy of  $\pm 5\%$  will be acceptable. In other cases, a tighter tolerance such as  $\pm 1\%$  is required. Then a standard technique is to make up part of R2 with a small trim pot, as in Figure 2. The effective range of R2 is  $2.07k \pm 10\%$ , which is adequate to bring  $V_{OUT}$  to exactly 22.0V. (Note that a 200 $\Omega$  rheostat in series with 1.96 k $\Omega \pm 1\%$  would not necessarily give a  $\pm 5\%$  trim range, because the end resistance and wiper resistance could be as high as 10 $\Omega$  or 20 $\Omega$ ; and the maximum value of an inexpensive 10% or 20% tolerance trimmer might be as low as 180 $\Omega$  or 160 $\Omega$ .)

In some designs, the engineering policy may frown on the use of such trim pots, for one or more of the following reasons:

- Good trim pots are more expensive.
- Inexpensive trim pots may be drifty or unreliable.

National Semiconductor  
Linear Brief 46  
Robert A. Pease  
July 1979



A New Production Technique for Trimming Voltage Regulators

- Any trim pot which can be adjusted can be *misadjusted*, sooner or later.

To get a tighter accuracy on a regulated supply, while avoiding these disadvantages of trim pots, consider the scheme in Figure 3.

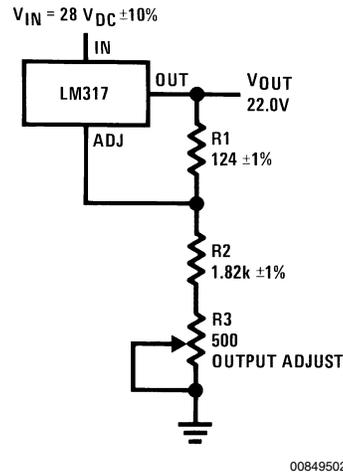


FIGURE 2. Regulator with Small Adjustment Range

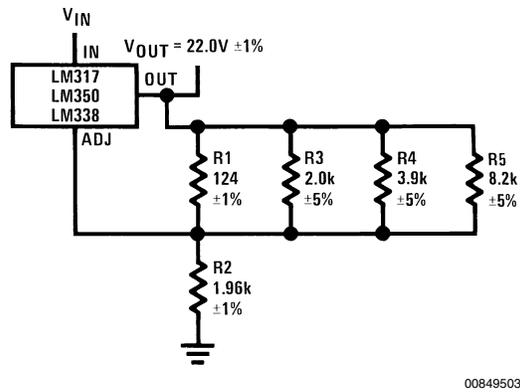


FIGURE 3. Regulator with Trimmable Output Voltage

When first tested,  $V_{OUT}$  will tend to be 4% to 6% higher than the 22.0V target. Then, while monitoring  $V_{OUT}$ , snip out R3, R4, and/or R5 as appropriate to bring  $V_{OUT}$  closer to 22.0V. This procedure will bring the tolerance inside  $\pm 1\%$ :

- If  $V_{OUT}$  is 23.08V or higher, cut out R3 (if lower, don't cut it out).
- Then if  $V_{OUT}$  is 22.47V or higher, cut out R4 (if lower, don't).

- Then if  $V_{OUT}$  is 22.16V or higher, cut out R5 (if lower, don't).

The entire production distribution will be brought inside 22.0V  $\pm 1\%$ , with a cost of 3 inexpensive carbon resistors, much lower than the cost of any pot. After the circuit is properly trimmed, it is relatively immune to being misadjusted by a screwdriver. Of course, the resistors' carcasses must be properly removed and disposed of, for full reliability to be maintained.

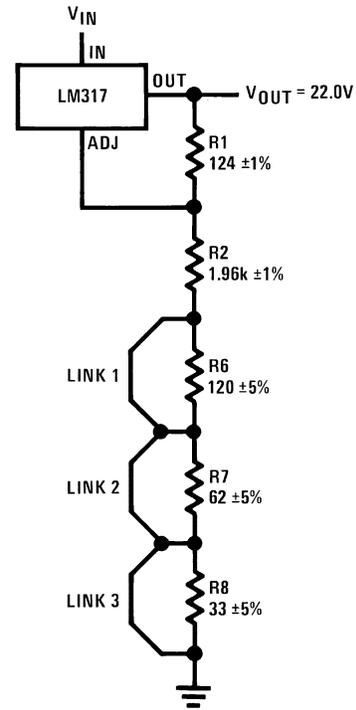
An alternate scheme shown in *Figure 4* has R6, R7, and R8 all shorted out initially with a stitch or jumper of wire. The trim procedure is to open up a link to bring a resistor into effect. The advantage of this circuit is that  $V_{OUT}$  starts out *lower* than the target value, and never exceeds that voltage during trimming. In this scheme, note that a total "pot resistance" of 215 $\Omega$  is plenty for a 10% trim span, because the *minimum* resistance is always below 1 $\Omega$ , and the maximum resistance is always more than 200 $\Omega$ —it can cover a much wider range than a 200 $\Omega$  pot.

The circuit of *Figure 5* shows a combination of these trims which provides a new advantage, if a  $\pm 2\%$  max tolerance is adequate. You may snip out R4, or link L1, or both, to accommodate the worst case tolerance, but in most cases, the output will be within spec without doing any trim work at all.

This takes advantage of the fact that most  $\pm 1\%$  resistors are well within  $\pm 1/3\%$ , and most LM337's output voltage tolerances are between  $-1/2\%$  and  $+1 1/2\%$ , to cut the average trim labor to a minimum. Note that L1 could be made up of a 2.7 $\Omega$   $\pm 10\%$  resistor which may be easier to handle than a piece of wire.

In theory, a 10% total tolerance can be reduced by a factor of  $(2^n - 1)$  when n binary-weighted trims are used. In practice, the factor would be  $(1.8^n - 1)$  if  $\pm 10\%$  trim resistors are used, or  $(1.9^n - 1)$  if  $\pm 5\%$  resistors are used. For n = 2, a 10% tolerance can be cut to 3.8% p-p or  $\pm 1.9\%$ . For n = 3, the spread will be 1.7% p-p or  $\pm 0.85\%$ , and most units will be inside  $\pm 0.5\%$ , perfectly adequate for many regulator applications.

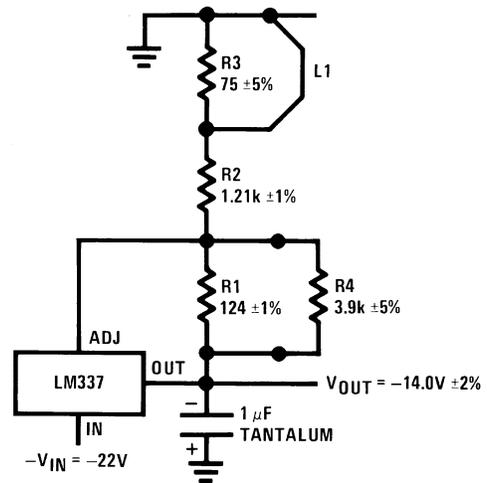
National Semiconductor manufactures several families of adjustable regulators including LM117, LM150, LM138, LM117HV, LM137, and LM137HV, with output capabilities from 0.5A to 5A and from 1.2V to 57V. For complete specifications and characteristics, refer to the appropriate data sheet or the 1982 Linear Databook.



00849504

If  $V_{OUT}$  is lower than 20.90V, snip link 1 (if not, don't).  
 Then if  $V_{OUT}$  is lower than 21.55V, snip link 2 (if not, don't).  
 Then if  $V_{OUT}$  is lower than 21.82V, snip link 3 (if not, don't).

FIGURE 4. Alternate Trim Scheme



00849505

If  $|V_{OUT}|$  is smaller than 13.75V, snip L1 and it will get bigger by 6%.  
 Then if  $|V_{OUT}|$  is bigger than 14.20V, snip R4 and it will get smaller by 3%.

FIGURE 5. Circuit Which Usually Needs No Trim to Get  $V_{OUT}$  Within  $\pm 2\%$  Tolerance

## Notes

### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



**National Semiconductor Corporation**  
Americas  
Email: support@nsc.com

[www.national.com](http://www.national.com)

**National Semiconductor Europe**

Fax: +49 (0) 180-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 69 9508 6208  
English Tel: +44 (0) 870 24 0 2171  
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor Asia Pacific Customer Response Group**

Tel: 65-2544466  
Fax: 65-2504466  
Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**

Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated