Resistor snipping trims regulator voltage to within 1%

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Five low-cost resistors are used in this production-line technique for setting the output voltage of a three-terminal regulator to within ±1% of the desired output voltage. Thus, expensive and often unreliable potentiometers can be eliminated by this iterative trimming procedure, which removes up to three resistors until the output voltage is within tolerance.

In a typical three-terminal adjustable regulator such as the LM117 (a), the output voltage will be:

$$V_{out} = V_{REF}(R_2/R_1 + 1) + R_2 I_{ADJ}$$

where V_{REF} is nominally 1.25 volts, R_1 and R_2 are the regulator's external voltage-programming resistors, and I_{ADJ} is 100 microamperes maximum. Generally, V_{REF} will vary less than ±3% under normal operating conditions; if R_1 and R_2 each have a tolerance of ±1%, the regulator's overall accuracy then becomes ±5%.

The standard method for attaining a 1% tolerance is to substitute a trimming potentiometer, R_T, and some fixed resistor, R_F, for R_2, where in general $R_{Tmax} + R_F$ will exceed the value of R_2 previously used by a factor of 10% or so. But this scheme may be superceded with the circuit shown in (b) to avoid the disadvantages of using a trimming potentiometer, one of which is a tendency to misadjust it sooner or later.

In this particular case, a 22-v output voltage is sought for a 28-v source input. When first measured, V_{out} will be 4% to 6% higher than the 22v target no matter what conditions exist within the regulator, because the effective value of R_1 is lowered (see equation). R_3, R_4, and R_5 are selected so that one or more may be systematically removed to bring V_{out} within limits.

The method is as follows:

- If $V_{out} \geq 23.08$, cut out R_3.
- If V_{out} is or then becomes ≥ 22.47, cut out R_4.
- If V_{out} becomes ≥ 22.16, cut out R_5.

Note that the values of R_3, R_4, and R_5 are independent of the output voltage desired; it is only necessary to select a new value of R_2 so that $V_{REF}(R_2/R_1 + 1)$ is a few percent below the desired output voltage, assuming a V_{REF} of 1.25. In practice, this means selecting R_2 to be proportional to the output voltage desired.

An alternative trimming scheme is shown in (c), whereby R_3, R_4, and R_5, placed in the R_2 line, are initially shorted by jumpers. Here V_{out} is initially lower than the target value and never exceeds that voltage during trimming.

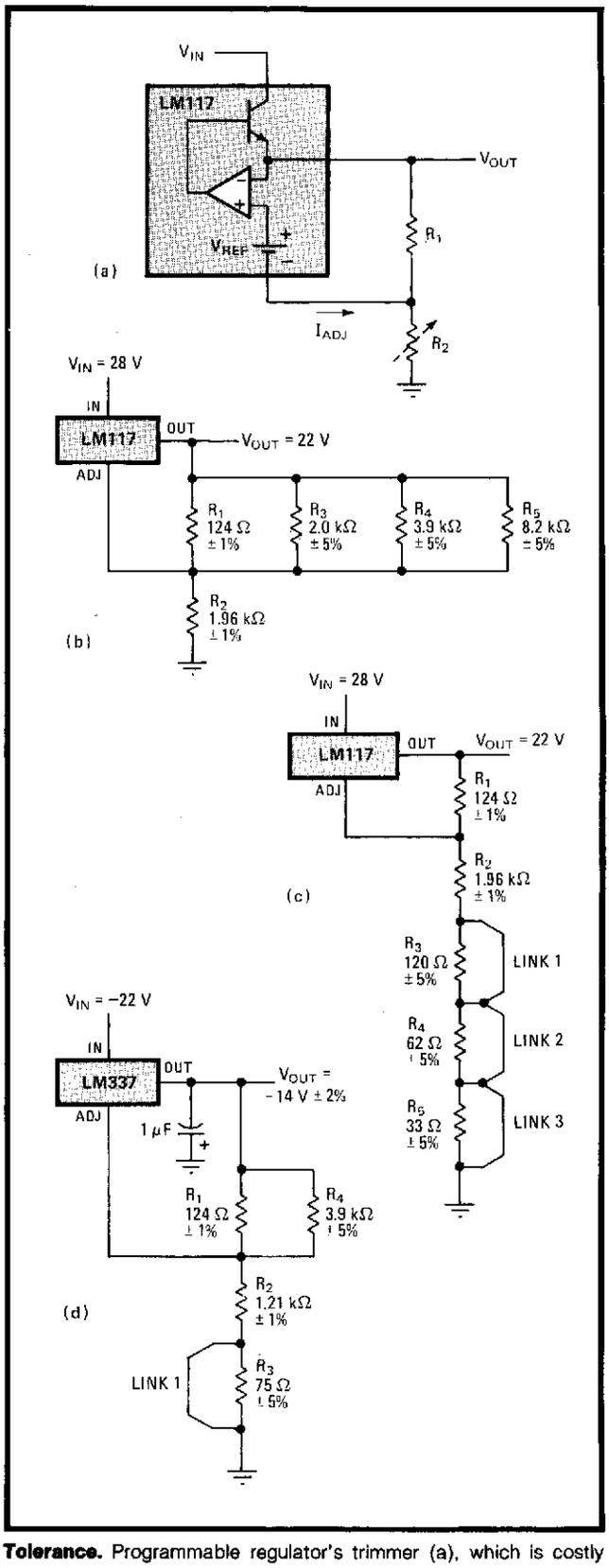
In this procedure:

- If $V_{out} \leq 20.90$, snip link 1.
- If V_{out} is or becomes ≤ 21.55, snip link 2.
- If V_{out} is or becomes ≤ 21.82, snip link 3.

When the output voltage is other than 22, R_3–R_5 need to be chosen in the same proportion to R_2. Thus if the scheme in (c) is used for $V_{out} = 12$, then $R_2 = 1.0$ kΩ, $R_3 = 62\Omega$, $R_4 = 31\Omega$, and $R_5 = 16\Omega$. Note too that when approach (b) is used, some care must be taken that all the snipped resistors be removed without shorting anything out. If (c) is used, one end of the cut link should be curled back to prevent shorting.

If 2% tolerance is acceptable, the circuit in (d) will provide trimming with one less resistor and fewer iterations. In this instance, the configuration is shown for the LM337 negative-voltage regulator, where the desired $V_{out} = -14$ v. If the magnitude of $V_{out} \leq 13.75$ v, link 1 is snipped. Then if $V_{out} \geq 14.20$ v, R_4 is cut out.

In most cases, no trimming at all will be required, because most ±1% resistors are well within a tolerance of ±⅓%, and most often the LM337's V_{ref} term is within 1½% of its nominal value. □



Tolerance. Programmable regulator's trimmer (a), which is costly and may drift, may be replaced with low-cost, fixed resistor network R_3–R_5 (b) for production-line trimming. Each resistor is systematically removed to bring V_{out} to within 1% of desired value. Alternate scheme uses resistors in series (c). If 2% tolerance is acceptable, one less resistor (d) and simplified procedure accomplishes task.