A Simple Method For Biasing TRANSISTORS

An easy step-by-step way to design stable amplifier stages using Ohm's law.

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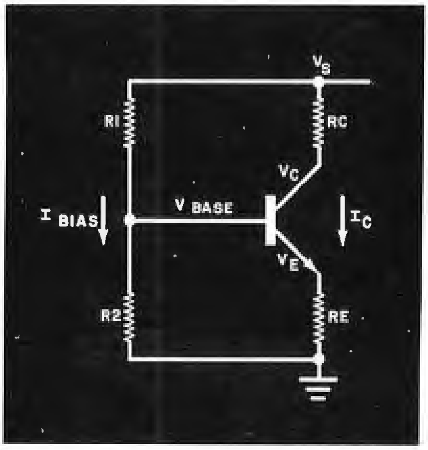
HERE is a simple way of determining the proper biasing of a bipolar transistor amplifier. It works for the majority of applications and has built-in protection against thermal runaway. All you need to know is the material of which the transistor is made (silicon or germanium) and Ohm's law.

First, there are some basic assumptions that can be made based on the superior quality of today's transistors. (1) Collector-to-base leakage current can be ignored. (2) The current gain (beta) is high enough that the base current can be ignored (or considered as a small part of the "bias" current). (3) Emitter current equals collector current. Based on these assumptions, we can use the simplified circuit model shown in the diagram.

The design of the bias circuit then consists of nine steps:

Step 1. Determine the collector current (same as the emitter current). Often this is determined by the load, or the test current given in the transistor specifications can be used. If the power supply is a battery, choose a small current for longer battery life. Typically, medium-signal transistors have a collector current of 1 to 10 mA.



For a small-signal transistor, it would be perhaps 0.1 mA.

Step 2. Determine the supply voltage. This is usually a standard value: 9, 12, or 24 volts depending on the battery or supply.

Step 3. We assume that the emitter voltage is to be 10% of the supply voltage so the emitter resistor is

$R_e = 0.1V_s/I_e$

The assumption for the emitter voltage provides thermal stability, allows for wide variations in beta and protects the emitter-base junction from a possible current overload.

Step 4. Calculate the base voltage. This depends on the semiconductor material, which determines the drop across the junction. For silicon, the drop is 0.7 V, and for germanium, it is 0.3 V. The base voltage is then the emitter voltage plus 0.7 or 0.3

Step 5. Assume that the "bias" current through *R1* and *R2* is 10% as much as the collector current. This is easier than considering that R_e times beta is in parallel with *R2*. In fact, we do not need to know beta if it is high enough because 10% or 20% variation in *R1* and *R2* would cause more change in bias current than the small base current in today's high-beta transistors. In fact, beta often varies from 100 to 300 for the same type of transistor.

Step 6. Calculate *R2* using base voltage and bias current.

$R2 = V_{base}/I_{bias} = V_{base}/0.1I_c$

Step 7. Calculate *R1*

$R1 = (V_s - V_{base})/I_{bias}$

Step 8. Choose collector voltage. Except for an emitter follower, the output signal is always taken from the collector. To avoid clipping, let $V_c = 0.5V_s$.

Step 9. Calculate R_c from I_c and V_c.

$R_c = V_c/I_c = 0.5V_s/I_c$.

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