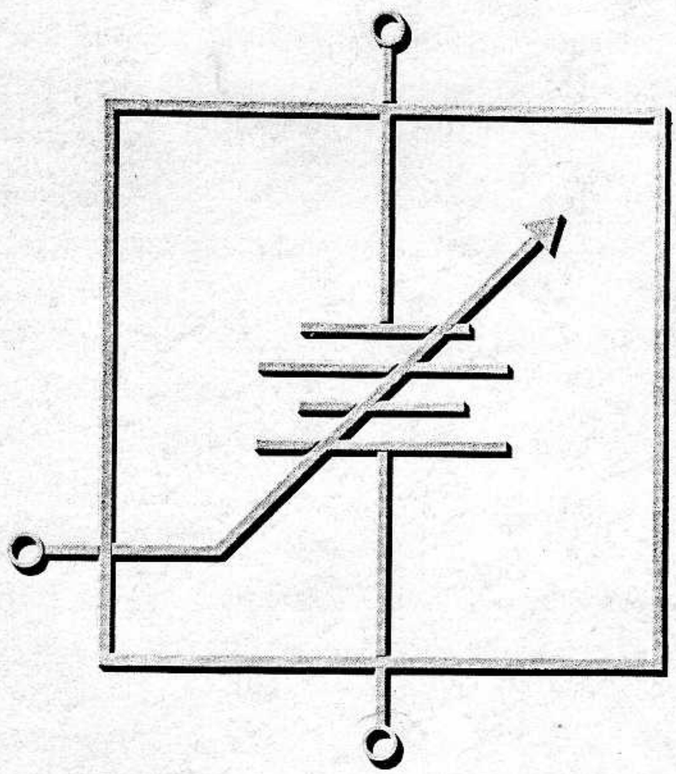
μA723

PRECISION VOLTAGE REGULATOR



Application Notes

FAIRCHILD
SEMICONDUCTOR

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CIRCUIT BUILDING BLOCKS FOR VOLTAGE REGULATORS

by Michael M. Scott

Today the engineer who must decide to buy out or build a power supply is faced with an impressive array of choices. He may buy complete power supplies from many vendors or build a supply using commercially available modules, hybrids or monolithic voltage regulators. He may even decide to design it himself with discrete components and integrated circuit op amps. Voltage regulators consist of basic building blocks shown in Figure 1. The goal is to assemble the blocks to get the typical "ideal" regulator (figure 2).

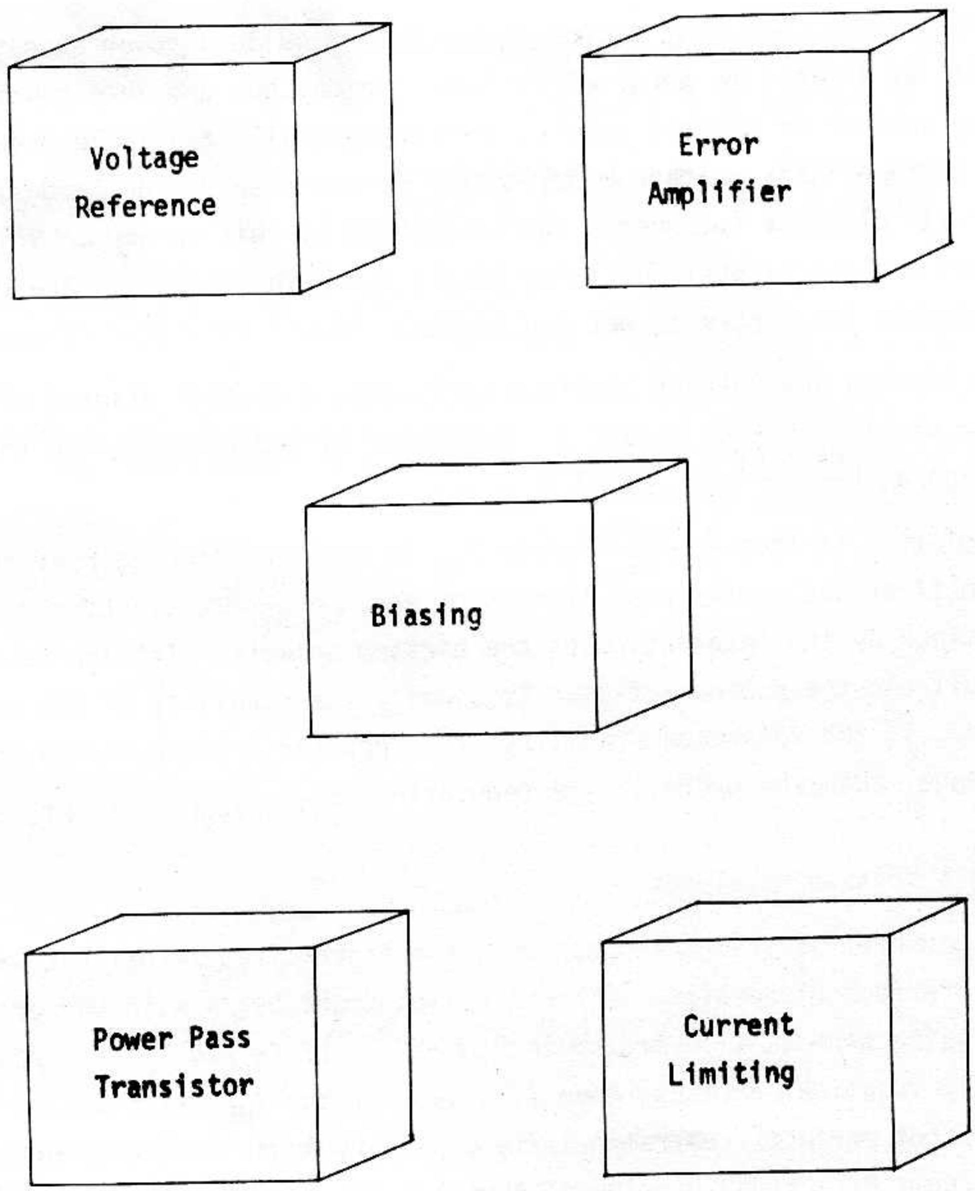
Ignoring biasing and current limiting symbology, a systems diagram of the regulator might look like Figure 3. Resistors R_1 and R_2 establish the output voltage at $[\frac{R_1 + R_2}{R_2} \times V_{REF}]$.

Load Regulation is then $\frac{\Delta A_{VO}/A_{VO}}{1 + \beta A_{VO}}$ where A_{VO} is the open loop gain of the error amplifier and series pass transistor and $\beta = \frac{R_2}{R_1 + R_2}$. Line regulation is determined by the interaction of the biasing networks with the rest of the circuit and the dominant factor is usually the stability of the voltage reference. If the reference stability is ΔV_{REF} for a given change in input line voltage, then the overall line regulation is $\frac{A_{VO}}{1 + \beta A_{VO}} \cdot \Delta V_{REF}$.

Designing a Voltage Regulator

A lot of engineering design and common sense is required to get hardware from the previous discussion. Circuit design might begin with one or more of the biasing schemes illustrated in Figure 4. If T_1 and T_2 in circuit A are exactly identical devices, then $I_1 = I_2$. If the V_{BE} match of the two devices is not perfect, the ratio I_1/I_2 will vary logarithmically with ΔV_{BE}. Circuit B is a PNP version of A with I_1/I_2 varying with the ratio of the collector areas. Temperature stability of these two circuits is poor, but an obvious advantage is their simplicity and minimum parts count.

The use of circuit C is becoming more and more popular today as FET prices decline. The tolerance in I_1 is poor, but it is useful in designing circuits whose current consumption is independent of supply voltage. Without its use, minimum pre-load requirements waste several milliamps in order to



BASIC BUILDING BLOCKS FOR VOLTAGE REGULATORS

FIGURE 1

SIMPLE REGULATOR BLOCK

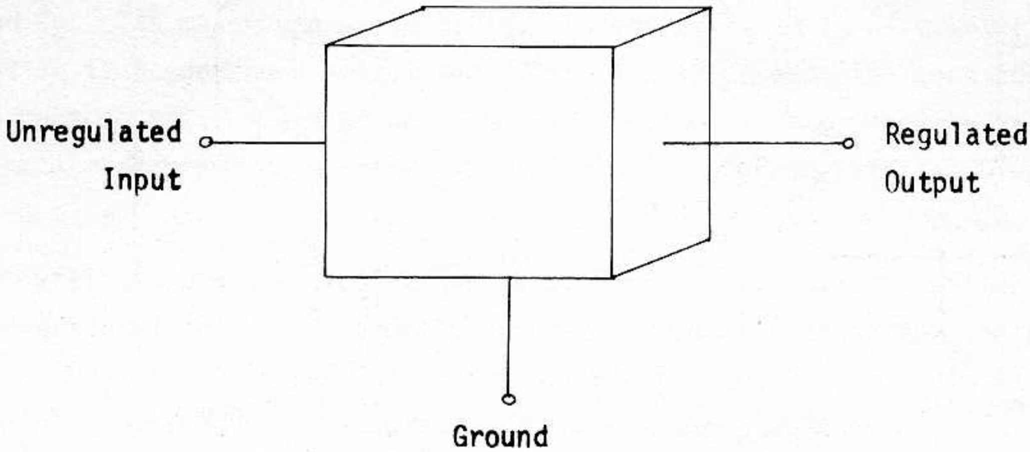


FIGURE 2

REGULATOR BLOCK DIAGRAM

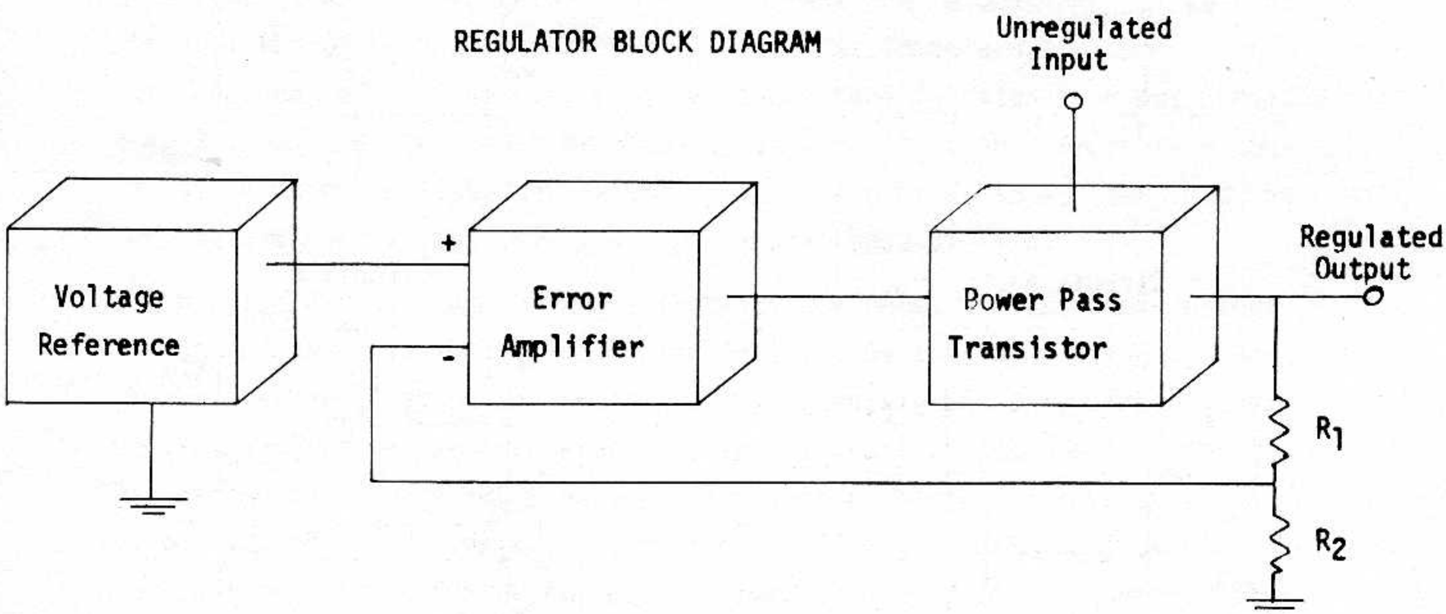


FIGURE 3

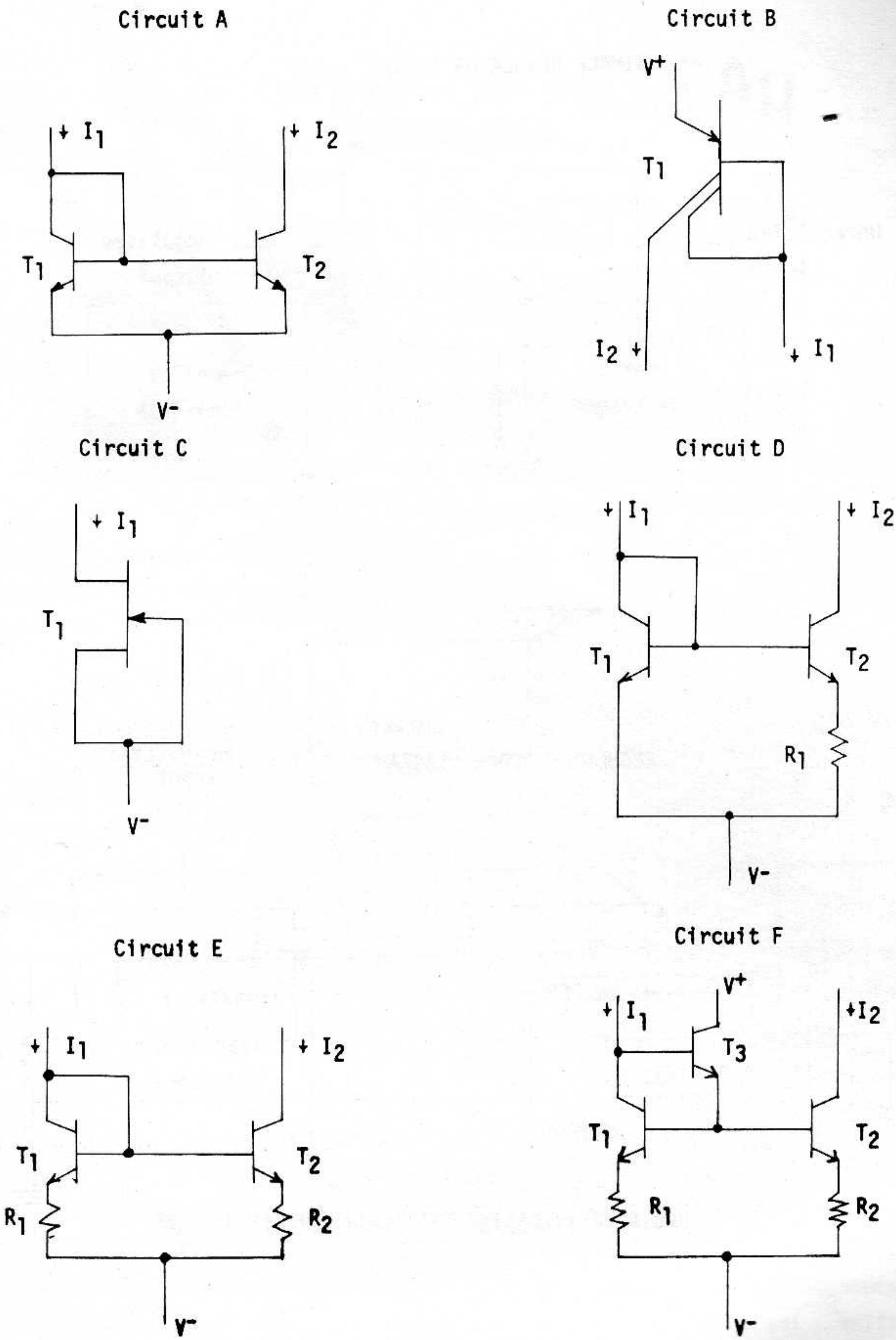


FIGURE 4

BASIC CURRENT SOURCE CONFIGURATIONS