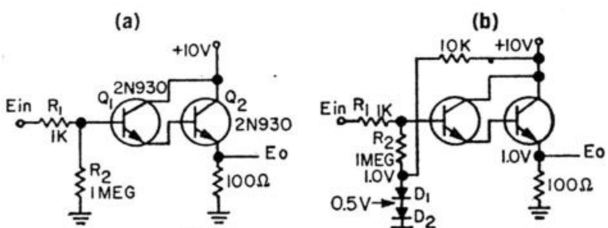
Temperature-Stabilized Darlington

USE OF DARLINGTON or beta-squaring circuits leads to severe offset-voltage changes as a function of temperature. If the ΔV_{be} figure is about 2 mv per deg C, a 25 C temperature change can give an output change of 50 mv per stage which can represent a 50 percent (or more) change in quiescent output.

Here are two circuit variations for minimizing or eliminating this temperature effect. Fig. 1a shows a typical Darlington while Fig. 1b shows a modification that includes a pair of diodes and an additional resistor. In these circuits quiescent levels are assumed for silicon transistors at temperatures of 0 C and 50 C, and it is assumed that I_{c2} is about 10 ma and I_{c1} about 0.1 ma. Values of V_{be} as a function of I_c and temperature are manufacturer's specs for the 2N930 but they are typical for silicons.

Fig. 1 The Darlington circuit (a) and a modified version (b) offering temperature compensation.



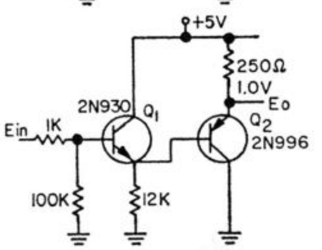


Fig. 2. Use of complementary transistors reduces offset voltages by cancellation.

Table 1

	Basic Ckt.		Modified Ckt.	
	0 C	50 C	0 C	50 C
V_{b1}	2.35	2.35	2.35	2.15
V_{b2}	1.75	1.85	1.75	1.65
V_{be1}	0.6	0.5	0.6	0.5
V_{be2}	0.75	0.65	0.75	0.65
V_{d1}	—	—	0.6	0.5
V_{d2}	—	—	0.6	0.5
E_o	1.0	1.2	1.0	1.0

Table 2

	0 C	50 C
V_{b1}	.85	.85
V_{b2}	.25	.35
V_{be1}	.6	.5
V_{be2}	.75	.65
E_o	1.0	1.0

Table 1. Voltage Levels in the Basic and Modified Darlington.

Table 2. Voltage Levels in the Complementary Circuit

Table 1 shows the effect on the output voltage of the temperature change. In the basic circuit, the 20 percent change in output could well have been a 100 percent change had the quiescent output been 0.2 v. Note how, in the modified circuit, the effect of ΔV_{be} of Q_1 and Q_2 on E_0 caused by temperature change is offset by identical changes in V_{d1} and V_{d2}.

A second approach to controlling the effect of V_{be} changes with temperature involves the use of complementary transistors as in Fig. 2. It is perhaps more subtle in that it virtually eliminates V_{be} offset voltages by cancellation.

If we assume the same quiescent voltages in Fig. 2 (Table 2) as in Fig. 1, then, at 0 C, $V_{be2} = 0.75$ v and $V_{be1} = 0.6$ v. But in Fig. 2, these voltages are of opposite polarity so the total offset voltage is the difference (0.15 v) rather than the sum (1.35 v), an improvement of nearly an order of magnitude.

At 50 C, $V_{be1} = 0.5$ v and $V_{be2} = 0.65$ v and, in Fig. 2, the total offset voltage is still 0.15 v rather than the 1.15 v of Fig. 1.

Though silicon transistors and diodes are used in these circuits, germaniums could be used just as well.

Low Cost Transistor Voltage Regulator

MANY APPLICATIONS REQUIRE an inexpensive, constant source of low voltage dc. Such a regulator, costing 5 to 7 times less than a zener diode, and having the same power rating, is given here. A further advantage is realized in that it can be set at the precise value of the voltage required, whereas the zener is purchased with a tolerance of 5 or 10 per cent.

This regulator was designed around a very inexpensive power transistor, the 2N554. By using a minimum of parts, and a silicon diode (1N462) for reference as opposed to a zener diode, the regulator was produced (in quantity) for less than two dollars.

The forward characteristic of the general purpose silicon diode was used rather than the back characteristic of a zener diode. A 2N404 transistor was chosen as a feedback amplifier because of its reliability, uniformity, and low cost. In addition, a 10 ohm thermistor was added to make the circuit perform at any temperature within the −55 to 71 C range. The input voltage source to this regulator is a sea water activated battery which has a voltage which varies from 12.5 to 14.7 v depending on salinity and temperature. The output voltage of this regulator, with design load of 600 ma, varies from 6.3 to 6.4 v over the voltage input and temperature ranges indicated.

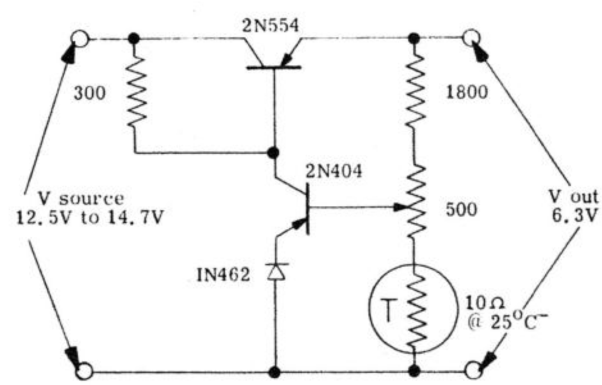


Fig. 1 Low cost transistor voltage regulator.