ideas for design

LED used as voltage reference provides self-compensating temp coefficient

Low-cost LEDs, when used as voltage references, can overcome some serious limitations of temperature-stable zener diodes.

When zener diodes are used with a transistor buffer or as part of a current source, the transistor's V_{be} must be compensated. This usually requires an extra diode or transistor. But a LED can serve as a voltage source below 5.1 V, and it needs no compensation, because a LED has the same drift as a typical transistor base-emitter junction already built in. At low currents a typical LED has a voltage drop of 1.4 to 1.7 V and a junction coefficient of about -2 mV/°C.

The LED-stabilized current source in Fig. 1 is shown with some typical loads. Without adjustments, the voltage across the emitter resistor—and hence the current through it—is very stable with temperature. Tests of the circuit have provided better than ±1/2% stability over the −55-to-100-C range—usually much better than needed for the type of loads shown. Other applications include coulometers, ramp generators, LED assemblies, bridges and special thermistors and other sensors.

The results will vary with the LED and transistor used. Some trimming of stability can be obtained by adjustment of the 10-kΩ resistor. Also, a change in the 301-Ω resistor will affect the temperature coefficient. The change in coefficients can be predicted from known semiconductor-junction characteristics. In Fig. 1 the load current is 2.5 mA.

Fig. 2 shows the use of a LED-transistor reference in a voltage-regulated power supply. The power supply can provide over 1-A output. With a 4-V change in the unregulated input, the output changes 4% when set to 1 V and only 2% at 5 V.

The LM395 is an integrated transistor that includes circuits for internal overcurrent and overtemperature protection. This transistor should be mounted on a heat sink for 1-A loads.

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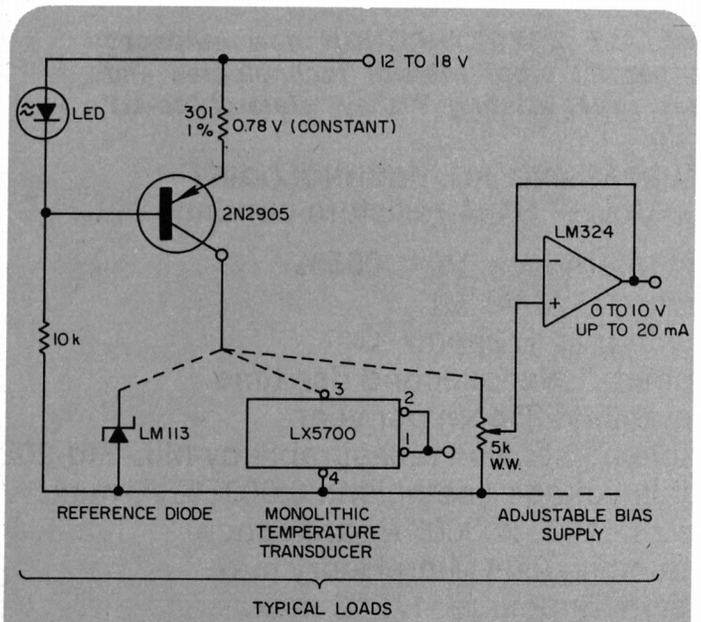
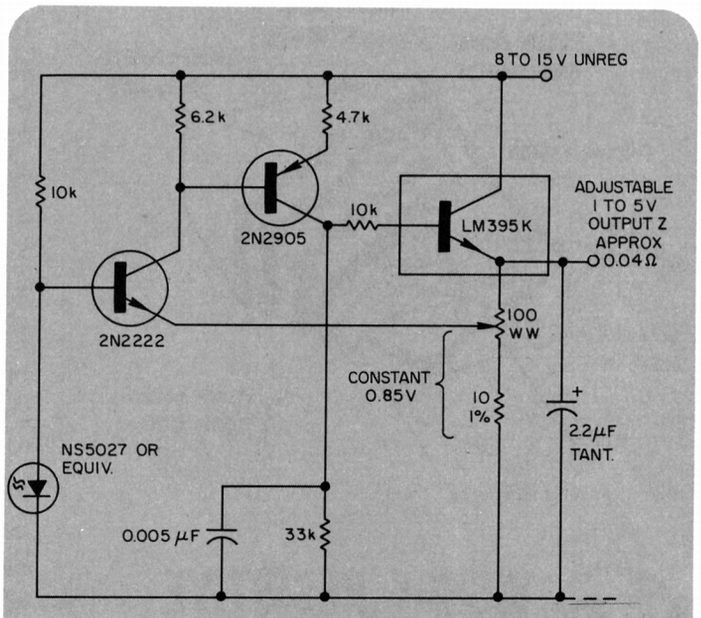


1. **LED voltage reference** in a transistor-buffered, constant-current circuit has built-in temperature compensation.



2. **The LED is used as a voltage reference** in this temperature-compensated, voltage-regulated power supply.