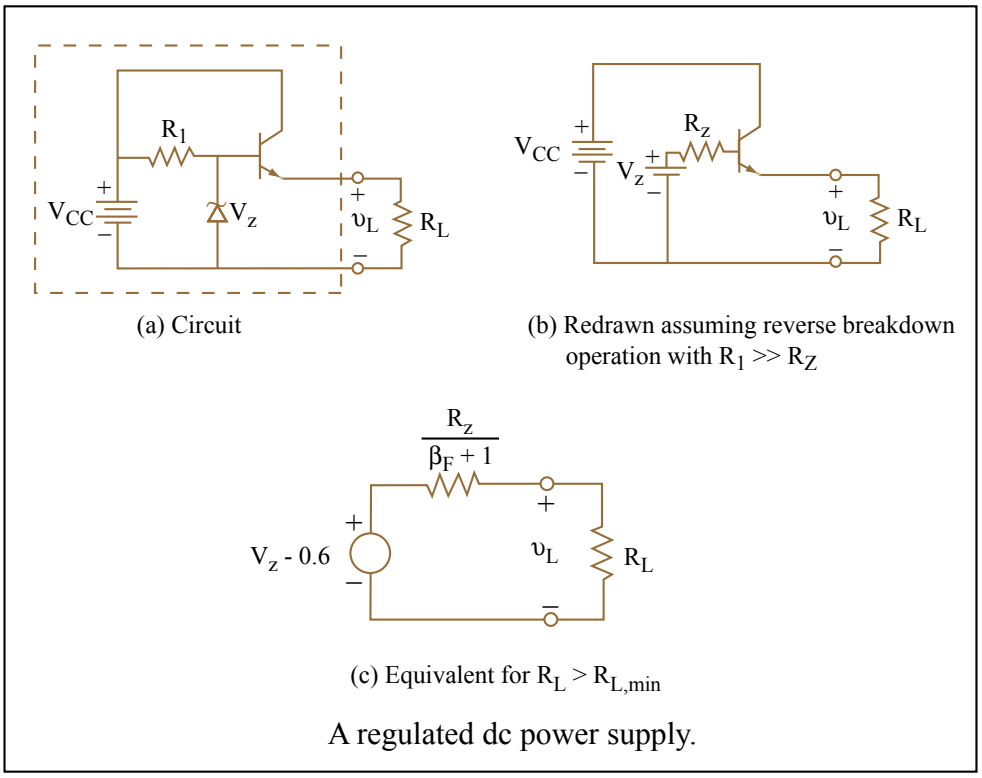
10.2.3 A Regulated dc Power Supply

Figure 10.11a shows a variation of the emitter-follower theme, this time combined with a Zener diode operating in reverse breakdown to produce a regulated dc output voltage across a load resistor R_L. Once again, the V_{CC} supply is playing a dual role, both as collector supply and as bias supply for both the base input to the transistor and the Zener diode. If we assume that the Zener is operating in reverse breakdown, and if we assume that the Zener impedance R_Z is much less than R_1 (see Section 8.3.4 and Fig. 8.23), we can redraw this circuit as in Fig. 10.11b.



A regulated dc power supply.

Figure by MIT OpenCourseWare.

Drawing on our analysis of the emitter follower, we have immediately from Eq. 10.23 that

$$v_L = \left[\frac{(\beta_F + 1)R_L}{R_Z + (\beta_F + 1)R_L}\right](V_Z - 0.6) \tag{10.40}$$

which for $(\beta_F + 1)R_L >> R_Z$ is effectively independent of R_L. Thus the emitter follower is acting like a dc voltage source of magnitude V_z - 0.6. The output voltage in our approximate analysis is also independent of V_{CC}. Thus any ripple that might be present on the V_{CC} supply is strongly attenuated by this regulator. Emitter followers can be used in this way to obtain well-filtered dc supply voltages at relatively modest cost.

The equivalent circuit of Fig. 10.11c shows the Thevenin resistance of the regulated supply is $R_Z/(\beta_F + 1)$. Derivation of this resistance from Eq. 10.40 is left as an exercise. Also left as an exercise is the derivation that the regulator works only for $R_L > R_{L\,min}$ where

$$R_{L\,\min} = \frac{R_1(V_Z - 0.6)}{(\beta_F + 1)(V_{CC} - V_Z)} \tag{10.41}$$

As a practical case, assume V_{CC} = 12 V, V_Z= 6.2 V, R_Z = 10 Ω, R_1 = 1 kΩ and β_F = 50. In that case the regulated output voltage is v_L = 5.6 V for $R_{L\ min}$ = 20 Ω. Equivalently, this supply can deliver regulated load current up to a maximum of $v_L/R_{L\ min}$ = 280 mA.