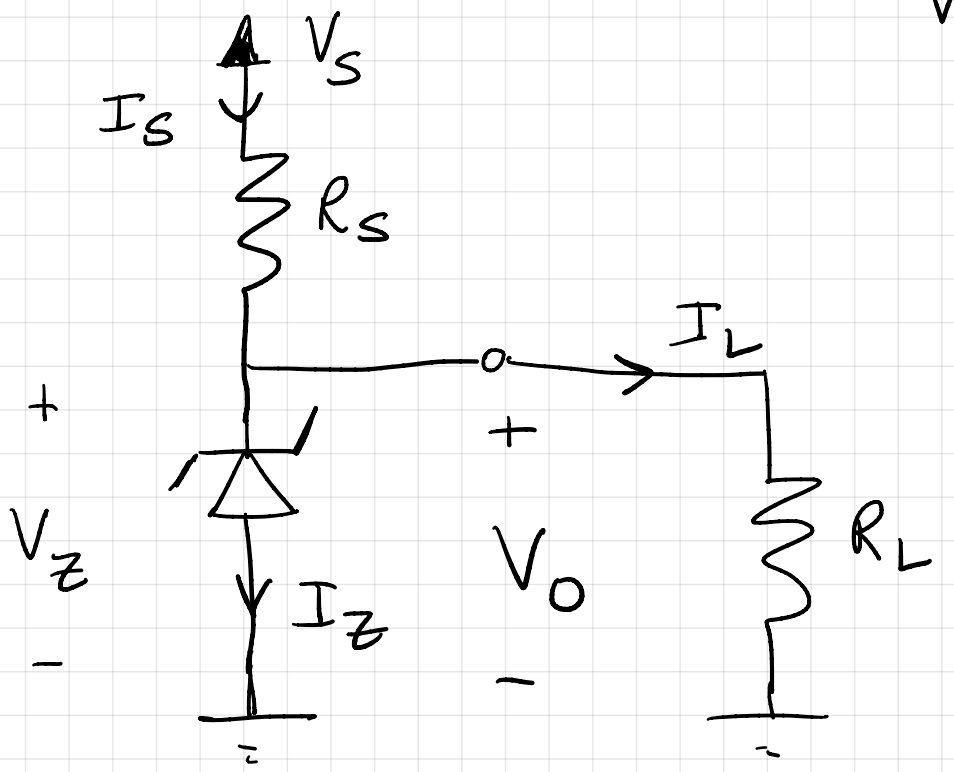
6.8 V zener diode Voltage Regulator



$V_S = 10 \pm 1\,V$

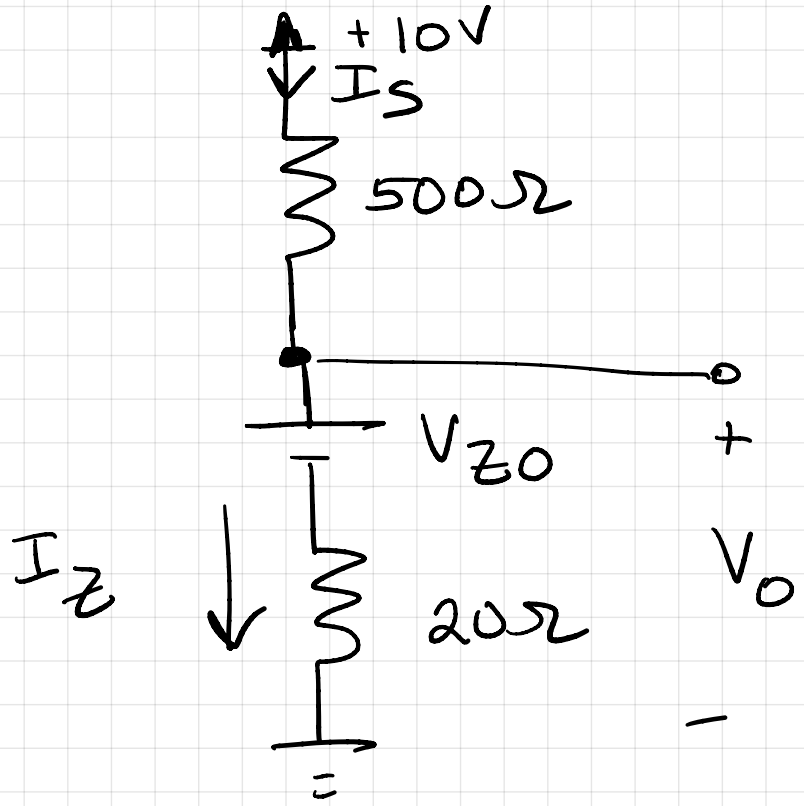
$R_S = 500\,\Omega$

$V_Z = 6.8\,V$

$I_Z = 5\,mA$

$r_Z = 20\,\Omega$

a) Find V_O assume no load $R_L \to \infty$ and V_S is nominal 10 V



$V_Z = 6.8\,V$

$I_Z = 5\,mA$

$V_{Z0} = V_Z - I_Z r_Z$

$= 6.8 - (5 \times 10^{-3})(20)$

$V_{Z0} = 6.7\,V$

$I_Z = \dfrac{10 - V_{Z0}}{500 + 20}$

$$I_Z = \frac{10 - 6.7}{520} = 6.35\,mA$$

$$V_O = V_{Z0} + 20 I_Z$$
$$= 6.7 + 20(6.35 \times 10^{-3})$$

$$\boxed{V_O = 6.83\,V}$$

b) ΔV_O w/ respect to V_S

$\pm 1\,V$ change in $V_S \Rightarrow \Delta V_O$

$$\frac{\Delta V_O}{\Delta V_S} = \text{line regulation } \frac{mV}{V}$$

$$I_Z = \frac{V_S - V_{Z0}}{R_S + r_Z}$$

$$V_O = V_{Z0} + I_Z r_Z$$

$$V_O = V_{Z0} + (V_S - V_{Z0})\left(\frac{r_Z}{R + r_Z}\right)$$

ΔV_o as function of ΔV_s

$$\Delta V_o = \frac{r_z}{R + r_z}\left(\Delta V_s\right)$$

$$\frac{\Delta V_o}{\Delta V_s} = \frac{r_z}{R + r_z} = \frac{20}{520} = 38.5 \times 10^{-3}$$

$$= 38.5 \frac{mV}{V} \longrightarrow \text{line regulation}$$

$$\Delta V_o = \left(38.5 \frac{mV}{V}\right)(\pm 1)$$

$$\Delta V_o = \underline{38.5\ mV} \longrightarrow \text{output voltage change for a given } \pm 1V$$

c) Find ΔV_o if we connect a load resistor that draws 1mA away from the zener diode

$I_L = 1mA$

$\frac{\Delta V_o}{\Delta I_L} \equiv$ load regulation

$$\frac{\Delta V_o}{\Delta I_L} \Rightarrow \frac{mV}{mA}$$

$$V_o = V_{zo} + I_z r_z$$

$$\Delta V_o = \Delta I_z (r_z)$$

$$\boxed{\frac{\Delta V_o}{\Delta I_z} = r_z = 20\,\frac{mV}{mA}}$$

$$\Delta I_z = -1mA$$

$$\frac{\Delta V_o}{\Delta I_L} = -20\,\frac{mV}{mA}$$

$I_L = 1mA$ $\qquad$ $\Delta V_o = -20mV$

d) ΔV_o for $R_L = 2k\Omega$

$$I_L \cong \frac{6.8}{2000} = 3.4mA$$

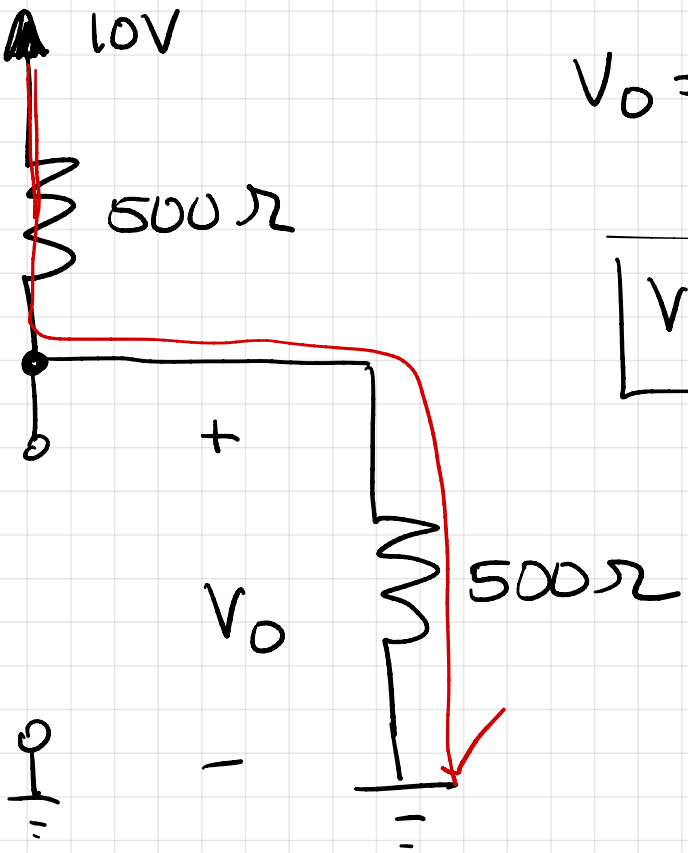
$$\Delta V_o = r_z \Delta I_z = -(20)(3.4\times10^{-3})$$

$$\Delta V_o = -68\,mV$$

e) $R_L = 500\,\Omega$

$$I_L \cong \frac{6.8}{500} = 13.6\,mA$$

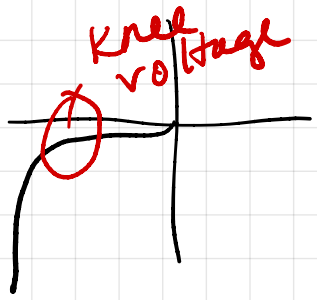
zener diode is no longer in breakdown



$$V_o = 10\left(\frac{500}{1000}\right)$$

$$\boxed{V_o = 5\,V}$$

f) What is the minimum R_L value such that we are on the edge of breakdown.

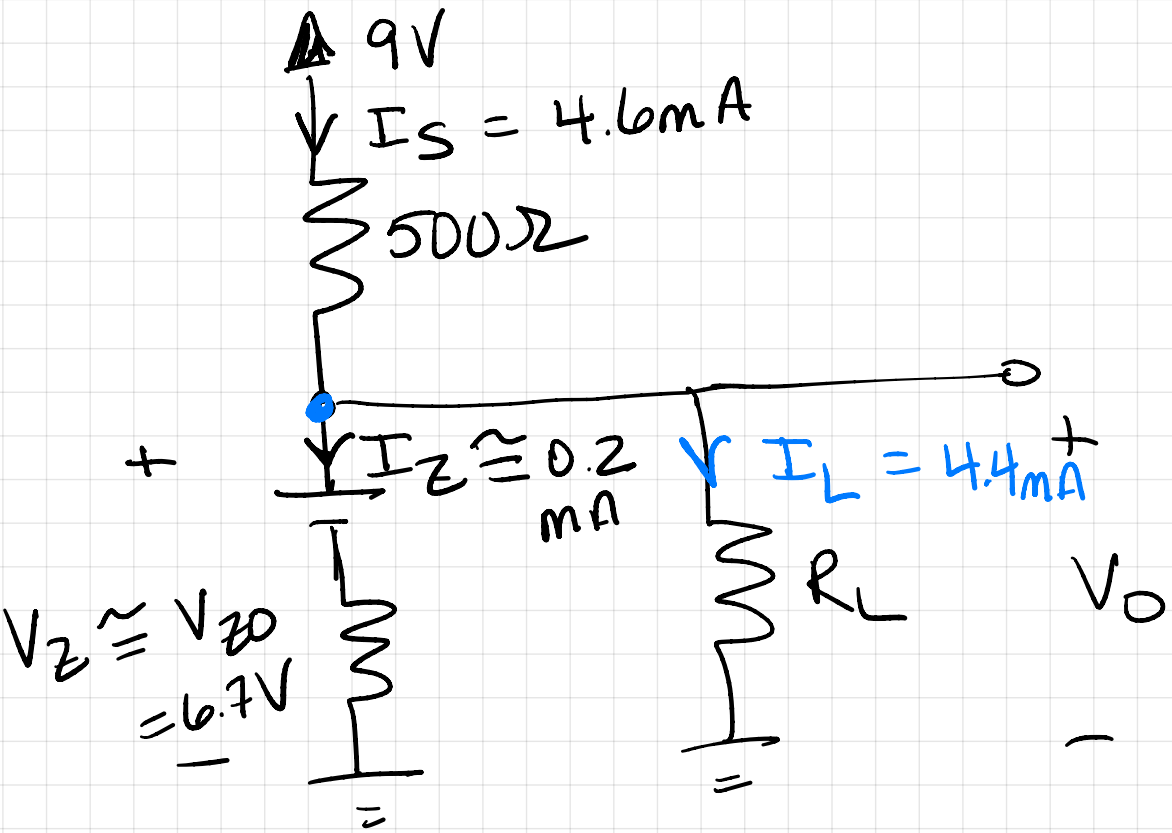


$$I_{ZK} = 0.2mA$$

$$I_Z \cong I_{ZK} = 0.2mA$$

$$V_Z \cong V_{Z0} = 6.7V$$

$$I_S = \frac{9 - 6.7}{500} = 4.6mA$$



$$R_L = \frac{V_Z}{I_L} = \frac{6.7}{4.4 \times 10^{-3}}$$

$$R_L \cong 1.5\ k\Omega$$