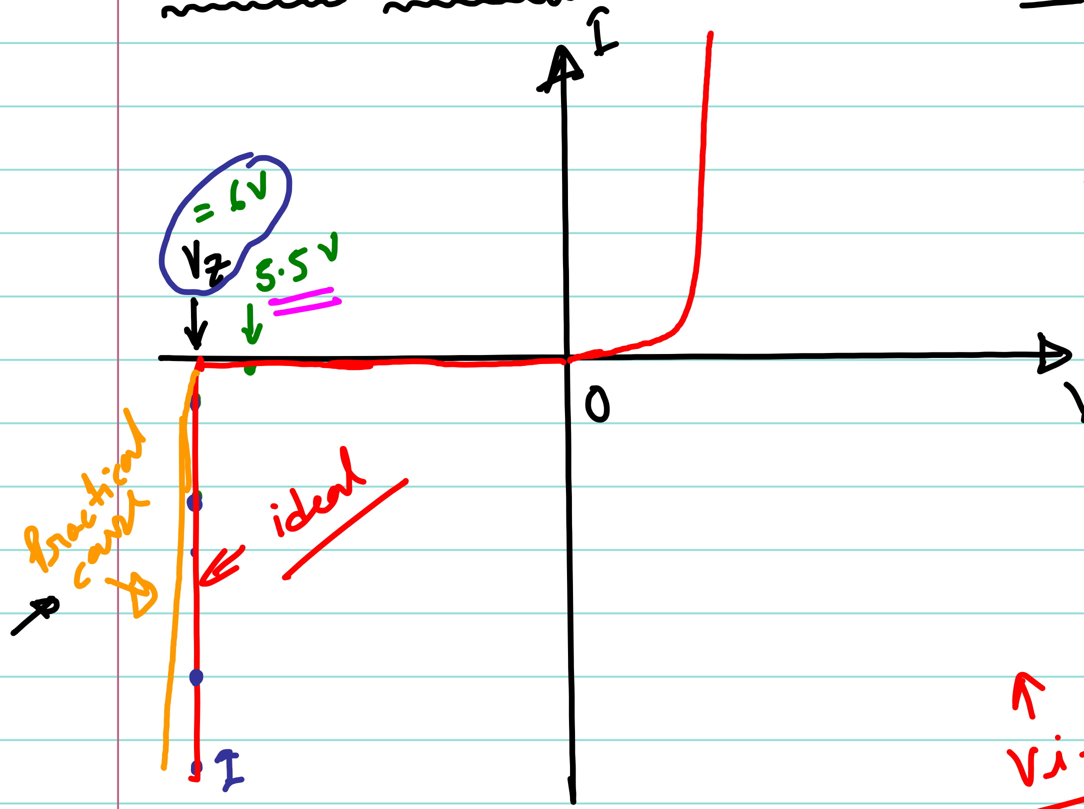
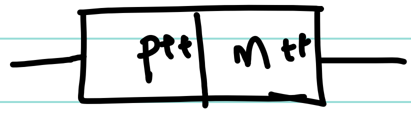
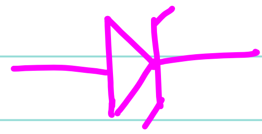
Lec-9

Zener Diode:

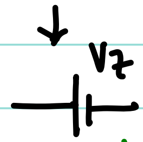


heavily doped





ckt. symbol.



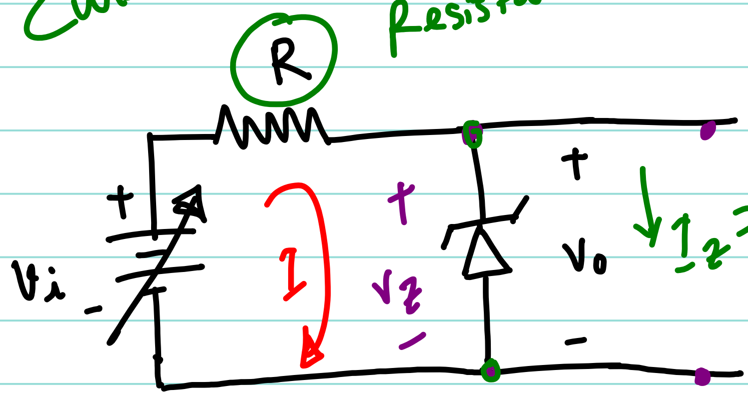
$I_Z \times V_Z$

$1A \times 6V$

$= 6W$

$\uparrow I = \dfrac{\uparrow V_i - V_Z}{R}$

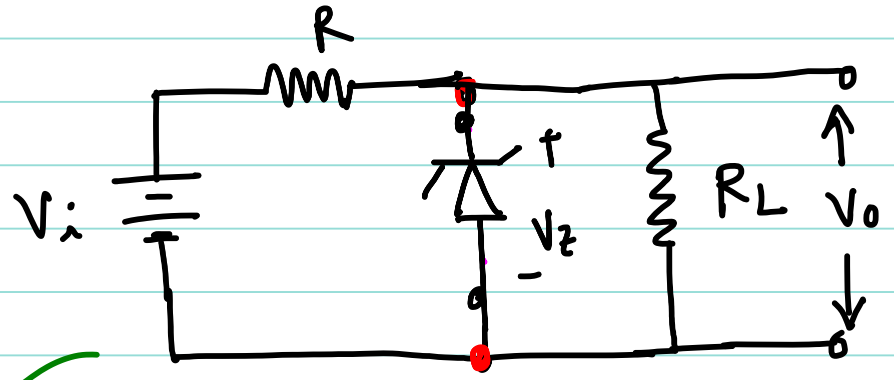
Current limiting Resistor.



$\downarrow I_Z = I$

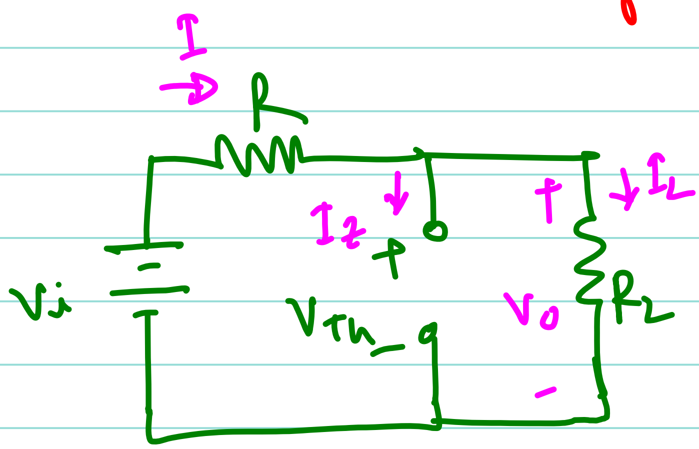
$\boxed{P_{Z,max} = 3W}$

Zener diode as voltage regulator:



V_o

Zener must be operating in breakdown



$$V_{Th} = V_i \times \frac{R_L}{R+R_L}$$

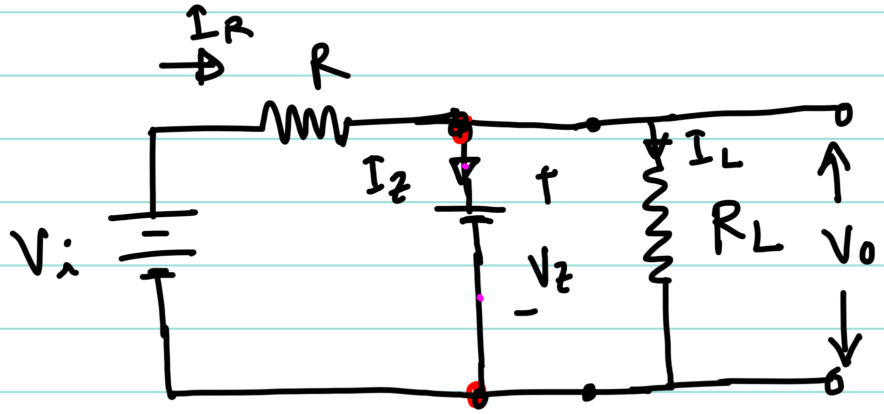
① $\boxed{V_{Th} > V_Z}$ *, acts as a regulator.

② $V_{Th} < V_Z$, then No Breakdown, No regulation

$I_Z \approx 0$, $I = I_L$

$$I_L = \frac{V_i}{R+R_L} \; ; \; V_o = I_L \times R_L = \frac{V_i}{R+R_L} \times R_L$$

$V_{th} > V_Z$



$$I_R = I_Z + I_L \quad ; \quad I_Z = I_R - I_L$$

$$I_R = \frac{V_i - V_Z}{R} \quad ; \quad I_L = \frac{V_Z}{R_L}$$

$$I_Z = \frac{V_i - V_Z}{R} - \frac{V_Z}{R_L}$$

Power dissipation across Zener $= I_Z \cdot V_Z = P_Z$

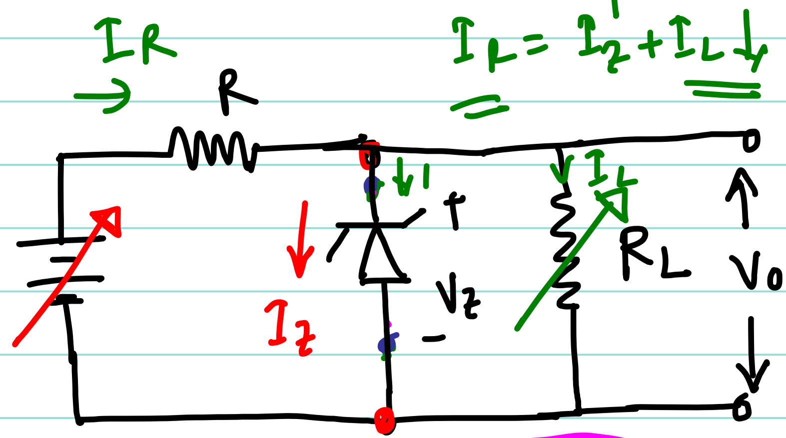
$$\underline{P_Z < P_{Z,\text{rated}}}$$

$P_{Z,\text{rated}} = 2W$

1.5 W

$V_{Th} > V_Z$

$I_R = I_Z + I_L$



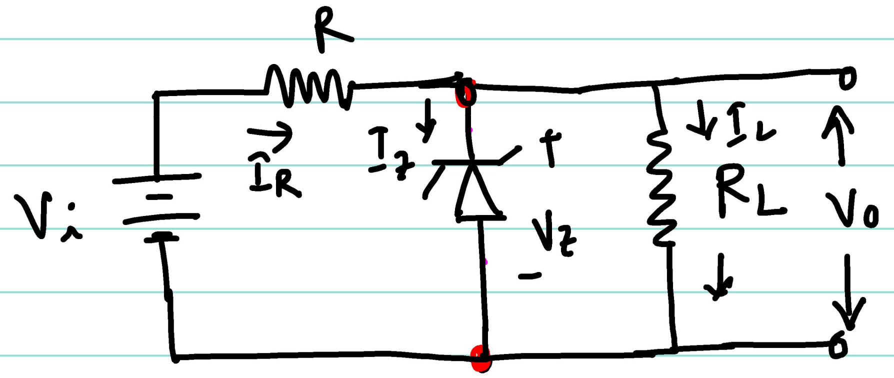
V_{Th}

( )

V_{th}

$V_{i,min} < V_i < V_{i,max}$

$R_{L,min} < R_L < R_{L,max}$



Considering, R_L is variable, find, $\left.\begin{array}{l} R_{L,min} \\ R_{L,max}. \end{array}\right\}$

→ For regulation, voltage across Zener should be $\geq V_Z$

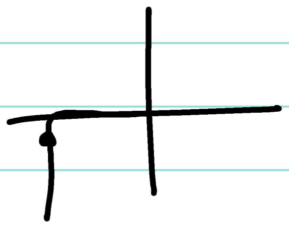
$$V_{Th} = V_i \times \frac{R_L}{R + R_L} = V_Z$$ for min value of R_L

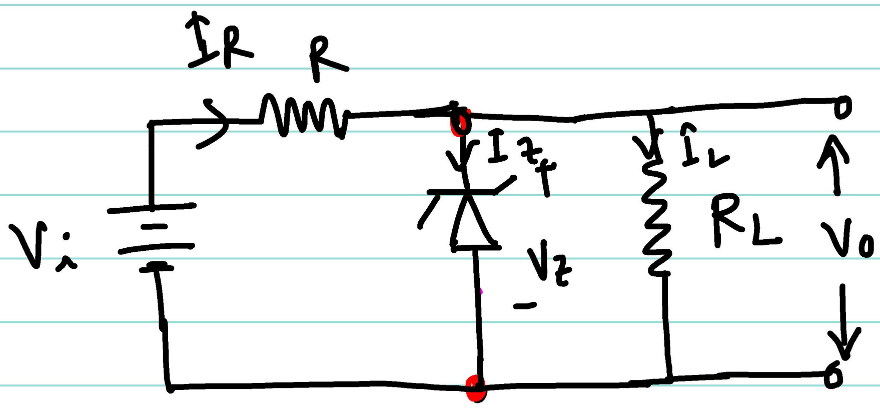
$$\rightarrow \quad R_{L,min} = \frac{V_Z \cdot R}{V_i - V_Z}$$

When, R_L is min, I_L is max, $\left(I_{L_{max}} = \frac{V_Z}{R_{L,min}} \right)$

$$\underset{=}{I_R} = \underset{\substack{\downarrow \\ \text{min}}}{I_Z} + \underset{\searrow \text{ max.}}{I_L} \qquad ; I_R = \frac{V_i - V_Z}{R}$$

— $P_{Z,min} = V_Z \cdot I_{Z,min}$





When R_L is max., I_L is min, I_Z is max.

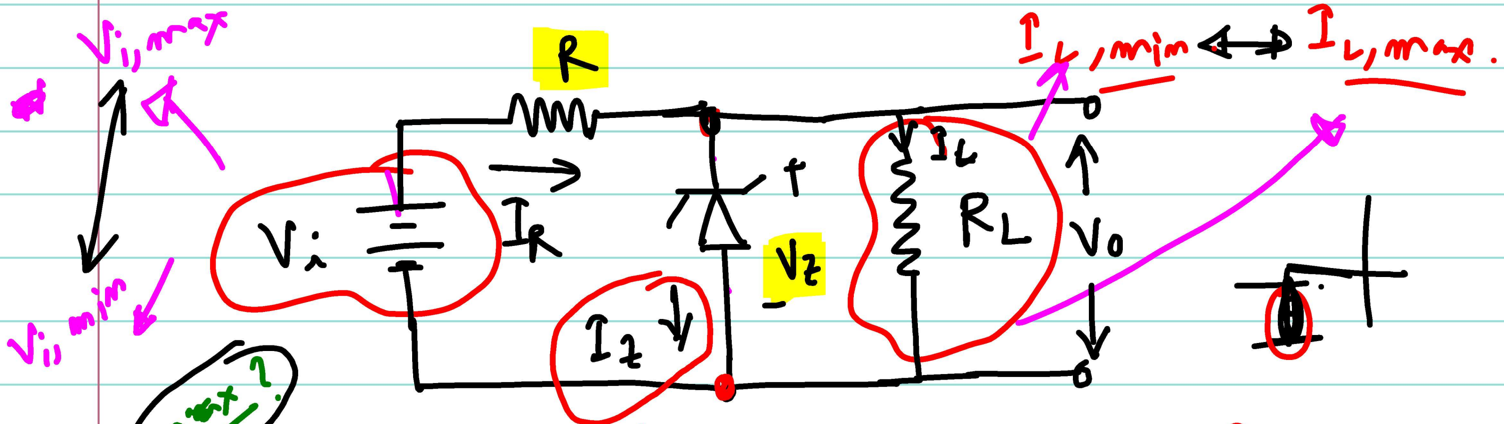
$$I_{Z,max} = \frac{P_{Z,max}}{V_Z}$$

$$R_{L,max} = \frac{V_Z}{I_{L,min.}}$$

$$I_{Z,max} + I_{L,min} = I_R = \frac{V_i - V_Z}{R}$$

$$\boxed{V_{i,min} < V_i < V_{i,max}}$$

H.W.



$I_{Z,max}$. $I_{Z,min}$.

$$I_R \cdot R + V_Z = V_i$$

$I_R = I_Z + I_L$ (min)

$$R = \frac{V_i - V_Z}{I_R} = \frac{V_i - V_Z}{I_Z + I_L}$$

max. $\uparrow$ $I_L + I_Z = I_R$ $\downarrow$ min.

$$\rightarrow I_Z = \frac{V_i - V_Z}{R} - \frac{V_Z}{R_L} \quad ; \quad I_Z = I_R - I_L$$

min $\qquad$ max

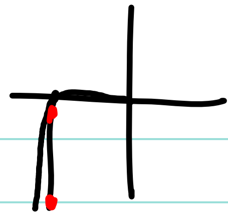
V_i is min

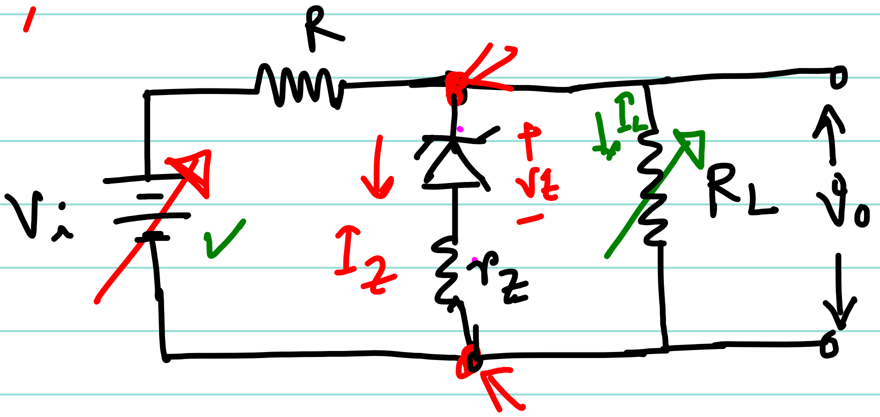
$$R = \frac{V_i(min) - V_Z}{I_Z(min) + I_L(max)}$$

$$R = \frac{V_i(max) - V_Z}{I_Z(max) + I_L(min)}$$

$I_{Z,max}$
$V_{i,max}$
I_L is min

$$I_{Z(min)} = I_{Z(max)} \times 10\%$$



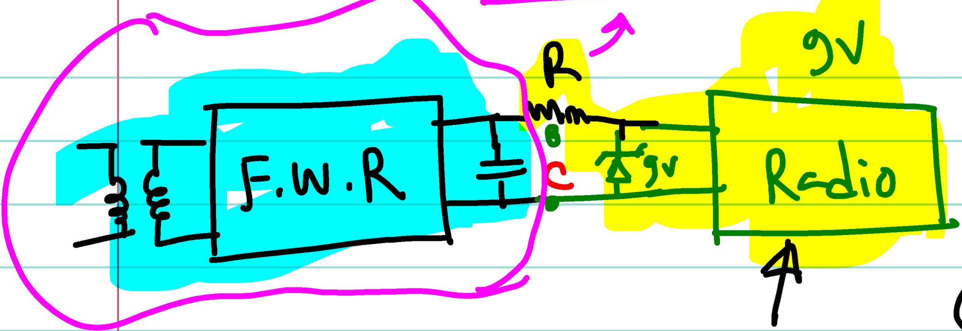


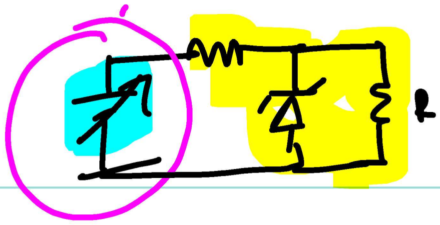
r_Z in few ohms to 10's of ohms

$$\text{Source Regulation} = \frac{\Delta V_o}{\Delta V_i} \times 100\% \quad ; \text{ No load}$$

$$\text{Load regulation} = \frac{V_{o,\,\text{no load}} - V_{o,\,\text{full load}}}{V_{o,\,\text{full load}}} \times 100\%$$

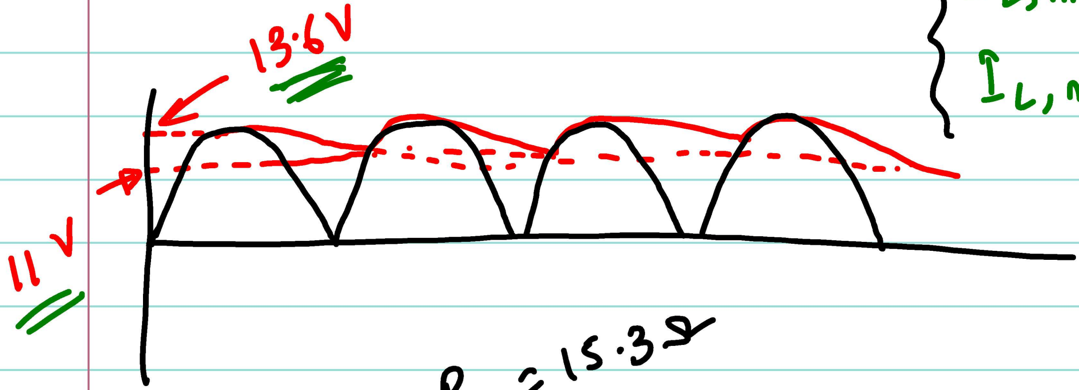
$R = 15.3\,\Omega$

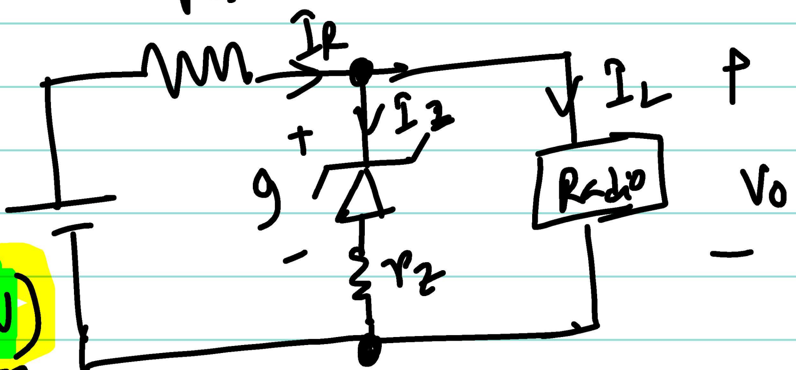




$r_z = 2\,\Omega$

$$\left\{ \begin{array}{l} I_{L,min} = 0 \\ I_{L,max} = 100\,mA \end{array} \right\}$$





$r_z = 2\,\Omega$

V_i $(11 - 13.6\,V)$

$\Delta V_i = \boxed{2.6\,V}$

$V_i = 13.6\,V$, $\quad I_z = \dfrac{13.6 - 9}{R + r_z} = \dfrac{13.6 - 9}{17.3} = 0.2659\,A.$

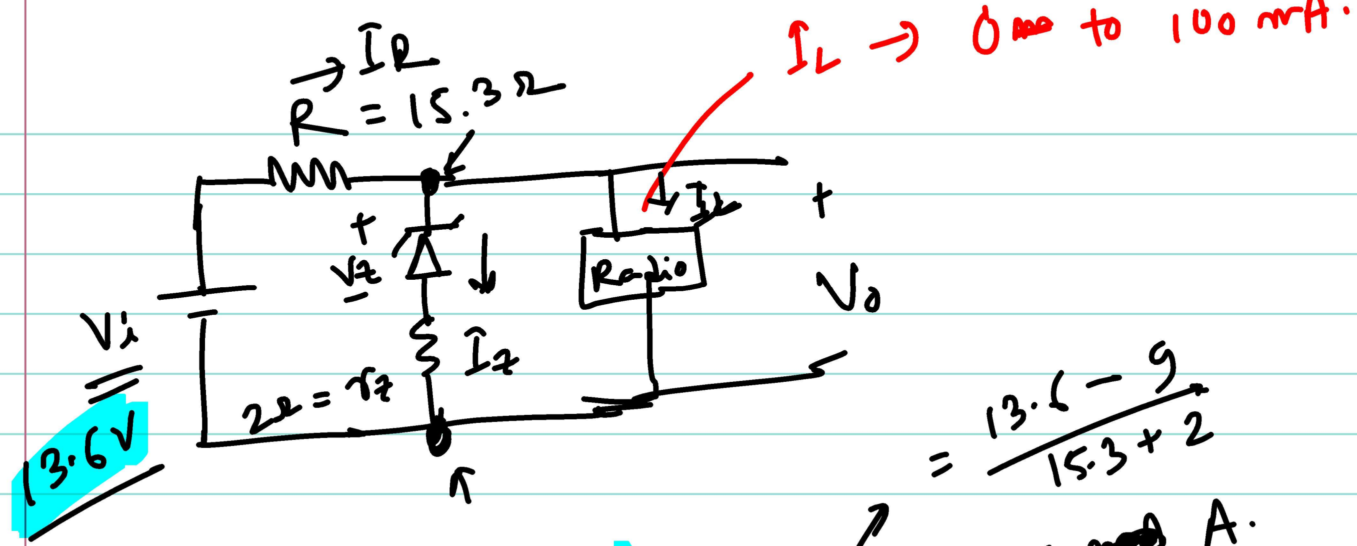
$V_0 = 9 + I_z \cdot r_z = 9.532\,V.$

$V_i = 11\,V$, $\quad I_z = \dfrac{11 - 9}{17.3} = 0.1156\,A.$

$V_0 = 9 + I_z \cdot r_z = 9.231\,V.$

$\frac{\Delta V_o}{\Delta V_{in}} \times 100\%$

Source Regulation $= \dfrac{9.532 - 9.231}{13.6 - 11} \times 100\% = 11.6\%.$



$V_i = 13.6V$

$V_i = 13.6\,V$, $I_L = 0$, $I_z = 0.265\,A.$

$$= \frac{13.6 - 9}{15.3 + 2}$$

$$V_o = 9 + I_z \cdot r_z = 9.532\,V.$$

$I_L = 100\,mA$

$$I_z = \frac{13.6 - (9 + I_z \cdot r_z)}{15.3} - I_L$$

$$I_z = 0.1775\,A.$$

$$V_o = 9 + I_z \cdot r_z = 9.355\,V.$$

$$\text{Load regulation} = \frac{V_{o,\,no\ load} - V_{o,\,full\ load}}{V_{o,\,full\ load}} \times 100\%.$$

$$= \frac{9.532 - 9.355}{9.355} \times 100\%.$$

$\rightarrow = 1.89\%.$