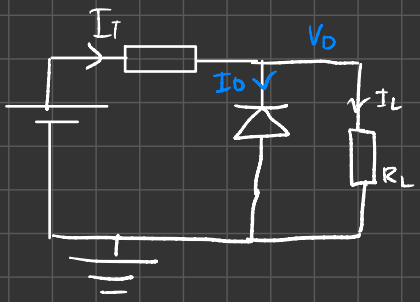
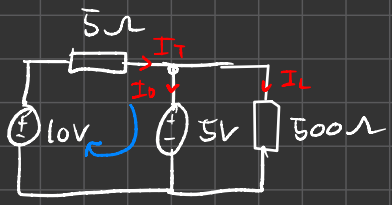
1)



Ideal:



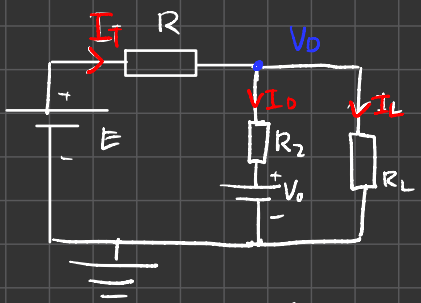
KVL: $10 = 5I_T + 5$

$\Rightarrow I_T = 1A$ ← $\frac{5}{500} = 10mA$

KCL: $I_T = I_D + I_L$

$1A = I_D + 10mA$

$\Rightarrow I_D = 0,99A$



$V_0 = V_D = 4,5V$

$R_Z = 8\Omega$

$I_{ZK} = 30mA$

KCL: $I_T = I_D + I_L$

$\Rightarrow \frac{10 - V_D}{5} = \frac{V_D - 4,5}{8} + \frac{V_D}{500}$

$\Rightarrow 100(10 - V_D) = 62,5(V_D - 4,5) + V_D$

$\Rightarrow (-100 - 62,5 - 1)V_D = -1281,25$

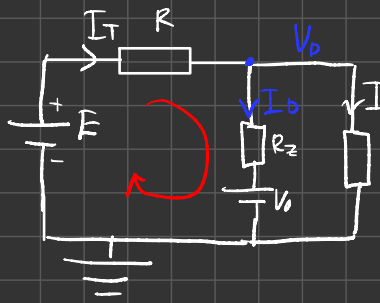
$\Rightarrow V_D = 7,84V$

$I_T = \frac{E - V_D}{R} = 0,432A$

$I_D = \frac{V_D - V_0}{R_Z} = 0,418A$

$I_L = \frac{V_D}{R_L} = 16,7mA$

2)



$E = 15V$ | $R = 100\Omega$ | $R_L = 1K\Omega$ | $R_Z = 7\Omega$ | $V_Z = 5,1V$ @ $I_Z = 49mA$ | $I_{Zk\,min} = 1mA$

$$V_0 = V_Z - R_Z \cdot I_Z = 5,1 - 7 \cdot 49mA = 4,76V$$

KCL: $I_T = I_D + I_L \Rightarrow \frac{15 - V_D}{100\Omega} = \frac{V_D - 4,76V}{7\Omega} + \frac{V_D}{1K\Omega}$

$$\Rightarrow 10(15 - V_D) = \frac{1000}{7}(V_D - 4,76) + V_D$$

$$\Rightarrow \left(-10 - \frac{1000}{7} - 1\right)V_D = -680 - 15c \Rightarrow V_D = 5,4$$

a)

$$I_T = \frac{15 - 5,34}{100} = 96mA$$

$$I_D = \frac{5,34 - 4,76}{7} = 91,4mA$$

$$I_L = \frac{5,34}{1000} = 5,4mA$$

b) $\frac{\Delta I}{\Delta V} = \frac{I_Z - I_{Zk}}{V_Z - V_{min}} = \frac{1}{R_Z}$

$$\Rightarrow V_{min} = V_Z - R_Z(I_Z - I_{Zk}) = 4,764V$$

$$I_{Lmin} = \frac{V_{min}}{R_L} = 4,764mA$$

$$E_{min} = R(I_{Zk} + I_{L_{min}}) + V_{min} = 5,34V$$

c) $\frac{\Delta I}{\Delta V} = \frac{I_{max} - I_Z}{V_{max} - V_Z} = \frac{1}{R_Z}$

$\Rightarrow$ I): $V_{max} = R_Z(I_{max} - I_Z) + V_Z$

II) $P_{max} = V_{max} \cdot I_{max} \Rightarrow (R_Z I_{max} - R_Z I_Z + V_Z) I_{max} = 7W$

$$\Rightarrow R_Z I_{max}^2 - R_Z I_Z I_{max} + V_Z I_{max} - 7 = 0$$

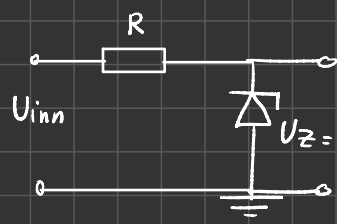
$$\Rightarrow R_z I_{max}^2 + (V_z - R_z I_z) I_{max} - 1 = 0$$

$$I_{max} = \frac{R_z I_z - V_z \pm \sqrt{(-R_z I_z + V_z)^2 - 4 \cdot R_z (-1)}}{2R_z} \approx 168{,}5\,mA$$

$$V_{max} = R_z (I_{max} - I_z) + V_z \approx 5{,}937\,V$$

$$E_{max} = R(I_{max} + \underbrace{I_L}_{\frac{V_{max}}{R_L}}) + V_{max} \approx 23{,}38\,V$$

3)



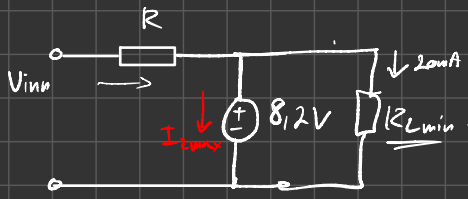
$P_{max} = U \cdot I = 1$

$U_{inn} = (15 \pm 3)V \rightarrow U_{inn\,min} = 12V$, $U_{inn\,max} = 18V$

$U_z = 8{,}2$

$I_{max} = 20\,mA$

$I_{min} = 5\,mA$



$$I_{Zmax} = \frac{P}{8{,}2V} = \frac{1W}{8{,}2V} = 122\,mA$$

$$R_{Lmin} = \frac{8{,}2}{20mA} = 410\,\Omega$$

$$12V = R I_{min} + 8{,}2V =$$

$$R_{max} = \frac{12 - 8{,}2}{I_{min}} = \frac{12 - 8{,}2}{25mA} = 152\,\Omega$$

$$R_{min} = \frac{18 - 8{,}2}{I_{Zmax}} = \frac{18 - 8{,}2}{122mA} \approx 80\,\Omega$$

$$81 \leq R \leq 152\,\Omega$$