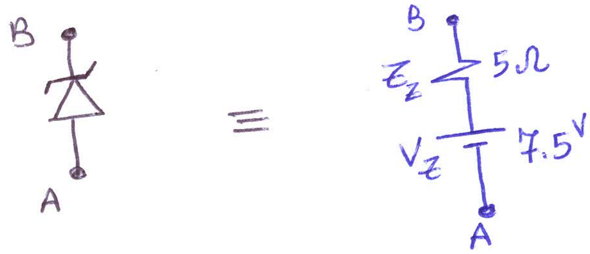
Ch.3 Homework solutions

Zener Diode

1 $V_Z = 7.5^V$, $Z_Z = 5\Omega$

∴ 

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2 From the characteristic curve :

the zener knee current = approximate minimum current ; I_{ZK}

$$I_{ZK} \simeq 3\,mA$$

at which $V_Z \simeq -9\ V$

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3 $\Delta I_Z = 30 - 20 = 10\ mA$; $\Delta V_Z = 5.65 - 5.6 = 50\ mV$

$$\because\ Z_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{50\,mV}{10\,mA}$$

$$\therefore\ \boxed{Z_Z = 5\ \Omega}$$

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4 Given : $Z_Z = 15\,\Omega$, @ $I_Z = 25\,mA$, $V_Z = 4.7^V$. Required : V_Z at $I_Z = 50\,mA$

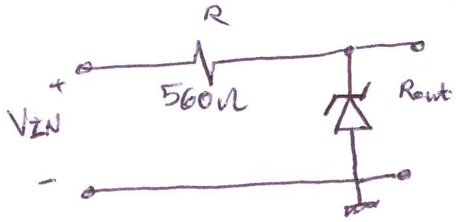
$$\because\ \Delta I_Z = 50\,mA - 25\,mA = 25\,mA$$

$$\because\ Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

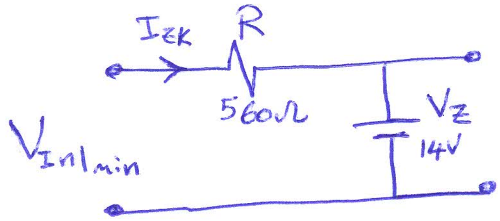
$$\therefore\ 15 = \frac{V_Z(50\,mA) - 4.7}{25\,mA}$$

$$\therefore\ \boxed{V_Z(50\,mA) = 5.075\ V}$$

6 ideal zener, $I_{ZK} = 1.5\,mA$, $V_Z = 14^V$. Req: $V_{in\,min}$ for regulation



the equivalent circuit: "ideal mode"



$$\therefore V_{In|min} = I_{ZK} R + V_Z$$

$$= (1.5\,mA)(560) + 14$$

$$= 1.5 * 10^{-3} * 560 + 14$$

$$\therefore \boxed{V_{In|min} = 14.84^V}$$ → min. input voltage that can be regulated.

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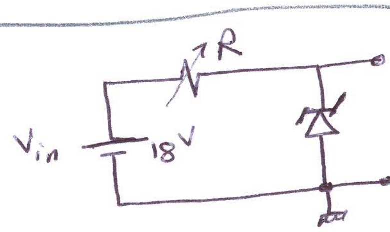
8 Given: $V_Z = 12^V$ @ $I_Z = 30\,mA$

$Z_Z = 30\,\Omega$

$V_{IN} = 18^V$



Req: $R = ??$ for $I_Z = 40\,mA$

$\because I_Z = \frac{V_{In} - V_Z}{R}$ $\therefore R = \frac{V_{IN} - V_Z}{I_Z} = \frac{18 - V_Z(40\,mA)}{40\,mA}$

$\because Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$ $\therefore 30 = \frac{V_Z(40\,mA) - 12}{40\,mA - 30\,mA}$

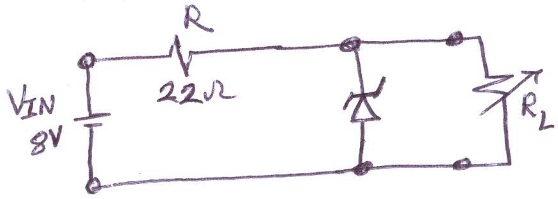
$$\therefore V_Z(40\,mA) = 12.3^V$$

$$\therefore R = \frac{18 - 12.3}{40\,mA} = \frac{5.7}{40 * 10^{-3}} \quad \therefore \boxed{R = 142.5\,\Omega}$$

10 Given: $V_Z(49\,mA) = 5.1^V$

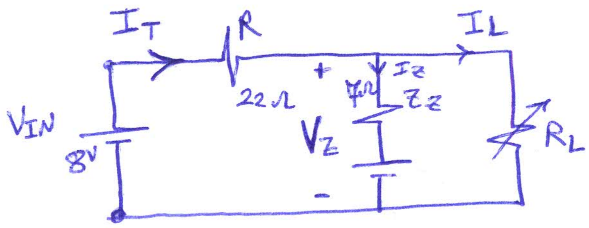
$I_{ZK} = 1\,mA$, $I_{ZM} = 70\,mA$

$Z_Z = 7\,\Omega$



Req.: $I_{L|min}$, $I_{L|max}$

The equivalent circuit model: "Practical model"



$\because I_L = I_T - I_Z \quad \therefore I_{L|min} = I_T - I_{Z|max} = I_T - I_{ZM}$

$I_{L|max} = I_T - I_{Z|min} = I_T - I_{ZK}$

$$I_T = \frac{V_{IN} - V_Z}{R}$$

$\because Z_Z = \frac{\Delta V_Z}{\Delta I_Z} \quad \therefore \Delta V_Z = \Delta I_Z Z_Z$

→ $I_{L|min} = ??$

$\therefore V_{ZM} = 5.1 + (70\,mA - 49\,mA) * 7 = 5.247$

at which $I_T = \frac{8 - 5.247}{22} \simeq 125.14\,mA$

$\therefore I_{L|min} = 125.14 - 70 \quad \therefore \boxed{I_{L|min} = 55.14\,mA}$

→ $I_{L|max} = ??$

$V_{ZK} = 5.1 - (49 - 1) * 10^{-3} * 7 = 4.764^V$

at which $I_T = \frac{8 - 4.764}{22} \simeq 147.1\,mA$

$\therefore I_{L|max} = 147.1 - 1 \quad \therefore \boxed{I_{L|max} = 146.1\,mA}$