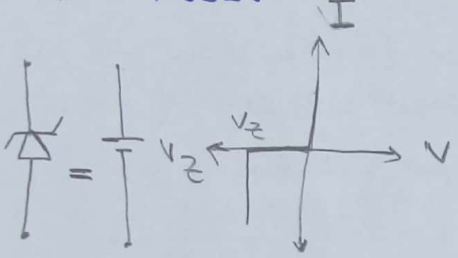
⇒ The Zener Diode

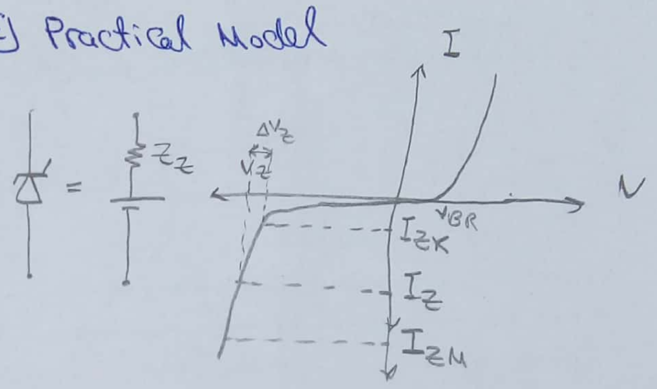
The Zener is a silicon PN Junction that is designed to operate in the reverse breakdown region . when the Zener reaches reverse breakdown , its voltage remains constant even though the Current changes drastically.

⊛ Zener equivalent Circuits

[1] Ideal Model



[2] Practical Model



→ $Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z}$

→ I_{ZK} is the minimum reverse current required to keep the Zener in breakdown for voltage regulation

→ I_{ZM} is the maximum reverse Current above it the Zener May be damaged.

note that $I_{ZK} < I_Z < I_{ZM}$ to keep the reverse voltage across the Zener Constant.

→ The Zener voltage Change with the Change in temperature according to

$$\Delta V_Z = V_Z * TC * \Delta T$$ where TC is percentage

$$\Delta V_Z = TC * \Delta T$$ where TC is in mV

$$I_{ZM} = \frac{P_{D(max)}}{V_Z}$$

⊛ Zener Diode Application

1- Zener regulation with a variable input voltage.

2- Zener regulation with a variable load.

3 - Zener limiter

Line regulation $= \dfrac{\Delta V_{out}}{\Delta V_{in}}$

Load regulation $= \dfrac{V_{NL} - V_{FL}}{V_{FL}}$

Sheet # 5

[1] given $Z_Z = 15\,\Omega$, $V_{Z_1} = 4.7\,V$ at $I_{Z_1} = 25\,mA$

find V_{Z_2} at $I_{Z_2} = 50\,mA$.

➡

$$Z_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{V_{Z_2} - 4.7}{(50-25)*10^{-3}} = 15 \Rightarrow V_{Z_2} = 5.075\,V$$

[2] given $V_Z = 6.8\,V$ at $25°C$ and $TC = +0.004\%/°C$

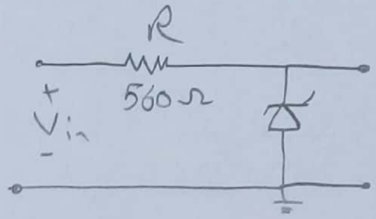
Find V_Z at $70°C$

➡

$$\Delta V_Z = V_Z * TC * \Delta T = 6.8 * (0.004/100) * (70-25) = 12\,mV$$

then the Zener voltage at $70°C$ $= V_Z + \Delta V_Z = 6.8 + 0.012 = 6.812\,V$

[3] given $I_{ZK} = 1.5\,mA$ and $V_Z = 14\,V$

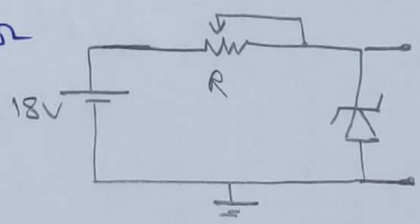


➡ $V_{in(min)} = V_R + V_Z = I_{ZK} * R + V_Z$

$V_{in(min)} = 1.5 * 0.56 + 14 = 14.84\,V$

[4] given $V_Z = 12\,V$ at $I_Z = 30\,mA$ and $Z_Z = 30\,\Omega$

find R for $I_Z = 40\,mA$



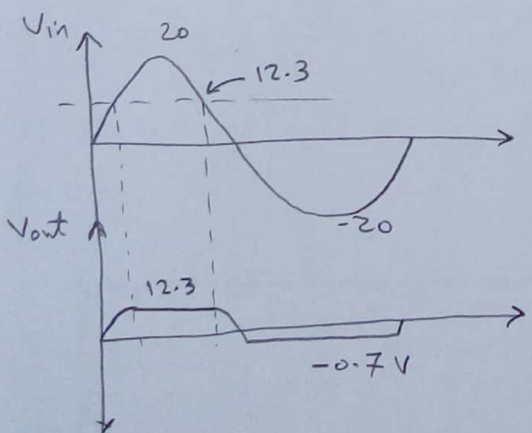
➡

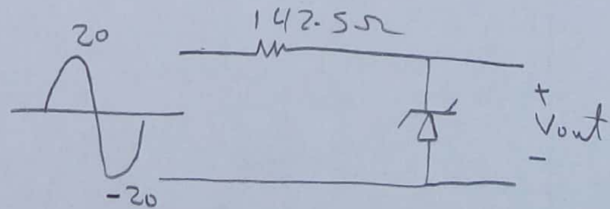
$\Delta V_Z = \Delta I_Z\, Z_Z = (40-30)*10^{-3} * 30 = 0.3\,V$

then V_Z at $I_Z = 40\,mA$ $= V_Z + \Delta V_Z = 12 + 0.3 = 12.3\,V$

$V_R = V_{in} - V_Z = 18 - 12.3 = 5.7\,V$

then $R = 5.7 / 40\,mA = 142.5\,\Omega$

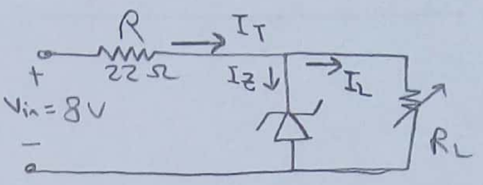




5 given $V_Z = 5.1\text{ V}$ at $I_Z = 49\text{ mA}$, $I_{ZK} = 1\text{ mA}$, $I_{ZM} = 70\text{ mA}$ and $Z_Z = 7\Omega$

find $I_{L(min)}$, $I_{L(max)}$

⇒



✱ Maximum Load Current.

$$V_{Z(min)} = V_Z - \Delta I_Z Z_Z$$

$$V_{Z(min)} = 5.1 - (49-1)\times10^{-3}\times 7 = 4.764\text{ V}$$

$$I_T = [V_{in} - V_{Z(min)}]/R = (8-4.764)/22 = 147\text{ mA}$$

$$I_{L(max)} = I_T - I_{ZK} = 146\text{ mA}$$

✱ Minimum Load Current

$$V_{Z(max)} = V_Z + \Delta I_Z Z_Z = 5.1 + (70-49)\times10^{-3}\times 7 = 5.247\text{ V}$$

$$I_T = (V_{in} - V_Z)/R = 125.1\text{ mA}$$

$$I_{L(min)} = I_T - I_{ZM} = 55.1\text{ mA}$$

✱ Example: Determine the output voltage waveform for each circuit