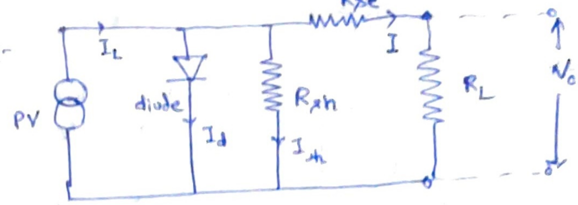
Equivalent Circuit of Solar Cell
Figure of merits of Solar Cell

O/p principle of solar cell is photovoltaic effect....

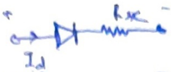
~~Figure of merits of solar cell:-~~

Eq ckt of solar cell:-



... In presence of illumination

In absence of illumination



$$I_d = I_0\left\{e^{\frac{q(V-IR_s)}{nKT}} - 1\right\}$$

$$I = I_0\left\{e^{\frac{q(V-IR_s)}{nKT}} - 1\right\} - I_L + \left[\frac{V-IR_s}{R_{sh}}\right]$$

Figure of Merit of Solar Cell:→

① Short ckt current (I_{sc}) ⓘⓘ Open ckt Voltage (V_{oc})

ⓘⓘⓘ Curve Factor ~~or~~ Fill Factor (FF) ⓘⓥ Efficiency

ⓥ Diode Identity Factor ⓥⓘ Parasitic Resistance,

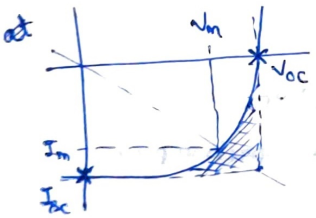
① Short ckt Current (I_{sc})

Considering shunt resistance $R_{sh} \simeq 100\Omega$, then $\left[\frac{V-IR_s}{R_{sh}}\right] \to 0$

$$\therefore I = I_0\left\{e^{\frac{q(V-IR_s)}{nKT}} - 1\right\} - I_L$$

where I_0 → Reverse Sat current
K → Boltzman Const.
n → diode ideality factor
T → Temp in K
I_L – Light generated current

at



At $V=0$, $I = I_{sc}$

$$I_{sc} = I_0\left\{e^{\cancel{\frac{-qIR_s}{nKT}}} - 1\right\} - I_L \quad \therefore I_{sc} \approx -I_L$$

ⓘⓘⓘ Fill Factor = defines degree of squareness of I-V-curve

$$= \frac{V_m I_m}{V_{oc} I_{oc}}$$

ⓘⓘ Open ckt Voltage (V_{oc})

At $I=0$, $V = V_{oc}$

$$0 = I_0\left\{e^{\frac{qV_{oc}}{nKT}} - 1\right\} - I_L$$

$$\therefore e^{\frac{qV_{oc}}{nKT}} = 1 + \frac{I_L}{I_0} \quad \text{or}$$

$$\text{Or } V_{oc} = \frac{nKT}{q}\ln\left(\frac{I_L}{I_0}\right) \Rightarrow V_{oc} = \frac{nKT}{q}\ln\left(\frac{I_{sc}}{I_0}\right)$$

$I_0 \sim 10^{-6} A \therefore \frac{I_L}{I_0} \gg 1 \qquad I_L \approx I_{sc}$

ⓘⓥ Efficiency (η)

$$= \frac{\text{OutPut}}{\text{Input}} = \frac{I_m V_m}{\underset{(A_c)}{\text{Cell Area}} \times \underset{(P_{in})}{\text{Power Input}}} \times 100\%$$

from solar radiation dd.

$$= \frac{I_{sc} V_{oc}}{A \times P_{in}} \times FF \times 100\%$$

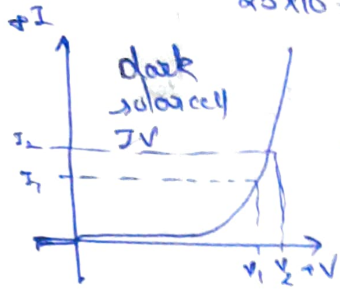
Now $I_{sc} \propto I_{int}$

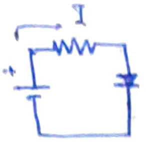
$V_{oc} \propto \ln(k I_{int})$

(v) diode ideality factor n or A

$$A = \frac{V_1 - V_2}{25\times10^{-3}\ln(I_1/I_2)}$$

where I_1, I_2, V_1, V_2 are respective voltage & current at diff pts during dark condn





In dark condition

$$I = I_0\left\{e^{\frac{q(V-IR_s)}{AKT}} - 1\right\}$$

$\because$ $V \gg IR_s$ & V is very high

$$\therefore I = I_0 e^{\frac{qV}{AKT}}$$

$$\therefore \frac{I_1}{I_2} = e^{\frac{q}{AKT}(V_1-V_2)}$$

$$\therefore (V_1 - V_2) \times \frac{q}{AKT} = \ln\left(\frac{I_1}{I_2}\right) \Rightarrow A = \frac{V_1 - V_2}{\ln(I_1/I_2)}\left(\frac{q}{KT}\right)$$

now at T = 300 K, $\frac{KT}{q} = 0.025$ $\therefore$ $A = \frac{V_1 - V_2}{\ln(I_1/I_2)\times25\times10^{-3}}$

(vi) Parasitic Resistances :- (R_s & R_{sh})

R_s has great influence on I_{sc} & FF

R_s has min influence on V_{oc}

In real cells power is dissipated through the resistance of the contacts & leakage resistance of device. These are effects are equivalent to a parasitic res R_s, R_{sh}

R_s arises from resistance of the cell material to current flow, particularly through the front surface to the contacts & from resistive contacts. Series resistance is a particular problem at high current densities, for instance under concentrated light.

R_{sh} arises from leakage of current through the cell, around the edges of the device & bet the contacts of diff polarity. It is a prob in poor rectifying devices.

Both R_s & R_{sh} have big impact on cell performance. Both of them reduce FF & ultimately η.

R_s to be kept as low as possible & R_{sh} as ↑ as possible