RENEWABLE ENERGY SYSTEMS 402

TUTORIAL # 1

12.08.07

SOLUTIONS

Problem 1:

Given PV Cell Parameters

Cell area : $0.005\ m^2$

Reverse Saturation Current $I_o = 10^{-11}$ Amps

Insolation : $1000\ W/m^2$

Short-Circuit Current I_{sc} : ~~Amp~~ 1.5 Amps

Temperature : 25°C

a) Cell Open Circuit Voltage :

$$V_{oc} = 0.0257 \ln\left(\frac{I_{sc}}{I_o} + 1\right) \text{ Volts}$$

$$= 0.0257 \ln\left(\frac{1.5}{10^{-11}} + 1\right) \text{ Volts}$$

$$\simeq 0.0257 \ln\left(\frac{1.5}{10^{-11}}\right)$$

$$= 0.0257 \times 25.73 = \underline{0.6613} \text{ Volts.}$$

b) The load Current when the O/P Voltage is 0.5 Volts

Diode Current $I_d = I_o \left(e^{qV_d/KT} - 1\right)$

$q = 1.602 \times 10^{-19}$ Coulombs, $K = 1.381 \times 10^{-23}$

Boltzman's Const.

T = Temp. in Kelvin = $273 + 25 = 298\ K$

Then $I_d = I_o \left[e^{38.9 V_d} - 1 \right]$

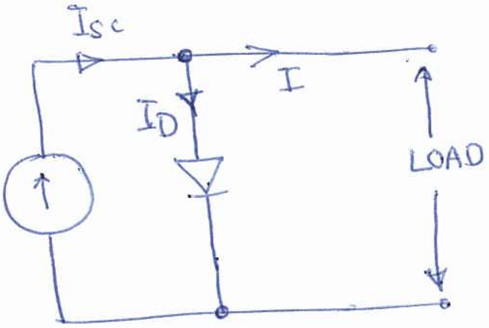
$V_d \rightarrow$ Diode Volt. drop.

$$I_d = 10^{-11} \left[e^{38.9 \times 0.6} - 1 \right]$$

$$= 10^{-11} \left[e^{23.34} - 1 \right] \approx 0.137 \text{ Amps}$$

$$= \underline{137 \text{ mA}}.$$

Now $I = I_{sc} - I_d$



PV Equivalent Circuit

Accordingly $I = 1.5 - 0.137 = 1.363$ Amps

c) Power delivered to the load = $1.36 \times 0.5 = 0.68$ Watts

d) Efficiency Of the Cell at $V = 0.5$ Volts.

$$\eta\% = \frac{P_{out}}{P_{in}} \times 100$$

$P_{out} = 0.68$ Watts ; $P_{in} = 1000\ W/m^2 \times 0.005\ m^2$ area

$= 5$ Watts Solar Power I/P

$$\therefore \eta\% = \frac{0.68}{5} \times 100 = \underline{13.6\ \%}$$

Problem 2 :

$$T_{cell} = T_{ambient} + \left(\frac{NOCT - 20}{0.8}\right) \cdot \overset{\text{in kW/m}^2}{S}$$

a) $$T_{cell} = 25 + \left(\frac{50 - 20}{0.8}\right) \cdot 1$$

$$= 25 + 37.5 = 62.5^\circ C$$

Max. Power drops by 0.5 % / deg C

PV module Power = 100 Watts (Given)

So. Max. Power @ ambient temp. of 25°C is

$$P_{max} = 100\left[1 - 0.005\,(62.5 - 25)\right]$$

$$= 100\left[1 - 0.005\,(37.5)\right]$$

$$= 81.75 \text{ Watts.}$$

∴ Drop of 18.75 % from the module power of 100 Watt.

b) $$T_{cell} = 0 + \left(\frac{45 - 20}{0.8}\right) \times 0.5$$

$$= \left(\frac{25}{0.8}\right) \times 0.5 = 15.625^\circ C$$

$$P_{max} = 100\left[1 - 0.005\left(15.625 - 0\right)\right]$$

$$= 92.1875 \text{ Watts}$$

∴ Drop of 7.81 % from the rated power of 100 Watts.

c) $T_{cell} = 30 + \left(\frac{45-20}{\cancel{0.8}}\right) \times \cancel{0.8}$

$= 30 + 25 = 55^{\circ}C$

$P_{max} = 100\left[1 - 0.005\left(55-30\right)\right]$

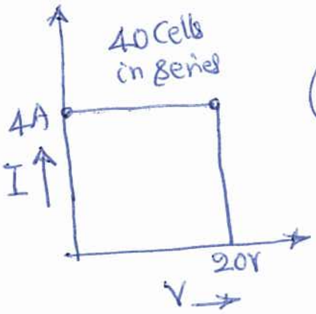
$= 87.5$ Watts

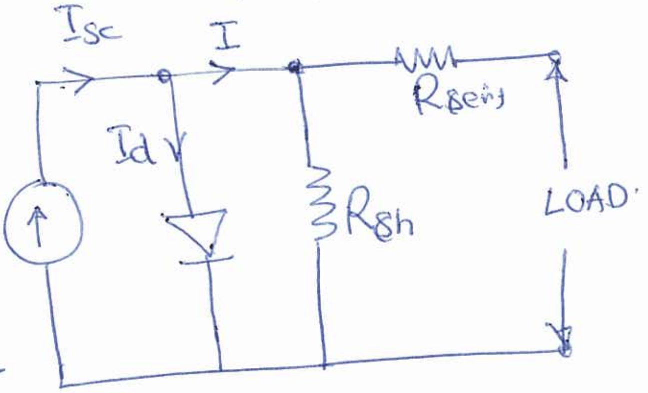
∴ Drop of 12.5 % from the rated power of 100 Watts.

3) 40 Cells in series ⟶ $40 \times 0.5V = 20$ Volts.

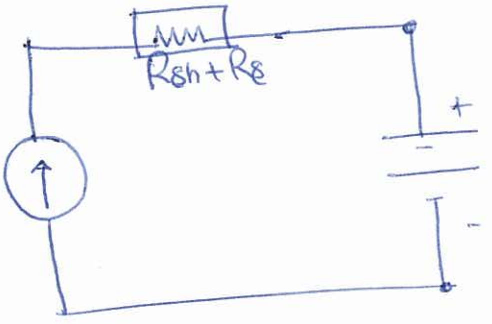
if 1 cell is shaded, there will be 39 cells — good ones

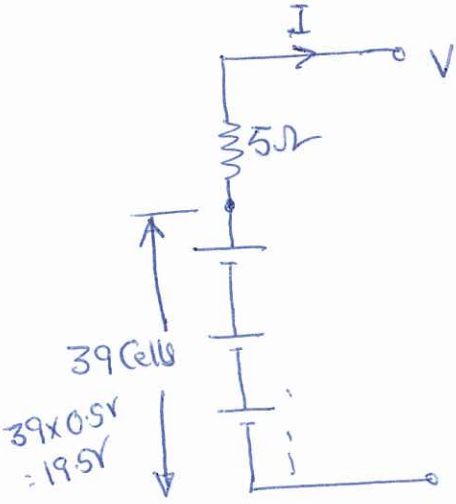
∴ $39 \times 0.5V = 19.5$ Volts.





Equivalent Circuit of P.V.





$I_{Battery} = \frac{19.5V - 12V}{5\Omega}$

$= 1.5$ Amps.

∴ Current is 1.5 Amps instead of 4 Amps.