Simulation of Stand-alone Photovoltaic System using Python

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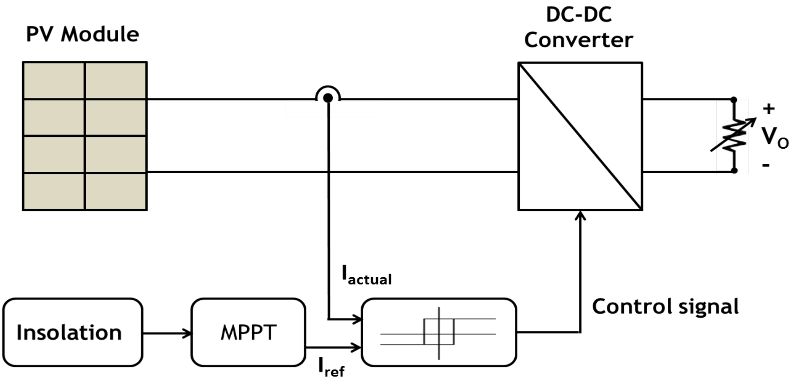
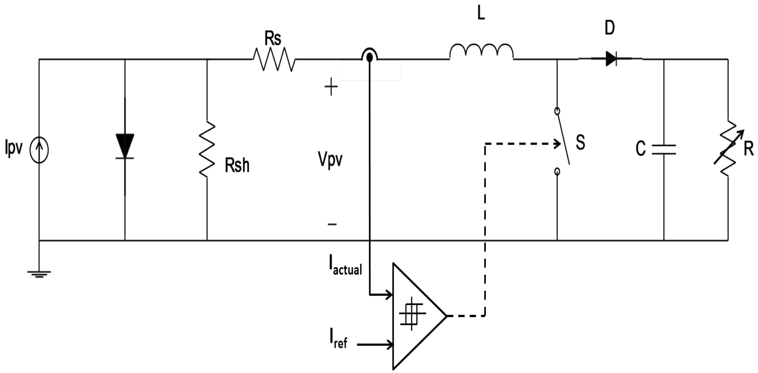
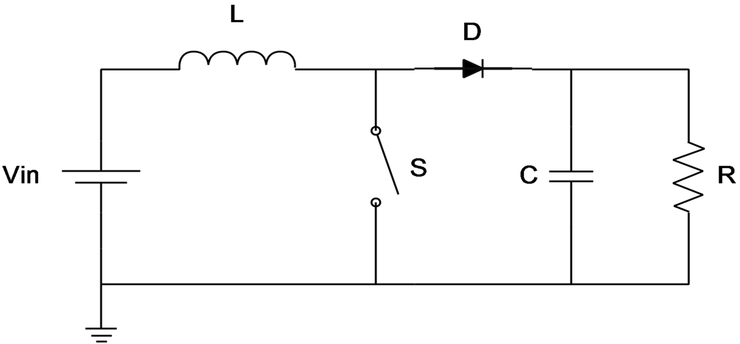
System Block Diagram



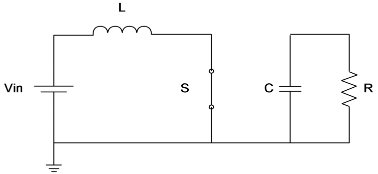
Circuit Diagram



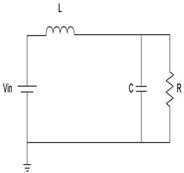
Boost converter



Case 1: when switch is ON



$$\frac{di}{dt} = \frac{1}{L}[V_{in} - (1 - S)V_c]$$



$$\frac{dV_{in}}{dt} = \frac{1}{C}[(1 - S)i - \frac{V_c}{R}]$$

Principal Symbols

- V_{pv} = PV module voltage
- I_{pv} = PV module currrent
- I_{ph} = Photo current
- I_{rs} = Reverse saturation current
- n_s = Number of cells connected in series
- n_p = Number of cells connected in parallel
- R_s = Series Resistance
- R_{sh} = Shunt Resistance
- T = Temperature in Kelvin
- B = Ideality factor of the diode
- q = Electron charge (1.602×10^{-19} C)
- K = Boltzmann's constant (1.38×10^{23} J/K)

PV Module: Mathematical Model

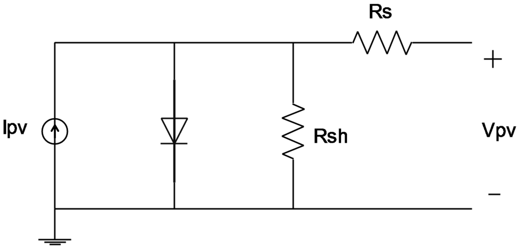


Figure: Typical PV cell

$$V_{pv} = (\frac{n_s kTB}{q}) * ln[\frac{n_p I_{ph} - I_{pv} + n_p I_{rs}}{I_{rs}}] - R_s I_{pv}$$

Electrical Characteristics

Symbol	Quantity	Value
P_{max}	maximum power	5.0 W
V_{max}	Voltage at P_{max}	17.2 V
I_{max}	Current at P_{max}	0.29 A
I_{sc}	Short circuit current	0.32 A
V_{oc}	Open circuit voltage	21.0 V

Results

VI characteristics of PV module at different insolations

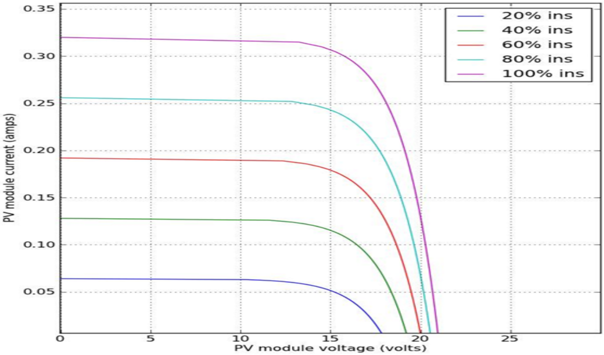


Figure: VI characteristics

Results

Power curves of the PV module at different insolations

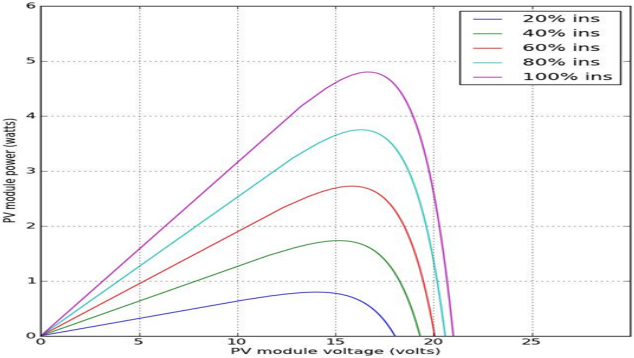
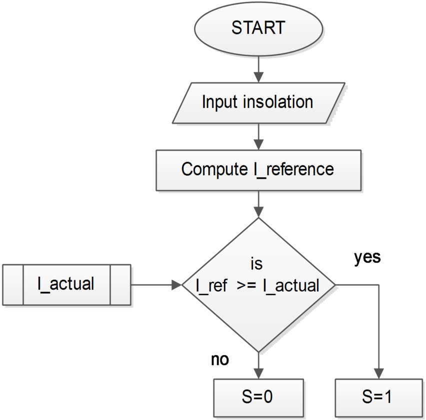


Figure: Power curve

Why Python?

- Python has all the features present in the other simulation softwares.
- Free and Open Source.
- Possibility of improving performance comparable to compiled languages.
- Possibility of developing GUI application.



flowchart to generate the switching pulses at MPP

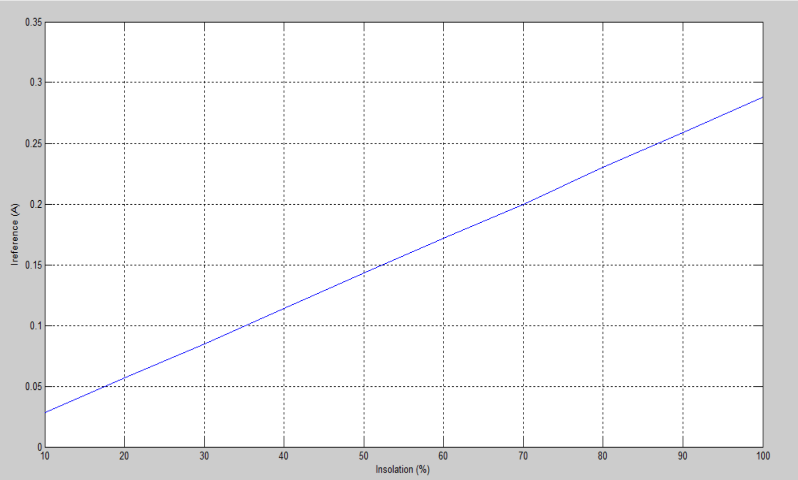
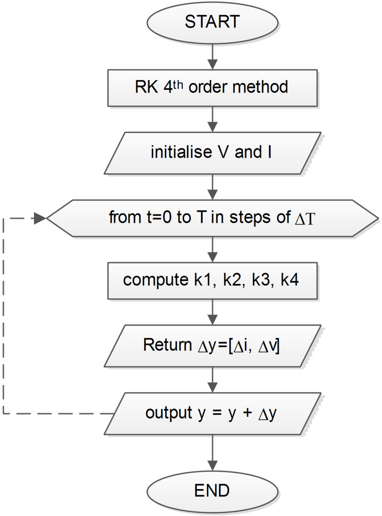
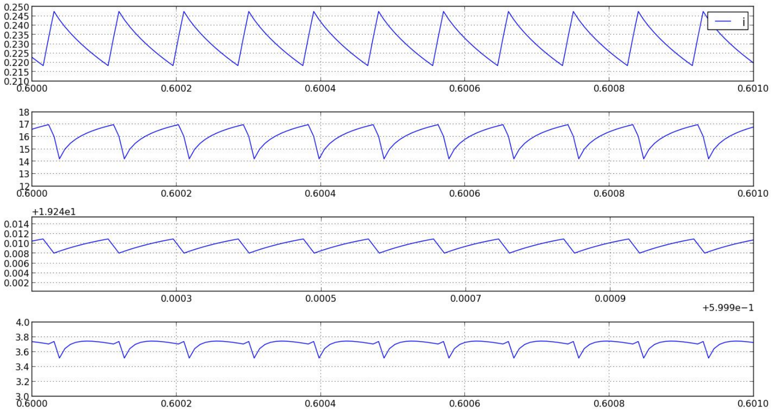


Figure: Plot of Ireference Vs Insolation



flowchart for system simulation

Results



0.250
0.245
0.240
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0.230
0.225
0.220
0.215
0.210
i
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18
17
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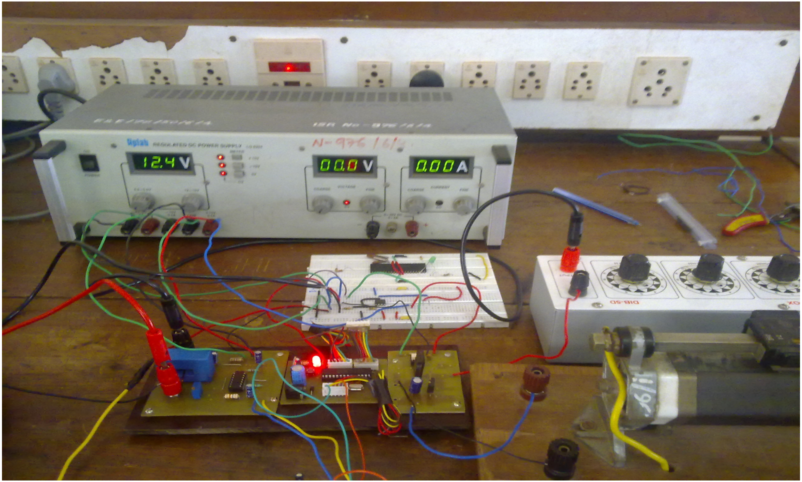
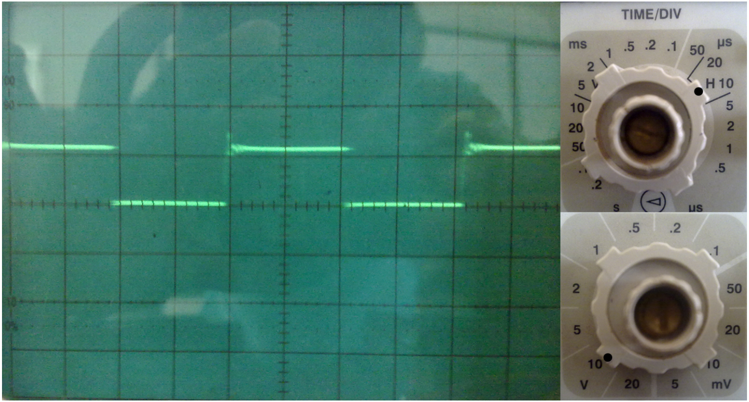
15
14
13
12
+1.924e1
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.0003
0.0005
0.0007
0.0009
+5.999e−1
4.0
3.8
3.6
3.4
3.2
3.0



Experimental setup

Results



Dutycycle when $R_{load} = 150$ ohms

Conclusion

- The system simulation has been carried out for one value of insolation & hysterisis band control has been used for generating switching pulses.
- Further the simulation can be carried out for different insolation levels.
- MPP tracking algorithms can be implemented.

References

E. Koutroulis, K. Kalaitzakis, and N.C.Voulgaris, *Development of a microcontroller-based, photovoltaic maximum power point tracking control system*, IEEE Transactions on Power Electronics, vol.16, no.21, pp. 4654, Jan.2001.

THANK YOU