PERFORMANCE OF PV SYSTEM MODELLING ON SIMULINK/MAT LAB

1. Om Prakash Singh 2. Dr. D.K Bhalla

Abstract:

There is a need of development of high-performance conversion system and study of effects of environmental parameters to make it economic viable and stable in integration with the utility grid. The PV system produces electric power with no hampering the atmosphere by straight converting the solar radiation into electric power. On the other hand, the solar radiation, not at all, remains stable. It keeps on unstable all over the day. The demand of the hour is to send invariable voltage to the grid irrespective of the deviation in solar irradiance and temperatures. The consumer wants to run the solar panel at its maximum energy transfer output by constantly utilizing the highest accessible solar power of the panel.

Key words; maximum power point tracking, open- circuit voltage, characteristic. MATLAB,

Grid, solar irradiance, and temperatures

1. INTRODUCTION:

Here are mainly two skills that utilized sunlight energy, namely solar thermal and PV cell. A solar PV cell converts the solar energy into the electrical energy by the photovoltaic consequence. Energy as of solar modules proposes numerous compensations, like requirement of small repairs and no ecological contamination. Solar module presents the basic power exchange element of a PV generator scheme. The output feature of solar module depends on the cell temperature and the solar insulation. As solar modules have nonlinear characteristics, it is essential to mold it for the aim and simulation of maximum power point tracking (MPPT) for solar system uses[1].

A module normally has a numeral of solar cells in series. The predictable system to representation a solar cell is to revise the p-n junction physics [2]. A solar cell contains a non- linear current-voltage (V-I) characteristic that is to be modeled by means of diode(s), resistors, and current source. Double-diode and single-diode models are generally utilized to create PV characteristics.

Solar PV Cell:

PV cells changes the sunlight honestly to electricity. They are fundamentally completed of a PN junction. **Fig.1(a)** presents the PN junction and **1 (b)** presents the solar current generation principle of PV cells. Actuality, as soon as sunlight falls on the solar cell, the photons are held by the semiconductor atoms, bitter electrons from the negative level. These liberated electrons find its pathway throughout an outdoor circuit towards the positive level consequential in an electricity current from the positive level to the negative one.

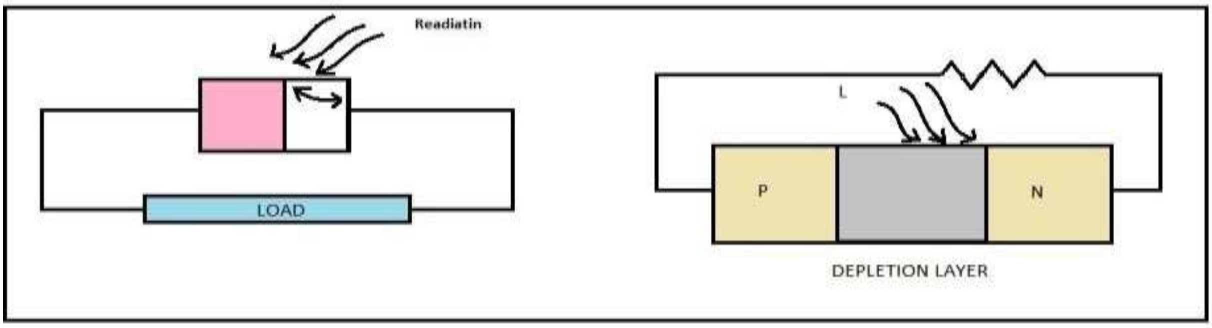


Fig. 1 (a) PN Junction Fig 1(b) Photo Current Generation

A solar cell produces a voltage something like 0.6 to 0.8 volts depending on the semiconductor and the built-up expertise. The voltage is very small, insufficient, as it is of no use. Consequently, to get advantage from this expertise, tens or more of solar Cells are linked in series to form a module. These modules will be interrelated in series and or parallel to make a panel. When the modules are linked in series, their voltages are additional with the same current and when they are joined in parallel; their currents are additional though voltage is same. But there are two main troubles with solar generation systems. One is the small transfer efficiency of solar power into electrical power and the additional is the non-linear individuality of solar panel that makes the electrical generated power vary with solar irradiation and temperature. PV Cell Operating Points: The current-voltage working distinctiveness of a solar cell has been illustrated in Fig 2. The parameters of a PV array are estimated in the ways given below.

$Itot = Np$ Is

$Vtot = NS$ Vs

$Rs,tot = NS\ Rs$ (1)

Where,

$Itot$ = Total current of PV module; $Vtot$ = Total voltage of PV module;

Rs,tot = Total series resistance of PV module; Rs = series resistance of PV module;

NS = Number of PV cells in series; Np = Number of PV cells in parallel,

The voltage output of PV module is estimated via multiplying the number of cells joined in series with the voltage of an individual cell and total current through multiplying the number of cells associated in series with the current of an individual cell. Similarly, the series and parallel resistance of PV array can be estimated. There are three important points on the current V/S voltage characteristics. The points are short-circuited current, open circuit voltage, and maximum power point. These points are identified operating points.

The open-circuit voltage is represented by point A on the working characteristics of a PV array as shown in fig 2. The corresponding circuit at O.C condition has been presented in fig 2. and neglecting the shunt resistance (Rsh), the equations (2) and (3) are to be utilized to symbolize the open- circuit voltage. and PV array current.

Fig. 2: Solar array operating points.

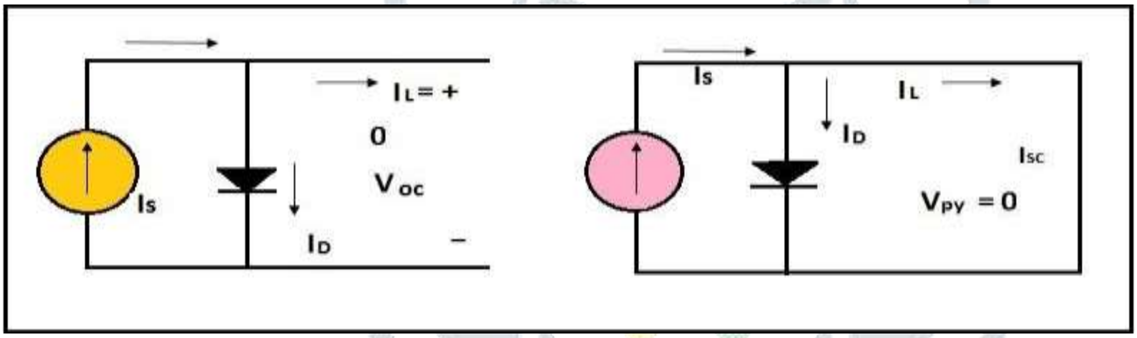


Fig..3 (a): Electrical circuit at O.C condition Fig.3(b): Electrical circuit at S.C condition

- $I_s - I_0[\exp(\frac{VOC}{\propto}) - 1] = 0$ (2)
- $V_{OC} = \propto \ln(\frac{il+I0}{I0})$ (3)

The current at point B in graph **fig 2.** represents the short-circuit current. The equivalent circuit at short circuit condition is shown in fig3., Neglecting; the series resistance, short circuit is represented by equation (5)

Isc = Is (5)

- *The load current at short circuit condition becomes equal to the solar current generated by PV module and the output voltage becomes zero. In case of open circuit voltage, the load current becomes zero, while the open circuit voltage will be the maximum voltage of the PV module.*

2. Load Characteristics Curve:

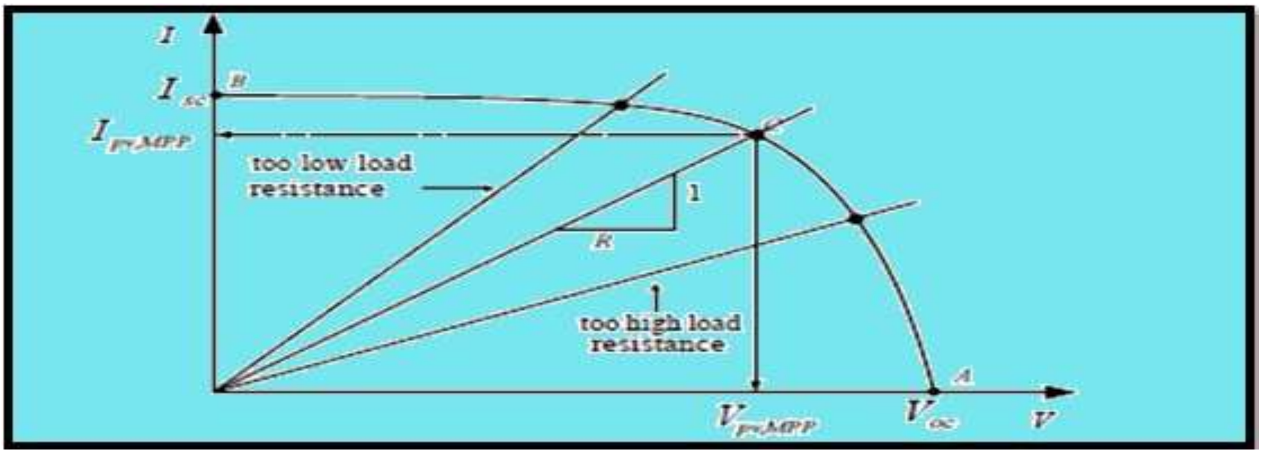


Fig.4: Working site of a PV module under stable irradiance and temperature

The meeting point of the load characteristics *and I-V* characteristics is the working point of a solar array under stable irradiance and solar cell temperature as shown in **Fig.4**.The load characteristic is signified via a straight line by means of slope *M=1/R= I Load/V*. The working spot moves about through the side of the *I-V* typical graph, i.e. from point B to point A, as load resistance enlarges beginning 0 to ∞. The utmost power spot lies at B, wherever the area below the *I-V* characteristic graph is highest. In favor of very high load resistances, the working spots leaves in to the CA section. For very-low load resistances, the working spot leaves in to the CB section. The highest power point is to be consequently, attained via matching load resistance to PV panel distinctiveness [10].

3. Solar array characteristics:

The solar current is non- linear variable and its value depends on solar irradiance. The output voltage and current of a solar module changes with variation in temperature and irradiance [5] The characteristics of PV-cell depend on insulation and temperature. These equations are evaluated for some selected values of irradiance and temperature. The I-V graph is plotted from the evaluated values.

- The output current (I_S) of a PV array *is* subjective to change in values of insulation *S*, while, output voltage (V_o) is about stable, as shown in **Fig.5(a)**. Defiantly, for the temperature so as to changes, output voltage appears to vary generally, but current is unaffected; as shown in **Fig.5(a).** The *P-V* characteristics of solar module are to be get as of *I-V* characteristics. The power output relationship is presented as ***P=Vo.I.*** The figure confirms the belief of current output I and voltage output on temperature and insulation interpret into trust of power output on Vo and I.

- The expected behavior of a solar-energy-conversion system is also confirmed from **fig.**5 (b). The output power decreases by declining in the value of irradiations. The decreased-power results from enlarged panel-temperature is not instantly clear, however is concordant through considerable consequence on open-circuit voltage Voc.

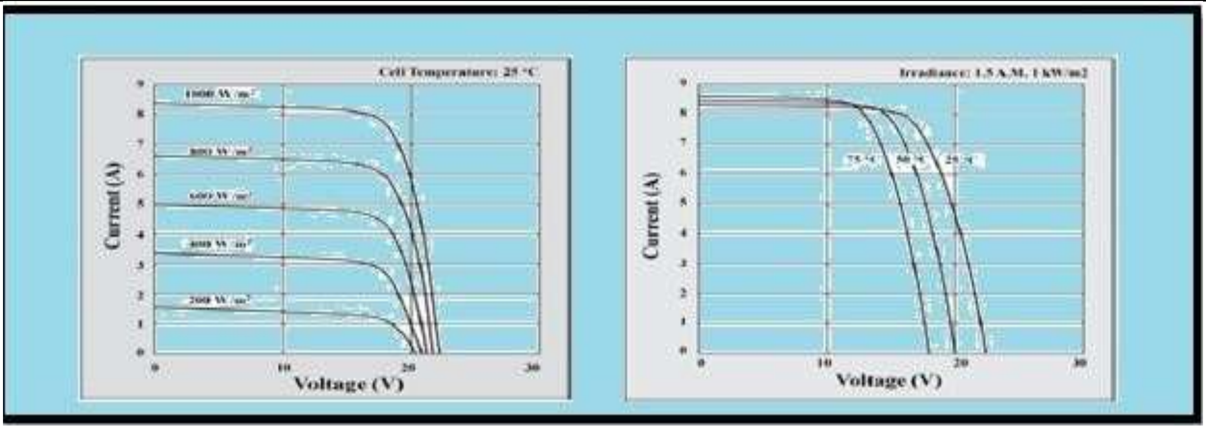


Fig 5: I-V graphs of a PV module [11] (a) for divergent values of irradiance S at 25℃
(b) for dissimilar values of temperature T at 1000W/m2

4. Correlation between Open Circuit Voltage and Temperature:

The voltage Output of a module, is in fact a changeable value, that is dependent on temperature. There is in fact a reverse correlation between module voltage and temperature. As soon as the module ‘s temperature is increased, the value of voltage decreases and vice versa. It is tremendously compulsory to judge the hot and cold temperatures throughout PV arrangement as presented in PV calculations in [6] [9] [7]. When the module's temperature is less than the standard test condition value of 25°C, the module ‘s opens circuited voltage, Voc value will, really, be better than the value mentioned in label he voltage Output of a module, is in fact a changeable value, that is dependent on temperature which is tremendously compulsory to judge the hot and cold temperatures throughout PV arrangement as presented in PV calculations in [6] [9] [12]. When the module's temperature is less than the standard test condition value of 25°C, the module ‘s open circuited voltage, Voc value will, really, be better than the value mentioned in label.

A case to the point, while the PV module get colder with 1°C, the solar voltage will raise by 8.7%. [2], [9] [7]. lett‘s assume the most terrible case of temperatures has been taken in [4] it shows for the facts recorded the standard maximum temperature was 14.4**°C** with irradiance of 123W/m2h in the month of December. Whereas the minimum standard temperature was obtained in January and the facts recorded was - 3.4°C with irradiance of 18W/m2 h. Considering as noted in [7], the functioning temperatures of the module is to be from -10°C to 50°C.

$$V_{OC} = V_{OC,SC} - [\, \beta \times (T - T_{STC}) \,] \qquad (5)$$

were,

V_{OC} = open circuit voltage, (V) $V_{OC,SC}$ = open circuit voltage at standard condition

β = voltage temperature coefficient, T = temperature of PV module at any instant Consequently using equation (5) for the most terrible atmosphere conditions we have the lowest and highest open circuit voltage as 296.9V and 302.2V respectively. This gives the voltage alteration of around to ΔV

5. Simulations of I-V curves and PV Curve

The current generated by PV module is directly proportional to light density Advanced levels of irradiance will drive extra electrons to run from the PV cells to the attached load. Conversely, the voltage produced by the PV module is exaggerated by the irradiance value, but the outcome is very small. As illustrated in Fig. 6, the voltage of module changes extremely small with unstable levels of irradiance. In the modules utilized in the here study system, the sun solar module has a coefficient of current of +0.0025 A/ °C [43]

1) Simulation of PV Module at standard condition:

- **Fig.6 (a**) shows, *I-V* graph for stable irradiances (1000W/m^2) and stable temperatures (25°C) **Fig.6(b)** Module's *P-V* graph for stable irradiances (1000W/m^2) and stable temperatures (25°C).

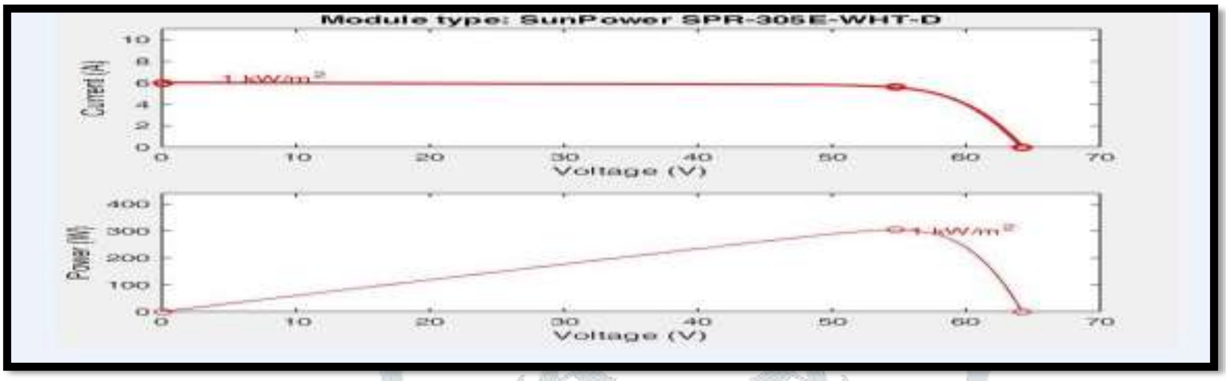


Fig 6 (a) Solar module for unpredictable irradiance and stable temperature

Fig 6(b): Solar module model for unpredictable temperature and stable irradiance

- **Fig.6 (a),** it presents solar module that has been modeled and simulated in Mat lab/for unpredictable irradiance and stable temperature at 25 °C. The model has been developed from equation (1) to (5).

2) Simulation when G varies from 400 to 1000 w/m² at 25°C.

Fig.7 (a) presents a *I-V* graph for variable irradiances and stable temperature, The irradiances vary between 400 to 1100 W/m2, while the temperature has been set up at 25°C While the irradiance is enlarged, the current is also raised. Voltage, whereas, continued comparatively stable all over the irradiance range. Fig.7(b) shows the P-V graph for variable irradiance and at 25°C constant temperatures.

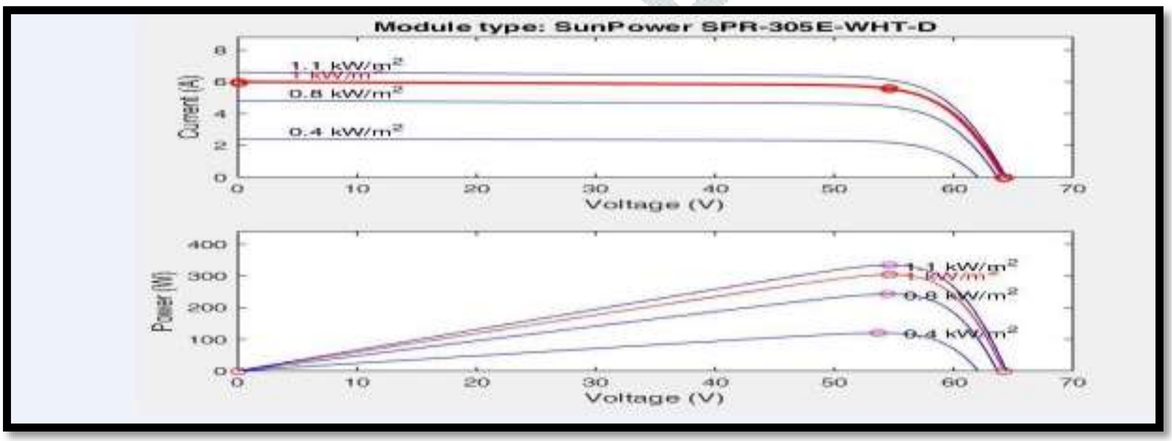
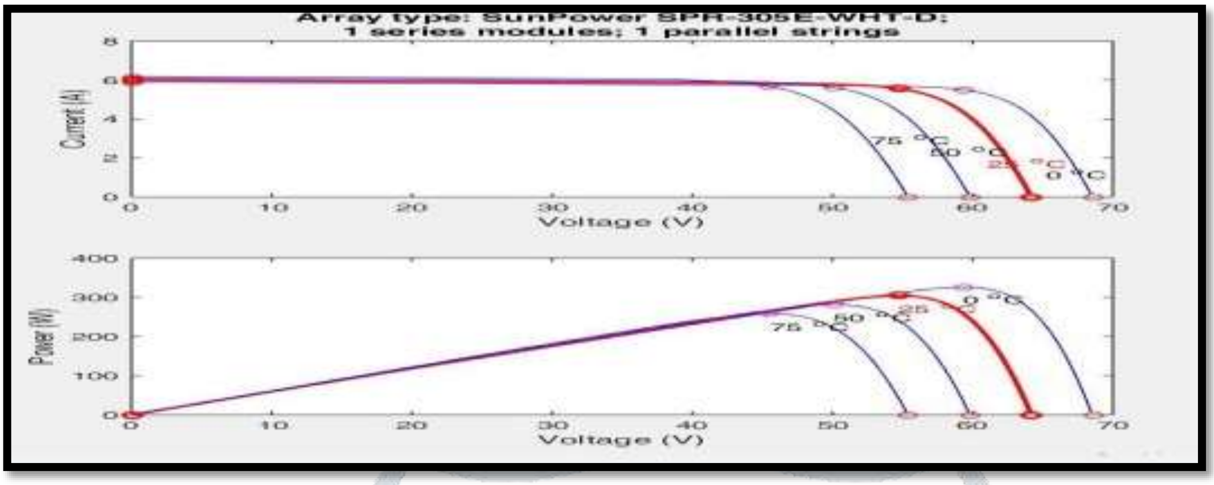


Fig. 7 Module's (a) *I-V* curves (b) *P-V* curves for unpredictable irradiance and stable temperature

3). Simulation when T varies from 0 °C to 75 °C, at 1000 w/m^2

The Output voltage of a module is dependent on temperature. There is in fact an opposite correlation between module voltage and temperature as illustrated in **Fig.8 (a) &(b)** As the module 's temperature is increased, the value of voltage decreases and vice versa. It has been observed that lesser the temperature, the maximum power is higher and the open circuit voltage is better. In addition, a smaller temperature provides to some extent small short circuit current.



.Fig. 8(a) Module's *I-V* (b) *P-V* for various temperatures and stable irradiance

Effect of series resistance changes

The standard P-V and I-V graph has been compared with the P-V and I-V curve of solar module. The I-V and PV graphs have been taken on Mat-lab with variable resistance in series and parallel to study the effect of variable resistance. The study shows that PV Cell has low series resistance. In some case, it is neglected. While, in the study the value of resistance is varied, to predict the effect of resistance on the output of the solar cell.

6. Simulation summary:

A solar cell model by means of Mat lab has been introduced. This model is on the basis of fundamental electrical circuit equations. The simulation results offer the viability of the projected model. A MATLAB draft permits to verify the panel output in unusual weather circumstances. It can be seen that a raise in temperature leads to reduce in open circuit voltage and a small decline in short circuit current for a specified solar irradiance whereas boost in irradiance leads to better boost in short- circuit current and small raise in open circuit voltage at a specified temperature.

The study shows the effects of parameters (Rs, Rsh) of the PV Cell on I-V and P-V curve. The simulation results also show that lesser the series resistance (Rs), privileged the open circuit voltage and in case of rising of shunt resistance (Rsh), output voltage increases. The optimal values of series resistance, and shunt resistance of reference module are 0.272Ω, and

271.6 Ω respectively at which highest power is obtained. The model has excellent accuracy in generating the P-V and I-V curves. Moreover, the model can be built for any general purpose in simulation software.

REFERENCES

1) C.Wang, "Modeling and Control of Hybrid Wind/Photovoltaic/Fuel cell Distributed Generation Systems," PhD Dissertation, Montana State University, Bozeman, 2006.

2) C.S.T. Huan-Liang Tsai, and Yi-Jie Su, "Development of Generalized Photovoltaic Model Using

MATLAB/SIMULINK," In *the World Congress on Engineering and Computer Science 2008*, San Francisco, USA, 2008.

3) Clean Energy Council, Tech Info Energy Efficient and Renewable Energy Bulletin.September2006.UpdatedNovember2009.http://www.solaraccreditation.com.a u/in stallerr sources'/tech info.html. accessed on November 10,2012

4) Configuration. IEEE Industrial Electronics, IECON 2006 - 32nd Annual Conference, ,

5) D. C. Martins, ―Analysis of a three-phase grid-connected PV power system using a modified dual-stage inverter,‖ International Scholarly Research Notices (ISRN) Re- newable Energy, vol. 2013, pp. 1–18, 2013.

6) D. L. Chandler, ―What can make a dent?‖ MIT News, Oct. 2011.

7) D. E. Rice, ―Adjustable speed drive and power rectifier harmonic—their effect on power systems components,‖ IEEE Trans. on Ind. Appl., Vol. IA-22, No. 1, Jan./Feb. 1986, 161.

8) *(EPEC), 2009 IEEE*, pp 1-5, Lab. de Investig. en Fuentes Alternativas de Energia (LIFAE), Univ. Distrital F.J.C., Bogota, Colombia, Oct. 2009. [Guillermo Velasco, Francesc Guinjoan, Robert Pique and Juan Jose Negron. Sizing

9) Energy Agency Implementing Agreement on Photovoltaic Power Systems, Report IEA PVPS T5-01, 1998.

10) *Energy, & Industry Applications*,pp 1-5, Sustainable Power Generation and Supply,

11) Enernex, ‖Integration Issues and Simulation Challenges of High Penetration PV,‖ Enernex, Knoxville, 2011 esources/tech-info.html. accessed on November 10, 2012

12) F. Blaabjerg, Z. Chen, and S. Kjaer, ―Power electronics as efficient interface in dispersed power generation systems,‖ IEEE Transactions on Power Electronics, vol. 19, no. 5, pp. 1184–1194, Sept. 2004