International Journal of Advanced Science and Technology
Vol. 29, No. 7s, (2020), pp. 5854-5860

PV - Wind Grid Connected System for the Rural Electrification

Shamshad Ali[1], Majid Jamil[2], M A Khan[3]
[1]*Department of Electrical and Electronics Engineering,*
Mewat Engineering College, Nuh,Haryana, India
[2] *Department of Electrical Engineering, Jamia Millia Islamia, New Delhi, India*
[3]*Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi, India*

Abstract

This paper present the experience acquired with a photovoltaic (PV) hybrid system simulated as an alternative to wind turbine with grid system for a residential home located in Haryana and Rajashthan, India. The hybrid system was designed to overcome the problem of climate change, to ensure a reliable supply without interruption, and to improve the overall system efficiency (by the integration of the rentable source). The system design philosophy was to maximize simplicity; hence, the system was sized using conventional simulation tool and representative insolation data. The system includes a 3.7 kW PV array, 10 kW load is connected. This paper deals with the generation of electricity by using two sources combine which leads to generate electricity with affordable cost without damaging the nature balance.

Keywords: *Solar Array, MPPT, STATCOM, 3-Phase inverter.*

1. Introduction

Electricity is most needed for our day- to-day life. There are two ways of electricity generation either by conventional energy resources or by non-conventional energy resources. Electrical energy demand increases day by day so to fulfill demand we have to generate electrical energy. Now-a-days electrical energy is generated by the conventional energy resources like coal, diesel, and nuclear etc. The main drawback of these sources is that it produces waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly, also damages the nature. The nuclear waste is very harmful to human being also. The conventional energy resources are depleting day-by-day. Soon it will be completely vanishes from the earth so we have to find another way to generate electricity [1].

2. Modelling of Solar Photovoltaic

Solar Energy: Solar panel is used to convert solar radiation to the electrical energy. The physical of PV cell is very similar to that of the classical diode with a PN junction formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electronproton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit. Solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage. Solar panels are the medium to convert solar power into the electrical power. In real conditions, the function of a photovoltaic system may be varied because of the intensity fluctuation of the solar radiation over a period of time. When the light of photovoltaic cells, which supplies an electrical resistance, changes, the power point shifts. This point can be seen experimentally, if the electric power, which is provided by the PV cell with a given power density E and applied on a variable electric resistance. Since the resistance varies, fluctuations can be measured in current and voltage by using the appropriate measurement devices; ammeter and voltmeter. The values of the

ISSN: 2005-4238 IJAST
Copyright © 2020 SERSC

electrical current in the maximum power point are symbolized with I_m andV_m[2]. The max power, which is a PV cell can produce, is calculated as follows:

$$P_{max} = V_{max} \times I_{max} \quad (1)$$

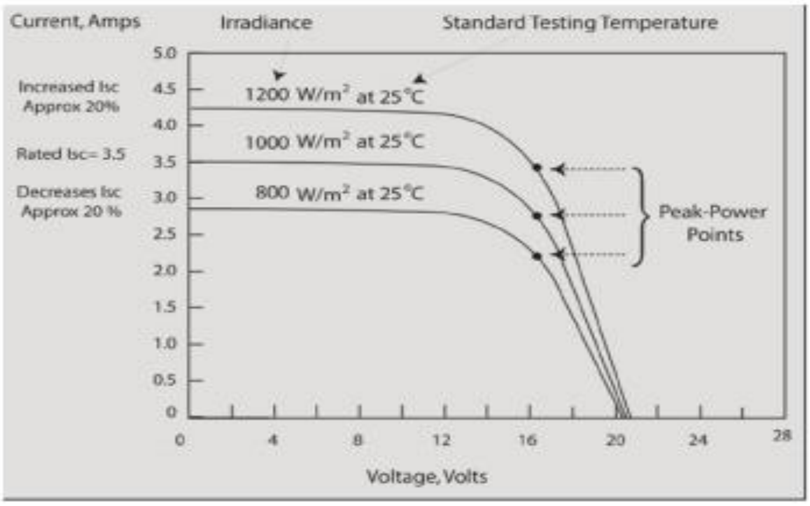

Fig-1 I-V Characteristics for various Solar Insolation

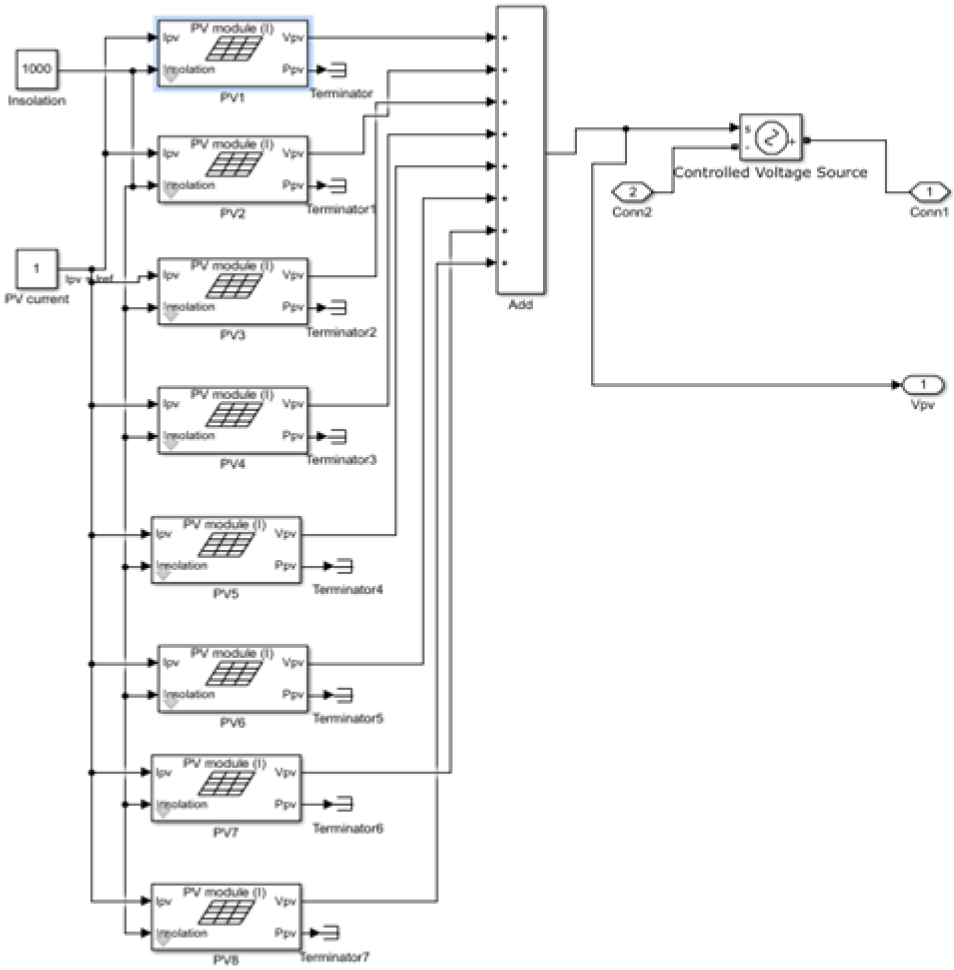

Fig-2 Simulink Model of SolarPhotovoltaic Array

ISSN: 2005-4238 IJAST
Copyright ⓒ 2020 SERSC

Rating of solar array is 400 volt. There are 8 plate (each can generate 50 volt) are connected in series.
To determine the size of PV modules, the required energy consumption must be estimated.

$$P_S = I_{ns(t)} * A_S * E_{ff(pv)} \quad (2)$$

Where, Ins (t) = isolation at time t (kw/m^2), A_S = area of single PV panel (m^2), Effpv = overall efficiency of the PV panels and dc/dc converters.

3. Modelling of Wind Turbine

Wind turbine is that system which extracts energy from wind by rotation of the blades of the wind turbine. Basically wind turbine has two types one is vertical and another is horizontal. As the wind speed increases power generation is also increases. The power generated from wind is not continuous its fluctuating. For obtain the non-fluctuating power we have to store in battery and then provide it to the load. The savonius wind turbine works due to the difference in forces exert on each blade. The lower blade (the concave half to the wind direction) caught the air wind and forces the blade to rotate around its central vertical shaft. Whereas, the upper blade (the convex half to wind direction) hits the blade and causes the air wind to be deflected sideway around it [3].

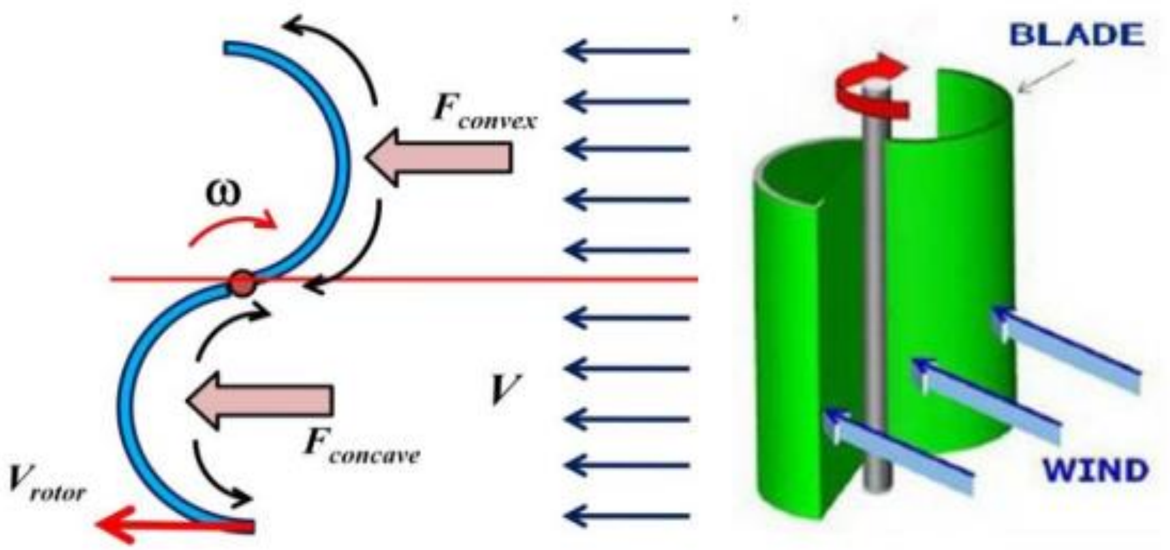

Fig-3 WindTurbine

Because of the blades curvature, the blades experience less drag force. When moving against the wind than the blades when moving with the wind. Hence, the half cylinder with concave side facing the wind will experience more drag force than the other cylinder, thus forcing the rotor to rotate. The differential drag causes the Savonius turbine to spin. For this reason, Savonius turbines extract much less of the wind's power than other similarly sized lift type turbines because much of the power that might be captured has used up pushing the convex half, so savonius wind turbine has a lower efficiency.

The power generated by wind energy is given by,
Power = (density of air*swept area*velocity cubed)/2.

$$PW = \tfrac{1}{2}\rho\,(A_W)\,(V)^3 \quad (3)$$

Where, P is power in watts (W);

ISSN: 2005-4238 IJAST
Copyright ⓒ 2020 SERSC

ρ is the air density in kilograms per cubic meter (kg/m³)
A_W is the swept area by air in square meters (m²) V is the wind speed in meters per second (m/s).

4. Characteristics of STATCOM

Shunt Controllers may be variable impedance, variable source, or a combination of these. In principle, all shunt Controllers inject current into the system at the point of connection. Various shunt connected controllers are: (1) Static Synchronous Compensator (STATCOM).

Typical Applications of STATCOM:(1) Effective voltage regulation and control. (2) Reduction of temporary over voltages. (3) Improvement of steady-state power transfer capacity. (4) Improvement of transient stability margin. (5) Damping of power system oscillations. (6) Damping of sub synchronous power system oscillations. (7) Flicker control. (8) Power quality improvement. (9) Distribution system applications [5].

The STATCOM uses this circuit to generate the inverter voltage V_2 voltage mentioned in the Static Synchronous Compensator (Phasor Type) block documentation. It consists of four 3-phase 3-level inverters coupled with four phase shifting transformers introducing phase shift of +/-7.5 degrees[6,7]. If V_K is the magnitude of the bus voltage to determine the reactive power flow, and the V_{VR} is the VSC output fundamental voltage. The operation of the STATCOM module is given by a source coupled in parallel to the node with series impedance ($YVR = GVR + jBVR$).

(2) Static VAR Compensator (SVC)[4]

The STATCOM (or SSC) is a shunt-connected reactive-power compensation device that is capable of generating and or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system.

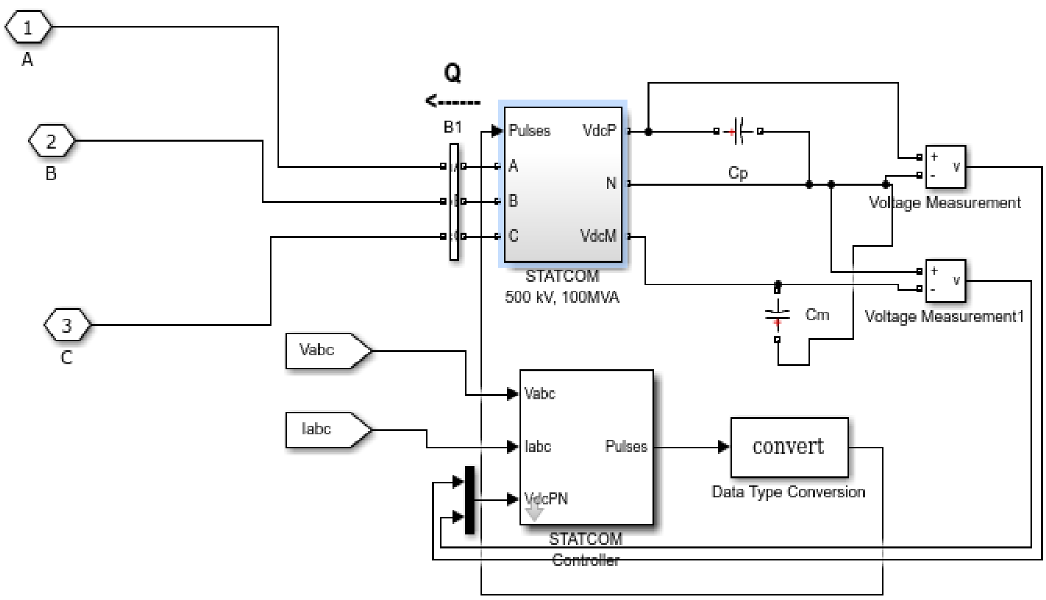

Fig-4 STATCOM

The reactive power is expressed as:

$$Q_{VR} = V_{VR}^2 BVR - V_{VR}[G_{VR}\cos(\delta_{VR} - \theta_K) - B_{VR}\sin(\delta_{VR} - \theta_K)] \quad (4)$$

Where, δ_{VR} and θ_K are the voltage phase angles. For V_{VR}>V_K, the controller generates reactive power and consumes reactive power when V_{VR}<V_K.

ISSN: 2005-4238 IJAST
Copyright © 2020 SERSC

5. Results and Discussion

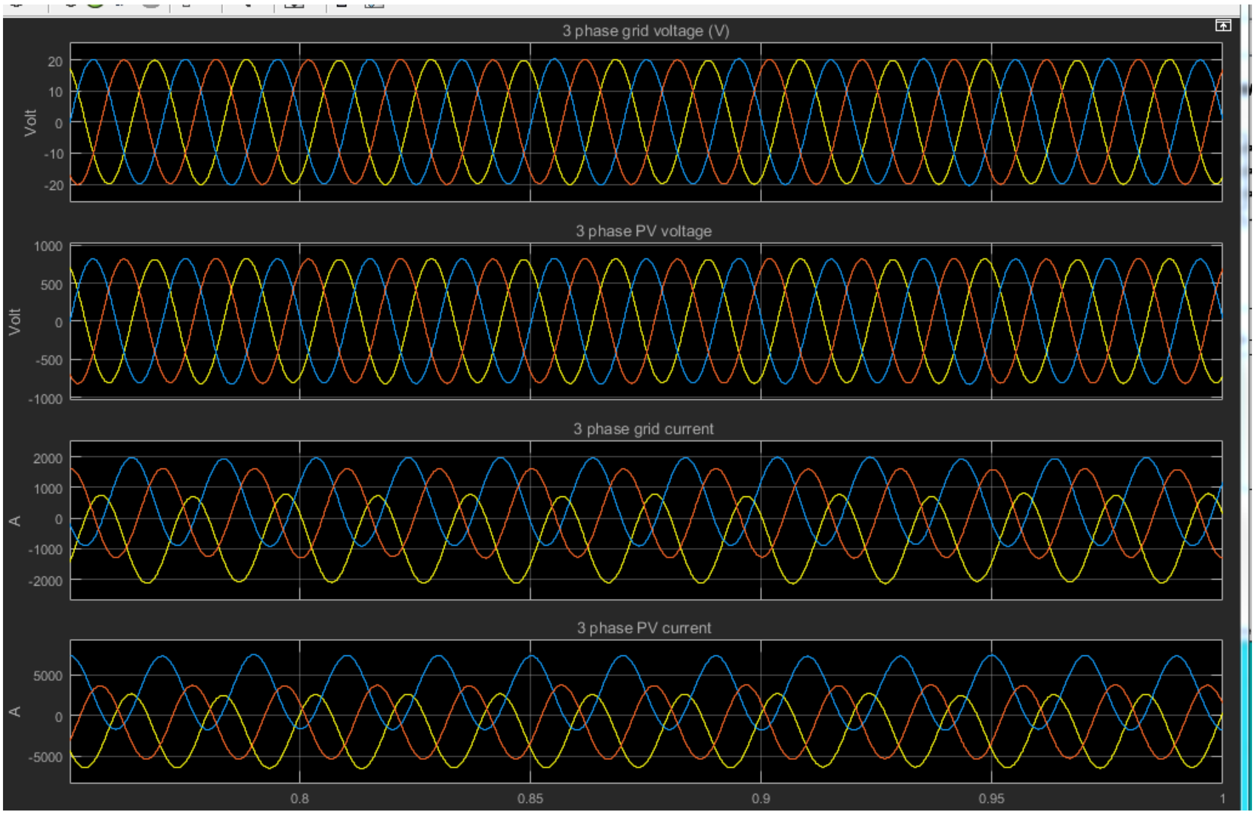

Fig-5 3-Phase Voltage and Current

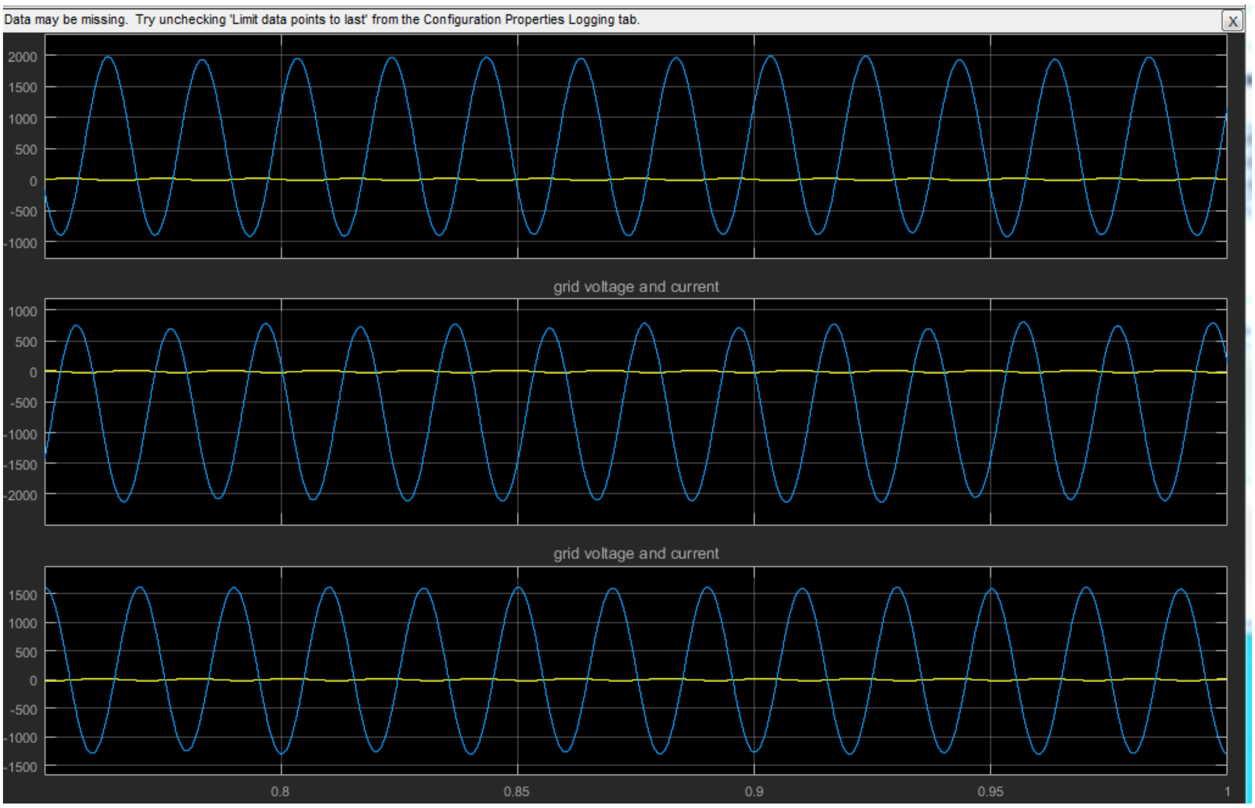

Fig-6 Grid Voltage and Current

ISSN: 2005-4238 IJAST
Copyright ⓒ 2020 SERSC

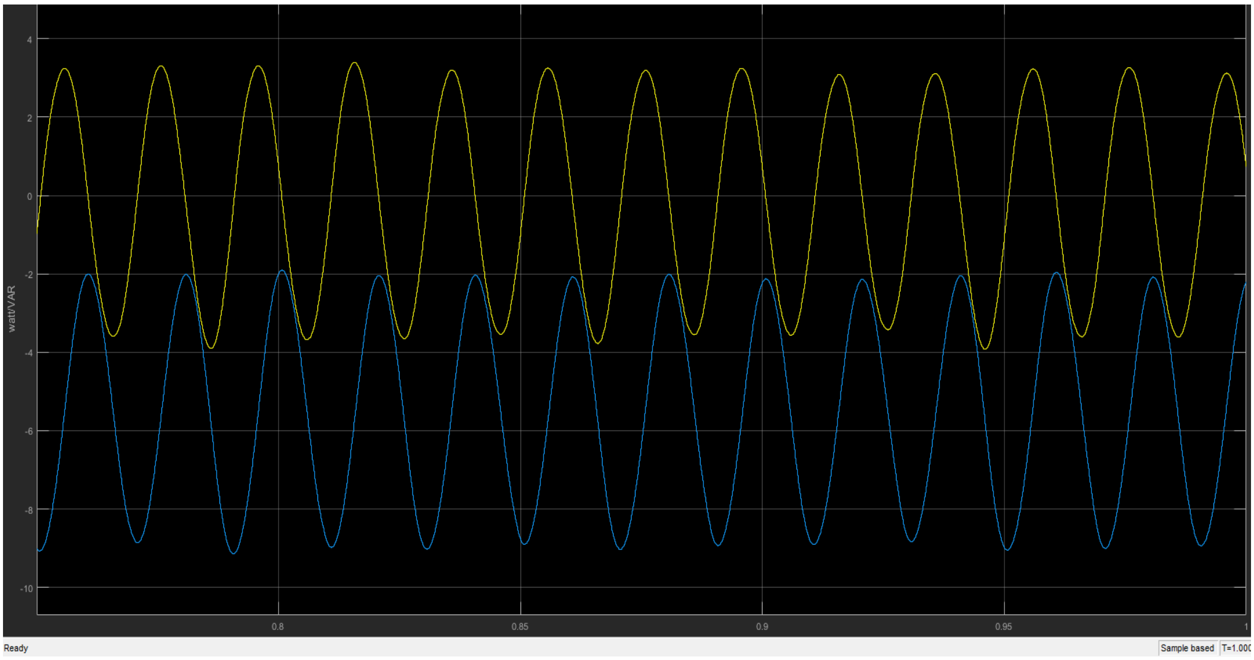

Fig-7 Active and Reactive Power of PV

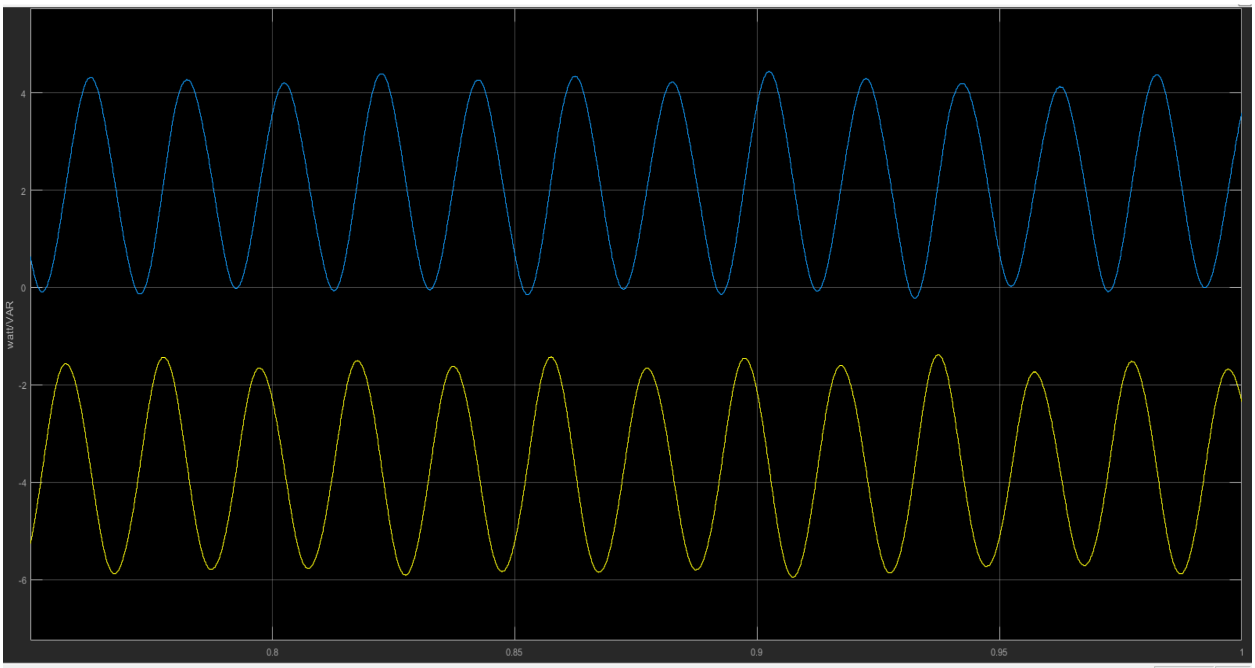

Fig-8 Active and Reactive Power of Grid

6. Conclusion

In this paper the design of hybrid system consisting of PV array, wind turbine with grid is carried out for providing reliable electrical supply in rural location of Haryana and Rajasthan state India. The proposed hybrid system comprises of 10 kW load power shared by solar system is nearly 40%. The performance for power quality and balanced network operation can be improved much more with the combination of active and reactive power. As a result, a new interpretation of the compensation phenomena for a voltage sag or swell has been presented in this paper to improve the power system quality.

ISSN: 2005-4238 IJAST
Copyright ⓒ 2020 SERSC

References

[1] M. M. Rahman, M. M. Hasan, J. V. Paatero, and R. Lahdelma, “Hybrid application of biogas and solar resources to fulfill household energy needs: a potentially viable option in rural areas of developing countries”, Renewable Energy, vol. 68, pp. 35-45, 2014.

[2] S. Bhardwaj, and S. K. Garg, “Rural electrification by effective mini hybrid PV solar, wind & biogas energy system for rural and remote areas of Uttar Pradesh”, International Journal of Computer Science and Electronics Engineering (IJCSEE), vol. 2, pp. 178-181, 2014.

[3] Muralikrishna, M., and V. Lakshminarayana. "Hybrid (solar and wind) energy systems for rural electrification." ARPN Journal of Engineering and Applied Sciences 3.5 (2008): 50-58.

[4] Pal, P., & Pali, L., ‘‘Congestion free analysis for emergency vehicles response in tri-city (Panchkula-Chandigarh-Mohali) using LTE-A’’, Modelling, Measurement and Control A, 91(2), 66–72, 2018. https://doi.org/10.18280/mmc_a.910206.

[5] N.G. Hingorani and L.Gyugi , “Understanding FACTS –Concepts and Technology of Flexible Ac Transmission Systems”, Standard Publishers Distributors, IEEE Press, New York, 2001

[6] N.G. Hingorani and L.Gyugi , “Understanding FACTS –Concepts and Technology of Flexible Ac Transmission Systems”, Standard Publishers Distributors, IEEE Press, New York, 2001

[7] Singh, D., Mishra, M. K., Lamba, A., & Swagatika, S. (2020). Security Issues In Different Layers Of IoT And Their Possible Mitigation. 9(04), 2762–2771. Retrieved from http://www.ijstr.org/final-print/apr2020/Security-Issues-In-Different-Layers-Of-Iot-And-Their-Possible-Mitigation.pdf

[8] Mohd Illyas, Shamshad Ali, M A Khan, “Modeling & Simulation of 10 kW grid connected PV generation system using MATLAB/Simulink”, International Journal of Applied Engineering Research, IJAER, Vol 13, no 24, pp 16962-16970, 2018, UGC approved, ISSN 09673-4562.

[9] P. Anand, S.K. Bath, and M. Rizwan, “Design of Solar-Biomass-Biogas Based Hybrid System for Rural Electrification with Environmental Benefits”, International Journal on Recent and Innovation Trends in Computing and Communication, vol.5 (6), pp. 450 – 456, 2017.

[10] Priyanka, S.K. Bath, and M. Rizwan, “Design and Optimization of RES based Standalone Hybrid System for Remote Applications”, Proceeding of 8 th IEEE conference on Innovative Smart Grid Technologies (ISGT 2017) sponsored by IEEE Power and Energy Society (PES), Washington DC, USA, April 23-26, 2017.

[11] M.J. Khan, A.K.Yadav, and L. Mathew, “Techno economic feasibility analysis of different combinations of PV-Wind- Diesel-Battery hybrid system for telecommunication applications in different cities of Punjab, India”, Renewable and Sustainable Energy Reviews, vol. 76, pp. 577–607, 2017.

[12] S. Bhardwaj, and S. K. Garg, “Rural electrification by effective mini hybrid PV solar, wind & biogas energy system for rural and remote areas of Uttar Pradesh”, International Journal of Computer Science and Electronics Engineering (IJCSEE), vol. 2, pp. 178-181, 2014.

[13] www.mnre.gov.in.

ISSN: 2005-4238 IJAST
Copyright © 2020 SERSC