Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 6, Issue 2; April-June, 2019, pp. 157-161

http://www.krishisanskriti.org/Publication.html

Mitigation of Blackouts in PV Grid Connected Distribution Sector

Prof. Leena G[1], Prof. Zaharuddin[2], Shyam Mohan Parashar[3] and Dr. Mayank Pande[4]

[1]*Electrical Department, MRIIRS, Faridabad*
[2]*Electrical Department Jamia Millia Islamia, Delhi*
[3]*Research Scholar, MRIIRS, Faridabad*
[4]*Electrical department, ABIT, Delhi*

Abstract— *Now a day due to growing demand, the overloading on a distribution system is becoming a problem which results in frequent blackouts. The most versatile way of tackling the problem is PV grid integration. The P-Q power control can be done from Inverter's side. Methodology adopted will be useful as the mitigation of blackouts can handle very efficiently by the PV inverter in both manmade and natural disaster conditions. The islanding mode operation of the PV system not only gives supply to the emergency loads but also relieves the system from excessive loading which in turn mitigates the blackouts in the system. The blackouts during the last few decades have been studied and the improvement in the correctives measures that were adopted will be dealt with within the constraints. Advantage of PV inverter's control is that when active power demand increases in conventional grid the frequency fall is corrected by the control at generator side which is too far from the load center, but owing to the fantastic property of PV inverters the under frequency compensation can be done at the load side which in turn is fast and power loss is also be minimum.*

Index Terms— *DISCOM (Distribution Company) , DG (Distributed generation) , P-Q Power, Blackouts, APC (Active power control), RPC (Reactive power control).*

1. INTRODUCTION

In a densely populated commercial area like Chandani Chowk in Delhi, due to immense increase in demand and space scarcity, the situation of distribution line is very dangerous. The constraints that affect the stability of the system are:

1. Reactive power demand more than supply which results in decrease in system voltage.
2. Active power demand more than supply which results in decrease in frequency.
3. The natural disaster may also lead in blackouts.
4. The manmade disaster is mainly due to point 1 and 2.

There are several other factors which are the causes of blackouts in power system. The critical analysis is done in the field and the main two factors are chosen for the present research work.

Due to limitations of fossil fuels and day by day increasing demand of energy, the convectional sources cannot fulfill energy demand in future. The only way to fulfill and meet out increasing demand of energy is non conventional energy sources. The grid connected PV system is one of the best way to meet out increasing demand of energy and grid inverters will be used to maintain the voltage and frequency profile of the grid during disaster period.

Due to growing demand, the overloading on a distribution system is becoming a problem which results in frequent blackouts. The most versatile way of tackling the problem is PV grid integration. The P-Q power control can be done from the invertor's side. The mitigation of blackouts can be very efficiently and effectively done by the PV inverter in both cases of disaster. The islanding mode operation of the PV system not only gives supply to the emergency loads but also relieves the system from excessive loading which in turn mitigates the blackouts in the system. Advantage of PV invertors control is that when active power demand increases in conventional grid the frequency fall is overcome by the control at generator side which is too far from the load center, but owing to the fantastic property of PV invertors the under frequency compensation can be done at the load side which in turn is fast and power loss is also minimum.

The manmade and natural disasters are the main causes of blackouts. After reviewing the major disasters that occurred throughout the world, a remedial measure will be developed incorporating the magnificent quality of PV inverter which enables the distribution sector not only to get relief from excessive loading both active and reactive but also during blackouts it helps in meeting the requirement of emergency loads.

2. LITERATURE REVIEW

In the literature review the papers reviewed are up to 2018. The literature review of past and present research in the area of "Mitigation of blackouts in PV Grid connected Distribution Sector" as voltage rise due to prominent limitation towards useful integration are well dealt in by employing effective and efficient methods (Awad et.al 2008), (Demirok et.al 2011). Some aspects are usefully considered to get overall Grid stability: devices operating as compensators and their control management (Lopes et.al 2006)

A. Current Reference Generation (CRG)

In Current Reference Generation control method for reactive power, the required current references will be set up according to the power components that are in power demand as referred in (Bojoi et.al 2011), (Baccino et.al 2012), (Benot et.al 2016).

Various control techniques for reactive power in the single-phase inverter are discussed in many papers and reports (Liu et.al 1999), (Liu et.al 2011), (Prayas Group 2014), (Soultanis & Hatziargyriou 2007), and direct-quadrature (d-q) transformation is described in (Liu et.al 1999), (Sun et.al 2012) papers. The theory of instantaneous reactive power injection may be regarded as the control technique that can be used to produce the two orthogonal current references. A signal integrator is used to monitor and adjust the voltage disturbances. The reactive power control techniques are also suggested in (Tobnaghi 2016) in the form of DFT and PLL (Zhang et.al 2011).

B. V- f control in Distributed Generation

In load variations or disturbances, the system voltage and frequency (V- f) goes beyond the prescribed range (Georgiadis 2010). To maintain voltage and frequency at required level, the inverters connected with distribution generations are responsible for maintaining voltage and frequency of the system. In past various researches have been done to find out V-f control methods in DGs of Grid connected PV system. In Grid connected PV system voltage and frequency (V-f) control can be done by using traditional droop control methods as described in (Awad et.al 2008), (Lopes et.al 2006), (Saadat 2002), (Vasquez 2008). An effective P-Q control technique have been described and discussed in (Pedrasa 2006).

The traditional concept about control of power (P-Q), fundamental frequency (f) and system voltage (V) at generation side and DISCOM side not at actual customer load side. In micro grid at low voltage, the line resistance (R) is highly greater than line reactance (X), It shows very close relationship voltage and frequency w.r.t to P- Q power as described in many papers (Alben et.al 2009), (Baccino et.al 2012), (Laaksonen et.al 2005), (Sao & Lehn 2008), (Ye Xu et.al 2013). A traditional technique is implemented as described in (Soultanis & Hatziargyriou 2007).

The scope of renewable energy based DGs are increasing in recent years and published in journal’s paper (Tobnaghi et.al 2016).

Hence, the challenges on Mitigation of blackouts in PV Grid connected Distribution Sectors can now more effectively handled. Very few researches have been done regarding voltage and frequency control to mitigate the blackouts in PV grid connected distribution Sector regarding future Challenges and mitigation methods for high photovoltaic penetration (Temitayo et.al 2018).

The rooftop grid integration system design and simulation have been described with the simulation results shown in (Omar & Mahmoud 2018, 2019) papers. An extensive survey has been done as case study for two major cities in India a report published by Federal Ministry for the Environment (Germany 2017). Although in the past the researchers have made extensive efforts towards the harnessing the solar energy for electricity generation but the management of the PV energy is not dealt in efficient way. India being the country which has an ample amount of solar energy throughout the year and interpolating the increasing demand of the electrical energy, a large scope is there to control the energy in a optimized manner. The dense loading on the distribution networks results in blackouts. The research gap is the control of the PV inverter for P-Q control to mitigate the blackouts. The researcher after reviewing a large number of research papers finds a scope in the future for the increase in reliability of the network by the virtue of slight modification in the present PV grid integration system.

The scholar has studied and reviewed the papers on the work done in this field and finds great scope for the research field as not much work has been done across the world to mitigate the blackouts. The blackouts before 1960s were dealt with the old conventional methods as the concept of renewable energy specially solar energy was not much developed. With the new inventions namely the solar power technology the management of the distribution network has become more manageable.

In India, Electricity Act 2003 has empowered the three companies to work independently viz: GENCOMS, TANSCOMS AND DISCOMS. Due to the independence of the DISCOMS, it is now possible to control active and reactive power at the distribution side. There are various methods of controlling active and reactive power. There are several successive attempts made towards reactive power control. The conventional approach was placement of fixed capacitors and switched capacitors. This scheme was modified through electronic tuning circuit and implemented as dynamic capacitive tuning of distribution network for smooth voltage control.

For active power control, the conventional method is Brown Bravery and Terrill regulators at generating side. This method is not efficient method as the time delay in transmitting the signal from load center to generating unit is quite high, so this has been further modified through automatic load control and active power control by adjusting PV Grid tied inverters. This approach is further refined and précised through SCADA to interpolate the excessive active power demand and automatic load shedding. The active power control is to be done at load side. Therefore, entire transmission line is relieved from excessive loading. Under distributed generation highly sophisticated Grid tied PV inverters gives highly sensitive reliable and quick control.

To control active- reactive (P-Q) power a simplified technique is developed, that suitable to the Indian scenario. For active power control, power transferring angle (δ) and for reactive power control , inject reactive power through placement of capacitance (STATCOM) that will limit the components of Ip=Im Cos θi ,and Iq=Im Sin θi for Vac .The above equations become a way to control both active and reactive power simultaneously in a PV connected Grid.Hence mitigation of blackout using STATCOMS and active - reactive (P-Q) power control by PV inverter connected in the roof top PV generation units as these units have been now grid connected, the active-reactive (P-Q) sudden power demands in conventional distribution networks can be easily controlled. A little work has been done in this area in other developed and developing countries. A practical setup of grid connected SPV system of 81 KWp is considered for the practical work.

3. DESCRIPTION OF WORK

Due to immense increase in the demand and decrease in supply the chances of blackout is increasing day by day. There is a range of factors responsible for blackouts. Some of the factors are to be considered in the work and selectively the most common factors will be considered for the solution towards the mitigation of the blackout. The Power system is a very vast area viz: generation, transmission and distribution. Owing to the development of the distributed generation and the fact that the most affected area of frequent blackouts is distribution; moreover the work done to mitigate the blackouts can be validated by DISCOM. Due to the aforesaid facts the research area is restricted to the distribution network only. The area of research work is focused on the active power control to manage the under frequency and over frequency problem, and reactive power control to manage the voltage profile. The selection of the research topic is justified.

4. METHODOLOGY

This paper focuses on to find the most efficient measures to mitigate the blackouts in a PV grid connected distribution network and is focused on the following,

1. To control PV inverter which in fact controls the P-Q power in order to mitigate the blackout is done in a practical PV grid integrated setup. Testing of reliability of the system at all adverse circumstances.
2. Finding the modification in the present conventional rooftop PV grid integration so as to optimize the energy management this will result in mitigation of blackout.
3. Simulated a 100 KWp PV system using MATLAB.

The real-time data is collected from the currently installed PV grid connected system in the distributed system. Simulation is done in MATLAB and the corrective measures are applied to the system by the PV inverter control. The artificial condition for the blackouts in the smart is created and the net effect of the control is analyzed. All the work is validated on IEEE standard network.. An algorithm is developed for the P-Q power control through PV inverter for a typical 100 KWp PV grid system. The P-Q control of a real distribution network if permitted by local DISCOM will be done and a range of possible ways to mitigate the blackouts will be explored.

5. TECHNICAL SPECIFICATION

Technical specifications of the PV Plant and simulation results.

The PV grid connected system considered for the study of the mitigation of blackouts in a Distribution system and its data table 1 is as under:

Table 1: Technical specifications:

PV Modules	315
PV Technology	Polycrystalline 320Wp
No. of module in series	20
Parallel string	16
Plant Rated Power	100 kWp
Area	400.0 m2
Tilt angle	25.0^0
Tracking System	Without Tracking System
Number of Inverters	(PCU) 2
Inverter Manufacturer	DELTA
Number of MPPTs	2

The PV Grid simulation was done under fault condition and the graph clearly indicate in Table 2 that under fault condition and other factors which may lead to the blackouts in distribution sector the system stabilizes itself, if proper and prompt P-Q control of PV invertor is done.

Table 2: List of events incepted on system for analysis

Sr.	Event	Time
1	Grid in islanded mode	0.3 s to 0.6 sec
2	Test load 1 made off	0.40 to 0.6 sec
3	Test load 2 made off	0.46 to 0.7 sec
4	At t=0.7 s restoration of the PV grid system takes place	

The Power profile as shown in the fig 1-2 clearly shows that the active and reactive power demand gap which would have been the key cause of the blackout. is efficiently met by the prompt and precise control of PV invertor.

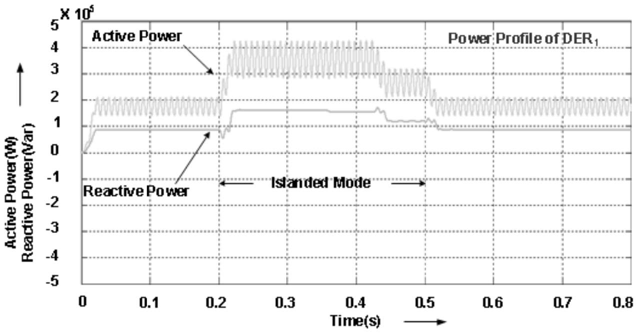

Fig.1: Power profile of PV Grid

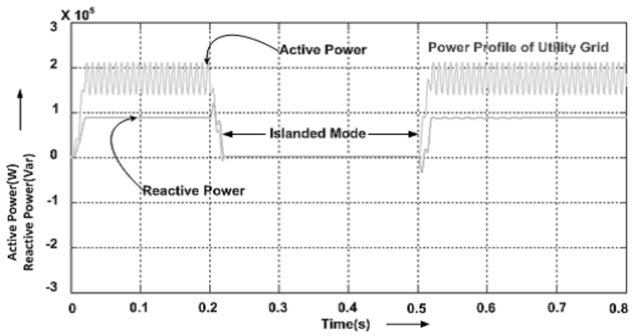

Fig. 2: Power profile of utility Grid

The false failure condition was created on the system and the time taken to stabilize the system was just 0.7 seconds by the precise control of the active and reactive power done at the invertor end.

6. CONCLUSION

The outcome of the work done meets the expectations and after analyzing the work done so far in this research objective is met as under:

1. The steps are taken to mitigate the blackouts in current scenario are more precise and effective then the reviewed work.
2. The control by PV invertor not only relieve the power system from excessive loading but also the reliability is increasing..
3. The proposed scheme if further modified as per the available newly developed technologies for the control of PV grid integrated distribution network may further stabilize the system and a robust system can be developed which is immune to the variable frequencies and variable voltage fluctuation which may otherwise lead to the collapse of the network.

References

[1] Alben, CARDENAS., Kodjo, AGBOSSOU. & Mamadou, Lamine., 2009, 'Islanding detection method for multi-inverter Distributed Generation.', *Electromagnetic Analysis and Applications , 1* (3).

[2] Awad , B. ,Wu, J. & Jenkins, N., 2008, 'Control of Distributed Generation.', *Electronik and Informationstechnik', 125* (12), 409-414.

[3] Baccino, F., Marinelli, M., Massucco, F., Silvastro, F., 2012, 'Low Voltage Microgrid under Islanded operation: Control Stratregies and experimental tests.' *8th Mediterranean conference on power generation, Transmission, Distribution & energy conversion-MEDPOWER*

[4] Benot, Bletterie. , Serdar, Kadam. , Roman, Bolgaryn. & Antony, Zegers., 2016, 'Voltage Control with PV Inverters in Low Voltage Networks—In Depth Analysis of different concepts and parameterization criterion.', *IEEE Transactions on Power system , 32* (1), 177-185.

[5] Bojoi, R.I, Limongi, L.R., Roiu, D. & Tenconi, A., 2011, 'Enhanced power quality control strategy for single-phase inverters in distributed generation systems.', *IEEE Transaction on Power Electronics , 26* (3), 798-806.

[6] Chang, C.H., Wu, F.Y. & Chen Y.M., 2012, 'Modularized bidirectional grid connected inverter with constant-frequency asynchronous sigma delta modulation'. *IEEE Transaction on Industrial Electronics , 59* (11), 4088-4100.

[7] Chen, Y.M., Chang, C.H., Liu, K.Y., 2009, 'Grid-tied inverter with current mode asynchronous sigma-delta modulation.', *Proceedings IEEE ECCE*, (pp. 928-933).

[8] Demirok ,Erhan., González ,Pablo Casado., Frederiksen ,Kenn H .B., Rodriguez ,Dezso Sera,Pedro., & Teodorescu,Remus., 2011, 'Local reactive power control methods for overvoltage prevention of distributed solar inverters in low-voltage grids.', *IEEE Journal , 1* (2), 174-182.

[9] Geetha, R., & Jayachitra, V., 2015, 'Simplified Reactive Power Control for Grid-connected Photovoltaic Inverters.', *Indian Journal of Science and Technology , 8* (13), 1-5.

[10] Germany, F. M. 2017, '*Analysis of Indian Electricity Distribution Systems for the Integration of High Shares of Rooftop PV.',* Environment Nature Conservation, Building and Nuclear Safety of the Federal Republic of Germany.

[11] Georgiadis, T., 2010, ' *Renewable Energy Grid Integration.',* Nova science Publisher.

[12] Jesus Garcia Benito, Rocio Hoya Arija, 2014, ' *An alternative Volt / VAR management scheme for Active Distribution Grids.'* ABB Technical report.

[13] Laaksonen, H., Saari, P. & Komulainen ,R., 2005, ' Voltage and frequency control of inverter based weak LV network microgrid.' *International Conference on Future Power Systems*, (pp. 6-16).

[14] Lopes, J A P, Moreira C. L., Madureira A.C., 2006, 'Defining Control Strategies for MicroGrids Islanded Operation.' IEEE Transactions on Power Systems,.vol.21(2), 916 - 924. .

[15] Liu, J., Yang, J. & Wang, Z., 1999, 'A new approach for single-phase harmonic current detecting and its application in a hybrid active power filter.' *Proceedings IEEE IECON/IECON*, (pp. 849-854).

[16] Liu, L., Li, H., Wu, Z., Zhou,Y., 2011, 'A cascaded photovoltaic system integrating segmented energy storages with self-regulating power allocation control and wide range reactive power compensation.' *IEEE Transaction on Power Electronics , 26 (12),* 3545-3559.

[17] Ministry of New and Renewable Energy., 2014, ' *Physical Progress (Achievements).'* Govt. of India.

[18] Ministry of New and Renewable Energy., 2016, '*State wise installed Solar Power capacity.'* Govt. of India.

[19] Omar, M. A. & Mahmoud, M.M., 2019, 'Design and Simulation of a PV System Operating in Grid-Connected and Stand-Alone Modes for Areas of Daily Grid Blackouts.' *Journal of Photoenergy* , pp. 1-9.

[20] Omar, M. A. & Mahmoud, M.M., 2018, 'Grid connected PV-home systems in Palestine: A review on technical performance, effects and economic feasibility.', *Renewable and Sustainable Energy Reviews , 82* (3), 2490-2497.

[21] Pedrasa, M.A. & Spooner, T.A. , 2006, 'Survey of techniques used to control microgrid generation and storage during island operation.' *Proc Australian Universities Power Engineering Conference.*

[22] Prayas (Energy Group) Report, 2014, '*Grid Integration of Distributed Solar Photovoltaics (PV) in India.'* Prayas (Energy Group).

[23] Saadat, H. , 2002, ' *Power System Analysis.'* Mc Graw Hill Inc.,US.

[24] Sao, C.K. & Lehn, P.W., 2008, 'Control and Power Management of Converter Fed Microgrids.' *IEEE Transactions on Power System , 23* (3), 1088-1098.

[25] Soultanis, N. L. & Hatziargyriou, N. D., 2007, 'Control issues of inverters in the formation of L. V. Micro-grids.' *Power Engineering Society.*

[26] Sun, P., Liu, C., Lai, J.S., Chen, C.L., 2012, 'Grid-tie control of cascade dual buck inverter with wide-range power flow capability for renewable energy applications.' I*EEE Trans on Power Electronics , 27* (4), 1839-1849.

[27] Tobnaghi, D.M., 2016, 'A Review on Impacts of Grid-Connected PV System on Distribution Network.' *International Journal of Electrical, Computer Energetic Electronic and Communication Engg. , 10* (1), 137-142.

[28] Temitayo, O. Olowu., Aditya, Sundararajan., Masood, Moghaddami., Arif, Sarwat., 2018 , '*Future Challenges and Mitigation Methods for High Photovoltaic Penetration: A Survey.'* Department of Electrical and Computer Engineering. Miami: Florida International University.

[29] Vasquez, J. C., 2008, 'Adaptive droop control applied to distributed generation invertersconnected to the grid.' *IEEE International Symposium on Industrial Electronics , August ,* pp. 2420-2425.

[30] Xu, S., Wang, J. & Xu, J., 2013, ' A current decoupling parallel control strategy of single-phase inverter with voltage and current dual closed-loop feedback.' *IEEE Transaction on Industrial Electronics, 60*(4), 1306-1313.

[31] Ye Xu, Zhao-hong Shi, Jin-quan Wang, Peng-fei Hou ., 2013, 'Discussion on the Factors Affecting the Stability of Micro grid Based on Distributed Power Supply.' *Energy and Poer Engineering, 5*(4B).

[32] Zhang,Q., Sun, X.D., Zhong, Y.R., Matsui & M. , Ren, B.Y., 2011, ' Analysis and design of a digital phase-locked loop for single-phase grid-connected power conversion systems.' *IEEE Transaction on Industrial Electronics, 58*(8), 3581-3592.