Design and Examination of a Robust Controller for Distributed Power Generation Applications

K. Lakshmi Venkateswaramma[1], Ch. Srinivas[2], Rushi Santhosh Singh Thakur[3]
[1]P.G. Student, Department of Electrical & Electronics Engineering, MVR College of Engineering & Technology, Paritala.
[2]Assistant Professor, Department of Electrical & Electronics Engineering, MVR College of Engineering & Technology, Paritala.
[3]Associate Professor, Head E.E.E., MVR College of Engineering & Technology, Paritala.

***Abstract* - The vitality necessities are expansions in everyday life; it presents the new innovation called disseminated power era, it implies the force era is situated at close to the heap focus. The current control methods are utilized as a part of either matrix associated mode or islanding mode. This paper proposes the control technique to alleviate the unsettling influences in lattice joined and islanding state of DG system. To enhance the unwavering quality of power conveyed to the load a vigorous controller is composed and mimicked in grid associated distributed system and islanding conditions. The controller is modelled and re-enacted in the matlab/simulink platform.**

***Keywords* - Distributed Power Generation, Grid, Islanding.**

I. INTRODUCTION

With the expanding rivalry alongside the force organizations to make safe to a more prominent degree clients, the weight to keep up a high level of nonstop power administration quality and consistency is felt by the service organizations. Therefore in a deregulated market environment, current practices of disengaging the DG resulting an unsettling influence will never again be a functional or fearless arrangement. As the result one of its obligations regarding future thought, the execution of deliberate islanding of DGs. Islanding is a condition in which a micro grid or a portion of the power grid .which contains both load and distributed generation (DG), is cut off from the remainder of the utility system and continues to operate.

Through the network associated operation, each DG framework is by and large worked to give or infuse preset energy to the lattice, that is the present control mode in firm synchronization with the matrix .while the miniaturized scale network is separate from the principle matrix, every DG framework needs to sense this islanding circumstance and must be changed to a voltage control mode to supply consistent voltage to the nearby delicate burdens. This paper says a control system that is utilized to actualize network associated and deliberate islanding operations of miniaturized scale frameworks. The portrayed strategy proposes two control calculations in particular, one for lattice associated operations and the other for purposeful islanding operations.

II. PROPOSED CONTROLLER

This system consists of the micro source that is represented by the dc source, the conversion unit which performs the interface function among the dc bus and the three –phase ac world in addition to the LCL filter that transports and distributes the energy to the end use and the load. The controller provides a stable DG output and maintains the voltage at the point of common coupling (PCC) before and after the grid is disconnected.

Under normal operation, each DG system in the micro grid usually works in a stable current control mode in order to provide a predetermined power to the main grid. When the micro grid is disconnects from the main grid, each DG inverter system must sense this islanding situation and must change to a voltage control mode. In this mode, the micro grid will provide a constant voltage to the local load.

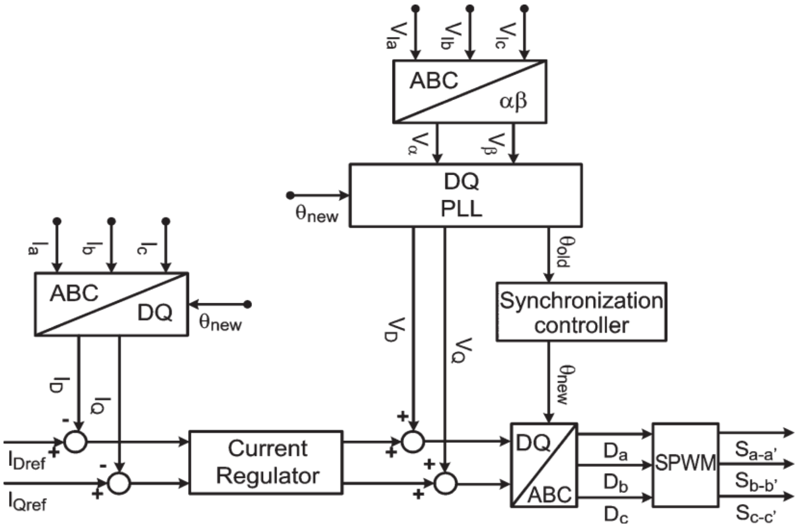

Fig.1: Block Diagram Of The Current Controller For Grid Connected.

Grid Connected Operation Mode

For grid connected operation, the controller is intended to supply a constant current output. The main aspect to consider in grid connected operation is synchronised with the grid voltage. For unity power factor operation, it is vital that the grid current reference signal is in phase with the grid voltage .This grid synchronization be able to be carried out by using a PLL. Fig.1 shows the control topology used.

When using current control, the yield current from the filter, which has been transformed interested in a synchronous frame by Park's transformation and regulated in DC quantity, is fed back and compared among the reference currents I_{DQref}. This generates a current error that is passed to the current regulator (PI controller) to make the voltage references for the inverter. So as to get a better-quality dynamic response, V_{DQ} is fed forward. This is done as the terminal voltage of the inverter is treated as a interruption, and the feed forward is used to compensate for it.

The voltage references in dc quantities V_{DQref} are transformed into a at a standstill frame by the inverse of Park's transformation and are utilized as command voltages here generating high frequency pulse width-modulated voltages.

Loss of Main Detection

The time at which the micro grid is disconnect from the main grid (intentional-islanding operation) must be detected in order for the DG system to change between grid-connected and intentional-islanding manners . This recognition is done by using a DQ-PLL which consists of the Clarke's transforrmation, Park's transformation, PI regulator, and an integrator.

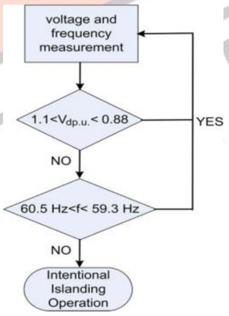

Fig.2: Intentional- Islanding Detection Algorithm.

The lock is realized by set Vq to zero. A PI controller can be used to manage this variable, and the output of this regular is the grid frequency. Additional to the frequency, the DQ-PLL is capable of tracking the magnitude of its input sig- nals, e.g., the grid voltages. These two parameters namely frequency and voltage magnitude, are used in the islanding-detection algorithm to notice the grid condition. Then, the algorithm sends a signal to switches the inverter to the appropriate interface control.

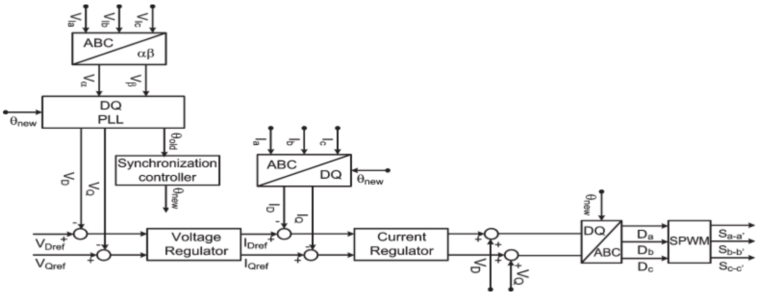

Fig.3: Block Diagram Of The Voltage-Controlled Inverter.

Although serving as superior indications for islanding detection, the rapid voltage and frequency variations go ahead to a serious concern. The DG would work out of the permissible voltage or frequency range rapidly after islanding occurs.

Intentional-Islanding Mode

The voltage closed-loop control for intentional-islanding operation is shown in Fig3. The control works as voltage regulation through current compensation. The controller uses voltage compensators to generate current references for current regulation
As shown, the load voltages (VD and VQ) are forced to track its reference by using a PI compensator (voltage regulator).The outputs of this compensator (IDref and IQref) are compared with the load current (ID and IQ), and the error is fed to a current regulator (PI controller). The output of the current compensator acts as the voltage reference signal that is fed to the sinusoidal pulse width modulator to generate the high- frequency gating signals for driving the three-phase voltage source inverter. The current loop is included to stabilize the system and to improve the system dynamic response by rapidly compensating for near-future variations in the load voltages. In order to get a good dynamic response, VDQ is fed forward. This is done because the terminal voltage of the inverter is treated as a disturbance, and the feed forward is used to compensate for it.

Synchronization For Grid Reconnection

When the grid-disconnection cause disappears, the transition from islanded to grid-connected mode can be started. To avoid hard transients in the reconnection, the DG has to be synchronized with the grid voltage. The DG is operated in the synchronous island mode until both systems are synchronized. Once the voltage in the DG is synchronized with the utility voltage, the DG is reconnected to the grid, and the controller will pass from the voltage to the current control mode.

III. CONTROL ANALYSIS AND STABILITY

The control technique has two sorts of control operation. They are current and voltage controls. These control methods correspond to the system’s operating mode (grid connected or islanding, respectively). In order to determine the constancy of these two controllers, their transfer functions also determined.

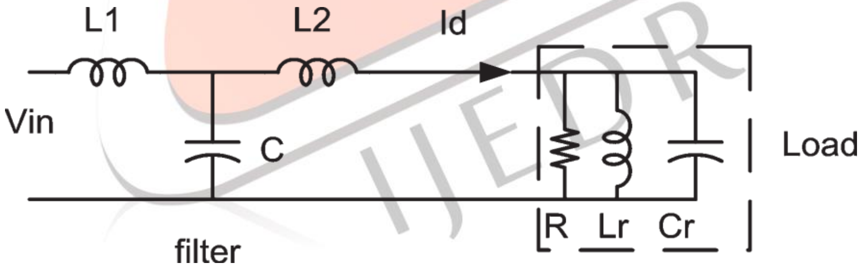

Fig.4: LCL Filter with parallel RLC load

Current Controller Transfer Function

The PI controller produces a signal that is proportional to the time integral of the controller. The PI controller transfer function is given by

$$T(S) = \frac{s^3+8.72*10^3 s^2+6.51*10^7 s +4.03*10^9}{s^4+9.46*10^3 s^3+1.04*10^8 2+3.31*10^{11} s +3.22*10^{12}}$$

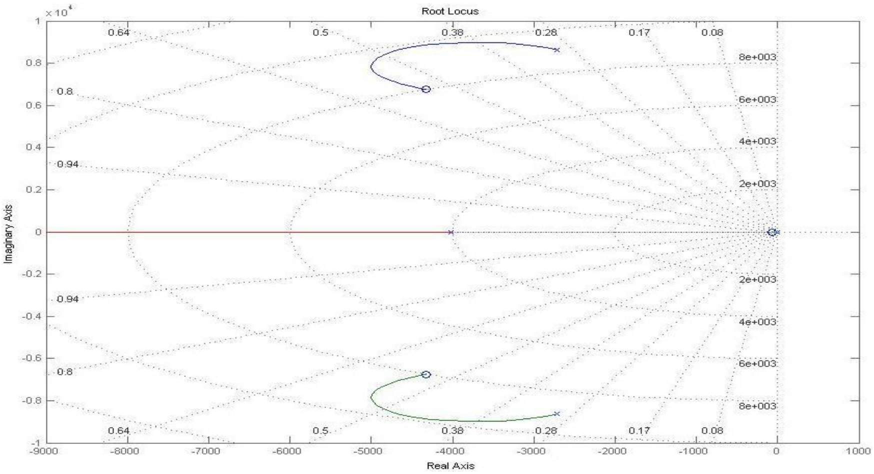

Fig.5: Stability analysis of the current controlled inverter.

Voltage Current Controller Transfer Function:

The voltage closed-loop control for intentional-islanding operation is shown in Fig. 6.

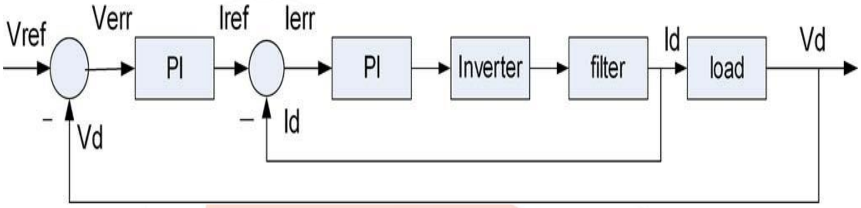

Fig.6: Block diagram of the voltage current controlled inverter.

$$T(S) = \frac{s^4+8.79*10^3 s^3+6.56*10^7 s^2+8.06*10^9 s+6.45*10^7}{s^5+1.42*10^4 s^4+1.46*10^8 s^3+6.44*10^{11} s^2+3.49*10^{13} s+2.79*10^{11}}$$

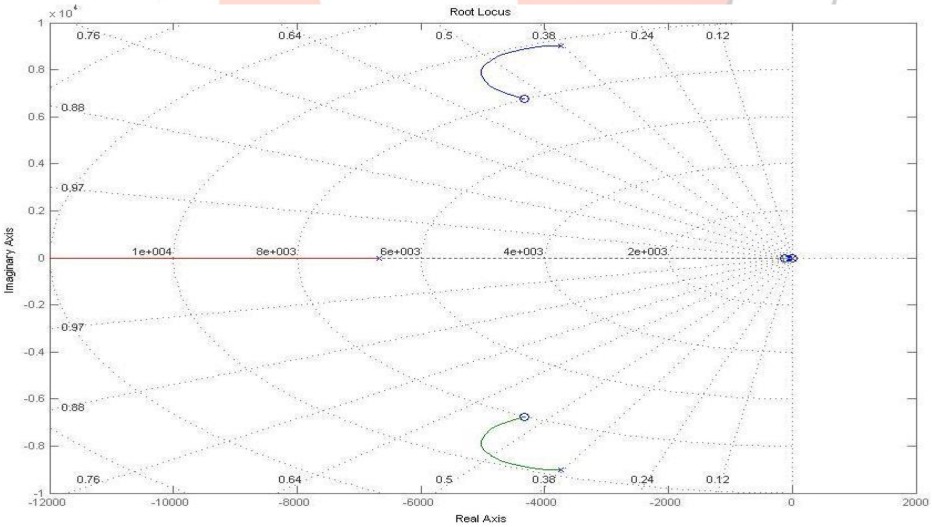

Fig.7: Stability analysis of the voltage current controlled inverter.

IV. SIMULATION RESULTS

The performance of the projected control strategies was evaluated by processor simulation using MATLAB. This system was tested under the following conditions:

1) switching frequency f_S: 10 kHz;
2) output frequency: 60 Hz;
3) filter inductor L_i: 1 mH;
4) filter inductor L_L: 0.5 mH;
5) filter capacitor C_f: 31 μF;
6) dc-link voltage V_{dc}: 400 V;
7) output phase voltage $V_{o1\phi}$: 120 Vrms;
8) output capacity: 10 KW.

The *RLC* load was used to be significant at 60 Hz and to consume 10 KW. The DG system was designed to supply 10 KW and zero reactive power. The processor was operated initially in grid-connected operation. The grid was cut off at 0.3 s, and this event was senced at 0.30155 s . later than 0.30155 s, the control method was shifted from current to voltage- controlled operation.

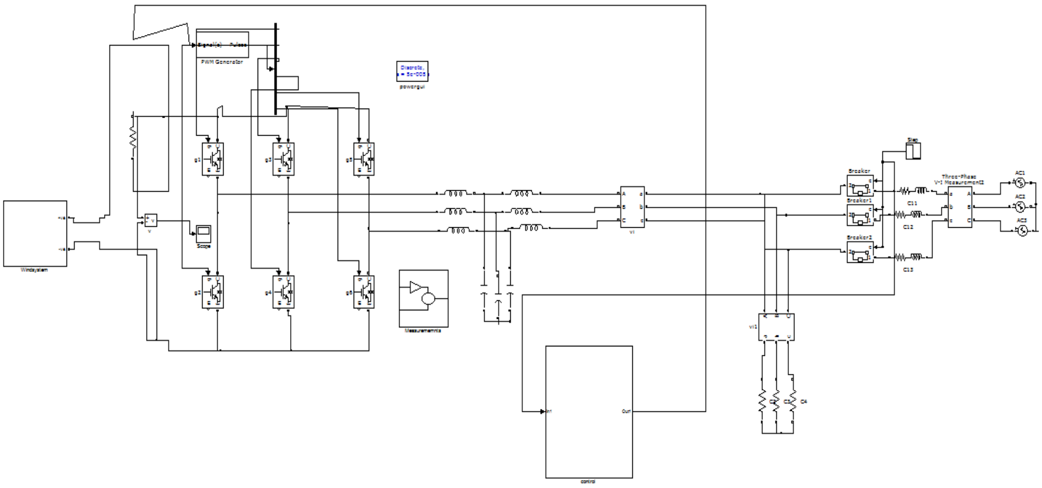

Fig.8: Proposed Simulink Model Of Grid Connected Distributed Power System.

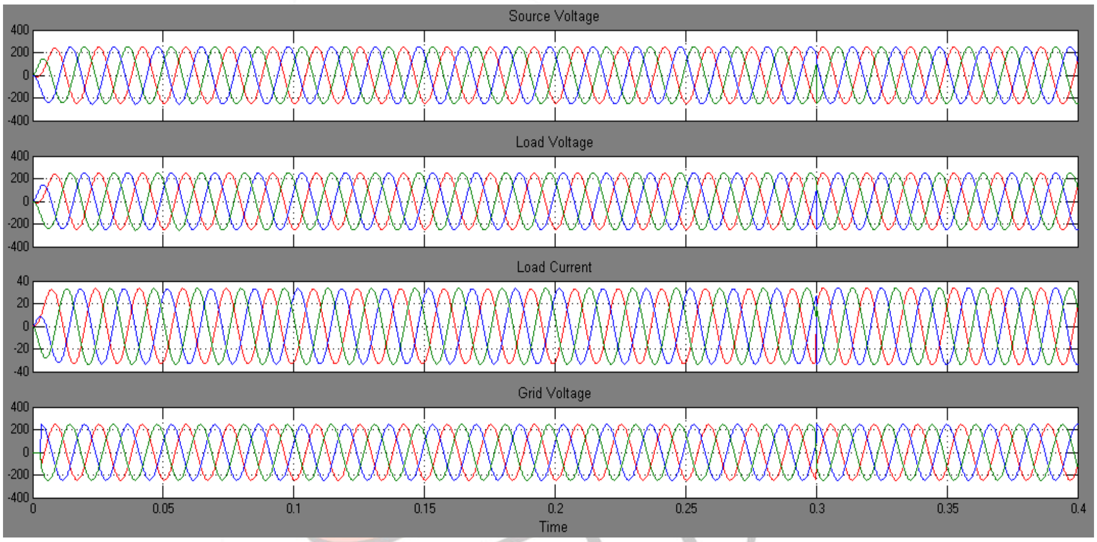

Fig.9: Source Voltage, Load Voltage, Load Current, Grid Voltage with constant current controller.

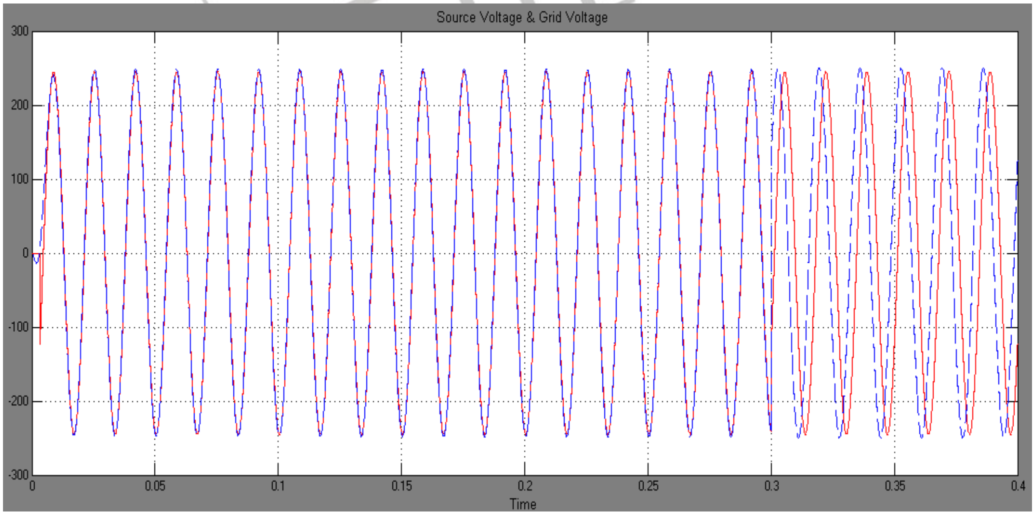

Fig.10: Synchronization of Source Voltage & Grid Voltage with constant current controller.

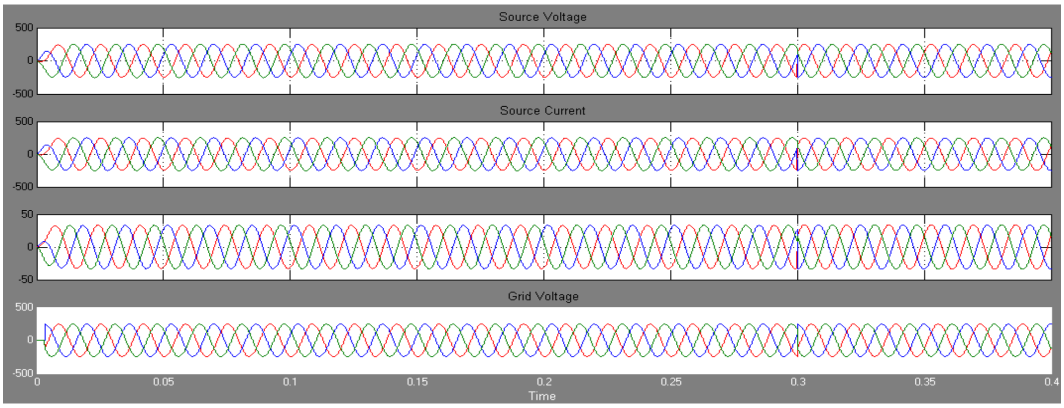

Fig.11: Source Voltage, Load Voltage, Load Current, Grid Voltage with constant voltage current controller.

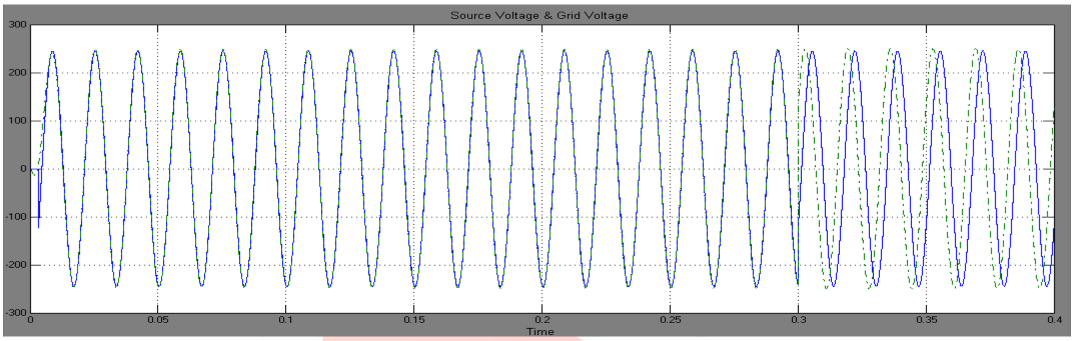

Fig.12: Synchronization of Source Voltage & Grid Voltage with constant voltage current controller.

V. CONCLUSION

A voltage and current controller was planned with interfacing control methods one for grid associated operation and the other for purposeful islanding operation. An islanding-location calculation, which was in charge of the switch between the two controllers, was displayed. The recreation results demonstrated that the discovery calculation can recognize islanding occasions and changes in the loads and can apply the load shedding calculations when required. The re-closer calculation causes the DG to resynchronize itself with the system. Furthermore, it is demonstrated that the reaction of the proposed control plans is fit for keeping up the voltages and streams inside passable levels amid matrix joined and islanding operation modes. The simulation results demonstrated that the proposed control plans are fit for keeping up the voltages inside of the standard reasonable levels amid grid connected and islanding operation modes.

VI. REFERENCES

[1] D. Jayaweera, S. Galloway, G. Burt, and J. R. McDonald, “A sampling approach for intentional islanding of distributed generation,” IEEE Trans. Power Syst., vol. 22, no. 2, pp. 514–521, May 2007.

[2] J. M. Guerrero, J. C. Vásquez, J. Matas, M. Castilla, and L. García de Vicuña, “Control strategy for flexible microgrid based on parallel line interactive UPS systems,” IEEE Trans. Ind. Electron., vol. 56, no. 3, pp. 726–736, Mar. 2009.

[3] P. Fuangfoo, T. Meenual,W.-J. Lee, and C. Chompoo-inwai, “PEA guidelines for impact study and operation of DG for islanding operation,” IEEE Trans. Ind. Appl., vol. 44, no. 5, pp. 1348–1353, Sep./Oct. 2008.

[4] E. Carpaneto, G. Chicco, and A. Prunotto, “Reliability of reconfigurable distribution systems including distributed generation,” in Proc. Int. Conf. PMAPS, 2006, pp. 1–6.

[5] IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems, IEEE Std 929-2000, 2000, p. i.

[6] IEEE Standard for Interconnecting Distributed Resources With Electric Power Systems, IEEE Std 1547-2003, 2003, pp. 0_1–16.

[7] H. Zeineldin, E. F. El-Saadany, and M. M. A. Salama, “Intentional islanding of distributed generation,” in Proc. IEEE Power Eng. Soc. Gen. Meeting, 2005, vol. 2, pp. 1496–1502.

[8] S. Alepuz, S. Busquets-Monge, J. Bordonau, J. A. Martinez-Velasco, C. A. Silva, J. Pontt, and J. Rodriguez, “Control strategies based on symmetrical components for grid-connected converters under voltage dips,” IEEE Trans. Ind. Electron., vol. 56, no. 6, pp. 2162–2173, Jun. 2009.

[9] G. Franceschini, E. Lorenzani, C. Tassoni, and A. Bellini, “Synchronous reference frame grid current control for single-phase photovoltaic converters,” in Conf. Rec. IEEE IAS Annu. Meeting, 2008, pp. 1–7.

[10] C.-S. Wu, H. Liao, Y.-B. Wang, Y.-C. Peng, and H.-H. Xu, “Design of intelligent utility-interactive inverter with AI detection,” in Proc. 3rd Int. Conf. Electr. Utility DRPT, 2008, pp. 2012–2017.

[11] J. Selvaraj and N. A. Rahim, “Multilevel inverter for grid-connected PV system employing digital PI controller,” IEEE Trans. Ind. Electron., vol. 56, no. 1, pp. 149–158, Jan. 2009.

[12] J. M. Espi Huerta, J. Castello, J. R. Fischer, and R. Garcia-Gil, “A synchronous reference frame robust predictive current control for three phases grid-connected inverters,” IEEE Trans. Ind. Electron., vol. 57, no. 3, pp. 954–962, Mar. 2010.

Bibliography

K. Lakshmi Venkateswaramma received B.Tech degree in Electrical and Electronics Engineering from gudlavalleru engineering college., affiliated to JNTUK, in 2012. She is pursuing M.Tech in the department of Electrical and Electronics Engineering with specialization in Power Electronics and Drives .M.V.R. College of Engineering & Technology, Paritala, A.P, India. She interests in research include Power Electronic Converters and Drives.

CH.Srinivas was born in Machilipatnam, Andhra pradhesh, India. He received the B.Tech degree in Electrical & Electronics Engineering from the D.M.S.S.V.H. College of Engineering, Machilipatnam, in the year 2011 and the M.Tech degree in Power System Control & Automation Engineering from SRI VASAVI ENGINEERING COLLEGE, Tadepalligudem, in year 2013.

He is currently working as Assistant Professor in M.V.R. COLLEGE OF ENGINEERING & TECHNOLOGY VIJAYAWADA. His area of interest is Distributed Power Generation. He published Six international journals & presented a paper in national conference.

Rushi santhosh singh thakur has received his B.Tech degree from Sir C.R Reddy college of engg. , Eluru and M.TECH degree from J.N.T.U Hyderabad. At present he is working as associate professor and HOD Dept of EEE in M.V.R.College of Engineering, Paritala Krishna dt, A.P. His areas of interest are Drives, Power Electronics, Electrical Circuits, and Control Systems, Power Systems.