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Grid Connected Efficient Controller To Improve Power Quality Using Islanding Operation

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Abstract—**This paper summarize the problems and solutions of the power quality in microgrids. Here control technique is implemented to operate micro grid in both grid connected mode called current controlled mode and grid disconnected mode called voltage controlled mode. A new algorithm implemented to identify the islanding mode and it operates the grid in intentional mode which is called islanding mode where DG and load is isolated from the utility system.This simple control strategy in micro grid model is realized with MATLAB and necessary paramaters are designed by using simulink model. A reclosure algorithm has been used for DG to resynchronize the inverter voltage with the grid. The quality of power can be improved by this proposed method.**

Index Terms **—Distributed Generation, Microgrid, Intentional Islanding, Synchronization controller, PLL, Grid tie inverter, power quality, Grid management.**

I.INTRODUCTION

The recent trends in small scale power generation using increased concerns on environment and cost of energy, the power industry is experiencing fundamental changes with more renewable energy sources (RES) or micro sources such as photovoltaic cells,wind turbines being integrated into power grid in the form of distributed generation (DG).These DG systems are normally interfaced to the grid through power electronics and energy systems[1]. One of the most critical sections of the control system for a distributed generation units interconnection to the utility grid lies within grid-connected converters control and protection system specifically islanding algorithm. This controller is able to determine whether it is safe to remain connected to the grid.The islanding detection which integrated into control system to prevent undesirable feeding of loads during fault condition and disconnections from the grid as intentional [2].

Islanding is a condition in which a microgrid or a portion of the power grid,which contains both load and distributed generation (DG),is isolated from the remainder of the utility system and continue to operate someislanding are: Non-intentional islanding occurs if after the fault it is not possible to disconnect the DG;non-intentional islands must then be detected and eliminated as fast possible. Intentional islands refers to the formation of islands of predetermined or variable extensions;these islands have to be supplied from suitable sources able to guarantee acceptable voltage support and frequency,controllability and quality of the supply and may play a significant role in assisting the service restoration process.Basicallysome of islands operated in autonomous mode,not connected to the supply system;the whole microgrid can be seen from the distribution system as a single load angle has to be designed to satisfy the local reliability requirements,in addition to other technical characteristics concerning frequency,voltage controland quality of supply[2].

II.POWER MISMATCHES

The effect of power mismatches between DG and the loads have in terms of voltage and frequency. The DG can supply anywhere from partial to the full load demand or even an excess of power to source the grid.

A. ACTIVE POWER MISMATCH

If the active power portion of the load demand that is calculated is coming from the DG,the following is found

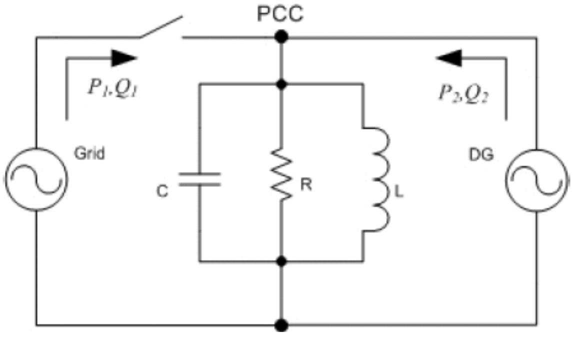

Fig 2 Generic Interconnected System

$$P_{DG} = \frac{\mathbf{3V^2PCC}}{\mathbf{Reff}} \text{---------}\mathbf{(1)}$$

Where Reff is the equivalent resistance seen by the DG for the amount of power it is supplying.If the grid fails and only DG is left to supply the load at a constant active power,the voltage at the PCC would naturally change.

$$P_{DG} = \frac{\mathbf{3(V'PCC)^2}}{\mathbf{R}} = \frac{\mathbf{3(v_{pcc}+\triangle V)}}{\mathbf{R}} \text{---------}\mathbf{(2)}$$

As such,R_{eff} can be written as a function of true load resistance,the voltage and change of voltage that would occur at the PCC,seen in (3) by equatingand solving (1) and (2)

$$R_{eff} = f(R, V_{PCC}, \triangle V) = R\left(\frac{V_{PCC}}{V_{PCC} + \triangle V}\right)^2 \text{ ------- } (3)$$

Thus to find the power mismatch from the load demand and DG we can write following:

$$\triangle P = P_{demand} - P_{DG} = 3V^2_{PCC}\left(\frac{1}{R} - \frac{1}{R_{eff}}\right) \text{ --------}(4)$$

Put (3) into (4), we get reduced equation of (5) showing that an active power mismatch between load and DG will cause voltage variations if grid fails.

$$\triangle P = \frac{3V^{2P}CC}{R}\left(1 - \left(\frac{V_{PCC} + \triangle V}{V_{PCC}}\right)^2\right) \text{ ----------- } (5)$$

B. REACTIVE POWER MISMATCH

Now consider the reactive power mismatch between the DG and load during a grid fault.The demand required by the load is equal in (6)

$$Q = \frac{3V^2}{\omega_{lineL}}(1 - \omega^2 LC) \text{ --------- } (6)$$

The resonant frequency of the load is determined by the LC relationship. Therefore we can rewrite (6) as (7)

$$Q = \frac{3V^2}{\omega_{lineL}}\left(1 - \frac{\omega^2 line}{\omega^2 resonant}\right) \text{ ------ } (7)$$

If the grid stopped supplying its portion of the load's demand of reactive power,the line frequency would drift to the resonant frequency to force the mismatch to become zero.Therefore,let us write resonant frequency as a term of the line frequency and the frequency drift due to mismatch.

$$\triangle Q = \frac{3V^2}{2\pi f_{LineL}}\left(1 - \frac{f^2 line}{(f_{line} + \triangle f)^2}\right) \text{ --------- } (8)$$

When the max/min values of the voltage and frequency deviations are into (5) and (8), an NDZ range for power mismatch can be calculated.As such, it seen that the standard OVP/UVP, OFP/UFP schemes are not enough to minimise the NDZs. [3]

III. ISLANDING DETECTION ALGORITHM

Islanding is the condition where the DG remains operating in the distribution system with the utility disconnected. In the past years, several islanding detection methods can be categorized into two main groups:passive and active methods.passive methods depends on measuring system parameters and then thresholds are set to these paramaters to differentiate between an islanding and a non islanding condition. Active methods directly interact with the power system operation by introducing perturbations in the inverter output.The most commonly used islanding method is the Over/Under Voltage and Over/Under Frequency.

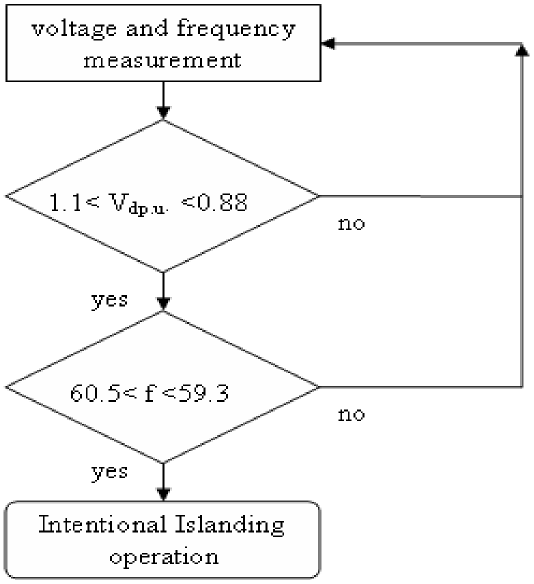

Fig 2.Intentional Islanding Algorithm

The DG interface control designed in this paper provides constant DG output and maintains the voltage at the Point of common coupling (PCC) at 1p.u. maintaining both the voltage and power constant during an islanding is not feasible for standalone operation of the DG since both depends on each other, and the OVP/UVP and OFP/UFP could be used to detect islanding[4].This detection method will operate efficiently for large mismatch between load and DGcapacity.Unfortunately,if the load closely matches the DG capacity,the frequency will reach the threshold value after a very long time.The DG was designed to supply 100kW.The grid disconnects at t=5 seconds and the frequency at the PCC drifts away from the 60Hzvalue.It can be seen that the time for the frequency to reach the 59.3 HZ threshold is greater than 5 seconds.[8]

IV. CONTROLLERS

The system consists of a microsource that is represented by the dc source.Under normal operation, each DG inverter system in the microgrid usually works in constant current control mode in order to provide a preset power to the main grid.When the microgrid is cut off from the main grid,each DG inverter system must detect this islanding situation and switch to a voltage control mode.In this mode,themicrogrid will provide a constant voltage to the local load[2]

Condition 1 . WHEN GRID ISDISCONNECTED

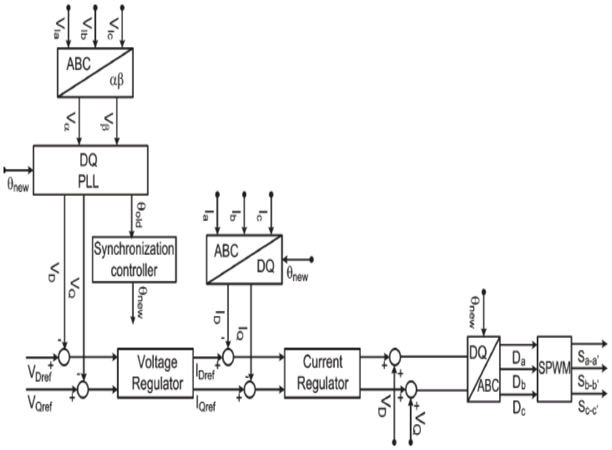

Fig 3.voltage controller when grid is disconnected

Condition 2 : WHEN GRID IS CONNECTED

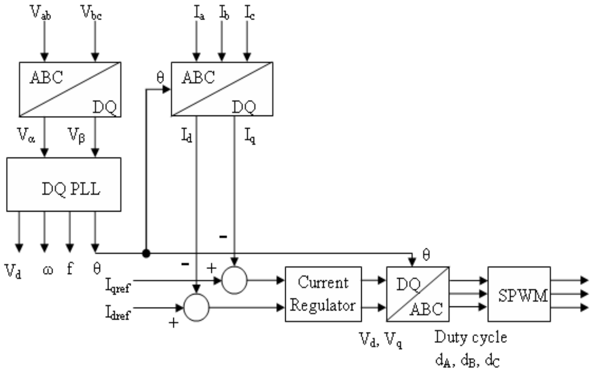

Fig 4.current controller when grid is connected

For grid connected operation,the controller is designed to supply constant current output.A phase locked is used to determine the frequency and angle reference of the point of common coupling (PCC) voltage.To simplify the design and operation of the controller,the control of the system is designed in a synchronous reference frame (SRF) [5]

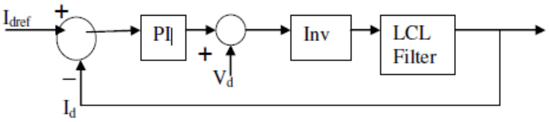

Fig 5 . Block diagram of current controlled inverter

The inverter currents are transformed into a synchronous frame by park's transformation and regulated in dc quantity corresponding to the current references Idqref.In the following stage,the voltage reference indc-quantities Vdq which being processed by PI controllers are transformed into a stationary frame by the inverse of park's transformation and utilized as command voltages for generating high frequency pulse width modulated(PWM)voltage.[11]

When using the current control,the output current from the filter is fed back and compared with references current Iref and the error is passed to the PWM to generate voltage reference for the inverter.In order to get a good dynamic response Vdq is fed forward.For unity power factor operation, iqref is set to zero.[2]

A . INTENTIONAL ISLANDNG OPERATION MODE

The voltage closed loop control islanding operation is shown.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 output of this compensator (Idref and Iqref) are compared with 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 high frequency gating signals for driving the three phase voltage source inverter.

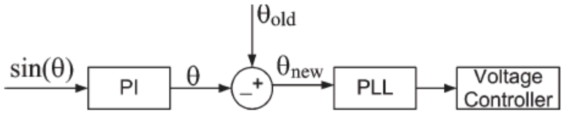

Fig 6 . Synchronization Controller

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.

B. 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 aresynchronized.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.Thissynchronization is achieved by implementing the following algorithm.[5]

1) Assume that the phase difference between the grid and inverter voltages is given by

$$\Theta = \llcorner V_{G-\ \llcorner V_I} \text{-----------} (9)$$

2) Inorder to obtain the information of Θ, two sets of voltage values are used

$$K = V_{Ia}V_{Ga} + V_{Ib}V_{Gb} + V_{Ic}V_{Gc}$$

$$= \frac{3}{2}\,[\cos(\Theta)]$$

$$g = V_{Ia}V_{Gb} + V_{Ib}V_{Gc} + V_{Ic}V_{Ga}$$

$$= \frac{3}{4}[-\cos(\Theta) + \sqrt{3}\sin(\Theta)] \text{-------} (10)$$

Using the variable k and g, sin (Θ) can be found as

$$\mathrm{Sin}(\Theta) = \frac{\frac{4}{3}g + \frac{2}{3}}{\sqrt{3}}\,K \text{------------} (11)$$

Synchronized controller shows how sin (Θ) can be obtained the new phase angle for which the grid and inverter voltage are synchronized.

V. RESULT AND ANALYSIS

The below output waveforms shows the result of normal voltage of the grid,voltage obtaining with fault condition and voltage obtained after compensating the fault by using proposed control strategy:

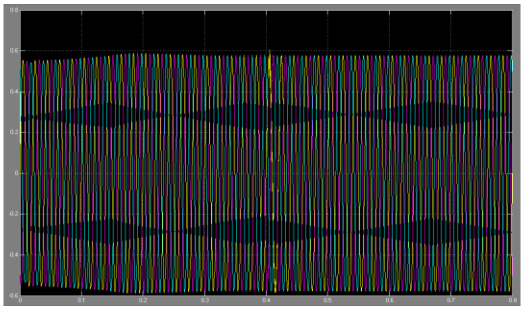

Fig 7 output waveform of normal grid voltage.

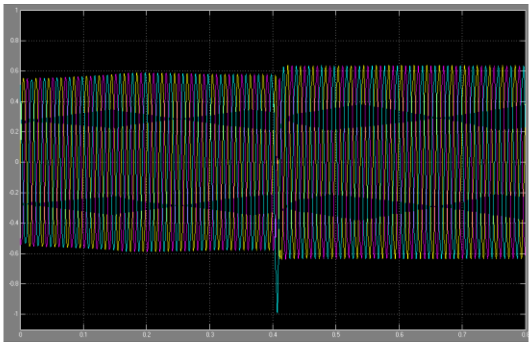

Fig 8 output volage waveform with fault occurs at 0.4 transition time.

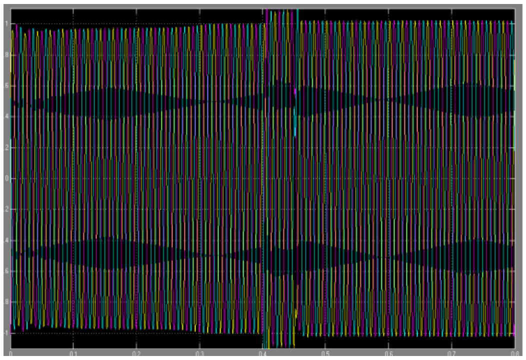

Fig 9 output voltage after compensating the fault within consecutive cycles.

VI COORDINATED CONTROL OF AC AND DC MICROGRIDS

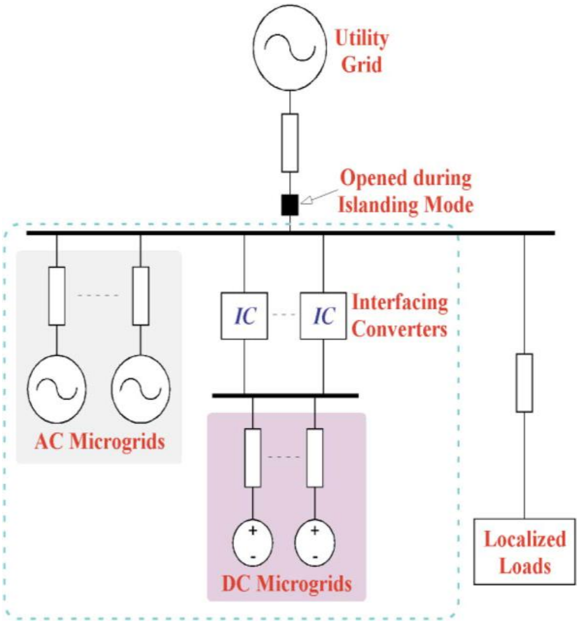

Fig 107 Example layout of ac and dc microgrids tied by interfacing converter

Probably, the simplest approach is to treat each microgrid as an independent network with either dc sources supplying only dc loads or ac sources supplying ac loads.That certainly defeats the purpose of linking the two microgrids and would require much higher source ratings in order to always meet supply and demand within each microgrid.To better coordinate the microgrids and to hence lower the source ratings, some forms of energy sharing between them must be introduced with preferably no or only slow communication link

The main contributing dc sources would undeniably be solar energy and fuel cells, and for storages, it would be different types of batteries and capacitive storage medium.For an acmicrogrid, the thought of grouping these dc entities together to form a dc microgrid for powering localized dc loads might equally be feasible with a significant reduction in power conversion stages expected.

VII CONCLUSION

In this paper a controller is designed both for grid connected operation and the other for Intentional islanding operation.An algorithm for the detection of islanding is presented which was responsible for the switch between the two controllers and also a reclosure algorithm which causes the DG to resynchronize itself with the grid is also designed.

Thus the paper summarize the traditional independent inverter and Grid connected inverter control strategy, combining the distributed power and microgrid inverter characterisitics, a suitable microgrid inverter control strategy is put forward.Switching between Grid connected mode and Grid disconnected mode for microgrid inverter has been studied.On the Grid disconnected operation microgrid inverter supplies the important loads that ensures load voltage and frequency stability.Microgrid inverter can smoothly switch between Grid connected operation and Grid disconnected operation, and switching operation of the system has good performance.The system controller design is simple,practical and efficient,easy to implement.The simulation results show that the proposed control method is feasible and effective.

Future work also expected in terms of cooperative control for power quality enhancement in microgrid,e.g., in the area of electrical vehicles.In these applications, the huge charging current of the electrical vehicle may deteriorate power quality.In this case, cooperative control can be integrated into the vehicle charger to assist improving voltage fluctuations and voltage harmonics in the low voltage distributed system.

REFERENCES

[1] Yun Wei Li, Member, IEEE, and Ching-Nan Kao,” An Accurate Power Control Strategy for Power- Electronics-Interfaced Distributed Generation Units Operation in a Low-

Voltage MultibusMicrogrid", IEE transaction on power electronics,vol.24, no. 12, december 2009

[2] Irvin J. Balaguer, UthaneSupatti, Qin Lei, Nam-Sup Choi,"Intelligent control for intentional Islanding Operation of Microgrids" ICSET 2008.

[3] Thacker,T.; Wang,F.; Burgos, R.; Boroyevich,D.;"Islanding Detection Using a Coordinate Transformation Based Phase-Locked Loop,:PowerElectronics Specialists Conference,2007, PESC 2007,IEEE,pages: 1151-1156,17-21 June2007.

[4] L.Qin, F.Z. peng, and I.J. Balaguer,"Islanding control of DG in microgrids,"in proc.IEEE 6th IPEMC,2009, pp.450-455.

[5] Irvin J. Balaguer,Qin Lei, Shuitao Yang, UthaneSupatti,FangZhengPeng," Control for Grid connected and Intentional Islanding Operations of Distributed Power Generation",IEEE transactions on industrial electronics,vol.58,no. 1, january 2011.

[6] Jayaweera, D; Galloway, s; Burt, G; McDonad, J.R.;" A Sampling Approach for Intentional Islanding of Distributed Generation,"PowerSystems,IEEE Transactions on, Volume 22, Issue 2, pages:514-521,may 2007.

[7] Carpaneto, E.; Chicco, G.; Prunotto, A., "Reliability of reconfigurable distribution systems including distributed generation," International Conference on Probabilistic Methods Applied toPower Systems, pages:1 – 6, 11-15 June 2006.

[8] Zeineldin, H.; El-Saadany, E.F.; Salama, M.M.A., "Intentional islanding of distributed generation," Power Engineering Society General Meeting, 2005. *IEEE*, Vol. 2, pages: 1496 – 1502, 12-16 June 2005.

[9] IEEE Std. 1547, "Standard for Interconnecting Distributed Resources with Electric Power Systems," 2003.

[10] Wu Chun-Sheng; Liao Hua; Wang Yi-Bo; Peng Yan-chang; Xu Hong- Hua, "Design of intelligent utility-interactive inverter with AI detection," Third International Conference on Electric Utility Deregulation and Restructuring and PowerTechnologies, DRPT 2008, pages: 2012 – 2017, 6-9 April 2008.

[11] T.C. Green; M. Prodanovic, "Control of inverter-based micro-grids," Electric Power SystemsResearch, Distributed Generation: Volume 77, Issue 9, pages 1204-1213, July 2007.

[12] J. C. Vasquez, J. M. Guerrero, J. Miret, M. Castilla, and L. G. de Vicuña, "Hierarchical control of intelligent microgrids," *IEEE* Ind. Electron. Mag., vol. 4, no. 4, pp. 23–29, Dec. 2010.

[13] M. Savaghebi , A. Jalilian, J. C. Vasquez, J. M. Guerrero, and T.-L. Lee ,"Voltage harmonic compensation of a microgrid operating in islanded andgrid-connected modes," in *Proc. ICEE*, 2011, pp. 1–6.

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