

Intelligent Islanding and Seamless Reconnection Technique for Micro grid and UPQC with Power Grid by Fuzzy Logic Controller

Dr P Sharath Kumar ¹, T.Kranthi Kumar²

^{1,2}Dept. of Electrical and Electronics Engineering, Avanthi Institute of Engineering & Technology, Ranga Reddy,
Telangana, India

ABSTRACT: In this thesis a new proposal for the placement, integration, and control of unified power quality conditioner (UPQC) in distributed generation (DG)-based grid connected/autonomous micro grid/micro generation (μ G) system has been proposed along with fuzzy logic controller. Here we using fuzzy logic controller instead of using other controllers i.e. The fuzzy controller is the most suitable for the human decision-making mechanism, providing the operation of an electronic system with decisions of experts. At the Point of Common Coupling (PCC) the DG converters (with storage) and the shunt part of the UPQC Active Power Filter (APFsh) is placed. Before the PCC the series part of the UPQC (APFse) is connected and in series with the grid. The dc link can also be integrated with the storage system. In the UPQC as a secondary control an intelligent islanding detection and reconnection technique (IR) are introduced Hence, it is termed as UPQC μ G –IR.. During the interconnected and islanded mode, DG converter with storage will supply the active power only and the shunt part of the UPQC will compensate the reactive and harmonic power of the load. During the voltage disturbance including phase jump, it also offers the DG converter to remain connected. The advantages of the proposed UPQC μ G –IR over the normal UPQC are to compensate voltage interruption in addition to voltage sag/swell, harmonic, and reactive power compensation in the interconnected mode. . The simulation was done by using MATLAB/Simulink software.

KEYWORDS: Distributed generation (DG), intelligent islanding detection (IsD), microgrid, Fuzzy logic controller, power quality, smart grid, unified power quality compensator (UPQC).

I. INTRODUCTION

The issues of a successful integration of unified power quality conditioner (UPQC) along with fuzzy logic controller in a distributed generation (DG)-based grid connected microgeneration (μ G) system are primarily: 1) for active power transfer control complexity; 2) during the islanded mode ability to compensate non active power; and 3) difficulty in the capacity enhancement in a modular way [1]. various operational changes are involved, For a seamless power transfer between the grid-connected operation and islanded mode, such as switching between the current and voltage control mode, robustness against the islanding detection and reconnection delays, and so on .Clearly, these further increase the control complexity of the μ G systems.

A new placement and integration technique of UPQC have been proposed To improve the power quality in grid connected μ G systems and also to extend the operational flexibility. Which is termed as UPQC μ G. In the UPQC μ G integrated distributed system, at the Point of Common Coupling (PCC) μ G system (with storage) and shunt part of the UPQC are placed. The series part of the UPQC is placed before the PCC and in series with the grid. The dc link is also connected to the storage, if present. To maintain the operation in islanded mode and reconnection through the UPQC and fuzzy, communication process between the UPQC μ G and μ G system is mentioned in [4]. By implementing an intelligent islanding and novel reconnection technique with reduced number of switches that will ensure seamless operation of the μ G without interruption.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

In this paper, the control technique of the presented UPQC μ G and fuzzy logic controller in [4] is enhanced. Hence, it is termed as UPQC μ G-IR. The benefits offered by the proposed UPQC μ G-IR over the conventional UPQC are as follows. To observe the effect on the characteristic of voltage sag / swell and interruption for the techniques. Both in the interconnected and islanded modes, the μ G provides only the active power to the load. Therefore, it can reduce the control complexity of the DG converters. Islanding detection and reconnection technique are introduced in the proposed UPQC as a secondary control. In the secondary control a communication between the UPQC and μ G is also provided. The DG converters may not require to have islanding detection and reconnection.

In this paper Different power quality issues their causes and consequences and solution have been discussed with islanding and reconnection technique. From the simulation results UPQC improves the power quality of power system during sag, swell and interruption condition with islanding condition. The THD of the source current and load current is reduced.

II. WORKING PRINCIPLE

As shown in Fig 1, the Integration technique of the UPQC micro grid -IR to a grid connected and DG integrated micro grid system is proposed. To island and reconnect the micro grid system S1 and S2 are the breaker switches that are used to the grid as directed by the secondary control of the UPQC micro grid -IR.

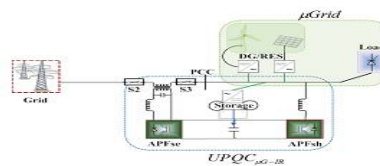


Fig.1 Integration technique of the UPQC μ G-IR. Working principle in

During the interconnected and islanded mode the working principle for this configuration is shown in Fig. 2 and 3. The operation of UPQC micro grid- IR can be divided into two modes.

A. INTERCONNECTED MODE

The Interconnected mode is shown in Fig 2. To the grid the DG source delivers only the fundamental active power, storage and load. To keep the THD at the PCC the APFsh compensates the reactive power and harmonic power (QH) of the non-linear load. By the active power from the grid/storage voltage sag swell/interruption can be compensated through the APFse. In any condition DG converter does not sense any kind of voltage disturbance at the PCC.

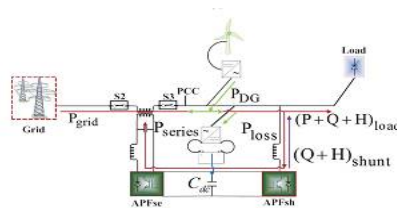


Fig.2 Interconnected mode

If the voltage interruption/black out occurs, UPQC sends a signal within a pre-set time to the DG converter to be islanded.

B. ISLANDED MODE

As shown in Fig.3 During the grid failure and DG converter remains connected the APFse is disconnected to maintain the voltage at PCC. The APFse is reconnected once the grid power is available. For other linear loads The APFsh still compensates the non-active power of the non-linear load to maintain undistorted current at PCC. Therefore, DG converter (with storage) delivers only the active power and hence from the system does not need to be disconnected.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

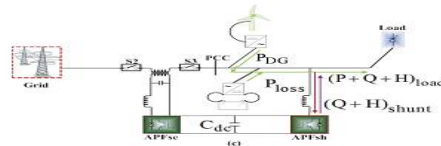
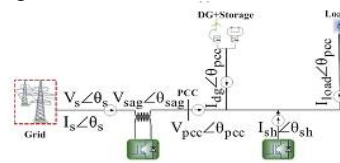


Fig. 3 Islanded mode

III. DESIGN ISSUES AND RATING SELECTION

According to the working principle, the APFse is able to work during voltage interruption/sag/swell up to a certain level before it is landed.. The APFsh always compensates QH power of the load. The fundamental frequency representation of the system and the voltage and current relations are derived in (1) and (2)



(d)

Fig. 4 fundamental frequency representation.

Therefore, design and rating selection for the APFse, APFsh, and series transformer together with the sizing of dc link capacitor are very important. These are discussed in the following section:

$$V_{pcc} < \theta_{pcc} = V_s < \theta_s + V_{sag} < \theta_{sag} \quad (1)$$

$$V_{pcc} < \theta_{load} = I_s < \theta_s + I_{dg} < \theta_{pcc} + I_{sh} < \theta_{sh} \quad (2)$$

Under any condition assume that $V_{pcc} = V_{dg} = V_{load}$ and $\theta_{pcc} = 0^\circ$.

A. SHUNT PART OF UPQCMG-IR (APFsh):

The phasor diagrams of The proposed system in different conditions are shown in Fig.5

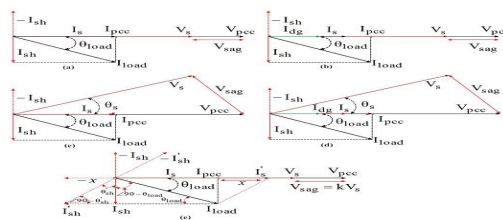


Fig 5 Phasor diagram of UPQCMG-IR when (a) no DG and $\theta_s = \theta_{pcc}$, (b) with DG and $\theta_s = \theta_{pcc}$, (c) no DG and $\theta_s = \theta_{pcc}$, (d) with DG and $\theta_s = \theta_{pcc}$, and (e) in-phase voltage compensation mode

APFsh compensates the non fundamental current of the load by injecting I_{sh} in quadrature to V_{pcc} at any condition. By injecting the required voltage to maintain the constant voltage and zero-phase at PCC When voltage sag appears in the supply side, APFse compensates the sag. From the source to complete the task, APFsh draws additional current, to supply power to the APFse. The increased source current I_s still remains in phase to the V_{pcc} . But this changes the magnitude and phase angle of the compensating current, as shown in Fig. 2(e) I_{sh} as an additional active component of current (x) is added to the shunt compensator current

In this case

$$\dot{I}_s = I_{pcc} + \dot{I}_{sh} \sin(\theta_{sh}) \quad (3)$$

$$\dot{I}_{sh} = I_{sh} / \cos \theta_{sh} \quad (4)$$

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

At PCC this ultimately increases the current and thus creates a VA loading impact on the APFsh

B .SERIES PART OF U P QCMG– I R (APFSE)

In the proposed integration technique when no energy is available from the DG unit. The APFse always appears in series with the grid and shunt the APF compensates the reactive and harmonic part of the load current, the active fundamental part of the load current (I_{loadfp}) flows through the APFse. Therefore, as the active load fundamental requirement the APFse must have at least the same current rating

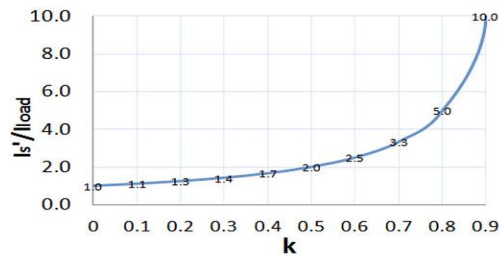


Fig. 6. Relation between source current, load current, and k for voltage sag compensation

$$I_{APFse,min} = I_{loadfp} \quad (5)$$

From Fig. 2(c) and (d), the general equation for voltage sag compensation by the APFse can be written as

$$V_{sag} = \sqrt{V_s^2 + V_{pcc}^2 - 2V_s V_{pcc} \cos(\theta_s - \theta_{pcc})} \quad (6)$$

The voltage rating of the APFse should be equal to the highest value of the injected sag voltage, thus

$$V_{APFse,rated} = V_{sag,max} = kV_{load,rated} \quad (7)$$

Assume k is the fraction of V_s that appears as a voltage sag

$$V_{sag} = kV_s = kV_{load} \text{ and } k < 1$$

Therefore, the VA rating of the APFse, can be calculated as

$$S_{APFse,rated} = I_{APFse,rated} V_{APFse,rated} = kV_{load,rated} \quad (8).$$

From Fig. 2, the active power transfer through the APFse can be calculated for the case when $I_{dg} = 0$

$$P_{APFse} = P_{loadf} \left[\frac{R_{lf}}{V_{load}} \cos(\theta_s - \theta_{pcc}) \right] \quad (9)$$

Under stable and in-phase operating conditions, assume that $\theta_s = \theta_{pcc} = 0$

$$P_{APFse} = \frac{kP_{load} V_s}{V_{load}} \quad (10)$$

Therefore, during voltage sag compensation, the source current that is transferred through the series transformer of the APFse, as shown in Fig. 2(e), can be calculated as

$$I'_s = \frac{P_{load}}{(1-k)V_s} = \frac{1}{(1-k)} I_{loadfp} \quad (11)$$

The voltage rating of the APFse is an important design parameter, as it determines some other characteristics, such as the compensating range, the need to include (and size of) energy storage devices, and the overall size of the series transformer. In addition, if the voltage rating of the APFse is increased, losses tend to increase. Therefore, the voltage injection capability should be chosen as low as necessary to reduce equipment cost and standby losses.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

Based on the minimization of the energy Control strategies are exchange during compensation or by reducing the voltage rating Thus, the size and VA rating of the series transformer depends on the amount of sag to be compensated.

DC Link Capacitor:

According to the working principle, during a high-sag/swell condition, the APFse should be able to work and even in the case of interruption (depending on the interruption time) before it goes to the islanded mode. At this stage, the dc link capacitor should be able: 1) to maintain the dc voltage with minimal ripple in the steady state; 2) to serve as an energy storage element to supply the non active power of the load as a compensation; and 3) to supply the active power difference between the load and source during the sag/swell or interruption period.

According to the calculation in [12], for the proposed system, the required capacitor size will be

$$C_{dc} = \frac{2S_{load}nT}{4cV_{dc}^2} \quad (12)$$

Where S_{load} is the total VA rating of the load, n is the number of cycles to perform the task, T is the time period, and c is the percentage of V_{dc} . For the supply continuity, DG storage system has also been introduced. Therefore, by the DG converters and storage the source current will maintain the required load current active component and the additional current will be provided. Thus, it will ultimately help to reduce the rating of the APFse converter. For the system a dc link connection between the capacitor and the DG storage has been proposed. It will help to reduce the size of the capacitor and provide power during the sag/interrupt condition.

IV. CONTROLLER DESIGN

The block diagram of the proposed UPQC μ G–IR controller is shown in Fig. 7.

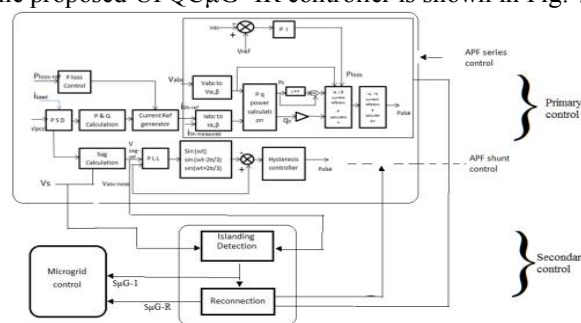


Fig. 7. Block diagram of the UPQC μ G–IR. (a) Controller. (b) Control algorithm

Except for the additional islanding detection and reconnection capabilities it has the same basic functionality as the UPQC controller. For the smooth operation a signals transfer between the proposed UPQC μ G–IR and the μ G is also required. Based on the overall integration technique and control strategy these signals generation are to improve the power quality during interconnected and islanded modes. This involves detecting islanding and reconnection that ensures the DG converter remains connected and supply active power to the load. The five main elements of the proposed UPQC μ G–IR controller are: 1) positive sequence detection; 2) series part (APFse) control; 3) shunt part (APFsh) control; 4) intelligent islanding detection (IsD); and 5) synchronization and reconnection (SynRec). As the IsD and SynRec features are new in UPQC, therefore, these have been described in details This reduces the control complexity of the converter as well as the power failure possibility in the islanded mode.

A. INTELLIGENT ISLANDING DETECTION

These are the most important features of the micro grid system. In that case, the placement of APFse in the proposed integration method of the system plays an important role by improving the operational flexibility of the DG converter in the microgrid system These are the most important features of the micro grid system. In that case, the placement of APFse in the proposed integration method of the system plays an important role by improving the operational flexibility of the DG converter in the microgrid system

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

Considering the future trends toward the smart-grid and μ G operation in connection with the distribution grid, the capability of: 1) maintaining connection during grid fault condition; 2) automatically detecting the islanded condition; and 3) reconnecting after the grid fault are the most important features of the μ G system. In that case, the placement of APFse in the proposed integration method of the system plays an important role by extending the operational flexibility of the DG converter in the μ G system

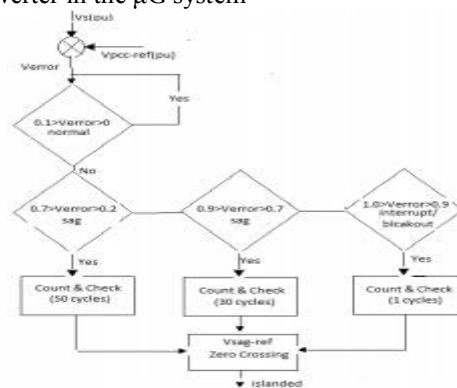


Fig.8. Algorithm for Is D method in UPQC μ G–IR.

To detect the islanding condition to operate the UPQC in islanded mode. Fig. 8 shows a simple algorithm that has been used. The voltage at PCC is taken as the reference and it is always in phase with the source and the DG converters, the difference between the $V_{pcc-ref}$ (pu) and V_s (pu) is V_{error} . To determine the sag/interrupt/islanding condition this error is then compared with the preset values (0.1–0.9) and a waiting period (user defined n cycles) is used. In this example: 1) if V_{error} is less than or equal to 0.6, then 60% sag will be compensated for up to 50 cycles; 2) if V_{error} is in between 0.6 and 0.9, then compensation will be for 30 cycles; and 3) otherwise (if $V_{error} \geq 0.9$) it will be interrupt/black out for islanding after 1 cycle

In the case of power quality problems, it is reported that more than 95% of voltage sags can be compensated by injecting a voltage up to 60% of the nominal voltage, with a maximum duration of 30 cycles. Therefore, based on the islanding detection requirement and sag/swell/interrupt compensation, islanding is detected and a signal $S_{\mu-1}$, as shown in Fig 2(b), signal is also generated in the proposed UPQC microgrid-IR to transfer it to the DG converters. As the series active power filter takes the responsibility for compensating voltage sag/swell/unbalance disturbances. Intelligence islanding detection algorithm in the proposed UPQC microgrid-IR can be simple and quite flexible. On the other hand, it will help to minimize the complexity of islanding detection technique

A. SYNCHRONIZATION AND RECONNECTION:

A smooth reconnection can be achieved when the difference between the voltage magnitude, phase, and frequency of the two buses are minimized or close to zero. Once the grid system is restored, the μ G may be reconnected to the main grid and return to its pre disturbance condition. The seamless reconnection also depends on the accuracy and performance of the synchronization methods [21]–[25]. In case of UPQC μ G–IR, reconnection is performed by the APFse. In addition, due to the control of sag/swell by the APFse, this UPQC μ G–IR has the advantage of reconnection even in case of phase jump/difference between the voltage of the utility and at the PCC.

Conditions for reconnection are set as: 1) assuming the phase difference between the utility grid and DG unit should be within $\theta_{sag-max}$; 2) instantaneous value of the two bus voltages becomes equal; and 3) these should occur at the zero-crossing condition

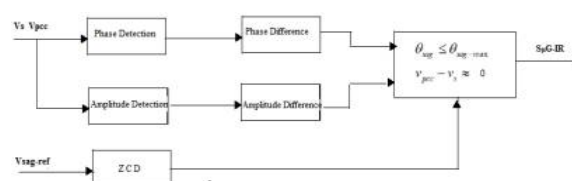


Fig .9 Synchronization and Reconnection method

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

$$\theta_{sag,max} = \cos[(\theta_s - \theta_{pcc})]^{-1} = 1/2 = 60^\circ \quad (13)$$

The relation for the phase difference and magnitude between Vs, Vpcc, and Vsag are also shown in Fig. 9(a). It also shows the zero-crossing point of the Vsag-ref depending upon the phase. This zero-crossing detection also indicates the point at which the instantaneous voltage difference between the utility and the PCC becomes zero. Detection of this zero-crossing point and activation of the switches S2 and S3, as shown in Fig. 1, at the same time are the key control of this reconnection method for a seamless transfer from the off-grid to the on-grid condition as well as changing the controller of the DG inverter from voltage to current control mode.

V. FUZZY LOGIC CONTROLLER

FLC is one of the most successful operations of fuzzy set theory. Its chief aspects are the exploitation of linguistic variables rather than numerical variables. FL control technique relies on human potential to figure out the system behavior and is constructed on quality control rules.. The basic structure of an FLC is represented in Fig.6.

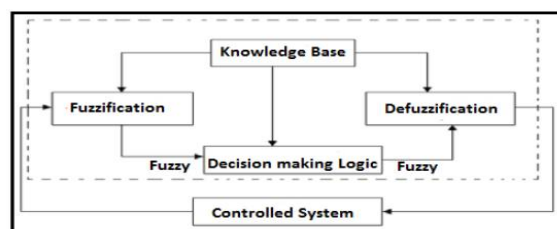


Fig.10. Basic structure of Fuzzy Logic controller

- A Fuzzification interface alters input data into suitable linguistic values.
- A Knowledge Base which comprises of a data base along with the essential linguistic definitions and control rule set.
- A Decision Making Logic which collects the fuzzy control action from the information of the control rules and the linguistic variable descriptions
- A Defuzzification interface which surrenders a non fuzzy control action from an inferred fuzzy control action. In this paper, an advanced control strategy, FLC is implemented along with UPQC for voltage correction through Series APF and for current regulation through Shunt APF. Error and Change in Error are the inputs and Duty cycle is the output to the Fuzzy Logic Controller as shown in Fig. 7-Fig.9

TABLE I. fuzzy rule representation

Change in error	Error						
	NB	NM	NS	Z	PS	PM	PB
NB	PB	PB	PB	PM	PM	PS	Z
NM	PB	PB	PM	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NM	NB
Z	PB	PM	PS	Z	NS	NM	NB
PS	PM	PS	Z	NS	NM	NB	NB
PM	PS	Z	NS	NM	NM	NB	NB
PB	Z	NS	NM	NM	NB	NB	NB

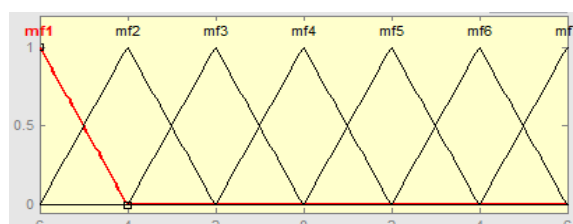


Fig. 11 input error membership functions

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

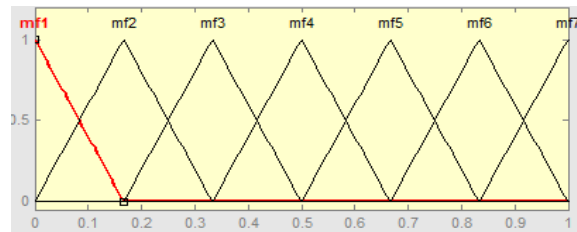


Fig. 12 change as error input

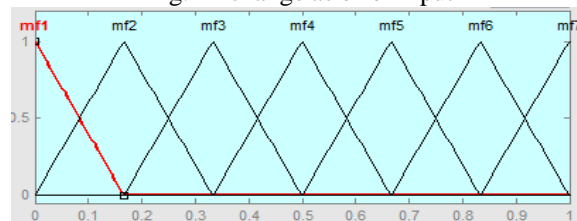


Fig. 13 Output variable membership functions

VI. SIMULATION RESULTS

A 3-phase, 3-wire active distribution network (230 VL–N) with the proposed UPQC μ G–IR and μ G, as shown in Fig. 1, has been developed in the MATLAB using RT-LAB (realtime simulation) tools to observe the performance in the real-time environment. The system is then tested in software-in-loop (SIL), i.e., both the controller and plant are simulated and controlled with the help of real-time communication through external AD/DA cards with appropriate time delay, which is termed as the hardware synchronization mode. Fig. 14 shows the real-time simulation structure in a SIL configuration used to develop the real-time environment by OPAL-RT.

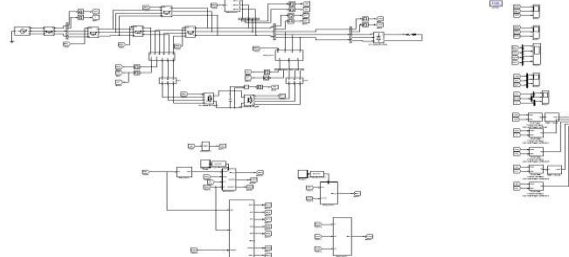
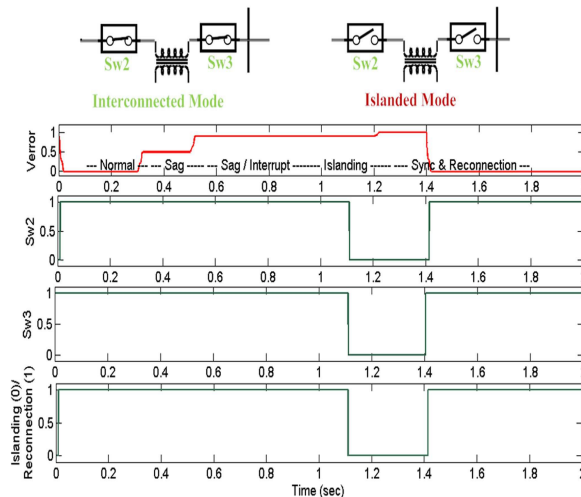


Fig. 14. Matlab model for proposed method



(a)

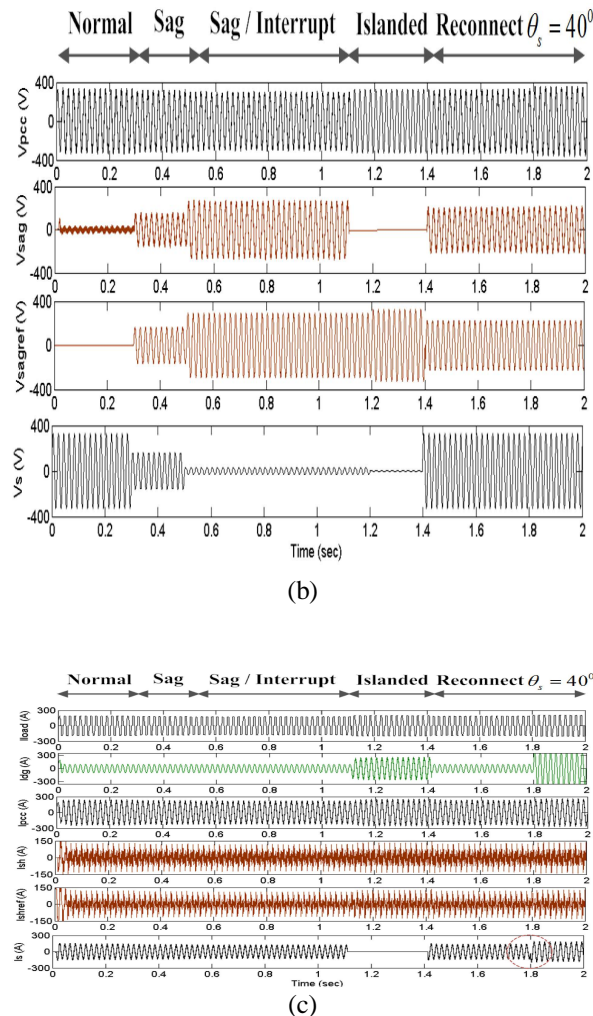


Fig. 15 (a) Switching positions during the operation. (b) Voltage and (c) current waveforms at different conditions and positions in the network, Performance of APFse in forward-reverse flow condition with compensating voltage sag (80%). Dynamic change

Interconnected Mode:

In this case, two possible mode of operation can be observed: 1) forward and 2) reverse flow. In the forward flow mode, the available DG power is less than the required load demand. The utility supplies rest of the power to the load. When the DG power becomes higher than the required load demand, the extra energy is transferred to the grid and storage and this is termed the reverse-flow mode. At this stage, the grid current becomes out of phase with the voltage at PCC. Here we using fuzzy logic controller instead of using other controllers i.e. The fuzzy controller is the most suitable for the human decision-making mechanism, providing the operation of an electronic system with decisions of experts.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

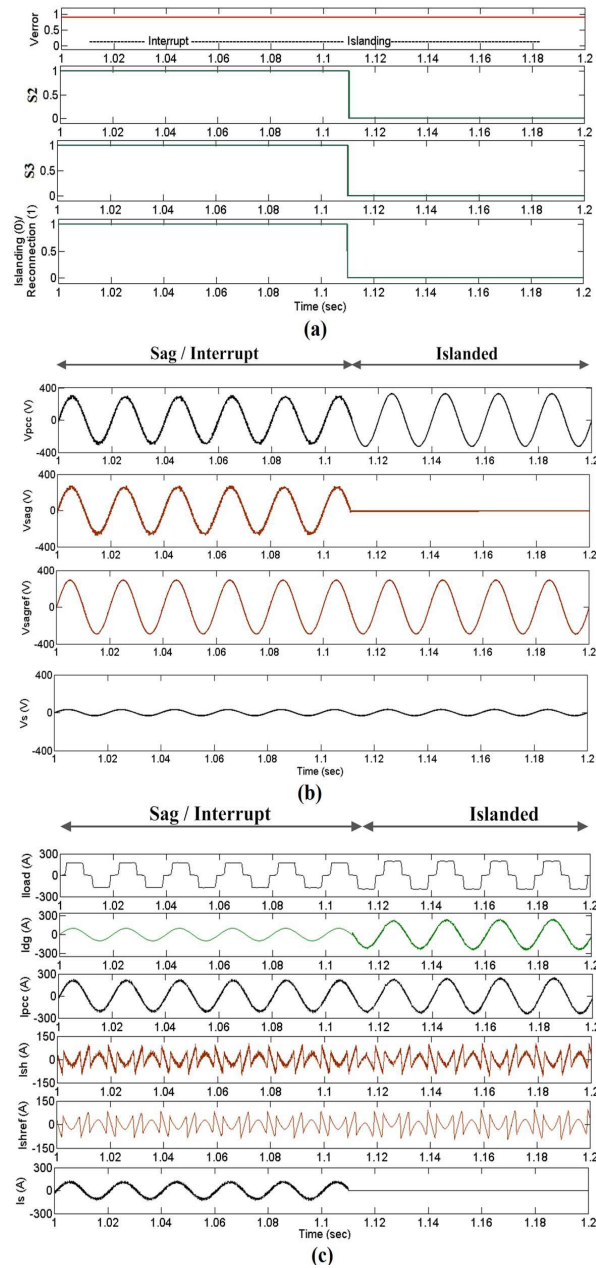


Fig. 16. Performance. (a) Switching (S2 and S3 are open).
(b)APFse. (c) APFsh during islanded mode.

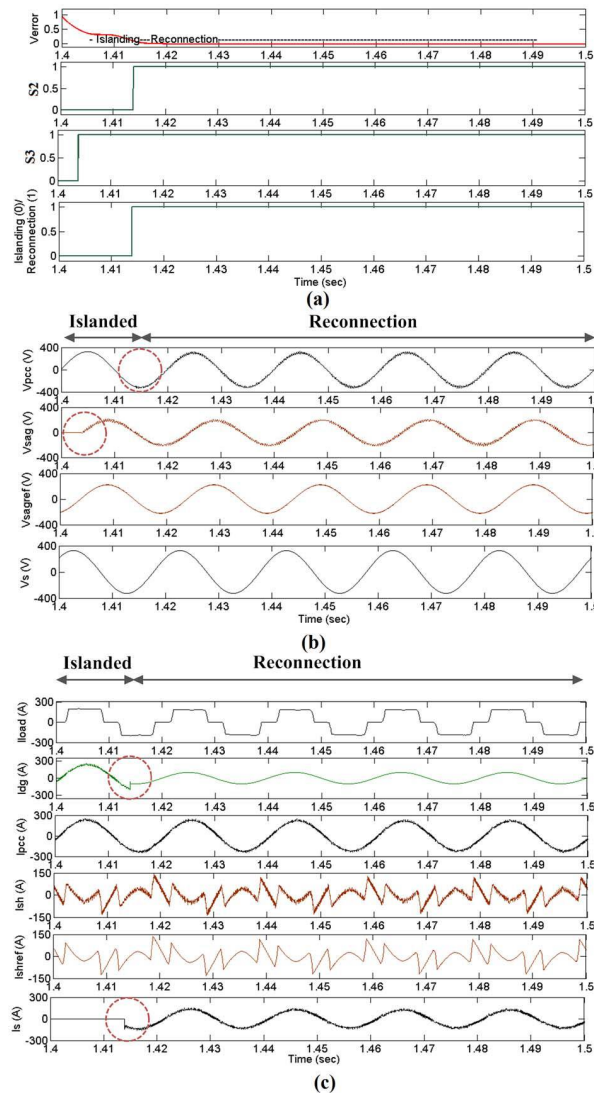


Fig. 17. Reconnection. (a) Switching (S2 and S3 instances are shown).(b) APFse (S3 is lost).(c) APFsh (S2 is closed as shown in switching diagram)

Islanding Detection

According to the IsD method, the APFse compensates the sag for up to 0.6 s (30 cycles) and then the system goes into islanded mode. A utility disconnection is applied at 1.11 s just after completing the 30 cycle count and then detecting the zero-crossing of Vsag-ref where S2 and S3 are opened.

VII. CONCLUSION

In this thesis a new proposal for the placement, integration, and control of unified power quality conditioner (UPQC) in distributed generation (DG)-based grid connected/autonomous micro grid/micro generation (μ G) system has been proposed along with fuzzy logic controller. This paper describes integration technique of the proposed UPQC μ G-IR in the grid connected μ G condition using fuzzy logic controller. The performance with off-line simulation has obtained by using MATLAB. The results show that the UPQC μ G-IR can compensate the voltage and current disturbance at the PCC during the interconnected mode. Performance is also observed in bidirectional power

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

flow condition. In islanded mode, the DG converters only supply the active power. Islanding detection and seamless reconnection technique by the UPQC μ G–IR and the dynamic change with bidirectional power flow are obtained in real-time for a DG integrated μ G System without compromising on power quality. Here we using fuzzy logic controller instead of using other controllers. The fuzzy controller is the most suitable for the human decision-making mechanism, providing the operation of an electronic system with decisions of experts.

REFERENCES

- [1] S. K. Khadem, M. Basu, and M. F. Conlon, “UPQC for power quality improvement in DG integrated smart grid network—A review,” *Int. J. Emerg. Electr. Power Syst.*, vol. 13, no. 1, p. 3, 2012.
- [2] A. Kahrobaeian and Y.-R. Mohamed, “Interactive distributed generation interface for flexible micro-grid operation in smart distribution systems,” *IEEE Trans. Sustainable Energy*, vol. 3, no. 2, pp. 295–305, Apr. 2012.
- [3] X. Yu, A. M. Khambadkone, H. Wang, and S. Terence, “Control of parallel-connected power converters for low-voltage microgrid—Part I: A hybrid control architecture,” *IEEE Trans. Power Electron.*, vol. 25, no. 12, pp. 2962–2970, Dec. 2010.
- [4] S. K. Khadem, M. Basu, and M. F. Conlon, “A new placement and integration method of UPQC to improve the power quality in DG network,” in *Proc. 48th UPEC*, vol. 1, Sep. 2013, pp. 1–6.
- [5] T. Jimichi, H. Fujita, and H. Akagi, “Design and simulation ation of a dynamic voltage restorer capable of significantly reducing an energy-storage element,” *IEEE Trans. Ind. Appl.*, vol. 44, no. 3, pp. 817–825, May/Jun. 2008.
- [6] M. Basu, S. P. Das, and G. K. Dubey, “Comparative evaluation of two models of UPQC for suitable interface to enhance power quality,” *Electr. Power Syst. Res.*, vol. 77, no. 7, pp. 821–830, 2007.
- [7] J. Nielsen, F. Blaabjerg, and N. Mohan, “Control strategies for dynamic voltage restorer compensating voltage sags with phase jump,” in *Proc. 16th APEC*, vol. 2, 2001, pp. 1267–1273.
- [8] D. M. Vilathgamuwa, A. R. Perera, and S. S. Choi, “Voltage sag compensation with energy optimized dynamic voltage restorer,” *IEEE Trans. Power Del.*, vol. 18, no. 3, pp. 928–936, Jul. 2003.
- [9] S. S. Choi, J. D. Li, and D. M. Vilathgamuwa, “A generalized voltage compensation strategy for mitigating the impacts of voltage sags/swells,” *IEEE Trans. Power Del.*, vol. 20, no. 3, pp. 2289–2297, Jul. 2005.
- [10] M. R. Banaei, S. H. Hosseini, S. Khanmohamadi, and G. B. Gharehpetian, “Verification of a new control strategy for dynamic voltage restorer by simulation,” *Simul. Model. Pract. Theory*, vol. 14, no. 2, pp. 112–125, 2006.
- [11] M. Moradlou and H. R. Karshenas, “Design strategy for optimum rating selection of interline DVR,” *IEEE Trans. Power Del.*, vol. 26, no. 1, pp. 242–249, Jan. 2011.
- [12] S. K. Khadem, M. Basu, and M. F. Conlon, “Harmonic power compensation capacity of shunt active power filter and its relationship with design parameters,” *IET Power Electron.*, vol. 7, no. 2, pp. 418–430, 2013.

BIOGRAPHY



Dr P Sharath kumar, Ph.D., Professor, Avanthi Institute of Engineering & Technology Affiliated to JNTUH Telangana, India



Mr T Kranthi Kumar, M.Tech., assoc. professor Avanthi Institute of Engineering & Technology Affiliated to JNTUH Telangana, India