

Integration of fuzzy logic controlled UPQC to micro grid with seamless reconnection and islanding mode.

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Abstract-Unified power quality conditioners (UPQCs) allow the mitigation of voltage and current disturbances that could affect sensitive electrical loads while compensating the load reactive power. Installation of minor power generation equipment at load facilities in power distribution system called distributed generation (DG) has become trendy these days. This paper illustrates the UPQC connected to DG micro-grid. DG system operating in grid connected mode and islanding mode were described. The paper mainly focuses the micro-grid seamless reconnection technique from islanding mode to grid connected mode using fuzzy controller. Algorithm for islanding detection in micro-grid for islanding reconnection (IR) is depicted. 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. The algorithm with proposed system was validated with results obtained using MATLAB/SIMULINK software.

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

I. INTRODUCTION

The challenging issues of a successful placement and integration of unified power quality conditioner (UPQC) in a distributed generation (DG)-based grid connected microgrid (μ G) system are 1) Control complexity for active power transfer; 2) ability to compensate non-active power during the islanded mode; and 3) difficulty in the capacity embellishment in a modular way [1]. For a smooth power transfer between the grid-connected system and islanded mode, various operational changes are presented, such as switching between the current and voltage control mode, robustness against the islanding detection and reconnection delays and method and so on [2], [4]. Clearly, these further increase the control complexity of the microgrid systems. To extend the operational flexibility and to improve the power quality in grid connected microgrid systems, a new control strategy placement and integration technique of UPQC have been proposed in [3], which is termed as UPQC μ G. In the UPQC μ G integrated distributed system, micro grid (with storage) and shunt part of the UPQC μ G

are placed at the Point of common coupling. The series of the UPQC is placed before the Point of common coupling and in series with the grid. DC link is connected to the storage also, if present.

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 provide 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. 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 [5]. In this paper, the control technique of the presented UPQC μ G and fuzzy logic controller in [6] is enhanced 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 [7]. 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.

- It can compensate voltage interruption/sag/swell and non-active current in the interconnected mode.
- Therefore, the DG converter can still be connected to the system during these distorted conditions. Thus, it enhances the operational flexibility of the DG converters/ μ G system to a great extent, which is further elaborated in later section.
- Shunt part of the UPQC Active Power Filter (APFsh) can maintain connection during the islanded mode and also compensates the non-active Reactive and Harmonic Power (QH) power of the load.

- Both in the interconnected and islanded modes, the μ G provide 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. A communication between the UPQC and μ G is also provided in the secondary control. The DG converters may not require having islanding detection and reconnection features in their control system [8-12].

II WORKING PRINCIPLE

The integration technique of the proposed UPQC $_{\mu$ G-IR to a grid connected and DG integrated μ G system is shown in Fig. 1(a). S2 and S3 are the breaker switches that are used to island and reconnect the μ G system to as directed by the secondary control of the UPQC $_{\mu$ G-IR. The working principle during the interconnected and islanded mode for this configuration is shown in Fig. 1 (b) and (c). The operation of UPQC $_{\mu$ G-IR can be divided into two modes.

A. Interconnected Mode

In this mode, as shown in Fig. 1(b), the following holds:

- 1) The DG source delivers only the fundamental active power to the grid, storage, and load;
- 2) The APFsh compensates the reactive and harmonic (QH) power of the nonlinear load to keep the Total Harmonic Distortion at the PCC within the IEEE standard limit;
- 3) Voltage sag/swell/interruption can be compensated by the active power from the grid/storage through the APFse, t. The DG converter does not sense any kind of voltage disturbance at the PCC and hence remains connected in any condition;
- 4) If the voltage interruption/black out occurs, UPQC sends a signal within a preset time to the DG converter to be islanded.

B. Islanded Mode

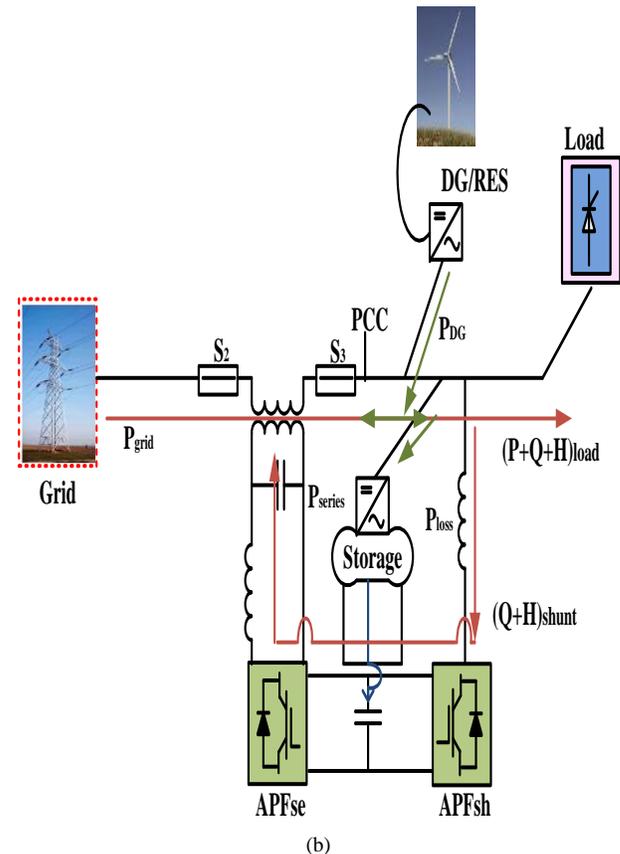
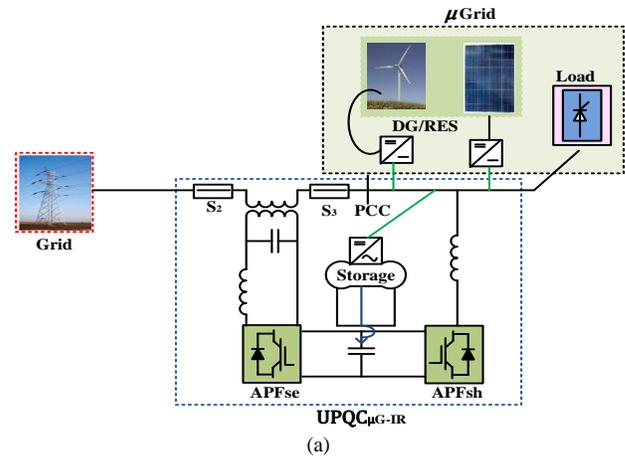
In this case, as shown in Fig. 1(c), the following holds:

- 1) The APFse is disconnected during the grid failure and DG converter remains connected to maintain the voltage at PCC;
- 2) The APFsh still compensates the nonactive power of the nonlinear load to provide or maintain undistorted current at PCC for other linear loads (if any);
- 3) Therefore, DG converter (with storage) delivers only the active power and hence does not need to be disconnected from the system;
- 4) The APFse is reconnected once the grid power is available.

From Fig. 1(a)-(c), it is clear that the UPQC $_{\mu$ G-IR requires two switches compared with four, as required for UPQC $_{\mu$ G in [4]. A detail of the switching mechanism is discussed in the controller design section.

III. DESIGN ISSUES AND RATING SELECTION

The fundamental frequency representation of the system is shown in Fig. 1(d) and the voltage and current relations are derived in (1) and (2). According to the working principle, the APFse is able to work during voltage interruption/sag/swell up to a certain level before it is islanded. The APFsh always compensates QH power of the load. Therefore, design and rating selection for the APFse, APFsh, and series transformer together with the sizing of dc link capacitor are very important.



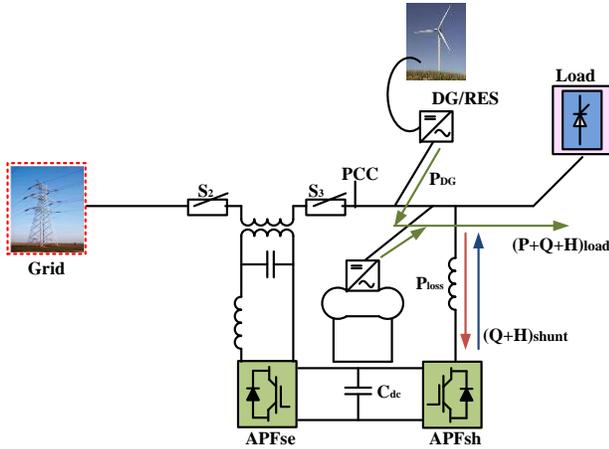


Fig. 1. (a) Integration technique of the UPQCμG-IR. Working principle in (b) interconnected mode, (c) islanded mode, and (d) fundamental frequency representation.

These are discussed in the following section:

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

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

Under any condition assume that $V_{pcc} = V_{dg} = V_{load}$ and $\theta_{pcc} = 0^\circ$. The phasor diagrams of the proposed system in different conditions are shown in Fig. 2.

A. Shunt Part of UPQCμG-IR (APFsh)

It is shown in Fig. 2 that for any condition, APFsh compensates the non-fundamental current of the load by injecting I_{sh} in quadrature to V_{pcc} . When voltage sag appears in the supply side, APFse compensates the sag by injecting the required voltage to maintain the constant voltage and zero-phase at PCC. To complete the task, APFsh draws additional current from the source, 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, I_{sh} as an additional active component of current (x) is added to the shunt compensator current now, as shown in Fig. 2(e).

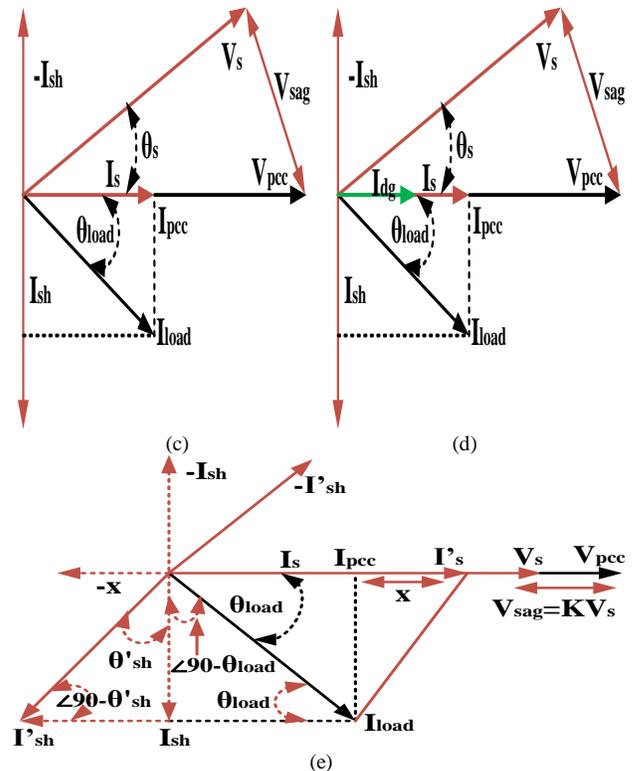
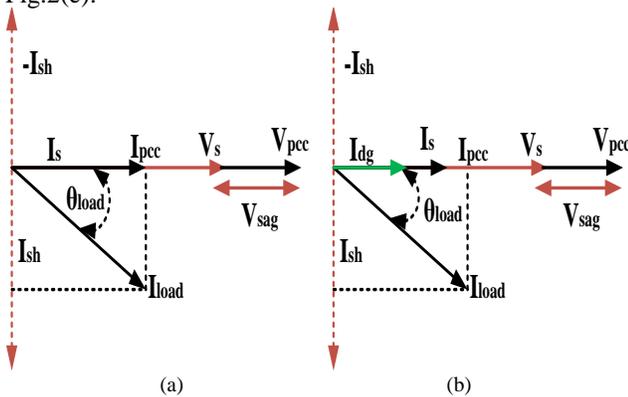


Fig. 2. Phasor diagram of UPQCμG-IR when (a) no DG and $\theta_s = \theta_{pcc}$, (b) with DG and $\theta_s = \theta_{pcc}$, (c) no DG and $\theta_s \neq \theta_{pcc}$, (d) with DG and $\theta_s \neq \theta_{pcc}$, and (e) in-phase voltage compensation mode.

In this case

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

$$I'_{sh} = I_{sh} / \cos(\theta'_{sh}) \quad (4)$$

This ultimately increases the current at PCC and thus creates a VA loading impact on the APFsh, which is also observed in [6].

B. Series Part of UPQCμG-IR (APFse)

The APFse always appears in series with the grid. In the proposed integration technique when no energy is available from the DG unit 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, the APFse must have at least the same current rating as the active load fundamental requirement

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

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 Vs 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

$$S_{APFse, rated} = I_{APFse, rated} V_{APFse, rated} = kP_{loadf, rated} \quad (8)$$

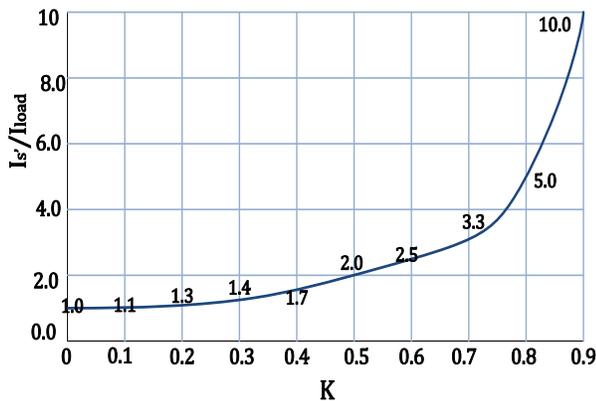


Fig.3. Relation between source current, load current, and for voltage sag compensation.

From Fig.2, the active power transfer through the APFse can be calculated for the case when Idg=0

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

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

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

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

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

Thus, the size and VA rating of the series transformer depends on the amount of sag to be compensated. Fig.3. shows how the source current increases with the value of k. Based on (6)–(11), and for a given value of k, there can be of multiple solutions for Vsag, I's, and P_{APFse}. Control strategies are based on the minimization of the energy exchange during compensation or by reducing the voltage rating [5]–[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, losses tend to increase if the voltage rating of the APFse is increased. Therefore, the voltage injection capability should be chosen as low as necessary to reduce equipment cost and standby losses.

C. DC Link Capacitor

According to the working principle, the APFse should be able to work during a high-sag/swell condition 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 nonactive 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. For a specific system, it is better to consider the higher value of C_{dc} so that it can handle all of the above conditions. It also helps to get a better transient response and lower the steady-state ripples. According to the calculation in [12], for the proposed system, the required capacitor size will be

$$C_{dc} = \frac{2S_{load} \cdot n \cdot T}{4 \cdot c \cdot V_{dc}^2} \quad (12)$$

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}.

It indicates that the size of the capacitor can be adjusted by the selection of cycles (n) for which the APFse will compensate. One of the purposes of the proposed integration technique of the UPQC_{μG}–IR is to maintain smooth power supply during sag/swell/interruption and extend the flexibility of the DG converters operation during interconnected and islanded modes. For the supply continuity, DG storage system has also been introduced. Therefore, a dc link connection between the capacitor and the DG storage has been proposed for the system. It will help to reduce the size of the capacitor and provide power during the sag/interrupt condition. Therefore, the source current will maintain the required load current active component and the additional current will be provided by the DG converters and storage. Thus, it will ultimately help to reduce the rating of the APFse converter.

IV. CONTROLLER DESIGN

The block diagram of the proposed UPQC_{μG}–IR controller is shown in Fig.4. It has the same basic functionality as the UPQC controller except for the additional islanding detection and reconnection capabilities. A communication channel (signals transfer) between the proposed UPQC_{μG}–IR and the μG is also

required for the smooth operation. These signals generation are based on the sag/swell/interrupt/supply failure conditions. This task is performed in Level 2 (secondary control) of the hierarchical control. Level 1 deals with the primary control of the UPQC to perform their basic functions in the interconnected and the islanded mode. The overall integration technique and control strategy 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. This reduces the control complexity of the converter as well as the power failure possibility in the islanded mode. The five main elements of the proposed UPQC_{μG-IR} controller are: 1) positive sequence detection; 2) series part (APF_{se}) control; 3) shunt part (APF_{sh}) 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.

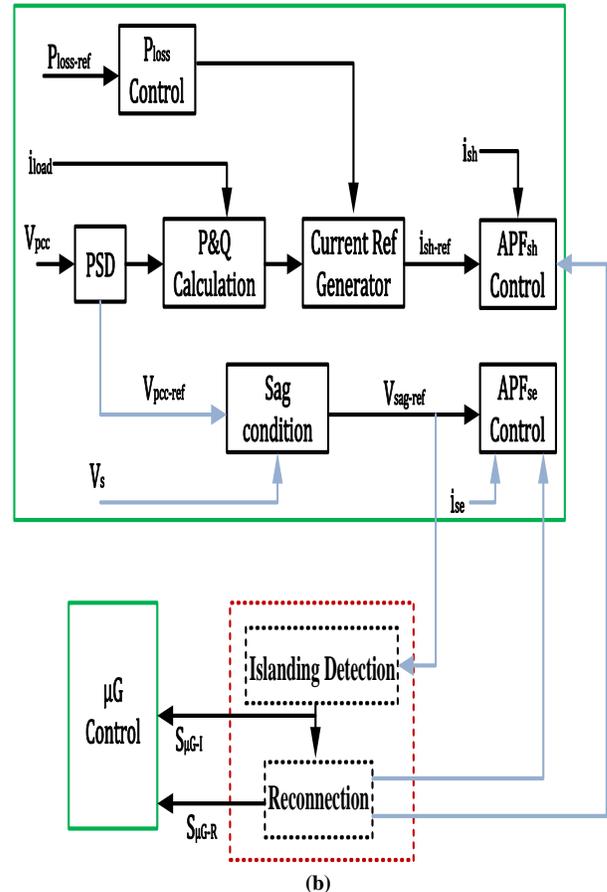
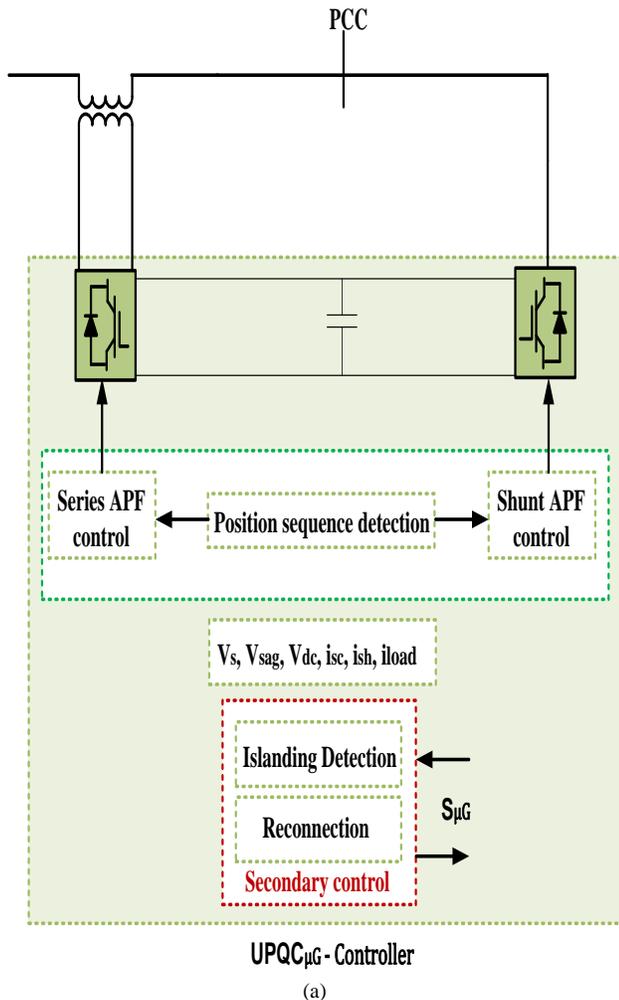


Fig.4. Block diagram of the UPQC_{μG-IR}. (a) Controller. (b) Control algorithm.

A. Intelligent Islanding Detection

Considering the future trends toward the smart-grid and μG 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 μG system. In that case, the placement of APF_{se} in the proposed integration method of the system plays an important role by extending the operational flexibility of the DG converter in the μG system.

In addition to the islanding detection, changing the control strategy from current to voltage control may result in serious voltage deviations and it becomes severe when the islanding detection is delayed in the case of hierarchical control. Therefore, seamless voltage transfer control between the grid connected and isolated controlled modes is very important. Both indirect and direct current control techniques are proposed in [2] to mitigate the voltage transients in transition mode, but these then increase the control complexity of the μG converters.

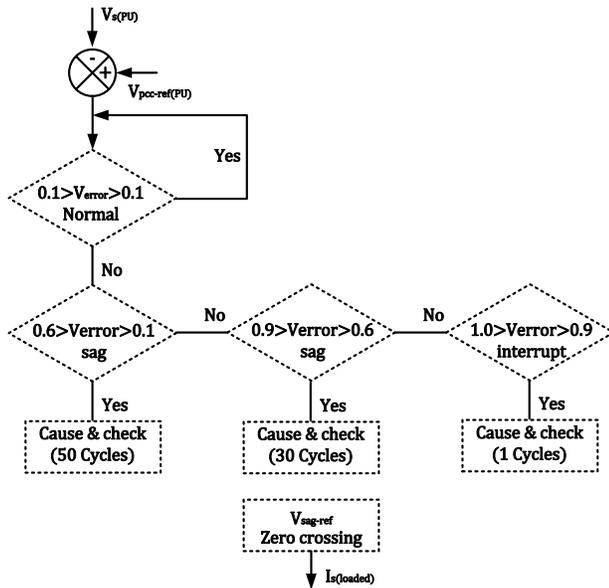


Fig.5. Algorithm for IsD method in UPQCμG-IR.

In the case of power quality problems, it is reported that more than 95% of voltage sags can be compensated by injecting a voltage of 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 $S_{\mu G-I}$, as shown in Fig.4(b), is also generated in the proposed UPQCμG-IR to transfer it to the DG converters. As the APFse takes the responsibility for compensating voltage sag/swell/unbalance disturbances (depending on the controller), IsD algorithm in the proposed UPQCμG-IR can be simple yet quite flexible. On the other hand, it will help to reduce the complexity of islanding detection technique or even can be removed from all the DG converters in a μG system. Fse takes the responsibility for compensating voltage sag/swell/unbalance disturbances (depending on the controller), IsD algorithm in the proposed UPQCμG-IR can be simple yet quite flexible. On the other hand, it will help to reduce the complexity of islanding detection technique or even can be removed from all the DG converters in a μG system.

Fig.5 shows a simple algorithm (with example) that has been used to detect the islanding condition to operate the UPQC in islanded mode. 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} . This error is then compared with the preset values (0.1–0.9) and a waiting period (user defined n cycles) is used to determine the sag/interrupt/islanding condition. 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.

This signal generation method is simple and can be adjusted for any time length and V_{error} condition. Thus, the intelligence can be achieved by introducing the operational flexibility of time and control of sag/interrupt compensation before islanding. As the seamless voltage transfer from grid connected to isolated mode is one of the critical tasks in transition period, the transfer is completed at the zero-crossing position of the APFse. Therefore, no voltage fluctuation or abrupt conditions occur.

It is to be noted that, this is the first time the algorithm and islanding techniques are introduced in the control part of the UPQC, which are intelligent and flexible in operation. According to Fig.1, the proper control and operation of the switches are very important for intelligent islanding and seamless reconnection. In that case, this paper presents a topology that represents a step forward compared with the use of intelligent connection agents (ICA) as presented, an additional module named ICA is connected to an existing μG with a number of current sources. The ICA module acts as voltage source to fix the voltage and frequency in islanding mode and is able to guarantee seamless connection/disconnection of the μG from the main grid. The UPQCμG-IR presented in this paper is not only able to perform these seamless transitions, but also improve the power quality with some operational flexibility. In addition, the UPQC having a series element (APFse) can perform the role of voltage source of the μG, and easily PCC voltage observation-based anti-islanding algorithm can be implemented, as shown in Fig.5. Notice that using conventional equipment, e.g., in grid connected PV systems, the non-detection zone (NDZ) increases with the number of PV inverters, since they are not able to distinguish between the external grids or other PV inverters output voltage, thus may remain connected for a dangerously long time. With the proposed UPQC control strategy, we can add it in an existing PV plant, and this unit will be the only one responsible of the voltage support and islanding detection, thus being more effective and reducing drastically the NDZ.

VI. FUZZY LOGIC CONTROL

Many applications, such as robotics and factory automation, require precise control of speed and position. Speed Control Systems allow one to easily set and adjust the speed of a motor. The control system consists of a speed feedback system, a motor, an inverter, a controller

and a speed setting device. A properly designed feedback controller makes the system insensible to disturbance and changes of the parameters.

A.PI Controller:

The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. Closed loop speed control systems have fast response, but become expensive due to the need of feedback components such as speed sensors. Speed controller calculates the difference between the reference speed and the actual speed producing an error, which is fed to the PI controller. PI controllers are used widely for motion control systems. They consist of a proportional gain that produces an output an output proportional to the input error an integration to make the steady state error zero for a step change in the input. PI controller is a generic control loop feedback mechanism (controller) widely used in industrial control systems – a PI is the most commonly used feedback controller and calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs. The PI controller calculation (algorithm) involves two separate constant parameters, and is accordingly sometimes called two-term control: the proportional, the integral values, denoted P, I. Heuristically, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve. There are several methods for tuning a PI loop.

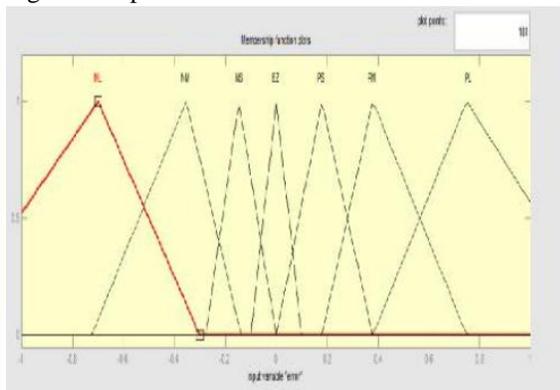


Fig.6. Membership functions of FLC

B.FLC Controller:

Fuzzy logic is widely used in control technique. The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as "true" or "false" but rather as "partially true". Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human

operators can understand, so that their experience can be used in the design of the controller of BLDC. The linguistic variables are defined as (NB, NS, Z, PS, PB) which mean big, negative small, zero, positive small and positive big respectively. The membership functions are shown in Fig. 6.

| u | e | | | | | | | |
|------------|----|----|----|----|----|----|----|----|
| | | NB | NM | NS | Z | PS | PM | PB |
| | | | | | | | | |
| | PM | Z | PS | PM | PB | PB | PB | PB |
| | PB | NS | Z | PS | PM | PB | PB | PB |
| Δe | PS | NM | NS | Z | PS | PM | PB | PB |
| | Z | NB | NM | Z | Z | PS | PM | PB |
| | NS | NB | NB | NS | NS | Z | PS | PM |
| | NM | NB | NB | NM | NM | NS | Z | PS |
| | NB | NB | NB | NB | NB | NM | NS | Z |

Table 1. The decision table of FLC.

As seen from table 1, each interval of each variable is divided into seven membership functions: Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (Z), Positive Small (PS), Positive Medium (PM) and Positive Big (PB).

C. Hybrid Fuzzy-PID Controller

Although it is possible to design a fuzzy logic type of PID controller by a simple modification of the conventional ones, via inserting some meaningful fuzzy logic IF- THEN rules into the control system, these approaches in general complicate the overall design and do not come up with new fuzzy PID controllers that capture the essential characteristics and nature of the conventional PID controllers. Besides, they generally do not have analytic formulas to use for control specification and stability analysis. The fuzzy PD, PI, and PI+D controllers to be introduced below are natural extensions of their conventional versions, which preserve the linear structures of the PID controllers, with simple and conventional analytical formulas as the final results of the design. Thus, they can directly replace the conventional PID controllers in any operating control systems (plants, processes).

The main difference is that these fuzzy PID controllers are designed by employing fuzzy logic control principles and techniques, to obtain new controllers that possess analytical formulas very similar to the conventional digital PID controllers.

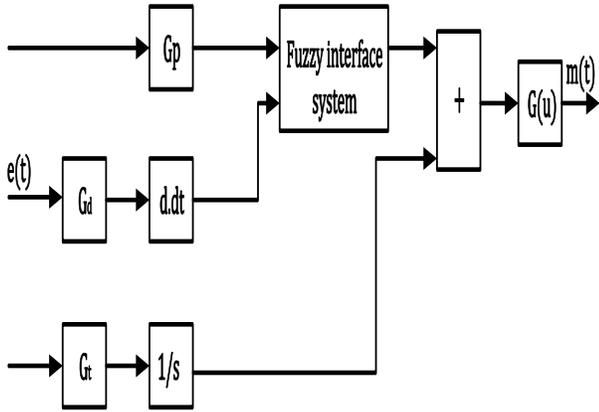


Figure.7. Hybrid Fuzzy PID Controller

IV.MATLAB/SIMULATION RESULTS

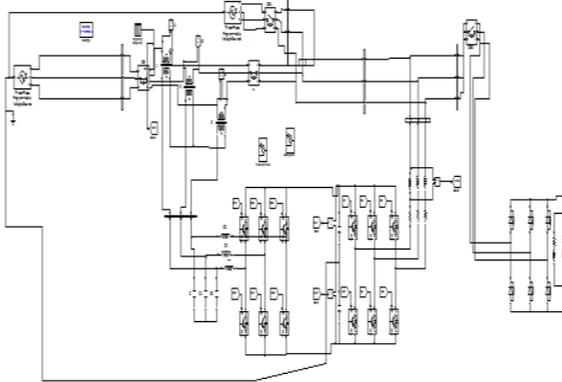


Fig.8 MATLAB/SIMULINK Circuit for the UPQCμG-IR

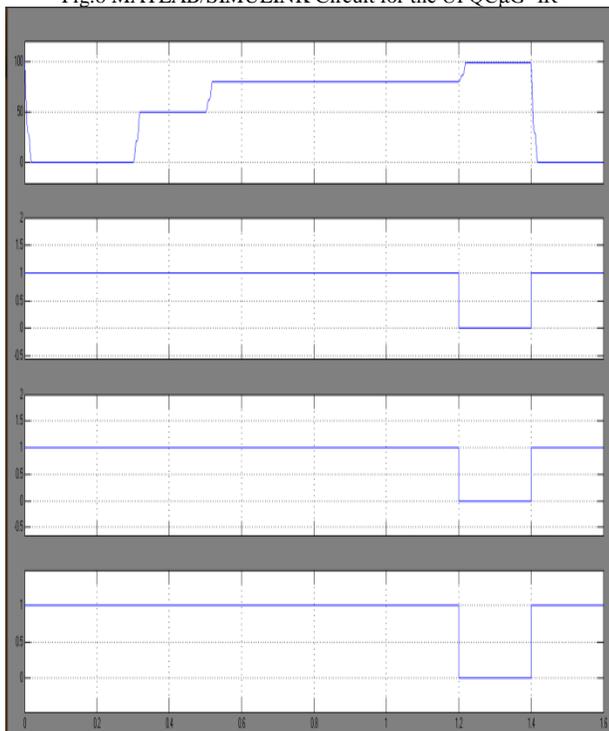


Fig.9 Error voltage, Switch 2 voltage, Switch 3 voltage and Islanding reconnection

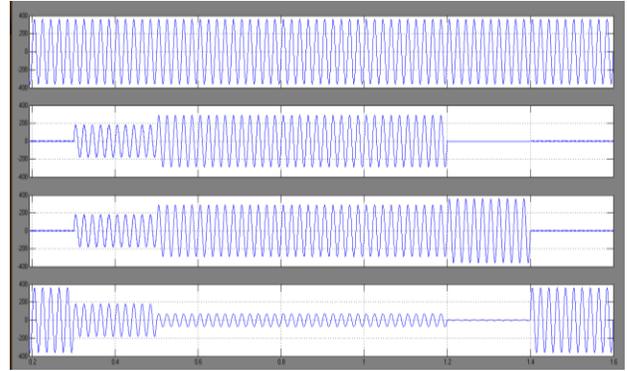


Fig.10 Point of Common Coupling (PCC) voltage, Sag Voltage, Reference sag voltage and supply voltage

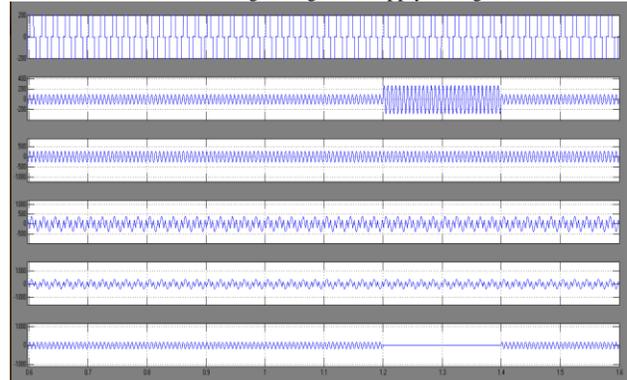


Fig.11 Load current, Distributed Generation current, Point of Common Coupling (PCC) current, Shunt current, Reference shunt current and Source current

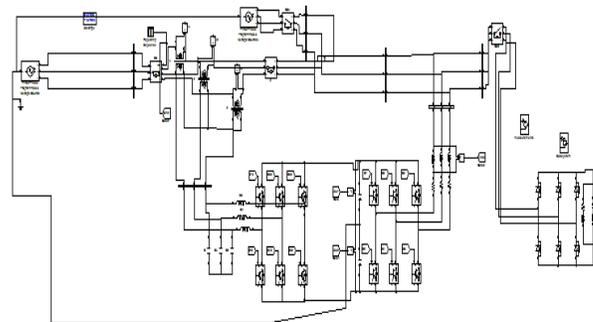


Fig.12 MATLAB/SIMULINK Circuit for the UPQCμG-IR performance

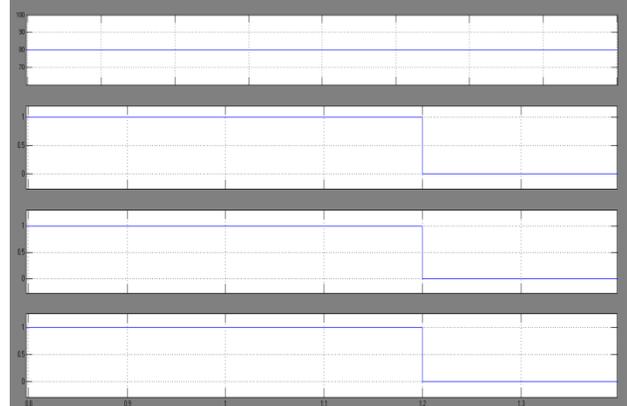


Fig.13 Error voltage, Switch 2 voltage, Switch 3 voltage and Islanding reconnection

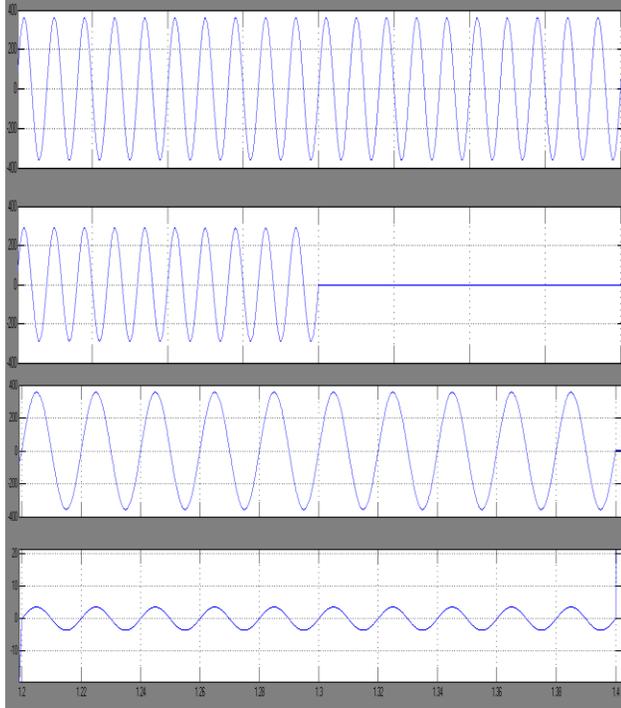


Fig.14 Point of Common Coupling (PCC) voltage, Sag Voltage, Reference sag voltage and supply voltage

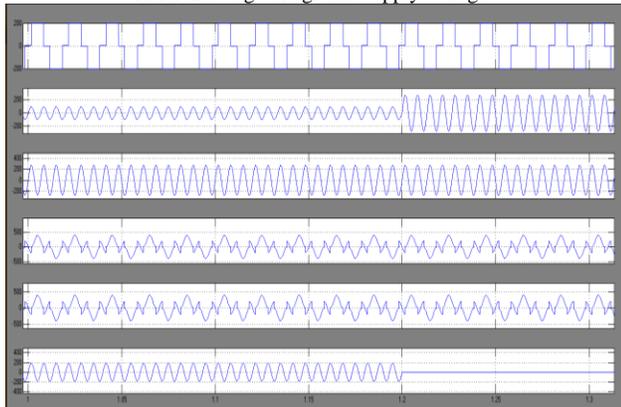


Fig.15 Load current, Distributed Generation current, Point of Common Coupling (PCC) current, Shunt current, Reference shunt current and Source current

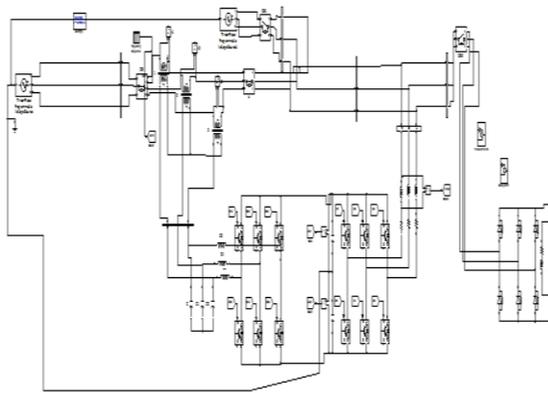


Fig.16 MATLAB/SIMULINK Circuit for the UPQCμG-IR reconnection

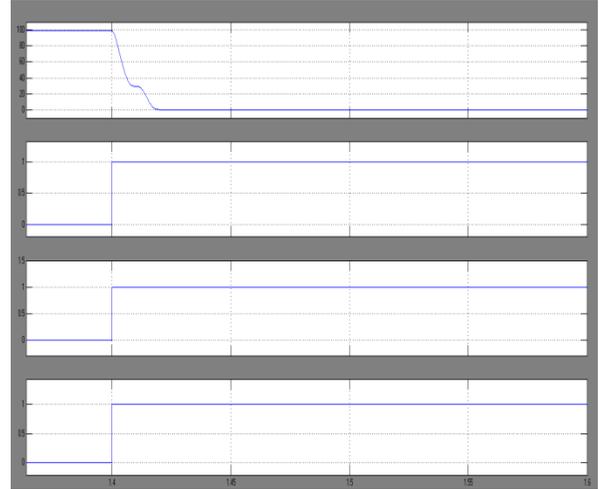


Fig.17 Error voltage, Switch 2 voltage, Switch 3 voltage and Islanding reconnection

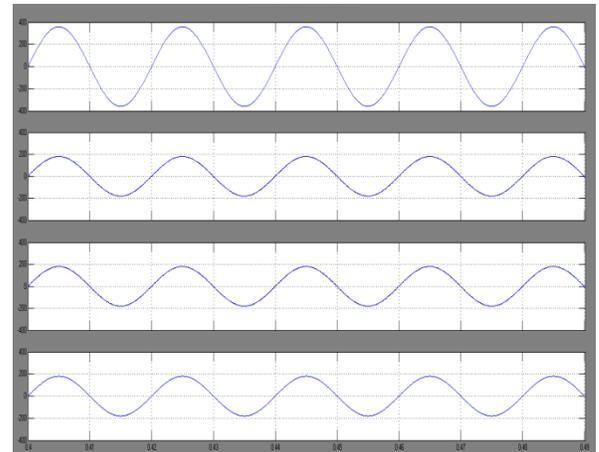


Fig.18 Point of Common Coupling (PCC) voltage, Sag Voltage, Reference sag voltage and supply voltage

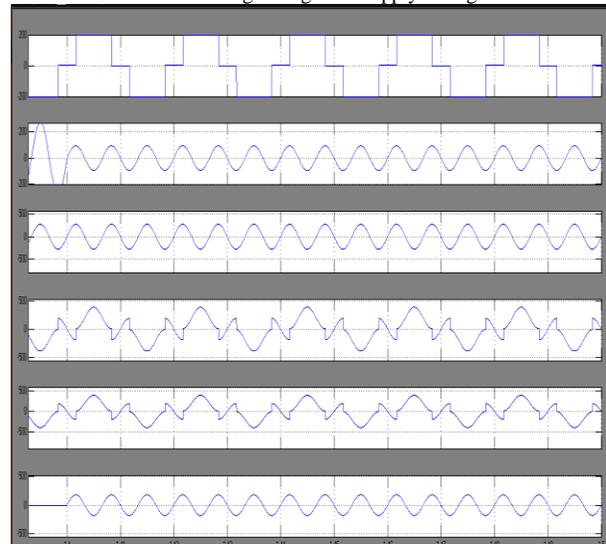


Fig.19 Load current, Distributed Generation current, Point of Common Coupling (PCC) current, Shunt current, Reference shunt current and Source current

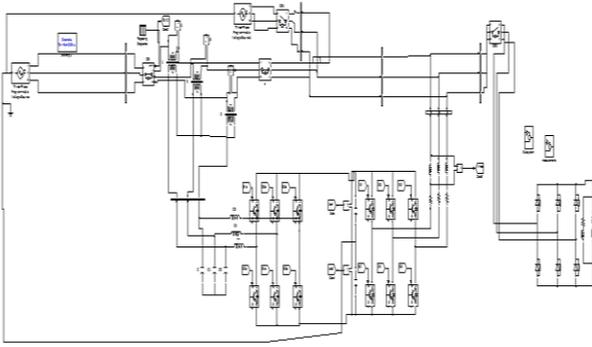


Fig.20 MATLAB/SIMULINK Circuit for the UPQC μ G-IR with PI controller

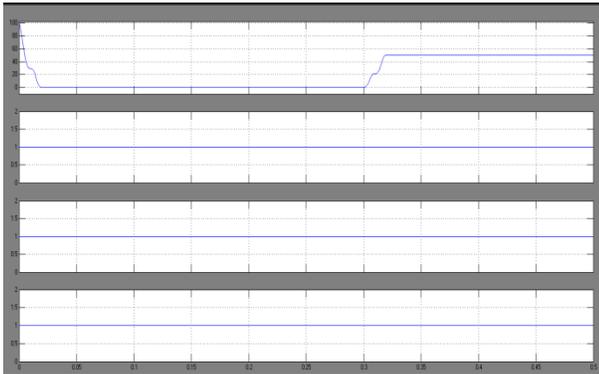


Fig.21 Error voltage, Switch 2 voltage, Switch 3 voltage and Islanding reconnection

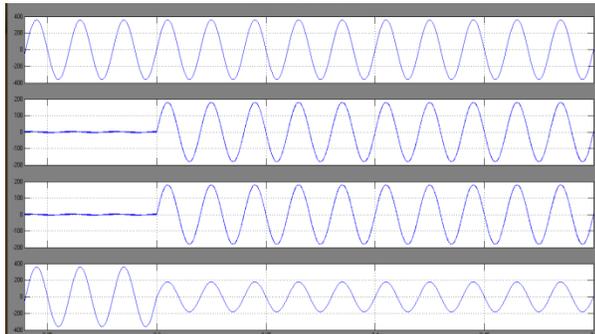


Fig.22 Point of Common Coupling (PCC) voltage, Sag Voltage, Reference sag voltage and supply voltage

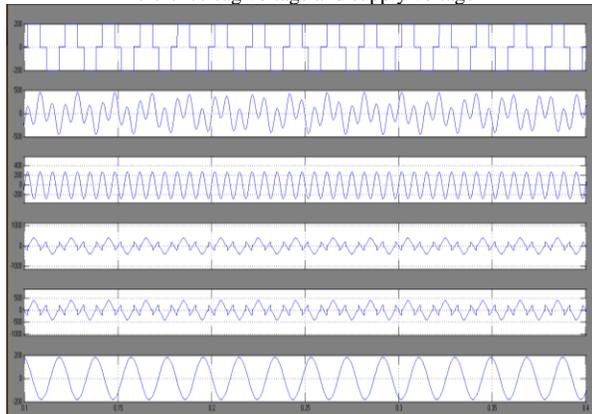


Fig.23 Load current, Distributed Generation current, Point of Common Coupling (PCC) current, Shunt current, Reference shunt current and Source current

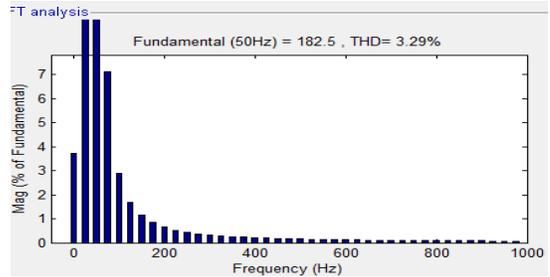
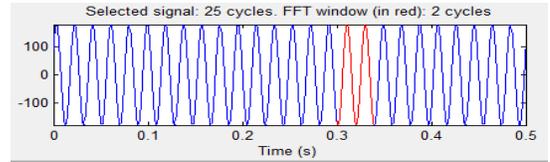


Fig.24 Source current THD

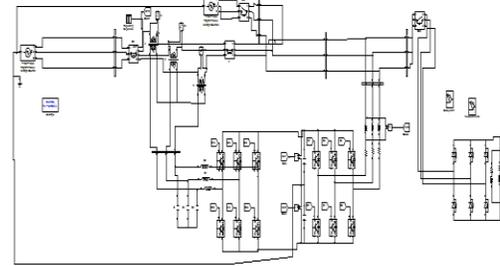


Fig.25 MATLAB/SIMULINK Circuit for the UPQC μ G-IR with FUZZY Logic controller

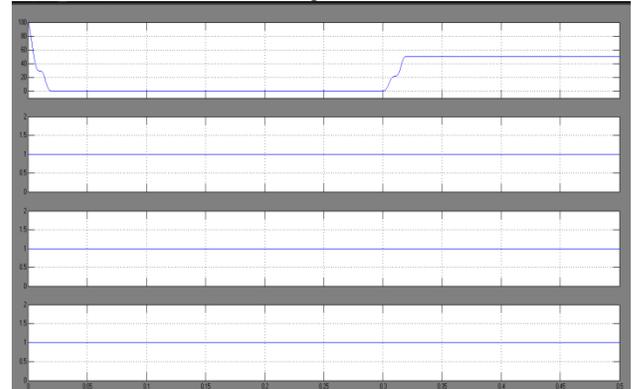


Fig.26 Error voltage, Switch 2 voltage, Switch 3 voltage and Islanding reconnection

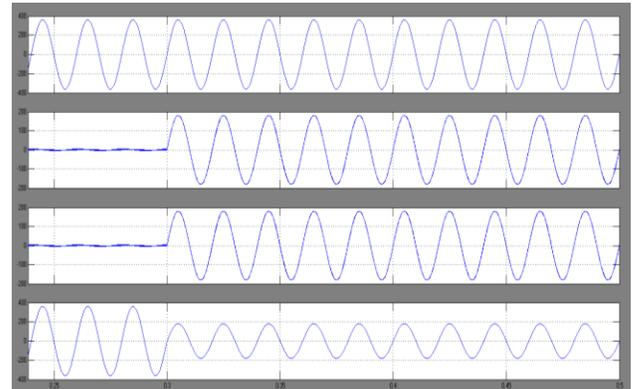


Fig.27 Point of Common Coupling (PCC) voltage, Sag Voltage, Reference sag voltage and supply voltage

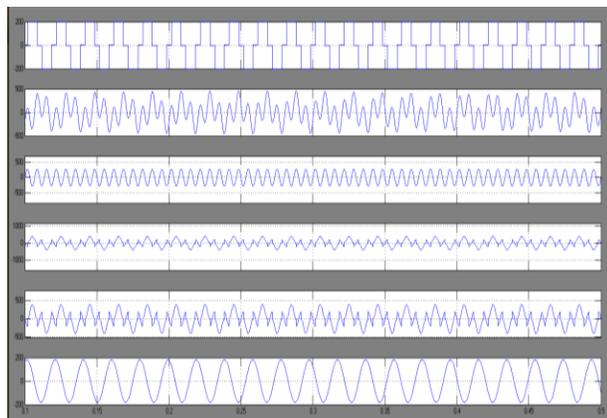


Fig.28 Load current, Distributed Generation current, Point of Common Coupling (PCC) current, Shunt current, Reference shunt current and Source current

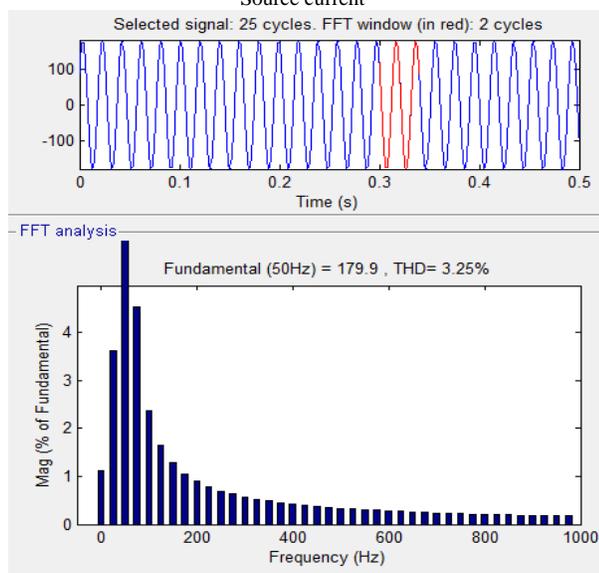


Fig.29 Source current THD

V.CONCLUSION

UPQC connected to micro-grid in islanding mode and grid connected mode was illustrated in this paper. Algorithm was presented for islanding detection and seamless reconnection of DG to grid is carried out by intelligent controller. Design configuration in different operating modes of DG was presented. Series controller of UPQC is responsible to compensate sag/swell in power system and shunt compensator of UPQC compensates the harmonic distortion and reactive power issues. This paper describes integration technique of the proposed UPQC μ G-IR in the grid connected μ G condition using fuzzy logic controller. Results prove the islanding DG reconnection to grid is done without any interruption with simultaneous compensation of sag/swell and harmonics. THD in source current is well maintained within limits.

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