A New Approach to Single Phase AC Microgrid System Using UPQC Device

N. Sangeetha, Dr.B. Gopinath, S. Muthulakshmi, Dr.M. Kalayanasundram and G. Suriya

Abstract--- *A single phase AC microgrid system with Unified Power Quality Conditioner (UPQC) and renewable energy source (solar) is combined with minimum number of buses which are interconnected in our system. The UPQC controller is designed to calculate the compensation current, voltage and power. The Pulse Width Modulation (PWM) converter is used to given triggering pulse to Voltage Source Inverter (VSI).*

The custom power device is used to compensate the power flow and increase voltage stability and suppress harmonics. After calculating the instantaneous real and imaginary power, the compensating reference current and voltage are calculated. Voltage stability occurs due to large electrical distance between source and load. The application of reactive power compensation or load shedding may prevent this type of voltage stability. The harmonics are generated by non linear load. These harmonics are eliminated by using UPQC device. The single phase AC microgrid system is also used to control the UPQC device, to maintain the power flow and improve Power Quality. The prototype implement in hardware.

Keywords--- *Microgrid System, Unified Power Quality Conditioner (UPQC), Power Quality.*

I. Introduction

THE increasing demand of Distributed Generation (DG) in recent years, to minimize the gap between the supply and load demand, is introducing some voltage and current disturbance and harmonics due to the generator types and the interfacing power electronics converters. Therefore, quality of power supply has become an important issue with the increasing demand of DG systems either connected to the grid through grid-tie inverters or work in isolated (microgrid) mode.

The custom power device is introduced in hingorani (1995). Implementation of Custom Power Devices (CPD) like Unified Power Quality Conditioner (UPQC) in DG or microgrid systems to improve the power quality is gaining greater importance. UPQC is the integration of series and shunt active filters, connected back-to-back on the dc side, sharing a common DC capacitor described by Fujita (1998) [8].

The series component of the UPQC is responsible for mitigation of the supply side disturbances: voltage sags/swells, flicker, voltage unbalance and harmonics. It inserts voltages so as to maintain the load voltages at a desired level; balanced and distortion free. The shunt component is responsible for mitigating the current quality problems caused by the consumer, poor power factor, load harmonic currents, load unbalance etc. It injects currents in the ac system such that the source currents become balanced sinusoids and in phase with the source voltages.

Among the available custom power device for voltage stability enhancement, the Unified Power Quality Conditioner (UPQC) is most versatile one. The UPQC is a solid-state controller based on high power electronics used to control active and reactive power flow and power quality issues in a transmission line. The UPQC consists of series and shunt voltage source inverter (VSI), which can be modelled as controllable voltage source. The particle swarm optimization algorithm, on the other hand, provides a model-free approach for UPQC, which is coded by using PIC microcontroller.

The UPQC employs two converters that are connected to a common DC link with an energy storage capacitor. The main components of the UPQC are series and shunt power converters, DC capacitor. Series converter is a voltage source converter connected in series with a ac line and act as a voltage source to mitigate voltage distortion. It eliminate supply voltage flickers or imbalance from the load terminal voltage and force the shunt branch to absorb current harmonics generated by the non-linear load.

Shunt converter is voltage source converter connected in shunt with the ac line and act as a current source to cancel current distortion to compensate reactive current of the load. Transformer are implemented to inject the compensation voltage and current, and for the purpose of electrical isolation of UPQC converters.

This custom power device is mainly employed to protect a critical non linear load by improving the quality of voltage across it, and to improve the wave form of the supply current.

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Literature Survey

Sudipta Chakraborty and simoes (2009) deals with the experimental microgrid system, a Unified Power Quality Conditioner (UPQC) are incorporated to control the power flow and power quality [31].

Fujita and Akagi (1998) describe the main purpose of the series-active filter is harmonics isolation between a subtransmission system and a distribution system. In addition, the series-active filter has the capability of voltage flicker/imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer Point of Common Coupling (PCC). The main purpose of the shunt active filter is to absorb current harmonics, compensate for reactive power and negative –sequence current, and regulate the dc-link voltage between active filters [8].

Chakrsboty (2007) et.al deals with Better utilization of the microgrid is achived by solving power flow and power quality issues using p-q theory based active filtering called universal active power line conditioner and unified power quality conditioner. A Distributed Intelligent Energy Management System (DIEMS) is implemented to optimize operating cost [4]

Benjamin Kroposki and Marcelo Simoes (2006) described by the many potential benefits for the energy supplier, such as released line capacity, reduced transmission and distribution congestion, grid investment deferment and improve grid asset utilization, and the ability of the distribution energy system to provide ancillary service, such as voltage support and stability, Volt-Ampere Reactive (VAR) support, and contingency reserves [3].

The method described by Moran (1999) et.al When a short circuit occurs in the power distribution system , larger current flow through the primary of the current transformers, generating dangerous voltages and currents in the secondary windings and damaging the PWM-VSI [16].

Correa (2003) et.al deals with the implementation of HFAC Microgrid. The UPQC can compensate for current and voltage harmonics and also for reactive power. The UPQC controller uses instantaneous values of load and source current and source voltage to obtain the actual active and reactive power component [6].

Srinivas Bhaskar Karanki (2010) et.al describe in distribution system, power quality (PQ) problems, such as flicker, harmonics, and voltage fluctuation are increasing. The simulation and experimental result that state feedback controller designed by using the PSO has better performance it reducing the THD (Total Harmonic Distrotion) of source current and load voltage [28].

Yamille Del Valle (2008) et.al deals with many areas in power system require solving one or more nonlinear optimization problems. Partical Swarm Optimization (PSO), part of intelligence family, is known to effectively solve large scale nonlinear optimization problem [35].

Ho (2005) et.al describe the PSO as a very strong competitor to other algorithms in solving Multiobjective Optimal Problems (MOP), even though very few work have been reported. The PSO method is a population based one and is described by its developers as an optimization paradigm, which models the social behaviour of birds flocking or fish schooling for food [11].

Lingfeng Wang and Chanan Singh Fellow (2009) described by an improved Particle Swarm Optimization (PSO) algorithm is developed to derive these non dominated solution. In PSO algorithms to mitigate or even cancel out the fluctuations, energy storage topologies, such as storage batteries can be employed. Employ a multicriteria approach to handle hybrid system design problems by taking into account multiple design objectives including economics, reliability, and pollutant emission [14].

Siva kumar (2011) et.al describe among all of the PQ problems, voltage sag is a crucial problem in distribution system. A new methodology is proposed to mitigate the unbalanced voltage sag with phase jumps by UPQC with minimum real power injection. Particle Swarm Optimization (PSO) has been used to find the solution of the objective function derived for minimizing real power injection of UPQC with the constraints [27].

Moleykutty George and Kartik Basu (2009) deals with Active Power Filter (APF) is mainly used for harmonic elimination, by injecting a current equal in magnitude but in phase opposition to the harmonic current to achive purely sinusoidal current waveform at the power system. The active power line conditioner systems are able to compensate reactive power, harmonics, zero sequence current, negative sequence current, voltage flicker,voltage sag/swell and voltage regulation [17].

Vadirajacharya (2012) et.al described by current source based UPQC is used large inductor in DC link, while voltage source UPQC is used large capacitor in DC link [33].

Sahaya Elsi and Rajaram (2012) described by Unified Series –Shunt Compensator (USSC) compensate a variety of power quality problems in a distribution system including voltage sag and voltage swell compensation, flicker reduction, unbalance mitigation and power flow control [24].

Akagi (1996) described in Active filters in a range of 50KVA-60MVA have been practically installed in Japan. Its used for harmonic solution their function from harmonic compensation of nonlinear loads into harmonic isolation between utilities and consumer, and harmonic damping throughout power distribution systems [10].

Shaktisinh (2013) et.al deals with the UPQC is able to compensate supply voltage power quality issues such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems such as, harmonics, unbalance, reactive current and neutral current. Among all these configurations, UPQC DG could be the most interesting topology for a renewable energy based power system [26].

Srikanth (2013) et.al describe with promising solution that deals with both load current and supply voltage imperfections is the Unified Power Quality Conditioner (UPQC) [29].

Sudharshan and vijayakumar (2012) describe a new concept of optimal utilization of a UPQC. The series inverter of UPQC is controlled to perform simultaneous:

- Voltage sag/swell compensation
- Load reactive power sharing with the shunt inverter.

Chaithanyakumar and varaprasad (2012) observe the power quality problems such as unbalanced voltage and current, harmonics by connecting non linear load to 3P4W system with Unified Power Quality conditioner. The UPQC also calculating the THD and active power and reactive power. A new control strategy is proposed to the control algorithm for series APF is based on unit vector template generation to compensate the current unbalance present in the load currents by expanding the concept of single phase P-Q theory [5].

Metin Kesler and Engin Ozdemir (2010) deals with UPQC system can improve the power quality at the point of common coupling (PCC) on power distribution system under non-ideal mains voltage and unbalanced load conditions. The instantaneous reactive power theory is used for shunt APF control algorithm by measuring mains voltage and currents. The conventional methods require measurements of the load, source and filter voltages and currents [15].

Shafiuzzaman (2011) et.al deals with the review of research work that has been completed so far on power quality issue. Emphasis has been given on incorporation techniques of UPQC in DG or microgrid system along with their advantages and disadvantages. More DGs such as Photovoltaic or Wind Energy Systems are now penetrating into the grid or microgrid. Again, numbers of nonlinear loads are also increasing. Therefore, current research on capacity enhancement techniques of UPQC to cope up with the expanding DG or microgrid system is also reviewed [25].

Devaraju (2010) et.al deals with the configurations, working and significant functions of each custom power device. The new technologies utilizing power electronics based concepts because these devices are capable of mitigating several power quality problems. The application of power electronics to power distribution system for the benefit of a customer or group of customers is called custom power. The custom power devices like Distribution Static compensator (DSTATCOM), the Dynamic voltage restorer (DVR) and Unified power quality conditioner (UPQC) [7].

Valsala and Padmasuresh (2013) describe with UPQC which is made up of a matrix converter to mitigate the current harmonics, voltage sags and swells and control the power flow with Bi directional capability for windmill. Matrix converter injects the compensation voltage on the load-side, so it is possible to mitigate the voltage sag/swell problems, resulting in an efficient solution for mitigating voltage and current related power quality problems [34].

Jenopaul (2011) et.al describe a model of custom power equipment, namely constant frequency unified power quality conditioner (CF-UPQC). When a unbalanced, and frequency sensitive load is supplied through CF-UPQC it will regulate the supply voltage, supply frequency and eliminates harmonics. The main aim of the CF-UPQC is to regulate supply frequency at the load terminal [13].

Ramchandra and Suma Deepthi (2012) deals with three controllers PI, ANN and Fuzzy logic controllers are proposed for the current control of shunt active power filter and ANN and Fuzzy are developed using the data from conventional PI controller [22].

PSO was introduced by Kennedy and Eberhart (1995), which is introduced by the social behavior of bird flocking and fish schooling. A concept for the optimization of nonlinear function using particle swarm methodology is introduced [12].

The peter (1998) describes a evolutionary optimization algorithm that is a hybrid based on particle swarm .When performing optimization on complex non-linear functions, optima can be located more quickly using population based algorithms than algorithms that consider only a single coordinate of search space at a time [21].

Abido (2002) describes PSO for optimal setting of Optimal Power Flow (OPF) problem control variables. The problem of the OPF is a highly nonlinear and a multimodal optimization problem, i.e. there exist more than one local optimum. The OPF problem solution aims to optimize a selected objective function such as fuel cost via optimal adjustment of the power system control variables, while at the same time satisfying various equality and inequality constraints. The equality constraints are the power flow equations, while the inequality constraints are the limits on control variables and the operating limits of power system dependent variables [1].

Mohamed Azab (2011) describes the PSO technique is employed for harmonic elimination in a three-phase VSI inverter feeding a squirrel cage induction motor. The proposed approach , the required switching angles angles are computed efficiency to eliminate low order harmonics up to the 23^{rd} from the inverter voltage wave from, whereas the magnitude of the fundamental component is controlled to the desired value. The PSO –based algorithm is determined with a high –precision set of solutions of switching angle with relatively high speed convergence [18].

Niknam (2011).et.al describes Improved Particle Swarm Optimization (IPSO) method for the multi-objective OPF problems. The multi-objective problems considers the cost, loss, voltage, stability, and emission impacts as the objective function. The cost reduction is an effective method to decrease the generation cost, also active power system transmission loss is considered as an objective function. By decreasing the loss in power systems, the total generation and consequently generation cost are reduced which increase social welfare [19].

Pathak Smita and Vaidya (2012) describes PSO is a relatively new evolutionary algorithm that may be used to find optimal solutions to numerical and qualitative problems. They would comparison of the PSO to other Artificial Intelligence (AI) Methods [20].

Ahmed (2012) et.al describes PSO algorithm for solving the optimal distribution system reconfiguration problem for power loss minimization. PSO-based approach to solve the loss reduction problem by the shunt capacitor insulation. This is done in two phases: first, the cirtical area of the power system is identified using the tangent vector technique, second, the PSO techniques are used to optimize the amount of shunt reactive power compensation in each bus [2].

Vatankhah and Hosseini (2012) describes optimum size and location of distributed generators (DG_s) are determined for maximizing voltage profile in distribution systems. They would new coding in PSO which includes both active and reactive powers of DG_s to achieve better profile improvement [32].

Ravi kumar(2012) describes the one among the compensating devices is UPQC, which specifically aims at the integration of series and shunt active power filter to mitigate any type of voltage and current fluctations and power factor coorection in the power distribution network such that improved power quality is made available at the common coupling [23].

II. Microgrid and Single Phase System

A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operates connected to a traditional centralized grid (macrogrid). This single point of common coupling with the macrogrid can be disconnected. The microgrid can then function autonomously. Generation and loads in a microgrid are usually interconnected at low voltage.

Microgrid generation resources can include fuel cells, wind, solar, or other energy sources. The multiple dispersed generation sources and ability to isolate the microgrid from a larger network would provide highly reliable electric power. Produced heat from generation sources such as microturbines could be used for local process heating or space heating, allowing flexible trade off between the needs for heat and electric power.

The microgrid proposed in india July 2012. A capacity of microgrid is given below.

- Small micro-grids covering 30–50 km radius.
- Small power stations of 5–10 MW to serve the micro-grids.
- Generate power locally to reduce dependence on long distance transmission lines and cut transmission losses.

A single phase High Frequency AC microgrid system described by correa (2003).

Power Quality Issues

The Following power quality issues are described by Shaktisinh (2013). Its presented in the microgrid connected single phase system.

Voltage Variation

The voltage variation issues result from the non linear load. The voltage variation is directly related to real and reactive power variation. The voltage variation commonly classified as under:

- Voltage Sag/Voltage Dips.
- Voltage swell.
- Short Interruption.
- Long duration voltage variation.
- Flicker

Harmonics

Harmonics are sinusoidal voltages or current having frequency that are integer multiples of the fundamental frequency (Fig 2.1).

The harmonics produce due to the operation of power electronic converters or the harmonics are generated by non linear load. By using the Unified power quality conditioner to mitigate harmonics. At high frequencies, power quality is improved because the harmonics are of higher order and easily filter out by moran (1999).

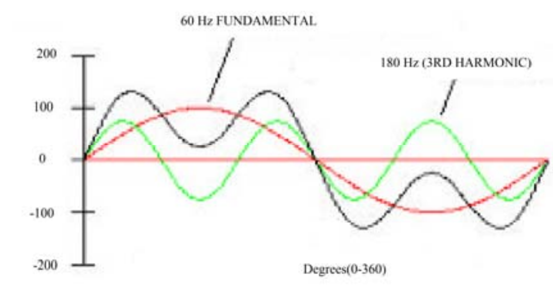

Fig. 2.1: Harmonics

III. Power Circuit of UPQC

UPQC is a combination of a shunt (Active power filter) and a series compensator connected together via a common dc link capacitor, which facilitates the sharing of the active power. Each compensator consists of IGBT inverter, which can be operated in current or voltage controlled mode. Depending upon the location of the shunt compensator with respect to series compensator, the UPQC model could be named as Right Shunt –UPQC or Left Shunt –UPQC shown in Fig 3.1.

The UPQC can be used for medium voltage and low voltage application. Incase low power application it is not convenient to install UPQC. The production of a UPQC against voltage surge and short condition to prevent its malfunction. The power circuit of UPQC generally consists of common energy storage unit, DC/AC converter and injection transformer.

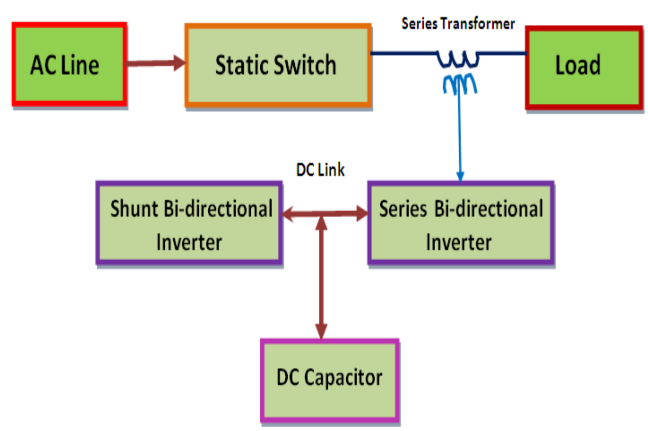

Fig. 3.1: Block Diagram of UPQC

Design of Power Inverter

Both series voltage control and shunt current control involve use of voltage source converters. Both these inverters are operated in current control mode employing PWM control technique. In this two inverters one connected across the load which acts as a shunt APF and other connected in series with the line as that of series APF.

Series Inverter Control

A series active filter acts as controlled voltage source by imposing high impedance for the harmonic currents, blocking their flow from both loads to source and source to load directions. The source voltage may contain zero, negative sequence as well as harmonic component, which need to be eliminated by series compensator.

Shunt Inverter Control

The main purpose of the shunt active filter is to absorb current harmonics, compensate for reactive power and negative sequence current injected by the load describe by moon han (2006). In addition, it controls current / voltage of the DC link to a desired value.

DC Link

A common dc link that can be formed by using a capacitor or an inductor. In the dc link is realized using a capacitor which interconnects the two inverters and also maintains a constant self-supporting dc bus voltage across it.

Energy Storage Unit

DC link (energy storage unit) supplies required power for compensation of load voltage during voltage sag/swell or current harmonics. UPQC generally consists of two voltage sourced inverter (series and shunt) using IGBT which operate from a common DC link storage capacitor. DC link connected to the battery storage system. Voltage interruption can also eliminated by the use of a UPQC with distributed generation. Photovoltaic generation as well as the function of a unified power quality conditioner.

IV. Particle Swarm Optimization Algorithm

PSO was introduced by Kennedy and Eberhart (1995), which is introduced by the social behaviour of bird flocking and fish schooling. A concept for the optimization of nonlinear function using particle swarm methodology is introduced. The peter (1998) describes a evolutionary optimization algorithm that is a hybrid based on particle swarm. When performing optimization on complex non-linear functions, optima can be located more quickly using population based algorithms than algorithms that consider only a single coordinate of search space at a time. Population-based search methods can be defined as follows:

$$P' = m(f(P)) \quad (1)$$

Where P is a set of position in search space, called the population, f is a fitness function that returns a vector of values signifying the optimality of each population member, and m is a population modification function that returns a new population. Particle swarm is population based search method with the form of Equation (1) where the manipulation function is based on models of insect swarm behaviour. Each individual contains a current location in the search space, a current velocity, and the best search space position found by this individual at this point in the search space position found by this individual at this point in the search. Specifically, an individual in a particle swarm optimization is manipulated using the following equation:

$$v_i' = v_i + U(0,1)(y_i - x_i) + U(0,1)(\hat{y} - x_i) \quad (2)$$

$$x_i' = x_i + v_i \quad (3)$$

$$y_i' = x_i \quad \text{when } (f(x_i) < f(y_i)) \quad (4)$$

$$\hat{y} = \min(y0, y1, \ldots\ldots, yn) \quad (5)$$

Where x_i is the i_{th} number of the population, y_i is the position in the search space previously visited by this individual that had the lowest fitness value (also called the personal best for the individual), v_i is the current velocity of the individual, ŷ is the best search space position found by any population member, α is a learning rate, referred to as the acceleration of the swarm, and U(0,1) is a uniform random variable over the interval (0..1). The method outlined in Equation 2-5 manipulates individuals in the population by accelerating them towards both the position of the individual's personal best and the position of the global best point found so far, with the relative amount of acceleration towards each determined stochastically.

Evolutionary computations are a distinct form of population-based search with the following format:

$$P' = \mu(s(f(P))) \quad (6)$$

Where μ is a mutation function that randomly varies a subset of the individuals in the population, and s is a selection function that removes poorly performing individuals and replaces them with copies of other population member called parents. Abido (2002) describes particle swarm optimization algorithm for optimal setting of Optimal Power Flow (OPF) problem control variables. The problem of the OPF is a highly nonlinear and a multimodal optimization problem, i.e. there exist more than one local optimum. The OPF problem solution aims to optimize a selected objective function such as fuel cost via optimal adjustment of the power system control variables, while at the same time satisfying various equality and inequality constraints. The equality constraints are the power flow equations, while the inequality constraints are the limits on control variables and the operating limits of power system dependent variables. Somasundaram and Muthuselvan (2010) describes PSO algorithm for solving Transient Stability Constrained Optimal Power Flow (TSCOPF) problems through the application of Gaussian and Cauchy probability distributions. Mohamed Azab (2011) describes to utilized the PSO to compute efficiently the switching angle of Selective Harmonic Elimination (SHE) in single phase inverter.

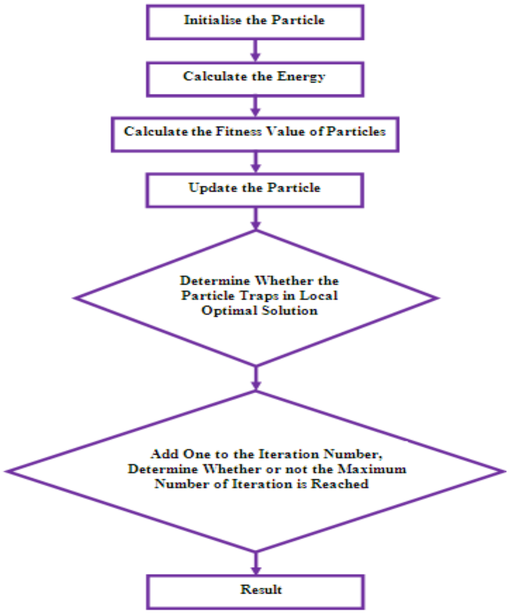

Fig. 4.1: Flowchart in PSO

V. Existing Model

In the experimental microgrid system, a universal active power line conditioner(UPLC) and a unified power quality conditioner(UPQC) are incorporated to control the power flow and power quality. Controller for both the UPQC and UPLC are developed based on the instantaneous single phase p-q theory, and controlled pulsewidth modulated inverters are then implemented to synthesize the desired compensating voltage and current.

Single Phase HFAC Microgrid

A single phase HFAC microgrid shown in Fig.5.1, the existing single phase HFAC based HFAC based microgrid is shown along with UPQC and UPLC. There are four high frequency buses in the microgrid system, as described next. In the source bus (bus1), a variety of renewable sources are connected along with energy storage system. The utility grid is connected in utility connection bus(bus 2) through a bidirectional converter and associated loads. In load bus(bus 3), high frequency loads are connected. The intermediate supply bus gets its supplies from Bus 1 and Bus 2, and then sends the power to Bus 3(load bus). Two static transfer switches (STS) are present in the existing microgrid structure to provide islanded mode of operation of the microgrid in case of grid failure.

The integration of the single phase HFAC microgrid with the three phase 60HZ utility grid and with the consumer load is discussed in[3]. Bus 1 and Bus 2 are connected by a controlled distribution line through a UPLC. The main function of the UPLC is to control the power flow between the source bus and the utility connection bus. The UPLC mitigates current harmonics present in the utility connection bus due to the connection of the bidirectional utility converter.

To maintain the power balance of the whole system with UPLC, another uncontrolled distribution line is required. In the existing microgrid structure, the intermediate supply bus, connected to both Bus 1 and Bus 2, works as the uncontrolled line. The voltage at the intermediate supply bus is distorted as the integration of all sources adds source voltage harmonics. Also, the loads connected across the load bus cause high level of harmonic content in the current coming out of the intermediate supply bus.

VI. Theoretical Design of Single Phase Microgrid Interconnected with UPQC Device

In power circuit consist of hybrid energy source (solar,wind) which are interconnected microgrid. This microgrid connected in three buses. Bus 1 is connected in linear load , bus 2 is connected utility transformer and bus 3 is connected non linear load.

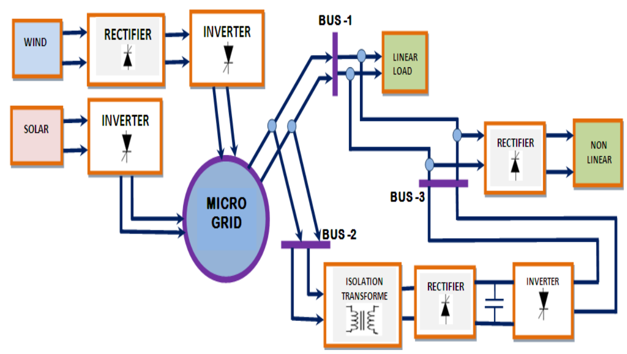

Fig. 6.1: Block Diagram of HFAC Micro Grid System

Consider fig 6.1 wind energy coupled with rectifier, which converts AC to DC source. The output of rectifier given through inverter, which converts DC to AC source. To consider solar energy coupled with inverter , which converts DC to AC. This hybrid energy source generate 12V which is connected in microgrid. The microgrid connected in buses, the bus 1 is connected in linear load. Bus 2 is connected in 1:1 isolation transformer, which connected in rectifier. The rectifier act as a filter, which connected in bus 3.

Practical Design of Single Phase Microgrid Interconnected with UPQC Device

In this section, discuss about operation of whole system. To consider fig 6.2 switching of MOSFET R1and R2 conduct positive half cycle and R3 and R4 are conduct negative half cycle, then R1 and R2 remains off. The driver circuit control two MOSFET switches shown in Fig 6.5.

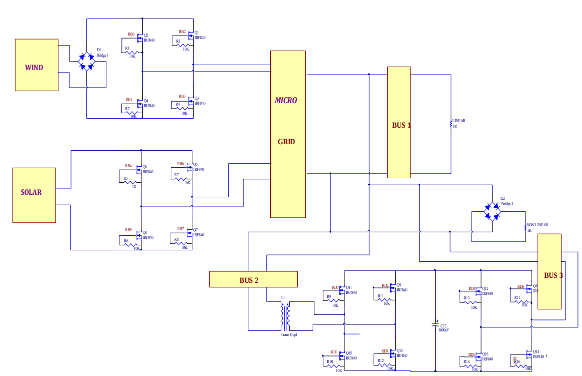

Fig. 6.2: Circuit Diagram of Power Circuit

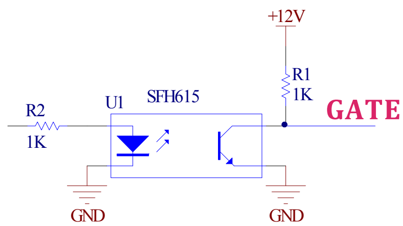

Fig. 6.3: Modeling of Optocoupler

To consider filter circuit MOSFET conduct both cycles. The use of optocoupler(Fig6.3) to give the gate pulse in MOSFET.

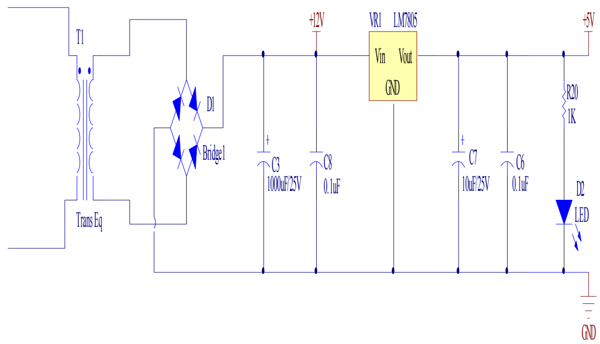

Fig. 6.4: Circuit Diagram of Power Supply Circuit

Power supply given through the system is shown in Fig 6.4. The isolation transformer maintain constant voltage. The transformer interconnected in bridge rectifier, which converts the source. The output of bridge rectifier connected in MOSFET.

To consider the switching process in MOSFET shown in fig 6.5. The positive halfcycle MOSFET connected in driver circuit HIN means MOSFET-1 is high and LIN means MOSFET-2 is low.

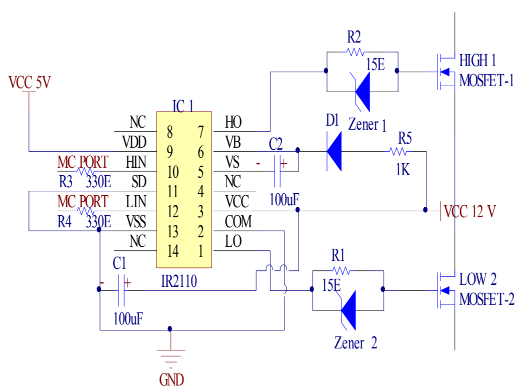

Fig. 6.5: Pin Diagram of Driver Circuit

VII. Hardware Realization

This chapter describes the prototype of the hardware realization of the project. The 230V AC supply is converted into 12V AC supply by using stepdown transformer. The 12V AC supply is converted into DC supply using rectifier. The DC voltage is converted into AC voltage using inverter. The MOSFET ratio is controlled by using driver circuit. The control circuit operates at 12V-20V. The power circuit operates in (0-230V). The optocoupller emitter is connected to MOSFET gate. This gate signal used to control the output voltage.

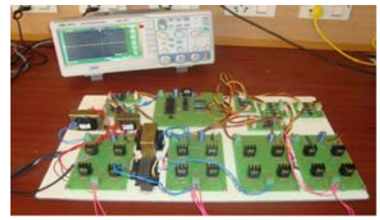

Fig. 7.1: Hardware Setup

Table 7.1: Hardware Requirement

S.NO	COMPONENTS	RANGE/TYPE
1	Resistor	1K,2K,3K
2	Capacitor	0.01µF,10µF,100µF
3	Diode	1N5408
4	Transformer	(0-230)V/(0-12)V
5	PIC micro controller	PIC16F882
6	Regulator	7800
7	UPQC	36V

Table 7.2: UPQC Designing Parameter

S.NO	PARAMETER	CAPACITY
1	linear Load	10k
2	Non linear Load	11k
3	Transformer turn ratio	1:1
4	Rated UPQC power	0.7 VA
5	Shunt-converter inductance	1mH
6	Charge resistor	50 Ω/10W
7	dc-link capacitors	7 µF , 5 µF
8	Series-converter filter inductance	0.2 mH
9	Series-converter filter capacitor	3 µF
10	Switching frequency	below 10 Hz
11	dc-link controlled voltage	$230V_{DC}$

PSO–based Driver Circuit

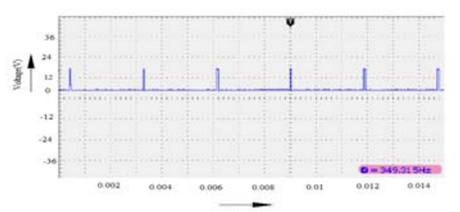

Fig. 7.2: Input of HFAC PSO–based Driver Circuit

The input put of HFAC driver circuit voltage is 16v and the time period is 0.0005 sec respectively and the frequency is 349.31Hz

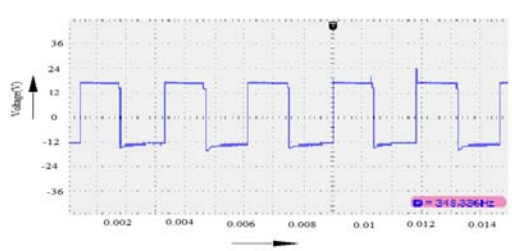

Fig. 7.3: Output of HFAC PSO based Driver Circuit

The output of driver circuit maximum voltage is 3.40v and the minimum voltage is -13.06v and the frequency is 348.336v.

Gate Signal for UPQC Device

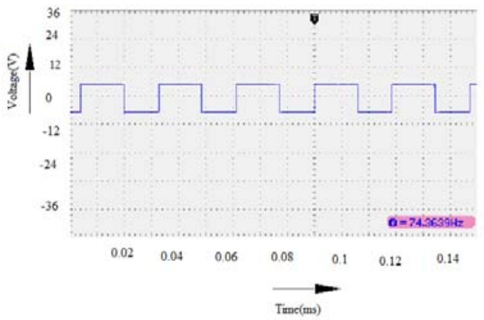

Fig. 7.4: Gate Signal for UPQC Device

The output of optocupler maximum voltage is 400mv and minimum voltage is –5.00v and the frequency is 74.3639Hz.

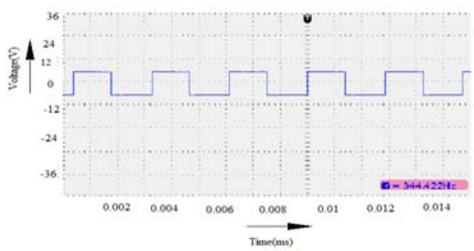

Fig. 7.5: HFAC Gate Signal for UPQC Device

The output of HFAC optocoupler maximum voltage is 600mv and minimum voltage is -5.00v and the frequency is 344.422Hz

Linear Load

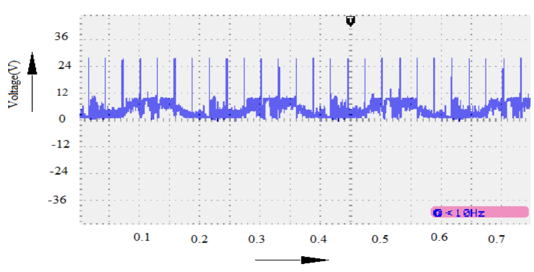

Fig. 7.6: Linear Load Bus Disturbance(without UPQC device)

The harmonics injection of linear load maximum voltage is 11.06 v and the minimum voltage is -200.00 v and the frequency is less than the 10Hz.

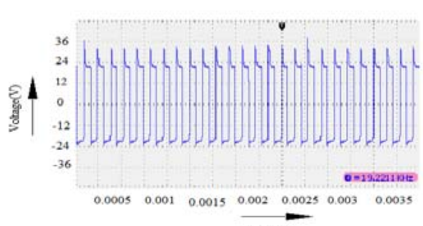

Fig. 7.7: Output of 10kΩ Linear Load

The output of linear load maximum voltage is 15.80v and the minimum voltage is -10.0v and the frequency is 19.2211Hz.

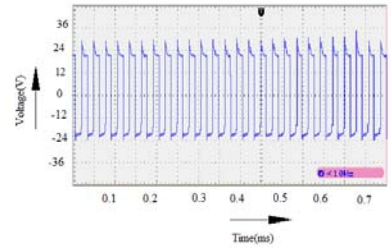

Fig. 7.8: Output of 10.5kΩ Minimum Load

The output of minimum load maximum voltage is 14.04v and the minimum voltage is -9.80v and the frequency is less than the 10Hz.

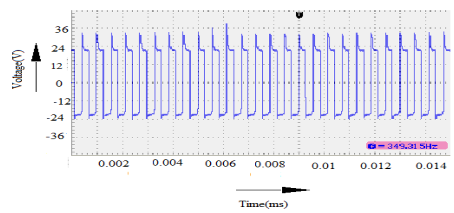

Fig. 7.9: Output of 11kΩ Maximum Load

The output of maximum load maximum voltage is 16.20vand the minimum voltage is -10.0v and the frequency is 349.31Hz.

Table 7.3: Performance of Single Phase Micro Grid System

Parameter	PSO Based Driver Circuit		Linear load bus disturbance	Bus2 Linear load bus (with PSO based –UPQC Device)			Bus3 (Non linear load bus)
	Input	*Output*		*10kΩ NL*	*10.5 kΩ NL*	*11 kΩ NL*	
V_{pp}	5.20v	16.80v	11.80v	24.2v	25.8v	26.2v	200mv
V_{max}	400mv	3.20v	11.60v	14.4v	15.8v	16.2v	400mv
V_{min}	-4.80v	-13.60v	-200v	-9.8v	-10v	-10v	200mv
Frequency (Hz)	49.9	348.3	<10	<10	19.2	348.3	-

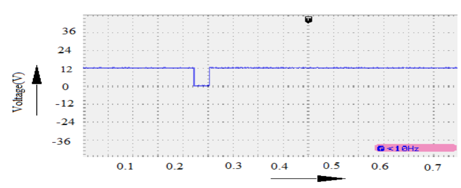

Fig. 7.10: Harmonic Injection of Non Linear Load

The harmonic injection of nonlinear load maximum voltage is5.40v and the minimum voltage is zero voltage.

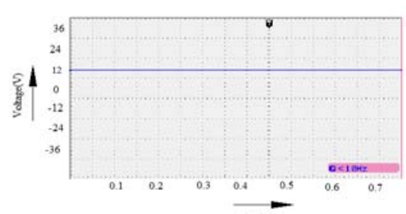

Fig. 7.11: Output of Non Linear Load

The output of nonlinear load maximum voltage is 400mv and mimimum voltage is 200mv.

VIII. CONCLUSION

A new approach to single phase AC microgrid system with using UPQC device successfully designed. The phrototype capacity of microgrid is 18V and system capacity is 36V, the frequency is 349Hz. The design of UPQC is used to eliminate the 3rd order harmonics and compensate the voltage unbalance system. The system used in linear and non linear load. The capacity of linear load is fixed resistive load the range is 10kΩ and the nonlinear load capacity is 11kΩ.According to this loads are used in our 3bus system. whenever the load bus voltage is affect the neighbour bus voltage is also changed. In this load buses, the linear load bus system is constant and nonlinear load system is time to time changes.

In our proposed problem due to creating of 3rd order harmonic due to elimination with the help of UPQC device. In our hardware desing part introduce the PSO algorithm incorporated. The test result are we have analysis the harmonic level, UPQC injection voltage, switching frequency.

Future work of the system is adding more then two loads. There are used various types of loads are interconnected in capacitive and inductive loads.

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