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POWER QUALITY IMPROVEMENT USING VARIOUS ENERGY SOURCES AND ENERGY STORAGE SYSTEM IN MICROGRID

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Abstract: *Renewable energy based distributed generators (DGs) play a dominant role in electricity production, with the increase in the global warming. Distributed generation based on wind, solar energy, biomass, mini-hydro along with use of fuel cells and micro turbines will give significant momentum in near future. A microgrid consists of cluster of loads and distributed generators that operate as a single controllable system. As an integrated energy delivery system microgrid can operate in parallel with or isolated from the main power grid. A control strategy is proposed to improve power quality and proper load sharing in both islanded and grid-connected modes. It is assumed that each of the DGs has a local load connected to it which can be unbalanced and/or non-linear. The DGs compensate the effects of unbalance and non-linearity of the local loads. Common loads are also connected to the microgrid, which are supplied by the utility grid under normal conditions. The efficacy of the controller has been validated through simulation for various operating conditions using MATLAB/ simulink.*

Key Words—*Distributed Generators (DGs), Static Synchronous Series Compensator (SSSC),Power Quality (PQ)*

1.INTRODUCTION

The micro-grid is relatively a small grid when it is compared to the main grid. It is made up of a control system, a distribution generation system and an energy storage system. Moreover, it can work in connection with the main grid or even working alone with disconnecting of the main grid. Modern sources depend upon environmental and climatic conditions hence make them uncontrollable. Because of this problem microgrid concept comes into feature which cluster multiple distributed energy resources having different operating principles. In grid tied mode distributed green sources operates like controlled current source with surplus energy channeled by the mains to other distant loads. There is need of continuous tuning of source outputs which can be achieved with or without external communication links. In case of any malfunctions grid tied mode is proved less reliable as this leads to instability [1]. discussed the advancement in DGs and microgrids there is development of various essential power conditioning interfaces and their associated control for tying multiple micro sources to the microgrid, and then tying the microgrids to the traditional power systems. The islanded mode of operation with more balancing requirements of supply-demand would be triggered when the main grid is not comparatively larger or is simply disconnected due to the occurrence of a fault [3]. The popularity of distributed generation systems is growing faster from last few years because of their higher operating efficiency and low emission levels. Distributed generators make use of several micro sources for their operation like photovoltaic cells, batteries, micro turbines and fuel cells. During peak load hours DGs provide peak generation when the energy cost is high and stand by generation during system outages. Microgrid is built up by combining cluster of loads and parallel distributed generation systems in a certain local area. Microgrids have large power capacity and more control flexibility which accomplishes the reliability of the system as well as the requirement of power quality [5]. The installation of distributed generators involves technical studies of two major fields. First one is the dealing with the influences induced by distributed generators without making large modifications to the control strategy of conventional distribution system and the other one is generating a new concept for utilization of distributed generators. The concept of the microgrid follows the later approach. There includes several advantages with the installation of microgrid [6]. The microgrid concept lowers the cost and improves the reliability of small scale distributed generators. The main purpose of this concept is to accelerate the recognition of the advantage offered by small scale distributed generators like ability to supply waste heat during the time of need [15]. The microgrid operates as a single controllable system which offers both power and heat to its local area. This concept offers a new prototype for the operation of distributed generation. To the utility microgrid can be regarded as a controllable cell of power system. In case of faults in microgrid, the main utility should be isolated from the distribution section as fast as necessary to protect loads. The isolation depends on customer's load on the microgrid. Sag compensation can be used in some cases with isolation from the distribution system to protect the critical loads [17]. To realize the emerging potential of distributed generation, a system approach i.e. microgrid is proposed which considers generation and associated loads as a subsystem. This approach involves local control of distributed generation and hence reduces the need for central dispatch. During disturbances by islanding generation and loads, local reliability can be higher in microgrid than the whole power system [18]. The economy of a country mainly depends upon its electric energy supply which should be secure and with high quality. The necessity of customer's for power quality and energy supply is fulfilled by distributed energy supply. The distribution system mainly includes renewable energy resources, storage systems small size power generating systems and these are normally installed close to the customer's premises [22]. The microgrid or distribution network subsystem will create less trouble to the utility network than the conventional micro generation if there is proper and intelligent coordination of micro generation and loads. In case of disturbances on the main network, microgrid could potentially disconnect and continue to operate individually, which helps in improving power quality to the consumer [23].

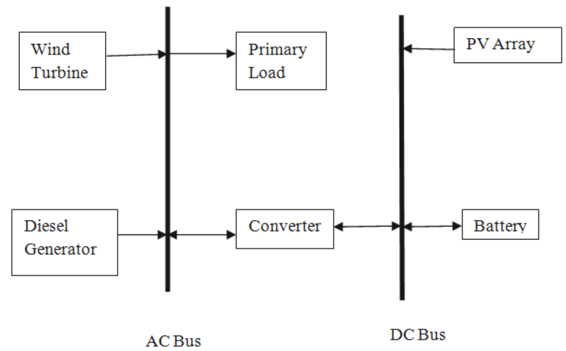

Fig.1: Single line diagram

2. RENEWABLE ENERGY SOURCES

Wind and solar renewable energy sources are used in this paper. Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power. In practice the wind power is carried out by either wind turbine or by wind mill. The kinetic energy of a wind stream is transformed into mechanical energy as a rotation of wind wheel and then the mechanical energy is converted into electric energy of the generator. Normally the horizontal axis wind turbines are used. Nowadays the maximum capacity of practical wind turbines are about 2-4 MW. Hub height of such wind turbine is 60-100 m and wind wheel diameter is 60-80 m. Wind turbines with low power are used for individual consumers and small economic objects.

Fig.2: Horizontal axis wind turbine model

Power of such wind turbines is 0.1-100 kW. Wind turbines with unit power from 100 to 2000 kW are most extended for the power purposes. A photovoltaic system makes use of some or more solar panels to convert the solar energy into electricity. It consists of various components which include the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. The basic principle behind the operation of a PV cell is photoelectric effect. In this effect electron gets ejected from the conduction band as a result of the absorption of sunlight of a certain wavelength by the matters are metallic or non-metallic solids, liquids or gases.

Table.1: Wind system description

Description	Data
Generator type	Doubly fed induction
Rated power	275 KVA
Poles	4- Pole
Power factor	0.8
Frequency	50 Hz
Stator voltage	480V
Cooling	Water cooled

The electron from valence band jumps to the conduction band when absorbed energy is greater than the band gap energy of the semiconductor. By these hole-electrons pairs are created in the illuminated region of the semiconductor. The electrons created in the conduction band are now free to move.

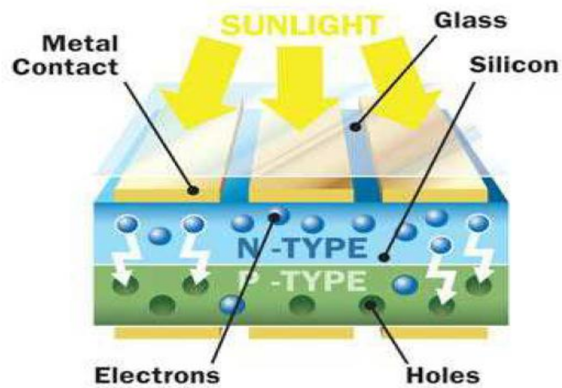

Fig.3: Working of PV cell

These free electrons are enforced to move in a particular direction by the action of electric field present in the PV cells. These electrons flowing comprise current and can be drawn for external use by connecting a metal plate on top and bottom of PV cell. This current and the voltage produces required power.

Table.2: PV module data

Description	Characteristic value
Type	Multi-crystalline silicon
Nominal peak power(Pp)	100 Watt
Rated voltage(Vt)	17.2 Volt
Rated current(Ir)	5.81 Ampere
Open circuit voltage(Voc)	21.1 Volt
Short circuit current(Isc)	3.8 Ampere
Company/ Country of origin	Photon Solar-India

3. CONVENTIONAL ENERGY SOURCES AND CONTROLLER

In this paper diesel generator is used to generate the power during unavailable renewable energy sources. The packaged combination of a diesel engine, a generator and various ancillary devices such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system is referred to as a generating set. Generating sets are selected based on the Electrical load they are intended to supply the electrical loads total characteristics and harmonic content including starting currents and non linear loads. Generators must provide the anticipated power required reliably and without damage and this is achieved by the manufacturer giving one or more ratings to a specific generator set model. A specific model of a generator operated as a standby generator may only need to operate for a few hours per year, but the same model operated as a prime power generator must operate continuously. When running, the standby generator may be operated with a specified overload that can be tolerated for the expected short running time. For generating electrical power, it is essential to rotate the rotor of an alternator by means of a prime mover. The prime mover can be driven by different methods. Using diesel engine as prime mover is one of the popular methods of generating power. When prime mover of the alternators is diesel engine, the power station is called diesel power plant. The mechanical power required for driving alternator comes from combustion of diesel.

As the diesel costs high, this type of power station is not suitable for producing power in large scale in our country. But for small scale production of electric power, and where, there is no other easily available alternatives of producing electric power, diesel power station are used. The UPFC controller is used to control and store the energy.

Description	Data
Generator type	Synchronous generator
Rated power	3.125 MVA
Rated line-line voltage	2400 volts
Rated frequency	50 Hz
Power factor	0.8
Rated speed	1500

Table.3: Diesel generator data

It consists of two voltage source converters; series and shunt converter, which are connected to each other with a common dc link. Series converter or Static Synchronous Series Compensator (SSSC) is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter or STATCOM is used to provide reactive power to the ac system, beside that, it will provide the dc power required for both inverter.

These two voltage source converters shared a common dc capacitor. The energy storing capacity of this dc capacitor is generally small. Therefore, active power drawn by the shunt converter should be equal to the active power generated by the series converter. The reactive power in the shunt or series converter can be chosen independently, giving greater flexibility to the power flow control.

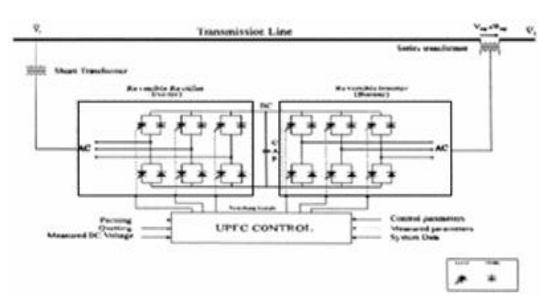

Fig.4: UPFC Controller

4. SIMULATION RESULTS

Simulation results using Matlab/ simulink are provided to verify the effectiveness of the proposed system. Fig.5 shows the total generation of wind power. During 3000 to 5000 hours per year the high amount of electricity is generated. Except those hours normal value of 6 KW power is generated.

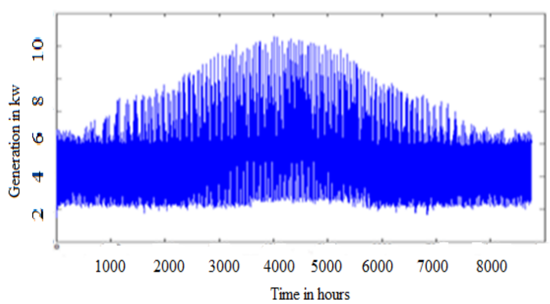

Fig.5: Wind Generation Output

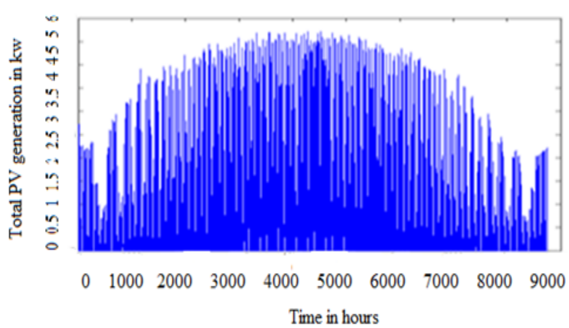

Fig.6: PV Power Generation

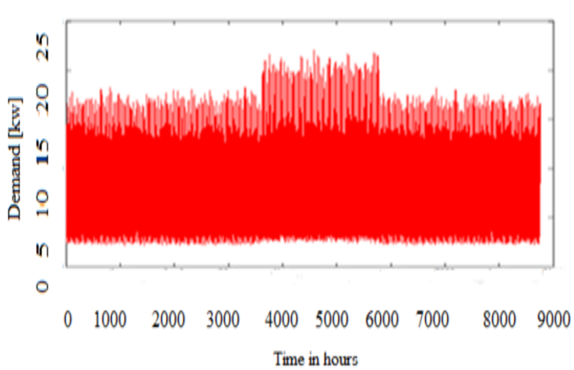

Fig.7: Total Renewable Energy Demand

Fig.6 describes the generation of PV power. In that generation is high during the 4000 to 5000 hours. Because of high temperature the generation of power is increased. Fig.7. describes the total demand of wind power. In that demand is high during the 4000 to 6000 hours. Because that time generation of hydro electricity is lower. Except that time the demand value is 16 to 20 KW.

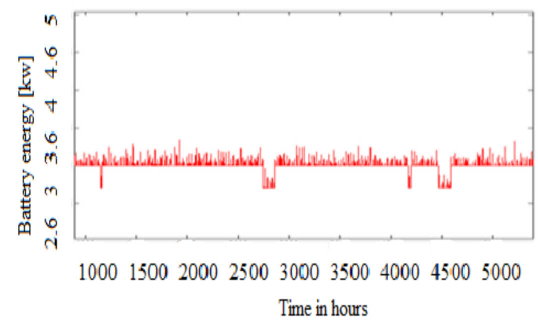

Fig.8: Total Renewable Battery Energy

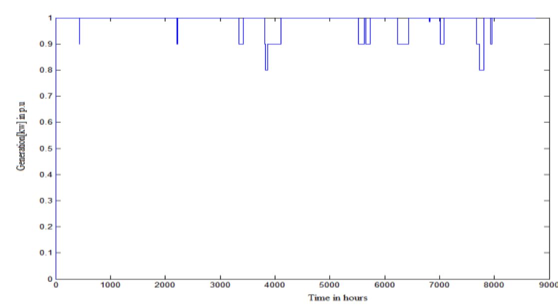

Fig.9: Generated Diesel Power

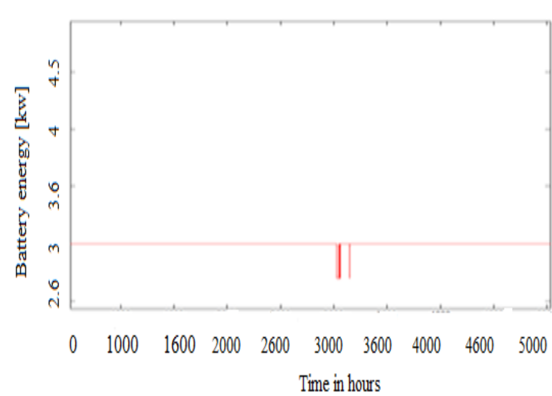

Fig.10: Diesel Battery Energy

If the generated power value is high means it is stored to the battery and also the demand value is lower than the generation means extra power is stored to the battery. If the generation value is low means that time battery stored power is used to utility. The above results are describes about the generation power and battery stored energy of the diesel generators. The diesel generators used for only demand is higher than the generation. Normally 3kw energy is stored in battery in the one year. And also discussed about PV voltage, current and power values. Then explains the wind power, wind turbine power and load voltage, current and power outputs are analyzed. In that fig.11 if the current value increased means voltage value also increased at a certain value after some time if the current reach the peak value means voltage value is decreased.

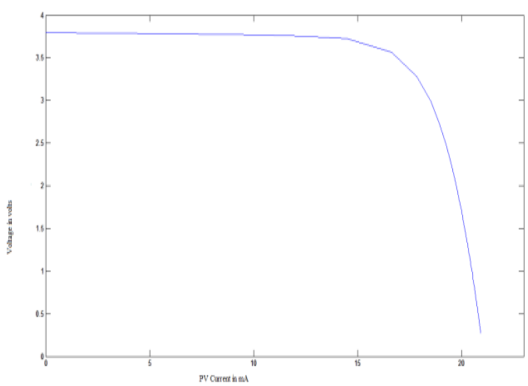

Fig.11: PV Current Vs Voltage Output

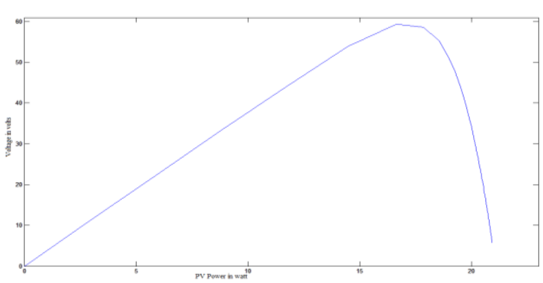

Fig.12: PV Power Vs Voltage Output

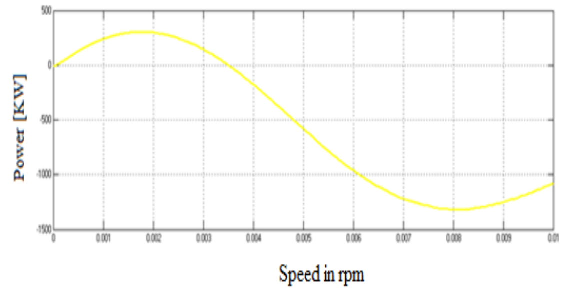

Fig.13: Wind Turbine Power

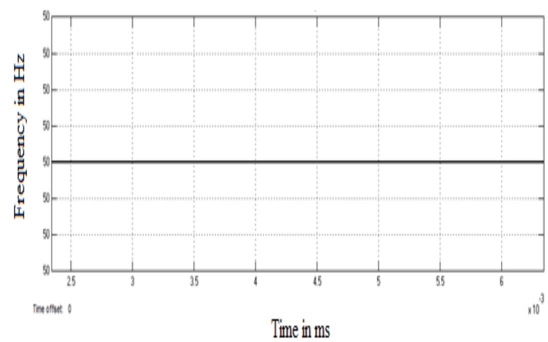

Fig.14: System Frequency

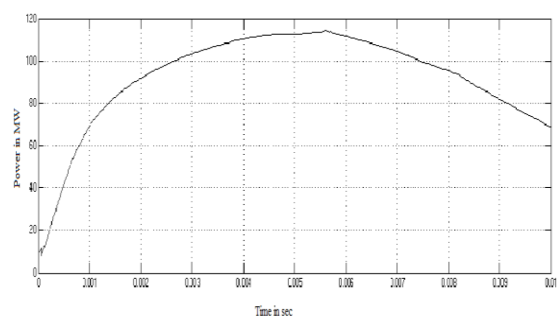

Fig.15: System Power

So the frequency of the system is constant using of controller then there is no fluctuation in the system.

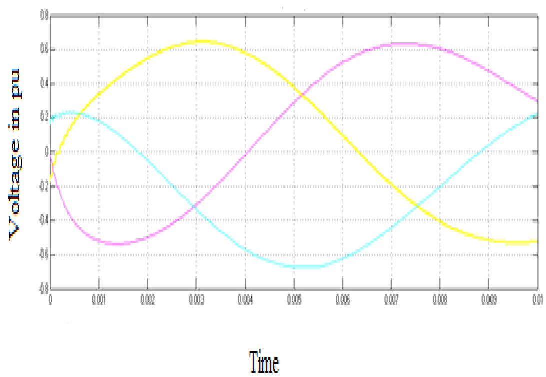

Fig.16: Load Voltage

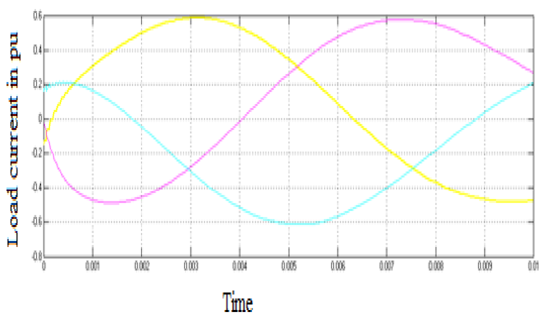

Fig.17: Load Current

So the system power quality is maintained then the system is always stable condition.

5. CONCLUSION AND DISCUSSION

This paper presents about to improve power quality in microgrid using renewable energy sources and energy storage system. The modeling of microgrid for power system configuration is done in MATLAB/SIMULINK environment. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. A power quality compression algorithm is an algorithm used in power quality analysis. To provide high quality electric power service, it is essential to monitor the quality of the electric signals also termed as power quality (PQ) at different locations along an electrical power network. Electrical utilities carefully monitor waveforms and currents at various network locations constantly, to understand what lead up to any unforeseen events such as a power outage and blackouts. Then it is monitored all the system data and individual data for the all renewable and conventional systems. Finally the system provides continuous quality power is supplied to the required demand.

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