Enhancement of Power Quality For Hybrid System by Using UPQC

Mrs. Pragati Bhapkar[1], Prof. Shridhar Khule[2], Prof. Poonam Desai[3]

[1] *Student, Department of Electrical Engineering, Matoshri College of Engineering and Research Centre, Maharashtra, India*
[2] *Head of Department, Department of Electrical Engineering, Matoshri College of Engineering and Research Centre, Maharashtra, India*
[3] *Asst. Professor, Department of Electrical Engineering, Matoshri College of Engineering and Research Centre, Maharashtra, India*

ABSTRACT

The domestic consumers in the remote areas not served by the main electrical grid network, diesel generators are the usual choice for power supply. As a result, plenty of servicing and maintenance needed onto these diesel generators. Thus, we proposed an idea of introducing wind turbine working together with the diesel generators to form a hybrid power system but after connecting wind system with the diesel there are certain power quality issues are created to reduce that issues author proposed a system by introducing UPQC in hybrid system.

In such system The DG converters (with storage) and the shunt part of the UPQC Active Power Filter (APFsh) is placed at the Point of Common Coupling (PCC). The series part of the UPQC (APFse) is connected before the PCC and in series with the grid. The dc link can also be integrated with the storage system. An intelligent islanding detection and reconnection technique (IR) are introduced in the UPQC as a secondary control. Hence, it is termed as UPQCμG −IR. The advantages of the proposed UPQCμG −IR over the normal UPQC are to compensate voltage interruption in addition to voltage sag/swell, harmonic, and reactive power compensation in the interconnected mode. 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. It also offers the DG converter to remain connected during the voltage disturbance including phase jump.

Keyword: - *Wind turbine, Diesel Generator, Battery, Distributed generation (DG), Intelligent Islanding Detection (IsD), Microgrid , Power quality, Unified power quality compensator(UPQC).*

1. INTRODUCTION

Energy Demand in isolated small islands and small un-electrified villages is gradually increasing. Thus, it is very important to meet the continually increasing demand of power. Also, it is necessary to go for fossil-fuel resources. Presently, generating systems especially in isolated small islands depend on diesel Generation. However, this supply power system is very costly as generation costs in isolated small islands involve transportation cost and an inventory carrying cost of fuel. On the other hand, there is a social interest for worldwide environmental concerns and a decline in fossil fuel assets. One of the solutions for these issues is to bring in renewable energy.

The hybrid generation power system is coming up. The system having an abundantly clean generation strategy can supply power to the load demand. However, if we use wind turbines, the output power is not constant and it varies with wind speed rise and fall. Furthermore, these fluctuations result in frequency variations one existing method to solve these issues is to install batteries which absorb power from wind turbine generators. The other method is to install a dump load which dissipates unpredictable power. Using these methods, the hybrid renewable power energy system generation system can supply almost good quality power.

In hybrid system the power quality issues are frequently occurred as the load changes therefore to mitigate the power quality issues FACTS device is used in the system which is named as UPQC. The challenging issues of a successful integration of unified power quality conditioner (UPQC) in a distributed generation (DG)-based grid connected micro generation (μG) system are primarily: 1) control complexity for active power transfer; 2) ability to compensate nonactive power during the islanded mode; and 3) difficulty in the capacity enhancement in a modular

way. For a seamless power transfer between the grid-connected operation and islanded mode, various operational changes are involved, such as switching between the current and voltage control mode, robustness against the islanding detection and reconnection delays, and so on. Clearly, these further increase the control complexity of the μG systems. To extend the operational flexibility and to improve the power quality in grid connected μG systems, a new placement and integration technique of UPQC have been proposed, which is termed as UPQCμG. In the UPQCμG integrated distributed system, μG system (with storage) and shunt part of the UPQC are placed at the Point of Common Coupling (PCC). [1] The series part of the UPQC is placed before the PCC and in series with the grid. The dc link is also connected to the storage, if present Renewable energy can make a important contribution in all areas. It is no longer alternate energy, but is gradually more becoming a vital part of the solution of the nation's energy needs. In term of all renewable energy categories. Renewable energy provides energy security to the system. Renewable energy is clean energy, good for the environment, both locally and worldwide.

The use of renewable energy is increasing day by day. There are many combination of self-governing hybrid system and grid connected hybrid system, in which solar-wind hybrid system is the best system as compare to other hybrid system. In underdeveloped countries, many persons spend more than their incomes on, fuel for cooking food; lighting and better survive of life etc. For all that purpose, there is need to develop new technologies and improved all which is already in exist. Hybrid energy system is one of the best possible solutions to solve this problem. Imagine a small Island as well as small villages of our country, where people need and where they need energy to get better the standards of their life. The fossil fuel prices exponentially increasing day by day and other sources are exhaust-able but in nature solar and wind available free of cost, so that it motivates to research in this field.

2. PROPOSED SYSTEM

Wind turbines used for particular maximum power output and wind speed. In wind turbine applications induction generators are popular. [2]

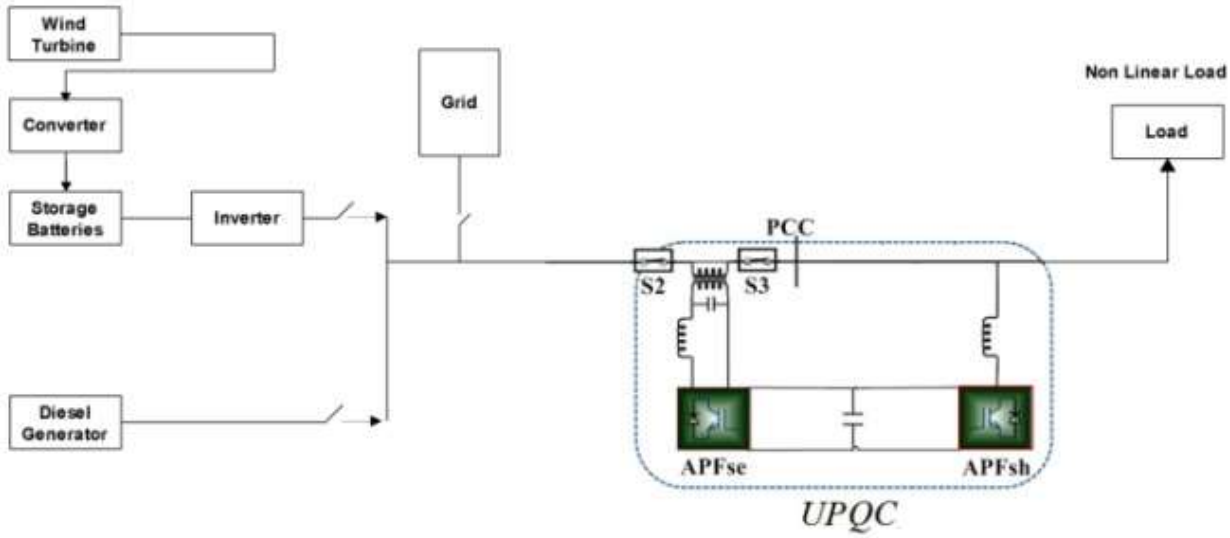

Fig -1: Proposed System

The operation of the induction machine is depend upon the sign of the electromagnetic torque and the slip, that is negative torque and slip correspond to generator operation whereas positive torque and slip correspond to motor operation. The power from the wind is given by [2]

$P = 0.5 * CpWv^3As$

Where ,

P is Power in watt,

W_V is wind speed in m/s

Cp is coefficient of performance,

As is swept area of the wind turbine blades in m^2

2.1 Wind Generator

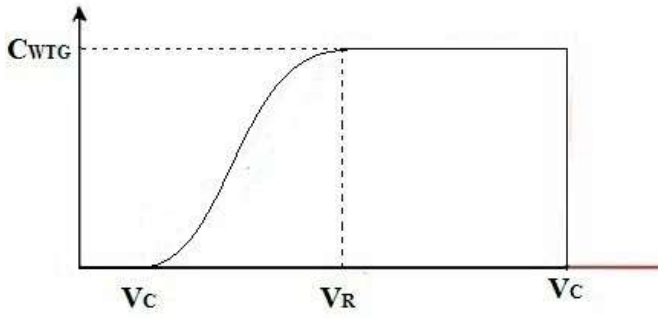

Fig -2: Wind Curve of Wind Turbine Generator [2]

Fig 2 shows that the wind curve of wind turbine generator, to any power output, a corresponding wind speed will found on this curve.[2]

Where,

V_c is the rated speed,
V_R is the cutout speed,
C_{WTG} is the rated Power output

.

2.2 Diesel Generator

Diesel engines are remote power systems in the world. Diesel generators operate at low load and poor fuel efficiency.[2] When diesel generators operates at low load operation engine maintenance requirements increased. Though the fuel consumption characteristic of a typical diesel generator is quadratic in nature, the linear function is,

$F = F0+Fip$

Where,

F is diesel generator fuel consumption rate, liters/hr
F0 is diesel generator fuel consumption at no load, liters/hr
Fip is incremental diesel fuel consumption rate, liters/hr.
P is diesel generator electrical power output, kW.

When diesel generator operates at less than 40% of full load efficiency will drop and its life decreases and frequency of maintenance increased. A diesel generator should not be switched on and without allowing it to run for a couple of hours, as this too will increase the frequency of the maintenance [3].

2.3 Battery Mode

Batteries are the simplest form of storing energy, but can be bulky and costly. In hybrid power system storage energy is used for a many purposes.

- To reduce the number of diesel stop/starts.
- To store excess wind energy.
- To reduce diesel running time for cycle charging.

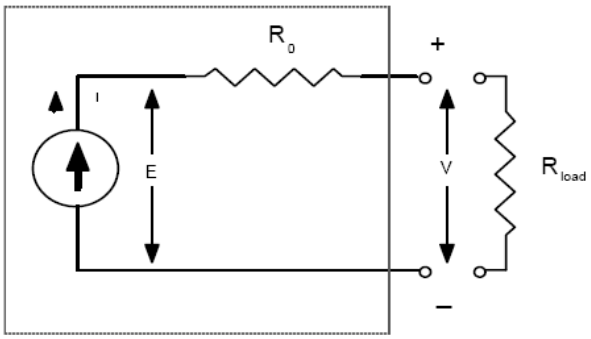

Fig -3: General battery model [2]

The fig.3 shows battery model, voltage source in series with resistance. The internal resistance, Ro, is assumed as constant and the internal voltage, E, varies with current state of charge. The terminal voltage, V, given by

$V=E-IR_0$

There are various types of batteries lead acid and nickel cadmium. In hybrid power systems lead-acid batteries are used due to its lower capital costs.[4] UPQC has two voltage-source inverters in three-phase four-wire or three-phase three-wire configuration. One is series inverter and other is shunt inverter. Series inverter is connected through transformers between the source and the common connection point. Shunt inverter is connected in parallel with the common connection point through transformers.[5]

3. WORKING PRINCIPLE

UPQC is the integration of series (APFse) and shunt (APFsh) active power filters, connected back-to-back on the dc side, sharing a common DC capacitor is shown in fig.1the working Principal for the system is divided in to two modes.

3.1 Interconnected mode

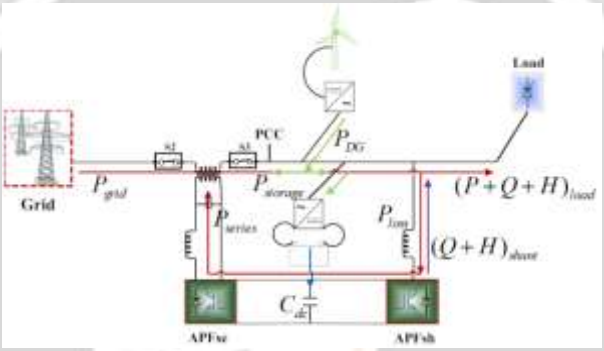

Fig -4: Working principle of interconnected mode.[1]

1.The DG source delivers only the fundamental active power to the grid, storage, and load;
2.The APFsh compensates the reactive and harmonic compensates the reactive and harmonic (QH) power of the non linear 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 APF_{se}. 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 or blackout occurs UPQC sends a signal within preset time to the DG converter to be islanded [1].

3.2 Island Mode

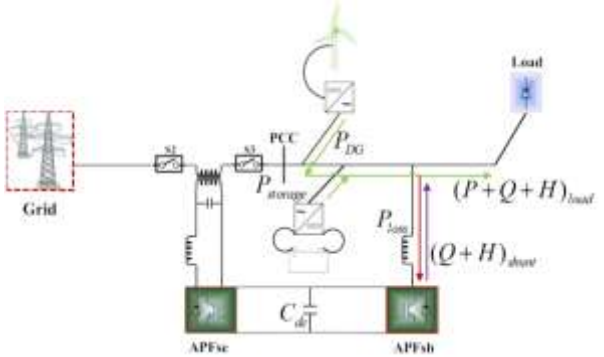

Fig -5: Working principle of islanded mode[1]

1.The APF_{se} is disconnected during the grid failure and DG converter remains connected to maintain the voltage at PCC;
2. The APF_{sh} 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 $_{APFse}$ reconnected once the grid power is available.[1]

4. UPQC

Basically UPQC (Unified Power Quality conditioner) is a equipment which is used for compensate for voltage distortion and voltage unbalance in a power system so that the voltage at load side is completely balance and sinusoidal & perfectly regulated and also it is used to compensate for load current harmonics so that the current at the source side is perfectly sinusoidal and free from distortions and harmonics. UPQC is a combination of a Shunt Active power filter and Series Active power filter. Here Shunt Active power filter (APF) is used to compensate for load current harmonics and make the source current completely sinusoidal and free from harmonics and distortions. Shunt APF is connected parallel to transmission line. Here Series APF is used to mitigate for voltage distortions and unbalance which is present in supply side and make the voltage at load side perfectly balanced, regulated and sinusoidal.[6]

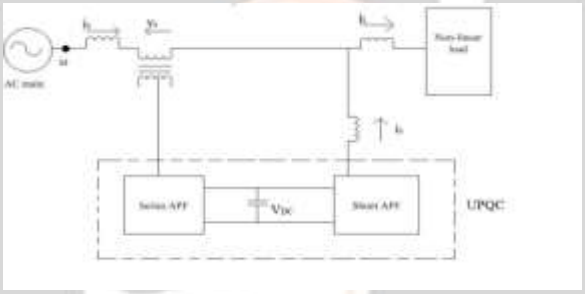

Fig -6: General UPQC block diagram[6]

Unified Power Quality Conditioner (UPQC) contains two IGBT based Voltage source converters (VSC), one shunt and one series cascaded by a common DC bus. Unified Power quality conditioner is a adaptable for different activities which contain of two voltage source converters (VSC) connected back to back through a common dc-link capacitor. [7]

4.1 Structure of UPQC

The shunt active filter is used for the power factor correction and compensation of load current harmonics and unbalances. Also, it maintains constant average voltage across the DC storage capacitor. The shunt part of the UPQC consists of a VSI (voltage source inverter) connected to the common DC storage capacitor on the dc side and on the ac side it is connected in parallel with the load through the shunt interface inductor and shunt coupling transformer.[8] The series active filter is used to compensate by fed the voltage in series with the supply voltage such that the terminal voltage of load is remains constant. This voltage injection is provided by the dc storage capacitor and the series VSI.[9]

4.2 Capacity enhancement of UPQC

The compensating the reactive harmonic components to improve the power quality of the DG integrated system as well as to avoid the large capacity centralized APF, parallel operation of multiple low power APF units are increasing. Like APF, UPQC can also be placed at the PCC or at a high voltage distribution line as a part of DG integrated network or in micro grid system to work both in interconnected or islanded mode.

- Multi-level converter based UPQC
- Multi-module converter based UPQC
- Multi-module (power cell) unit based UPQC

For increasing the converter operation voltage multi-level converter is used, eliminating the series connection of switching circuits. However, the output voltage of multilevel converter is complex to form and needs a huge number of back connection diodes.[9] Multi module H Bridge UPQC has the flexibility in expanding the operation voltage by increasing the number of H-bridge modules hence it is also be used. Here each phase contains of numbers of pairs of Hbridge modules are separated through a single-phase multi winding transformer. These Multi module techniques causes the symmetrical distribution of the load power through the components, but the classical design procedure must be refined to ensure the power cell components should be within its maximum ratings [10]. Hence, a proposed design procedure of UPQC with of extending capacity based on a modular approach is presented added in each single phase arrangement depending on the required compensating power.

5. CONCLUSION

Due to intermittent primary source wind power is fluctuated, when power is fluctuated stability of electrical network can damage due to this production and consumption is unbalance. Hence, It is necessary to use another source along with the wind generation system so by using diesel system along with wind system the generation done and the system becomes hybrid. It is also concluded that the voltage variations and load current harmonics are the two main issues arising when the distributed system is connected to the load or grid. Such types of power quality issues are minimize using UPQC. UPQC is hybrid filter which uses series APF for removal of voltage related problems like voltage dip/rise, fluctuation, imbalance and shunt APF for removal of harmonics in current harmonics.

5. REFERENCES

[1] Shafiuzzaman K. Khadem, Malabika Basu, Michael F. Conlon, "Intelligent islanding and seamless reconnection technique for micro grid with UPQC" in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 03, no. 2, June 2015.
[2] C. Kathirvel and Dr. K. Porkumaran, "Analysis and design of hybrid wind/diesel system with energy storage for rural application" In IEEE 978-1-4244-7398-4/10 ,2010.
[3] Morris Brenna, Roberto Faranda, and Enrico Tironi, "New Proposal for Power quality and custom power improvement: open UPQC" in IEEE Transactions On Power Delivery, Vol. 24, No. 4, October 2009.
[4] X. Yu, A. M. Khambadkone, H. Wang, and S. Terence, "Control of parallel-connected power converters for low-voltage microgrid—Part I: A hybrid control architecture," *IEEE Trans. Power Electron.*, vol. 25, no. 12, pp. 2962–2970, Dec. 2010.
[5] J. Rocabert, G. M. S. Azevedo, A. Luna, J. M. Guerrero, J. I. Candela, and P. Rodríguez, "Intelligent connection agent for three phase grid connected microgrids," *IEEE Trans. Power Electron.*, vol. 26, no. 10, pp. 2993–3005, Oct. 2011.
[6] V. Khadkikar, A. Chandra, A. O. Barry and T. D. Nguyen, "Conceptual Study of Unified Power Quality Conditioner (UPQC)", IEEE ISIE 2006, July 9-12, 2006.
[7] Chin H.Lo,Max.D.Anderson'Economic dispatch and optimal sizing in battery energy storage systems in utility load levelling operations' (1999)IEEE Transactions on energy conversion Vol 14, PP 824-829.
[8] S. K. Khadem, M. Basu, and M. F. Conlon, "UPQC for power quality improvement in DG integrated smart grid network-A review," Int. J.Emerg. Electr. Power Syst., vol. 13, no.1, p.3, 2012.
[9] M. Moradlou and H. R. Karshenas, "Design strategy for optimum rating selection of interline DVR,"*IEEE Trans. Power Del.*, vol.26, no. 1, pp. 242–249, Jan. 2011.
[10] F. Gao and M. R. Iravani, "A control strategy for a distributed generation unit in grid-connected and autonomous modes of operation," *IEEE Trans. Power Del.*, vol. 23, no. 2, pp. 850–859, Apr. 2008.