

# Power Quality Improvement In Microgrid Using Different Control Techniques

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**Abstract:** Today every country generates the electrical power from a variety of sources like hydro, photovoltaic, solar, thermal, wind, biogas, fuel cell etc. These sources of energy becomes successfully and more economical. In DG unit operation, inverters have the great importance. By installing the small distributed energy sources, micro grid provides the alternative method in generating electrical power at supply voltage level. Nowadays so many power electronics devices are interconnected which provides the safety, flexible and reliability of operation between micro grid and distribution system. The various non-linear and unbalanced loads in power system cause the power quality problems in the micro grid system. This paper presents the different method of controlling technique of power quality issues developed in the micro grid system.

**KEYWORD:** Microgrid, Renewable energy sources, Distribution Generation, Electricity generation, Energy storage.

## I. INTRODUCTION

In present days, because of depletion of non-renewable energy sources and increasing electricity demand, electric power systems are associating alternative renewable energy sources (RESs) including photovoltaic(PV), hydro, thermal, wind, biogas, fuel cells, and micro-turbines energy system. The power quality can offer greater reliability with help of distribution energy resources. DERs are electricity producing resources or controllable loads that are directly connected to a local distribution system. These resources are typically small scale generation of power. The transmission and distribution losses are reduced when the distribution voltage level is very nearly to load systems. The micro grids can be directly employ with distribution system. The DERs system used to decentralized, modulates, increases efficiency and have greater flexibility for the improvement of power quality operation and also reduced the amount of carbon emitted significance. Due to the development of advance technology in the power electronics, performed and efficiency of the distribution generation has been increased.

It is usually designed in such way that they can supply the power to the part of load after autonomously disconnection from the supply. The necessary care should take for the operation and control action of the microgrid which makes remain in isolated mode operation. When a micro grid operates in island mode, it acts like controllable load source and various system dynamic should be taken care [9]. The smooth transition of power takes from grid connection to island mode or vice-verse. When grid operates in stand-alone mode, various local load can be supply by the micro grid source for maintaining the voltage level and frequency according to the desired values. Voltage source inverter are developed based upon various control method to provide the harmonic free sinusoidal voltage and supply to the power system.

## II. Methodology

Various type of power quality issues are unbalanced voltage, transient voltage, flickering, harmonic distortion and electrical noise. Power quality and reliability problems are very importance due to use of several power electronics devices in industrial areas. The distribution generation and distributed energy resources provide the power quality in the micro grid. Due to this, the reliability of power can be distributed to the customer as per their demand.

The seamless operation switch can provides the stand- alone modes. In the grid connection to reduce the abnormal condition of the sensitive load. Power availability is a main role in islanded mode operation of micro grid because different non-linear and unbalanced loads are connected in large amount of the total load. This makes the power system as weak. The power electrical devices are controlled in such way that it filters the unwanted harmonics and unbalance load voltages. Mostly in micro grid connection, voltage sag, swells and transient voltages and harmonics are frequency occurring problems. The power generated from the different sources of energy like wind, solar, hydro or fuel cell etc. are most available in everywhere which cannot be connected into the grid before synchronization of voltages. The particular converter is necessary to convert the electrical output power to ac power distribution system. The interconnection of renewable energy sources and energy storage system are explain which are used in power electronic technology that connected as per required subjected to renewable energy sources (RES) and operation of power system. A DG inverter is provide for conversion of dc current to ac current which adjusts the magnitude and phase angle of the output voltage by using proper control strategic so to feed the required real and reactive power. Therefore the power quality issues are compensated by using various controls strategic of interconnected inverter in Fig 1.

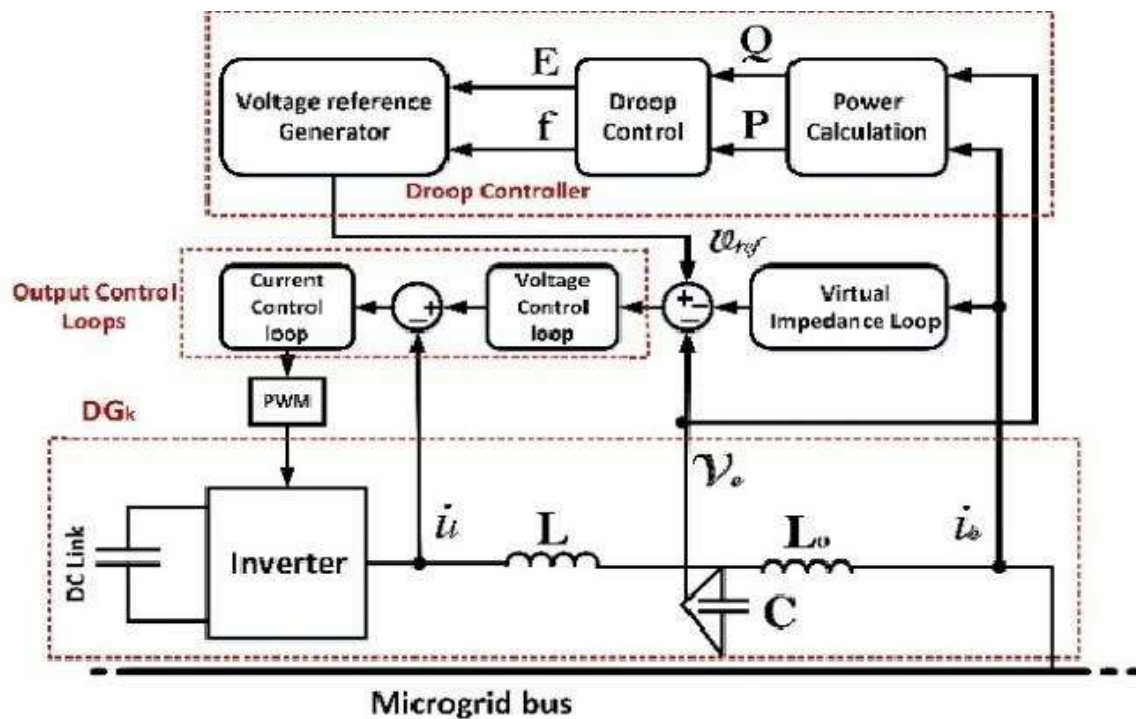


Fig1. Power Quality Improvement Method

### III. Control Strategy

The control of voltage and power can be done by the distribution generation inverter. The droop characteristic controls the real and reactive power to adjust the output of voltage and frequency of the inverter. The frequency oscillation can be control the voltage and current loop to filter the damping of oscillation.

#### A) Droop Control Method

It is autonomous approach for controlling the frequency and voltage amplitude of the generator connected to micro grid. It takes the advantages that real power controls frequency and that the reactive power controls the voltage. The power sharing can be done by the droop control method by using the real power controller and reactive power controller. The expression defining the real power frequency control of droop characteristic are expressed as

$$\omega(t) = \omega^* - (P_j^* - (t)) \tag{1}$$

$$\beta_j = \frac{\omega^* - \omega_{min}}{P_j^* - P_{j,max}} \tag{2}$$

Where  $(t)$  is the actual active power output of the Distributed generation system and  $\beta_j$  is the slope of the  $P$ -  $\omega$  droop characteristics

The expressions defining the reactive power voltage droop controllers are expressed as:

$$E(t) = E^* + (Q_j^* - (t)) \tag{3}$$

$$\zeta_j = \frac{E^* - E_{min}}{Q_{j,max} - Q_j^*} \tag{4}$$

Where  $(t)$  is reactive power output and is the slope of reactive – voltage droop characteristics.

The total harmonic distortion (THD) at the point of common coupling are minimized for the stand-alone and system relating the problem on reactive power sharing. The capacitive virtual impedance loop is used to control the voltage harmonics which occurs at PCC.

In grid connected mode, the current control loop is applied to flow the active and reactive power for the power grid and frequency operation. In autonomous mode, power converters are used for operation in three sub-modes like convection droop mode, PCS mode and synchronization mode. The  $(V_g/V_{dc})$  droop control which provides the dc link voltage at inverter output to maintain the power in micro grid.  $P$ - $V_g$  droop control maintains the voltage limiting the constant power band. The hierarchical control consist voltage droop control and impedance control loop for VSI based MG system. These maintaining the phase angle and voltage reference of real power and reactive power. Virtual inductor is used for inverter output of power electronic devices connect to DG

system which disconnect the coupling between real and reactive power. An enhanced droop control based on virtual impedance for controlling the frequency to minimize the reactive power load, unbalanced power load and distorted harmonic power load issues. Transient droop controller is used to minimize the transient voltage. Virtual inductance are connected in this controlled to avoid the harmonic voltage in grids. The droop control provides the active and reactive power influence on voltage and frequency. It supply the smooth voltage and frequency control but is mostly dependent on the specification between inverter connected distribution generation and load.

#### IV. Power Quality Improvement

The voltage source inverters are usually employed to control the voltage and frequency the micro grid for power quality and reliability operation of the power system by using different controller techniques. The different controller techniques are discussed below:

##### A) PI controller

PI controllers are in use for quite a long time especially in the stationary reference frame; but, it has its own drawbacks like steady-state errors, sensitive to parameter variations etc., Proportional–integral (PI) controllers are used to generate the reactive current component especially in direct-quadrature axis reference (d-q) frame as they have good performance when regulating DC quantities. The frequency of the micro grid can be found by frequency reference obtained from the power control loop using the phase locked loop (PLL).

##### B) Proportional-Resonant controller

It is used in narrow way which controls the sinusoidal signals. PR controller provides the reduction of the steady state error with system and minimization of harmonics. A PR controller has the basic transfer function with respect to voltage and current equation:

$$GV(s) = kpV + \frac{K_r V s}{s^2 + \omega^2} \quad (3)$$

$$GI(s) = kpI + \frac{K_r I s}{s^2 + \omega^2} \quad (4)$$

The PR controller is used to provide the better reference tracking and better load voltage regulation. Droop controller employed for average power components of the loads and Negative sequence output impedance (NSOIC). It has greater gain value nearly to resonant frequency.

The Resonant frequency implements the performance of the controller by maintaining the similar network frequency which adjust the grid frequency variation for current regulation and harmonic compensation.

##### C) Hysteresis controller

This controller also ensures the better transient variations. The advantage of this controller is very easy, simple in implementation and more dynamic response. The most challenging is to provide the output current ripple free.

##### D) H-Infinity controller

The H-infinity methods acquire the better performance in both parameter values changes and poor case interruption. Hysteresis current controller is common type of controller which has non-linear control loops. The series connected current –voltage control using this controller increases the power quality with help of inverter voltage and grid current.

##### E) Repetitive controller

Repetitive controller (RC) is a simple learning control which removes the errors in dynamic system by adopting the internal mode principle. The internal mode operation of an error provides the cascade of pole-pairs at number of selected frequency. The controller is perfect for utility converter containing the reference signals. The errors occurred in the system can be minimize by using the repetitive controller which is available in periodic waveform. The repetitive controller based on low pass filter used to attenuate the resonant peak of high frequency. Hence RC offers very less harmonics oscillation on output of non-linear load voltage and current.

##### F) Deadbeat controller

The most powerful achievement of the deadbeat controller is to provide the current control of interfaced inverter. The instantaneously current flowing to the DB have becomes importance due to its high bandwidth. This control is act as good due to its error compensation. The hybrid voltage controller is used for suitable voltage regulation and eliminates the disturbances. The deadbeat current controller used the voltage source inverter to get maximum performance of the voltage in inverter.



### G) Fuzzy and neural based controller

This control method includes the fuzzy and neural concept to increase the performance of the non-linear system of distribution generation for controlling the Real and Reactive power and minimize the harmonics transient voltage and unbalance voltage variations. The fuzzy controller controls the regulation of the system voltage and neuron controller avoids the harmonics and unbalance compensations.

The neural controllers transfer the information that proceeds in systematic way which perform the function of nerve system cooperating the time delay. The Neural networks contain the natural frame current controller.

### V. Power Quality Compensators

The power quality management are controlled by the power sharing algorithm. The power quality problems like unbalance voltage, transient voltage, flicker and harmonics occurred in load can be compensated in distribution generation system. This increases the performance in the power quality relating the active and reactive power deliver in Micro grid system. The power quality is compensated for attaining the high power factor and minimum distortion which makes the system flexibility.

Power quality compensator combines the series inverter and parallel inverter for maintaining the compensation of voltage, limitation of faults currents, balanced load voltage and power dispatch problem occurring in the distribution generation. The active, reactive and harmonics compensation are used for the improvement of the power factor of grid and minimize the THD of the current in grid.

It is important for consideration of forcing the renewable energy sources with different power rating, voltage and currents in a distribution networks. This provides the proper operation of controlling the micro grid for the power quality issue improvement and power sharing method in Distribution generation units.

### VI. Comparison of Control Strategies and Suggestions for Future Research

The controllers that are developed and designed in the literature addressing power quality issues have been discussed in this paper. The different features of some of the existing controllers are discussed here focusing the advantages and disadvantages. PI controller is simple in structure and provides good performance in a balanced system, but it is not at its best when applied to unbalanced system and to compensate harmonics in the system. PI regulators are not fast enough to achieve voltage regulation and mitigate voltage variations. PR controllers can ensure a zero steady state error with excellent reference tracking but only near the resonant frequency of the controller and can eliminate harmonics well.

Hysteresis current controller is simple in structure and provides fast transient response but it doesn't have fixed switching frequency. Dead beat controllers are also simple but are sensitive to variations of system parameters. On the other hand, Repetitive controllers are good in eliminating the periodical disturbances and reduces the harmonic distortions due to non-linear loads but with certain disadvantages like slow dynamics, poor accuracy etc., Fuzzy based controllers are insensitive to system parameter variations.  $H_{\infty}$  controller offers low THD and provides good performance under plant uncertainties and disturbances but is relatively slow in nature compared to other controllers.

### VII. Conclusion

This paper presents the concept of various types of control techniques for DG units in an island mode micro grid. The objective of this concept is to provide the overview of different control levels of the micro grid which is necessary for the design own smart micro grids and helps to control for better improvement of power quality. The major tasks incoming future will be interconnection of various micro grid into the power system because of renewable energy sources and increasing demand. Therefore it is important to know the design and implementation of controller for effective improvement of power quality. The literature reviews on inner loop control for controls of DG units completely based on the micro grid characteristics such as micro grid sensitive, robust controller, control for harmonics, resonant and predictive controllers, primary controller, droop based control are realized for the performance of power quality, power sharing, reliability and flexibility of the power system.

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