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INTEGRATION OF DISTRIBUTED GENERATION AND POWER QUALITY FOR NETWORK CAPACITY IMPROVEMENT

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ABSTRACT

In this paper a technical review of the Distributed generation and power quality is addressed. Various issues related to this power quality are also discussed. In order to mitigate these issues technique of integration of a Unified Power Quality Conditioner (UPQC) in a distributed generation network is also presented in the paper. Recent developments in capacity expansion techniques and the applications of UPQC in distributed generation networks are also identified.

Keywords: ***Power Quality, Distributed Generation, Unified*** **Power Quality** ***Conditioner (UPQC)***

1. INTRODUCTION

Production, transmission and distribution of energy have become one of the major concerns of experts nowadays. They are being utilized in a proper and high quality manner. Thus the issue of improvement of power quality is an important issue in research studies these days.

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One of the major factors that weaken the quality of power is distortion of harmonics. These harmonics gets generated either from consumption zone or production zone of energy [1]. The various factors of harmonic distortion can be mentioned as increase in the use of non-linear distributed devices in grid along with limited nominal values. Others factors include non-linear loads with continuous or random changes and extensive sets of power electronic component-based static converters with limited nominal values [2].

The distributed generation systems that are based on wind and solar energies have several advantages like ensuring system stability, voltage regulation, economic generation and environmental factors. Due to these advantages today DG has gained the attention of electricity markets [3,4]. The recent work in solar and wind- based DG systems are concentrating on improvement of various aspects like network connectivity issues, controlling the inverter/ converter to achieve maximum power production, stability problems, evaluation of the impacts of power system and etc. [5]. But still there is problem of inverse power problem that is caused due to flow of the current in the opposite direction from the main network [6].

The majority of the DG networks need a power electronics edge for converting the energy into grid attuned ac power. And the power electronics line has all the necessary circuitry for converting power from one form to another. These converters have both the rectifier circuit and an inverter circuit or only an inverter circuit. The converter has all the essential output filters. The power electronics interface can have protective functions for both the distributed energy system and the local electric power system. It will allow paralleling and disconnection from the electric power system. These power electronic interfaces not only enhance the operations of a grid but also provide a unique capability the DG units.

This paper describes the various power quality issues in grid connected distributed generation. The rest of this paper is arranged as follows: Section II describes power quality issues; Section III presents the mitigation i.e. UPQC for Power Quality Improvement in DG Section IV concludes the paper.

2. POWER QUALITY PROBLEMS

Power quality is the term used to describe the closeness with which the power delivered to the consumers meets the standards in terms of continuity of supply and characteristics of voltage, frequency. As power quality affects voltage quality of grid, it needs greater attention to improve power quality. Interconnection of DG causes power quality issues like voltage fluctuation, voltage sag, swell and unbalance in distribution system. They further affect operation of protection devices, loads, increases losses in transformers, cables and motors, causes interference with communication lines etc. Poor power quality due DG leads to

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reduced power factor and reduces system capacity. Hence, mitigation techniques are used for improving power quality to protect the sensitive loads from its adverse effect [15]. The problems related to power quality are:

1. Voltage dip: It is a dip for interval of 0.5 minute cycle to 1 minute cycle of 0.1 to 0.9 p.u. in rms voltage or current at the power frequency.
2. Small interruptions: It is defined as the decrease of voltage supply or load current that is smaller than .1 p.u. It is from few milliseconds to one or two seconds.
3. Large interruptions: It is defined as total interruptions of electrical supply for time duration larger than one to two seconds
4. Voltage spike: The fast variation of the voltage having durations of a number of microseconds to few milliseconds. These variations may cross thousands values, even at low voltage.
5. Voltage swells: It is defined as rise in voltage, at the power frequency, outside the normal tolerances. It is having duration of more than one cycle and typically less than a few seconds.
6. Harmonic distortion: It is defined as periodically distorted voltage or current waveform. These waveforms corresponds to the sum of various sine-waves having various magnitudes and phase at frequencies which are multiples of power-system frequency
7. Voltage fluctuation: It is a series of random voltage variations or systematic variations of voltage envelop but the variation does not exceeds the voltage ranges of 0.9 to 1.1 p.u. Oscillation of voltage value, amplitude modulated by a signal with frequency of 0 to 30 Hz.
8. Noise: It is defined as the superimposing of unwanted signals on the waveform of the wanted power system frequency.
9. Voltage Unbalance: It is defined as greatest voltage variation in a three-phase system in which the three voltage magnitudes or the phase angle differences among them are not same.

3. UPQC FOR POWER QUALITY IMPROVEMENT IN DG

UPQC is defined as the combination of Series shunt active power filters that are connected back-to-back on the dc side sharing a common DC capacitor. The series component of the UPQC is responsible for mitigation of the supply side disturbances like voltage sags, voltage swells, flicker, voltage unbalance and harmonics. It inserts voltages so as to maintain the load voltages at a desired level; balanced and distortion free.

Similarly 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

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in phase with the source voltages. The overall function of UPQC mainly depends on the series and shunt APF controller.

Various applications of UPQC include:

1. Voltage sags and swells correction
2. Voltage balancing
3. Voltage regulation
4. Flicker attenuation
5. VAR compensation
6. Harmonic suppression
7. Current balancing
8. Active and reactive power control[7]

Recent reports [7-14] show that significant research and development has been carried out on the application of UPQC to DG integrated network. As the UPQC can compensate for almost all existing PQ problems in the transmission and distribution grid, placement of a UPQC in the distributed generation network can be multipurpose. As a part of integration of UPQC in DG systems, research has been done on the following two techniques: DC-Linked and Separated DG-UPQC systems.

The need for monitoring of desired power quality in transmission levels as well as in low voltage distribution levels are increasing due to better customer service demand, reasonably priced meters, telecommunication development, network planning, operation and regulation requirements [1], which are also very important for the implementation of a smart grid distribution network.

B Han et. al [8] described results of a combined operation of the unified power quality conditioner with the distributed generation. The system proposed by the author consists of a series inverter, a shunt inverter, and a distributed generator connected in the dc link through rectifier. The system is useful in compensating voltage sag and swell, voltage interruption, harmonics, and reactive power in both interconnected mode and islanding mode. The performance of system was analyzed using simulations with power system computer aided design/electromagnetic transients dc analysis program, and experimental results with the hardware prototype. Through the work the power quality at the point of installation on power distribution systems or industrial power systems is improved significantly.

N. G. Jayanti et. al. [14] investigated the application of a unified power quality conditioner (UPQC). The role of the UPQC in enhancing the fault ride-through capability of the generator was also investigated under both full and partial terminal voltage restoration. A realistic estimation of the rating requirements of UPQC for this type of application was carried out. A general principle was presented to choose the most practical and economical

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rating of the UPQC. The performance comparison of a UPQC and a static synchronous compensator has been carried out and the UPQC is found to be more economical in relation to device rating.

4. CONCLUSION

A comprehensive review on the Distributed generation and power quality is provided in this paper. The problems related to power quality are also discussed. To enhance the electric power quality at distribution level a technique of UPQC is reported in this paper. A technique of UPQC is useful to compensate both voltage- and current-related power quality problems simultaneously. Different aspects of UPQC and up to date developments in this area of research have also been briefly addressed.

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