Research Article

ROLE OF FACTS DEVICES IN IMPROVING POWER QUALITY IN A GRID CONNECTED RENEWABLE ENERGY SYSTEM

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ABSTRACT:

Renewable energy sources (RES) are being increasingly connected in distribution systems utilizing power electronics converters. This paper presents a technical review of power quality improvement using facts devices associated with the renewable based distributed generation systems. For the proper selection of the facts devices the IEEE and IEC standards for grid connected renewable energy system is considered. This paper includes the integration of PV and wind energy system.

KEYWORDS: Power quality, Distributed Generation, Renewable Energy system, Grid Integration.

1. INTRODUCTION:

ELECTRIC utilities and end users of electric power arebecoming increasingly concerned about meeting the growing energy demand. Seventy five percent of total global energy demand is supplied by the burning of fossil fuels. But increasing air pollution, global warming concerns, diminishingfossil fuels and their increasing cost have made it necessary to look towards renewable sources as a future energy solution. Since the past decade, there has been an enormous interest in many countries on renewable energy for power generation. The market liberalization and government's incentives have further accelerated the renewable energy sector growth. Long transmission lines are one of the main causes for electrical power losses. Therefore emphasis has increased on distributed generation (DG) networks with integration of renewable energy systems in to the grid, which lead to energy efficiency and reduction in emissions. With the increase of renewable energy penetration to the grid, power quality (PQ) of the medium to low voltage power transmission system is becoming a major area of interest. Most of the integration of the renewable energy systems to the grid takes place with the aid of power electronics converters. The main purpose of the power electronics converter is to integrate the DG to the grid in compliance with power quality standards.

Solar and Wind are the most promising DG sources and their penetration level to the grid is also on the rise. Although the benefits of DG includes voltage support, diversification of power sources, reduction in transmission and distribution losses and improved reliability[1].Power quality problems are also of growing concern. This paper deals with a technical survey on the research and development of PV problems related to the solar and wind energy integrated to the grid and the impact of the poor power quality.

2. POWER QUALITY STANDARDS, ISSUES ANDITS CONSEQUENCES

A. International electro technical commission guidelines:

The guidelines are provided for measurement of power quality of wind turbine. The International standards are developed by the working group of TechnicalCommittee88oftheInternationalElectro-technical Commission (IEC), IEC standard 61400-21, describes the procedure for determining the power quality characteristics of the wind turbine.[2]The standard norms are specified.

a) IEC 61400-21: Wind turbine generating system, part-21. Measurement and Assessment of power quality characteristic of grid connected wind turbine) IEC 61400-13: Wind Turbine—measuring procedure in determining the power behavior) IEC 61400-3-7: Assessment of emission limits for fluctuating load IEC 61400-12: Wind Turbine performance. The data sheet with electrical characteristic of wind turbine provides the base for the utility assessment regarding a grid connection. Approximately 70 to 80% of all power quality related problems can be attributed to faulty connection and wiring[3].There are various categories of PQ problem such as electromagnetic interference,transients,harmonics and low power factor that are related to the source of supply and type of loads[4].

Among the above mentioned categories, harmonics are the most dominant one. The effect of harmonics on PQ are specially described in [5, 6] According to IEEE standards, harmonics in the power system should be limited by two different methods; one is the limit of harmonic current that a user can inject in to the utility system at the point of common coupling (PCC) and the other is the limit of harmonic voltage that the utility can supply to any customer at the PCC.

The voltage variation, flicker, harmonics causes the malfunction of the equipments namely microprocessor based control system, programmable logic controller; adjustable speed drives, flickering of light and screen. It may leads to tripping of contractors, tripping of protection devices, stoppage of sensitive equipments like personal computer, programmable logic control system. Thus it degrades the power quality in the grid.

3. Power quality issues in a grid integration of renewable energy system

A. Solar Photovoltaic System:

In this system the output of the PV panel depends on the solar intensity and the cloud cover.Therfore the PQ problems not only depend on irradiation but also are based on the overall performance of solar photovoltaic system including PV modules, inverters, filters controlling mechanism etc. Survey studies in[7], shows that the short fluctuation of irradiance and cloud cover play an important role for low voltage distribution grids with high penetration of PV.Therfore special attention should be paid to the voltage profile and the power flow on the line. It also suggests that voltage and power mitigation can be achieved using super-capacitors which result in an increase of about 20% in the cost of the PV system.

The general block diagram of grid connected PVsystem is shown in fig (1) below and the system can be a single phase or three phases depending on the grid connection requirements.

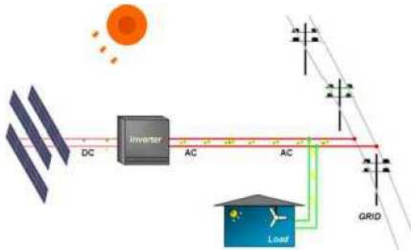

Fig 1: General structure of grid connected PV system

In general, a grid connected PVinverter is not able to control the reactive and harmonic currents drawn from non liner loads. A multifunctional PV inverter for a grid connected systemshown in fig (2) has been developed recently presented in [8].This system demonstrates the reliability improvement through UPS functionality, harmonic compensation, reactive power compensation capability together with the connection capability during the voltage sag condition.

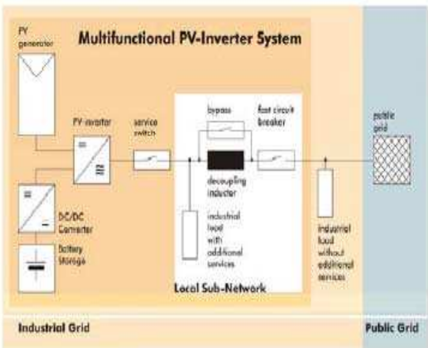

Fig.2.concept of Multifunctional PV-Inverter Systems

B. Wind Energy System

The American Wind Energy Association (AWEA) led to the effort in the United States for adoption of the grid code [9] for the interconnection of the wind plants to the utility systems. The rules for realization of grid operation of wind generating systems at the distribution network are defined as -per IEC-61400-21.It suggest that new wind farms must be able to provide voltage and reactive power control, frequency control and fault ride through capability in order to maintain the electric system stabllity.For the existing wind farms with variable speed, double fed induction generator(DFIG) and synchronous generators(SG),a frequency response in the turbine control system can be incorporated by a software upgrade. A recently purposed Z source inverter (ZSI) can be a good approach to mitigate the PQ problem for DG systems connected to the grid [10] fig3 below

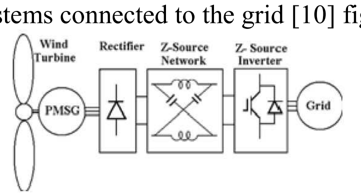

Fig.3.PMSG-based WECS with dc boost chopper and ZSI

4. Mitigation of PQ problems

There are two ways to mitigate the power quality problems-either from the customer side or from the utility side. The first approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. Several devices including flywheels, super capacitors, other energy storage systems, constant voltage transformers, noise filters, isolation transformers, transient voltage surge suppressors are used for the mitigation of specific PQ problems [11].Facts devices like DSTATCOM,DVR and UPQC are capable of mitigating multiple PQ problems associated with utility distribution and the end user appliances.

5. Role of FACTS Devices

Facts devices are a family of power electronic devices, or a tool box, which is applicable to distribution systems to provide power quality solutions.

STATCOM – STATIC SYNCHRONOUS COMPENSATOR The STATCOM (or SSC) is a shunt-connected reactive-power compensation device shown in fig(4) that is capable of generating and/ or absorbing reactive power[12] and in which the output can be varied to control the specific parameters of an electric power system. It is in general solid-state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source or energy-storage device at its input terminals. Specifically, the STATCOM considered in this chapter is a voltage-source converter that, from a given input of dc voltage, produces a set of3-phase ac-output voltages, each in phase with and coupled to the corresponding ac system voltage through a relatively small reactance (which is provided by either an interface reactor or the leakage inductance of a coupling transformer). The dc voltage is provided by an energy-storage capacitor.

A STATCOM can improve power-system performance in such areas as the following:

1. The dynamic voltage control in transmission and distribution systems;
2. The power-oscillation damping in power transmission systems;
3. The transient stability;
4. The voltage flicker control; and
5. The control of not only reactive power but also ifneeded) active power in the connected line, requiring a dc energy source

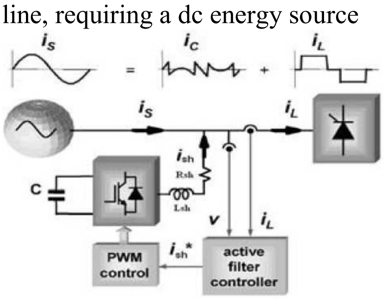

Fig 4.System configuration of STATCOM

As the traditional STATCOM works only in leading ang lagging operating mode,its application is therfore limited to reactive power support only.The fluctuating power due to the variation of wind cannot be smoothend by eactive power controlusing a STATCOM,because it has no active power control ability.To overcome this problem,Battery Energy Storage system (BESS) has been incorporated with

STATCOM[13] which has both real and reactive power control ability(fig5).

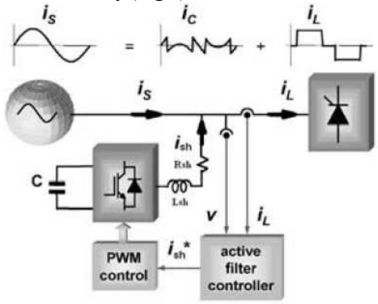

Fig 5.Power quality control using STATCOM with BESS

The DVR is a series connected facts device to protect sensitive loads from supply side disturbances. it can also act as a series active filter ,isolating the source from harmonics generated by loads. It consist of a voltage source PWM converter equipped with a dc capacitor and connected in series with utility supply voltage through a low pass filter and a coupling transformer[14] as shown in fig(6)

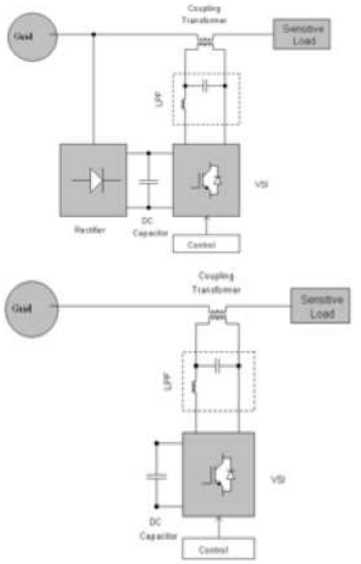

Fig 6 (a) Rectifier supported (b) DC capacitor supported DVR.

UPQC is the integration of series and shunt active filters, connected back to back on the dc side and share a common DC capacitor[15] as shown in fig (7).The series connected UPQC is responsible for mitigation of the supply side disturbances: voltage sags,flickers,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 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.

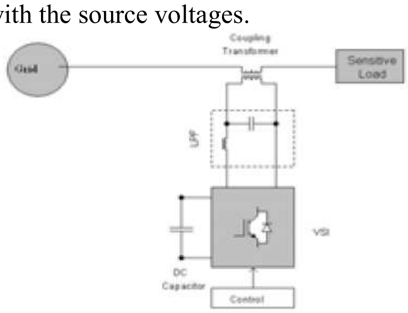

Fig 7: System configuration of UPQC

A structure has been proposed in [16] shown in fig(8),where PV is connected to the DC link in the UPQC as an energy source. It works both in interconnected and islanding mode.UPQC has the ability to inject power using PV to sensitive loads during source voltage interruption. The advantage of this system is voltage interruption compensation and active power injection to the grid in addition to the other normal UPQC abilities

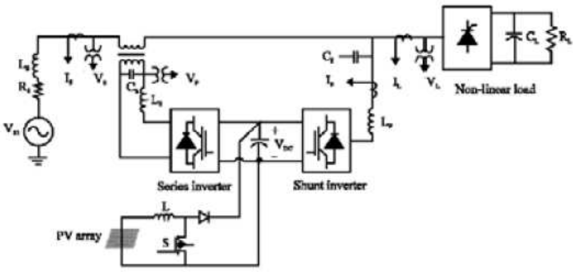

Fig. 8.Grid connected PV with UPQC

6. CONCLUSION

In this paper we present the role of Facts devices in improving power quality in a grid connected renewable energy system. Recent trends in the power generation and distribution systems show that penetration level of DG into the grid has increased considerably. End users appliances are becoming more sensitive to the power quality conditions. Extensive research on facts devices for the mitigation of PQ problems are also carried out. Facts devices are found to be very capable in integrating solar and wind energy sources to the grid.

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