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Power Quality Enhancement for Grid Connected Renewable Energy Source at Distribution Level-A Review

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ABSTRACT: Electric utilities and end users of electric power are becoming 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, diminishing fossil 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. Renewable energy source (RES) integrated at distribution level is termed as distributed generation (DG). The utility is concerned due to the high penetration level of RES in distribution systems as it may pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) issues. Therefore, the DG systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network.

I. INTRODUCTION

A. Renewable Energy Resources

Renewable energy encompasses a variety of resources and technology applications involving different policy and infrastructure needs. The term "renewables" generally is applied to those energy resources and technologies whose common characteristic is that they are non-depletable or naturally replenishable.

Access to quality, reliable and affordable energy is critical for promoting economic and social development in rural areas.

Fig. 1. Electricity generation by solar.

Due to increased standard of living, growing population, rapid industrialization etc., the energy demand has increased and hence the gap between generation and demand are increasing considerably. Distributed Generation (DG) is the power generation from locally available sources; generally renewable energy sources. DG is on the rise since distributed energy systems with renewable sources have great potential in providing reliable power to the rural areas where grid extension is difficult and uneconomical. The increasing demand for electrical energy and the focus on environmental protection motivated the efforts to concentrate on developing renewable energy sources. United Nations is planning 50% of total energy from renewable sources by 2050, Europe 20% by 2020 and India 15% by 2015.

Wind Energy

Wind farm needs to be located where there is relatively high average wind speed. Wind turbines directly generate electricity and quite efficient (not a heat engine).

Wind Energy is

- High net energy yield
- Renewable and free
- Very clean source of energy
- No pollution (air or water) during operation
- Low operating/maintenance costs
- Now almost competitive with hydro and fossil fuels
- Land can be used for other purposes
- Energy storage issues
- An intermittent source of energy; need backup (eg stored energy) for low-wind days

- Or must be connected to the electrical grid
- Only practical in areas that are windy enough
- Danger to birds

Fig. 2. Electricity generation by wind.

II. SYSTEM DESCRIPTION

Grid Connected Renewable Energy Source System

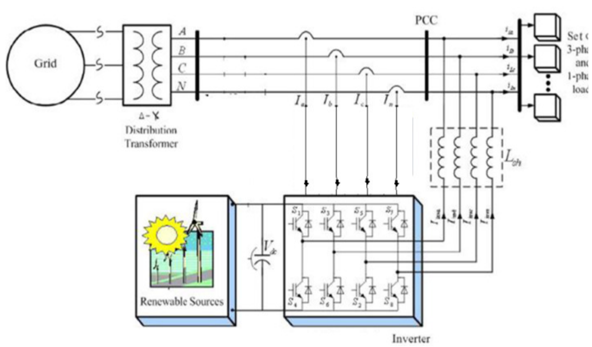

Fig. 3. Grid Connected Renewable Energy Source System.

The system consists of RES connected to the dc-link of a grid-interfacing inverter. The voltage source inverter is a key element of a DG system as it interfaces the renewable energy source to the grid and delivers the generated power.
The RES may be a DC source or an AC source with rectifier coupled to dc-link. Usually, the fuel cell and photovoltaic energy sources generate power at variable low dc voltage, while the variable speed wind turbines generate power at variable ac voltage.
Thus, the power generated from these renewable sources needs power conditioning (i.e., dc/dc or ac/dc) before connecting on dc-link. The dc-capacitor decouples the RES from grid and also allows independent control of converters on either side of dc-link.
Renewable energy source (RES) integrated at distribution level is termed as distributed generation (DG). The utility is concerned due to the high penetration level of intermittent RES in distribution systems as it may pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) issues. Therefore, the DG systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network.
With the advancement in power electronics and digital control technology, the DG systems can now be actively controlled to enhance the system operation with improved PQ at PCC.
However, the extensive use of power electronics based equipment and non-linear loads at PCC generate harmonic currents, which may deteriorate the quality of power The non-linear load current harmonics may result in voltage harmonics and can create a serious PQ problem in the power system network.
Active power filters (APF) are extensively used to compensate the load current harmonics and load unbalance at distribution level. This results in an additional hardware cost. However, a system incorporated the features of APF in the, conventional inverter interfacing renewable with the grid, without any additional hardware cost has been designed.
III. Functions of Grid-Interfacing Inverter
The grid-interfacing inverter can effectively be utilized to perform following important functions:
a) Transfer of active power harvested from the renewable resources (wind, solar, etc.)
b) Load reactive power demand support
c) Current Harmonics compensation at PCC
d) Current unbalance and neutral current compensation in case of 3-phase 4-wire system.
The grid-interfacing inverter can be utilized to:
i) Inject real power generated from RES to the grid,
ii) Operate as a shunt Active power filter (APF)

Operation

- DC-Link Voltage and Power Control Operation
- Due to the intermittent nature of RES, the generated power is of variable nature. The dc-link plays an important role in transferring this variable power from renewable energy source to the grid. RES are represented as current sources connected to the dc-link of a grid-interfacing inverter. The systematic representation of power transfer from the renewable energy resources to the grid via the dc-link is shown in figure.

The current injected by renewable into dc-link at voltage level Vdc can be given as,

$$Idc1=PRES/Vdc$$

Where, PRES is the power generated from RES.
The current flow on the other side of dc-link can be represented as

$$Idc2=Pinv/Vdc=(PG+PLoss)/Vdc$$

Where, Pinv, PG and Ploss are total power available at grid-interfacing inverter side, active power supplied to the grid and inverter losses, respectively.
If inverter losses are negligible then

$$PRES=PG$$

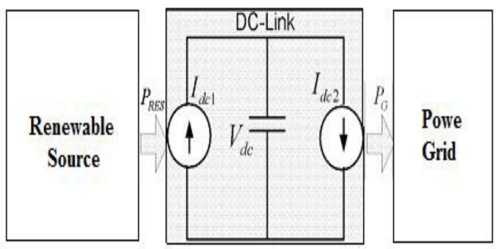

Fig. 4. DC-Link equivalent diagram.

Application of Renewable Energy Sources Energy efficient house; wind power on roof and Solar panels for heat and electricity.

IV. CONCLUSION

A novel control of an existing grid-interfacing inverter to improve the quality of power at PCC for a 3-phase 4-wire DG system has been presented. It has been shown that the grid-inter-facing inverter can be effectively utilized for power conditioning without affecting its normal operation of real power transfer. We can eliminate the need for additional power conditioning equipment to improve the quality of power at PCC.
When the power generated from RES is more than the total load power demand, the grid-interfacing inverter with the proposed control approach not only fulfils the total load active and reactive power demand (with harmonic compensation) but also delivers the excess generated sinusoidal active power to the grid at unity power factor.

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