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Power stability in Distribution Systems Employing Wind Energy Load

[1]Venkatesan , [2] S.Jerril Gilda
[1] *Pursuing M.E (Power systems), Dept of EEE, Sri Muthukumaran Insttitute of Technology, Chikkarayapuram, Chennai, Tamil Nadu, India.*
[2] *Assistant Professor Dept. of EEE, Sri Muthukumaran Insttitute of Technology Chikkarayapuram, Chennai, Tamil Nadu, India*

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ABSTRACT:

The development in renewable energy sources like solar wind energy systems leads to increase the voltage quality issues like voltage sag, voltage swell, Harmonics, transients etc., These WPPs mostly do not correlate with consumer load demand in time scales due to its high intermittency. Therefore, it leads to one of the main causes of destabilizing the power system. This paper analysis the power quality issues due to wind power penetration and discuss about various methods of voltage control to mitigate the problems related to it. Discuss about various types voltage control and briefly discuss about real time controller system which is having back to back convertor, PLL and current controller systems. This system will increase the reliability of the grid and ensure continuous availability of power to the consumer with good voltage and power quality. It will also encourage the use of renewable energy utilisation and reduce significant environmental damage caused by conventional power sources.

I. INTRODUCTION

Modern industrial processes containing voltage sensitive devices are vulnerable to degradation in the quality of power supply. Voltage fluctuations, often in the form of voltage sags can cause severe disruptions and result in substantial economic loss. Therefore cost-effective solutions can help such sensitive loads made through momentary power supply disturbances have attracted much research attention. Also the lack of fossil energy source and increased awareness of environmental impacts causes renewable energy sources i.e. PV and wind to the effect of wind power is felt not an issue to the grid operators.

Since the WPPs are located in remote areas it is having major effects at local PCC levels. As it is far away from the conventional; power plants, which are having good control techniques, they cannot contribute the control of voltage fluctuations
due to wind power plants. Normally flickering may happen due to WPP blade pitch error, yaw error, wind shear, speed changes due to turbulences etc.,. Reserve load may use for
power and voltage stability but it is not worth in terms of fast load variations like wind energy. The system disturbance increases with increasing nominal apparent power of the WPP/Wind farm and decreasing with decreasing short circuit power. In all types of WPP power fluctuations may happen due to varying wind and tower shadow.

Increase rating of DG unit and improve the capacity of storage systems are help to increase reliable penetration of RPGs in order to reduce fossil fuel consumption and reduce Carbon to save the environment. Increase in cost due to DG and energy storage conversion process which will also increases cost of power system and reduces the advantages of Renewable Power Generation. Storage systems are in operation with power system having large investment and space requirements and having loss in conversion process. Keep the RPGs near load centre will improve stability but having some practical difficulties as they posses larger area (solar plant) and they need a particular environment (wind power plants.).

The demand side management techniques used for mitigating the intermittency property of the RPGs in to the power system. When power generation from RPGs increases, then the load demand is increased .Power generation reduces, then load demand reduction taken place. Load scheduling, using freewheel energy, direct ON/OFF load are some of load demand management

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methods. However these load management methods are in the time frame of hours and not suitable in real time variations like in WPPs.

Increase in WPPs systems can affect grid operation when it reaches certain limit. WPPs not like conventional plant which are having good control system over stability of the grid. But in case of WPPs some special methods involved in managing voltage, active and reactive power at fault conditions in grid.

II. ISSUES IN GRID INTEGRATED OPERATION OF WPPS AND SOLUTIONS

Power system stability

Increase in WPPs will create problems in power system stability. WPPS can create stability problem in transmission and distribution systems by altering the power flow depending upon source of power. Methods like Fault ride through avoid unnecessary tripping of WPPs and ensure stability of the power system.

Frequency Control

Sudden loss of WPPs may create frequency problems in grid. WPPs are used for balance control by running in under load operation and load will increase while sensing low frequency. Conventional power plants having good control in instantaneous frequency control. Generally WPPs are used in secondary frequency control.

Load Balancing

When frequency goes high balancing can be achieved by switch off the WPPS one by one or by adjusting the pitch angle power generation can be reduced. Some of WPPs should stay disconnected and whenever frequency get low it will get connected to the grid to balance the load.

Voltage flickering and harmonics

When WPP blades cross tower shadow and gives short term variations in output may affect power and cause flickering. Variations in aerodynamic power convert in to output power fluctuations which may cause flickering. Power electronic controllers which are connected with WPPS are helping to reduce flicking.

III. CONVERTER SYSTEM FOR VOLTAGE CONTROL

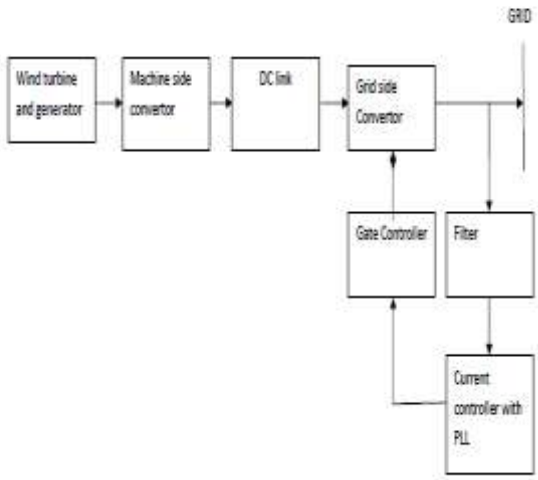

Fig 1 **Block diagram of WPP – GRID voltage regulating system**

Control of active and reactive power of loads for demand-response management under increased penetration of renewable power generations (RPGS) at distribution level made by Modelling and control of voltage source converter for grid bus voltage regulation is proposed. So by controlling active vs reactive power will control the voltage at the time of fluctuations. The increased in penetration of wind energy in grid is associated with adverse impact on voltage quality. A permanent magnet synchronous generator Based variable pitch wind energy conversion system is modelled with a wind speed considering stochastic and periodic effects.

Wind turbine, Derive train and PMSG generates power and connected with grid through

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two converter circuits. The Machine side converter used to control active and reactive power of the input system through rotor of the generator by receiving or injection the current. DC link normally referred as buffer between two power terminals. Grid side convertor used to control the voltage at grid side which is our requirement.

IV. OVERVIEW OF THE SYSTEM

1.1 wind turbine and PMSG model

The Wind Turbine block a model is actually the steady-state power characteristics of a wind turbine. The stiffness of the drive train is infinite and the friction factor and the inertia of the turbine are combined with those of the generator coupled to the turbine. The three inputs are i) the PMSG speed pu of the nominal speed of the generator, the pitch angle in degrees, and the wind speed in m/s. The tip speed ratio λ obtained by blade speed and the wind speed . The mechanical torque applied to generator and electrical torque produced in generator which is used for stability analysis of wind PMSG model.

The output power is given by

$$Pm = \frac{C_p \rho A V_{wind}^3}{2}$$

C_P performane coefficient of the turbine
ρ Air density
A Turbine swept area
V_{wind} Wind velocity

3.2 Control of Machine Side Converter

The wind turbine can extract maximum power at given point of time by getting maximum speed by varying pitch control. So the speed of turbine is varying by wind speed. PMSG speed is controlled for achieving maximum power .It is attained by controlled switching of Machine Side Converter (MSC). The MSC is controlled by aligned with synchronously rotating stator flux frame he MSC is connected in back to back configuration with Grid-Side Converter (GSC) with common DC bus. The DC bus acted as a buffer and also stabilizes the voltage at its terminal of both converters. The MSC allows generation of power at variable frequency

3.3 Control of Grid side convertor

The GSC is also controlled by making its reference frame aligned with the grid voltage. The active power delivered from the MSC is transferred to the grid through the GSC. The active power control is obtained through the GSC with the help of PLL and current controller package

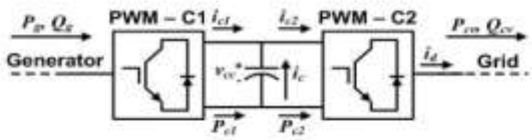

Fig 2 Back to Back convertor model

The simplified equation for active power flow and reactive power flow causes variation in voltage is given below

$$\Delta V = \frac{PR + QX}{V_r}$$

V_r Grid voltage
P, Q Active and Reactive power of WPP
R and X Resistance and Reactance of line
Δ V voltage variation between WPP and Grid

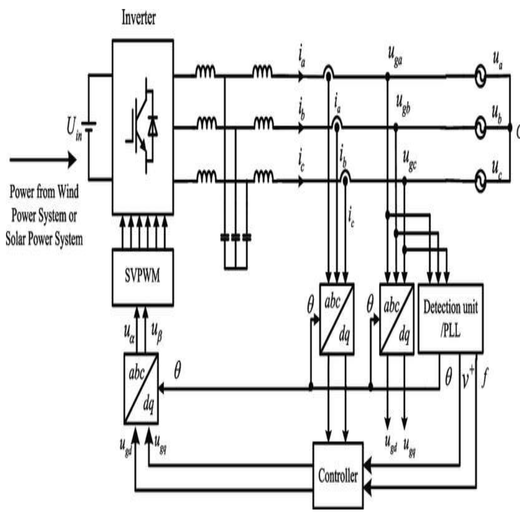

Fig 3 **Current Controller with PLL**

PLL and Current controller used for stabilize the active and reactive power by nullifying the voltage variation.

The PLL system is a feedback system with a PI controller tracking the phase angle of grid voltage and control the active and reactive power. The three phases of the grid voltage fed to the PLL output is the phase angle of one of the three phases. The purpose of the feed forward frequency is to have the PI-regulator control for an output signal that goes to zero. Current controller output having dq component and output of current controller and PLL convert into ABC component and fed to gate pulse generator for GSC. Active and Reactive power controlled by the convertor and voltage variation controlled by

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this action.

V. CONCLUSION

This paper discussed about a proposed model of a system which used to maintain the voltage profile in a distributed system which is predominantly having renewable energy power as a source. The simulation model for wind turbine, PMSG and real time voltage control system has been done for grid power and voltage regulation.

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