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A Study of Power Quality in Grid Interconnection with DFIG

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Abstract— A growing number of nations have recognized the economic, social and environmental benefits of renewable energy and are enacting tax incentives and other policy measures favorable to renewable technologies. To analyze the various aspects of grid interconnection with DFIG using MATLAB. This paper is based on the performance of renewable source of energy (wind). This analysis is based on the MATLAB Simulation, With the help of this software & using simulation technique analysis of Performance is done & Power Quality Problems such as voltage sag, voltage flicker and unbalance voltage due to fault are also analyzed. This paper shows the power electronic grid interconnection supports the variable speed wind power, real and reactive power control, and reduces the influences of fluctuations in the wind such as voltage flickers. Nonetheless, it generates other problems due to the switching devices of the power converters. One problem of the grid interconnection is harmonic distortions of the grid currents and voltages. The harmonic distortions degrade the power quality. This leads to more severe problems in the power system such as transformer saturations, failure of protective devices, etc

Index Terms— RES, WTG, PV, DFIG, FSIG

I. INTRODUCTION

Nowadays, the renewable energies are the only sources that can replace fossil combustibles. These new sources are mainly clean , safe and quite cheap for the user. Among them, the wind power has driven a considerable attention these last fifteen years . The call for improved renewable energy technologies is increasing due to the global warming. It affects humans in several aspects such as economies, public health, environment, etc. The global warming is caused from green house gases, which comes from burning fossil fuels such as oil or coal. The advent of renewable energy resources is the promising solution to the problems. There are several renewable energy resources for the electrical power system. Among those, wind energy is one of the fastest growing renewable energy resources.

The high electrical power can be generated from an aggregation of multiple wind turbines as a wind farm or wind park. To interconnect the wind energy to the utility grid, there must be and appropriate grid interconnection and control system to ensure high power quality and stability.

Renewable Energy Sources (RES) have become widely used in most developed countries Ireland, Germany, Spain and Scotland etc. Some examples of the commonly used renewable energy sources include wind turbine generators (WTGs), photovoltaic systems (PV systems), hydro-turbines and fuel cells just to name a few and they have become familiar on grid.

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One of the advantages of RES is that they are environmentally friendly as opposed to conventional sources of generation such as coal and oil powered generators.

In recent years, concerns regarding pollution and energy shortage have prompted governments around the world to push for alternative energy sources such as wind power, solar energy and small hydro-electric power. Different power quality aspects usually considered important are transient voltage variations and harmonics. Embedded generation plants can cause transient voltage variations on the network of relatively large current changes during connection and disconnection of the generator. The magnitude of the current transients can to a large extent be limited by careful design of the embedded generation plant, although for single generators connected to weak systems the transient voltage variations caused may be the limitation on their use rather than steady-state voltage rise [4].

Power quality is a term that means different things to different people. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as "the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment. Electrical equipment susceptible to power quality or more appropriately to lack of power quality would fall within a seemingly boundless domain. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a household appliance. All of these devices and others react adversely to power quality issues, depending on the severity of problems.

A simpler and perhaps more concise definition might state: "Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy."

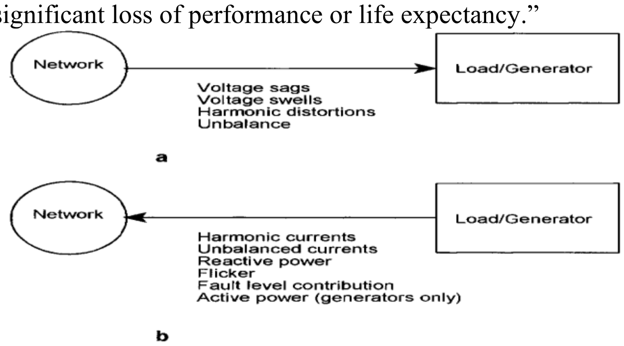

Fig 1: Origin of power quality issues

Fig 1 shows the various effects which may be considered to originate in the transmission and distribution networks and which can affect the voltage to which loads and generators are connected. Two aspects of power quality are usually considered to be important:

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(i)Transient voltage variations and
(ii)Harmonic distortion of the network voltage.

II. POWER QUALITY ISSUES

There are economic impacts on utilities their customers and suppliers of load equipment. The power quality can have direct impact on many industrial consumers. Principal phenomenon causing electromagnetic disturbances leading to failure of power quality are: Conducted low frequency phenomenon, Radiated low frequency phenomenon, unidirectional transients, Oscillatory transients, Electrostatic discharge phenomenon, and nuclear electromagnetic pulse. The Main Power Quality Issues affected by Distributed Generation are Harmonic distortion, Loading concerns, Voltage flicker, Voltage regulation

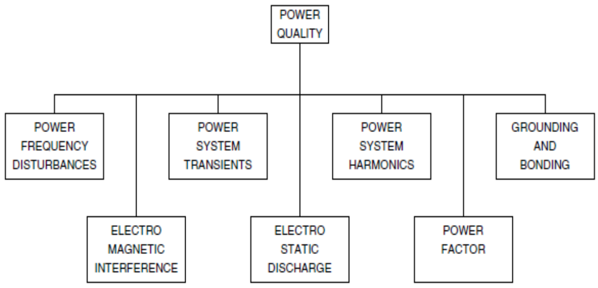

Fig 2:Power Quality concerns

The term transient has long been used in the analysis of power system variations to denote an event that is undesirable and momentary in nature. The notion of a damped oscillatory transient due to an RLC network is probably what most power engineers think of when they hear the word transient. Transients can be classified into two categories, impulsive and oscillatory.
Impulsive transient is type of transient disturbance that may enter the power system. Impulsive are not usually transmitted far from source of where they enter the power system. In some cases they may propagate for same distance along distribution utility lines .
Impulsive transients are normally characterized by their rise and decay times, which can also be revealed by their spectral content.

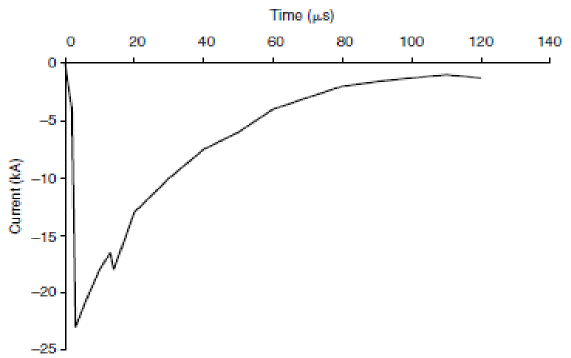

Fig 3:Impulsive transients

The instantaneous voltage or current value of an oscillatory transient varies its polarity quickly .it is described by its spectral content or predominant frequency ,magnitude and duration. Oscillatory transients with a primary frequency component greater than 500 kHz and a typical duration measured in microseconds (or several cycles of the principal frequency) are considered high-frequency transients.

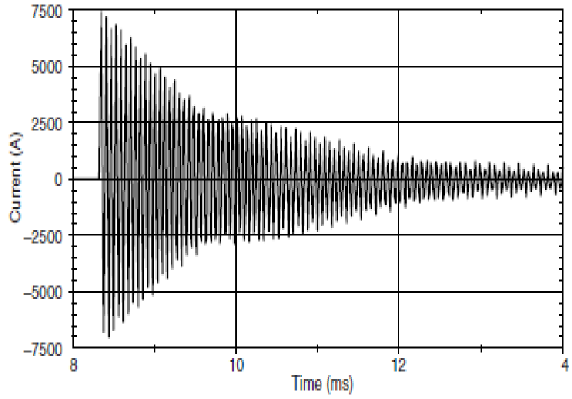

Fig 4:Oscillatory transients

III. EMBEDDED GENERATION TECHNOLOGY AND INTERCONNECTION

National programs inside the European community are directed to increase the share of renewable energy sources and the efficiency of power generation by cogeneration of heat and power. Targets are set from the European Commission for each country. The share of renewable of the electric energy consumption has to be increased until 2010 6om 14 %to 22%.Further more, the share of heat Taking into account that the wind power will grow preliminary by the way of large wind farms feeding into the transmission grids with additional 40 GW installed power until 2010 (today appr. 25 GW are installed), the dispersed generation shall achieve an additional growth of 290 T W a to meet the mentioned goals .
Large generating units can be made efficient and operated with only a relatively small number of personnel. The interconnected high voltage transmission network allows generator reserve requirements to be minimized and the most efficient generating plant to be dispatched at any time. The conventional arrangement of large power system shown in figure 5.

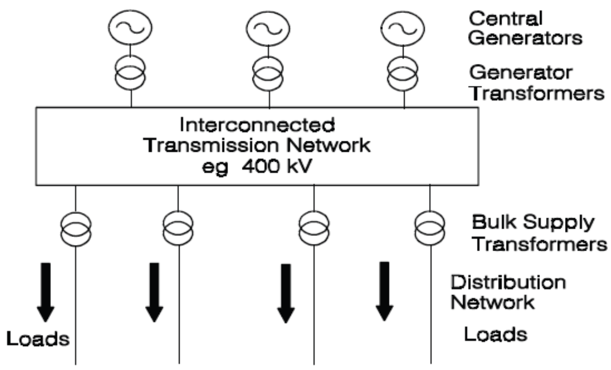

Fig 5:Conventional large electric power system

IV. GRID INTERCONNECTION OF WIND DRIVEN DOUBLY FED INDUCTION GENERATOR

In recent years, concerns regarding pollution and energy shortage have prompted governments around the world to push for alternative energy sources such as wind power, solar energy and small hydro-electric power.

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Due to the continued growth in wind energy, power utilities' interests have shifted from the power quality issues caused by wind power to potential stability problems. In the traditional wind energy conversion schemes, the majority of the wind farms employed fixed-speed induction generators (FSIG) together with power factor correction capacitors; no fast-dynamic compensation was typically available. Recently, the doubly-fed induction generator (DFIG) based wind turbine generator (WTG) offers the possibility of dynamic voltage or power factor control using the generator power electronics converters. [24]

The most commonly used generator type in modern wind turbines is the DFIG. The back-to-back frequency converter in combination with pitch control of the rotor blades enable variable speed operation, leading to higher energy yields compared to fixed speed wind turbines. Since the IGBT converter is located in the rotor circuit, it only has to be rated to a small portion of the total generator power (typically 20-30%, depending on the desired speed range). In a DFIG system the function of the grid side converter is to maintain the DC voltage and to support the grid with reactive power during a fault. Especially when the machine rotor is short circuited through the crowbar resistors, the generator consumes reactive power. This reactive power has to be compensated by the grid side converter. The rotor side converter controls active and reactive power of the DFIG and follows a tracking characteristic to adjust the generator speed for optimal power generation depending on wind speed .

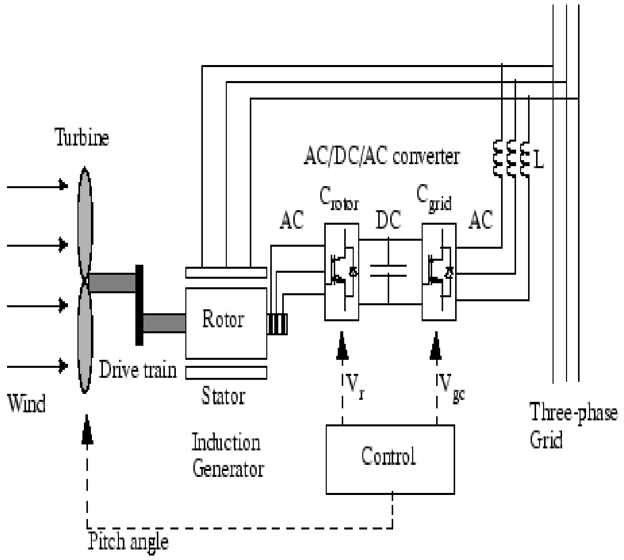

Fig 6:Wind Turbine Doubly-Fed Induction Generator

A wind farm having 6 wind turbines of range 1.5 Mw connected to the 25KV distribution system which give power to a grid of 120KV through 20 km and 10 km line and feeder of 25 KV having load of 500KW at bus 25. Protection system monitors the voltage, current and machine speed. The DC link voltage is also monitored.

V. SIMULATION

Wind turbines use a doubly-fed induction generator (DFIG) consisting of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. . For wind speeds lower than 10 m/s the rotor is running at sub synchronous speed . At high wind speed it is running at hyper synchronous speed. .

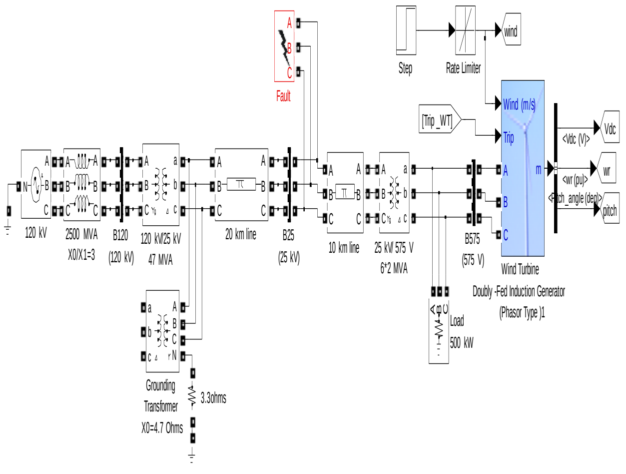

Fig 7:Simulink model of grid interconnection with DFIG

Result:-

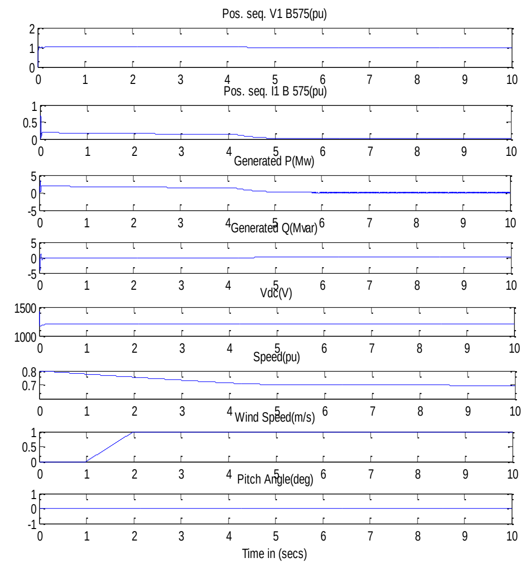

Fig 8:Response of Grid Interconnection with DFIG

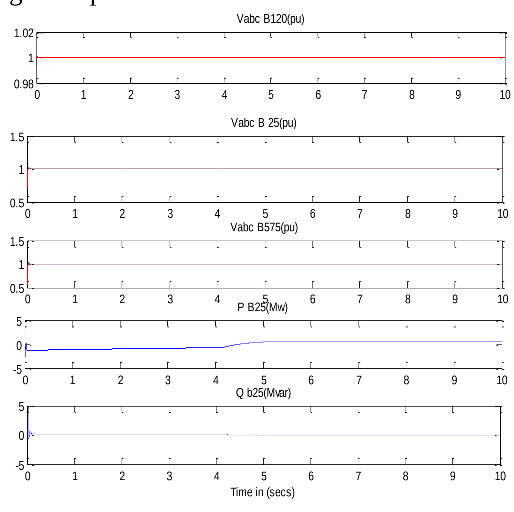

Fig 9: Response of Grid Interconnection with DFIG with fault

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Wind speed block is used to specify the wind speed. Initially we take the wind speed at 8 m/s when time =5s. The speed of wind increases suddenly at 14 m/s .Stimulate the model and observe the signals on the "Wind Turbine" and that scope monitors the various parameters like as wind turbine voltage, current, generated active and reactive powers. DC bus voltage and turbine speed. At the above time given the generated active power reach its rated value 9MW and turbine speed changes from 0.5 pu to 1.21pu.

VI. CONCLUSION

The system operated with standalone operation of synchronous generator indicates the system is balanced and operates normally. In this voltage and current remains constant and operation is stable. The standalone operation of DFIG may have unstable operation. The source voltage and current has harmonic distortions. However the system can be made stable by using sensorless control and low reactive power demand. Three phase short-circuit fault is operated at the middle of line. During the fault the electromagnetic torque is very small and the generator accelerates. The torque of the turbine is naturally decreased during fault, as the generator speed is increasing and wind speed remain constant.

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