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CHALLENGES IN POWER QUALITY AND ITS MITIGATION IN WIND INTEGRATED GENERATING POWER SYSTEM

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Abstract- Due to an increase in the production of various industries, the employment of automated systems, and the consequent use of numerous appliances on both the sending end and the receiving end of the power system, the world's energy consumption has been rising quite quickly in recent decades. As a result, maintaining the quality of the power is crucial for maintaining stability. The greatest problem in the current electrical power system without compromising the quality and flow of power is penetration of such sources to generate electricity due to variations in the availability of natural resources. Maintaining a strong, dependable, and exceptionally smart generation, distribution, and transmission infrastructure is crucial. In order to preserve consistent quality & flow of electricity with its stability, this paper presents many power quality difficulties & tasks in the penetration of renewable energy resources with solutions. The article outlines the methods put in place on the power system to reduce power quality issues.
Keywords: PQ, DFIG, voltage sag, voltage swell, THD, GSC, RSC, STATCOM, TVSS, DVR.

1. INTRODUCTION

The reliability of the electrical power system has been a worry for many electrical engineers. They notice that it has an impact on the fundamental electrical system characteristics, such as current, voltage, often bus voltage, power factor, and frequency of the system that is supplied to the end users at the system's output, who operate as the system's primary consumers of electricity. They deal with the quality of the power at all levels of the electrical power system, including the transmitting and receiving ends. Basically, alternating sinusoidal voltage distortion or disturbance is what causes power quality issues. Maximum power-consumption machines in the past could withstand distortion, but today's extremely sensitive equipment, like computers, needs a source with good power quality in order to remain reliable [14]. The investigation, measurement, improvement, and maintenance of sinusoidal bus load voltage can be used to define the term "power quality." There are two sources—conventional and non-conventional—that can be used as fuel to generate power, depending on the issue at hand.

1.1 Conventional System

- Thermal generating system
- Hydroelectric system
- Nuclear electric system

1.1 Non-Conventional system

- Solar Generating system
- Wind electric generating system
- Tidal electric system
- Biogas electric generating system

Non-traditional systems are among those that are showing interest in supplying electricity to the intended regions. They utilise sustainable resources like wind, solar, etc. In particular, these renewable energy sources offer eco- and environmentally-friendly energy to regions and nations with insufficient fossil fuel supplies. The majority of problem-based scenarios in an electrical power system arise from the interconnection of generators, conductors, highly rated transformers, and the variable nature of the loads. Due to these various uncertainties, maintaining clean and reliable power is more difficult.

To have a significant impact on the plant, it is essential to integrate non-conventional energy (NCE) sources into the grid, such as wind energy. A critical consumer-focused analysis, power quality is impacted by the distribution and transmission systems. In general, there are two types of wind turbines: fixed-speed turbines and variable-speed turbines. When compared to fixed-speed turbines, which have an approximately constant rotor speed, variable speed turbines operate with a variable rotor speed. The mechanical torque on the grid is affected by the fluctuation sent by both wind turbines. Voltage sags, voltage swells, flickers, harmonics, etc. are a few of the different power quality problems related to wind systems.

2. VARIOUS POWER QUALITY PARAMETERS

Another description of the power quality is clear and distorted power. Whereas clean power is defined as power that runs at a desired amplitude and frequency and has sinusoidal current and voltage without any distortion. Power that has altered in sinusoidal voltage and current with change in its magnitude is referred to as distorted power. The electrical system's many natural and man-made occurrences give room for distortion of the sine waveform of voltage and current. Use of nonlinear loads, inadequate wiring and grounding, and adjustable speed drives are characteristics of these incidents. The following are the different power quality parameters:

2.1 Voltage Sags and Swells

Voltage sags are voltage drops that last for a brief period of time. Bus voltage is reduced over a period of time greater than 8 milliseconds (0.5 cycles), but less than 1 minute. Between 10% and 90% of the typical R.M.S voltage's amplitude was lowered. Voltage sags on the distribution and transmission lines are caused by both the sending and the receiving end users. Voltage sag happens far more frequently than other similar performance restrictions. It decreases the amount of energy given to the end users, which causes computer processes to fail, speed drives to shut down, and motors to overheat.

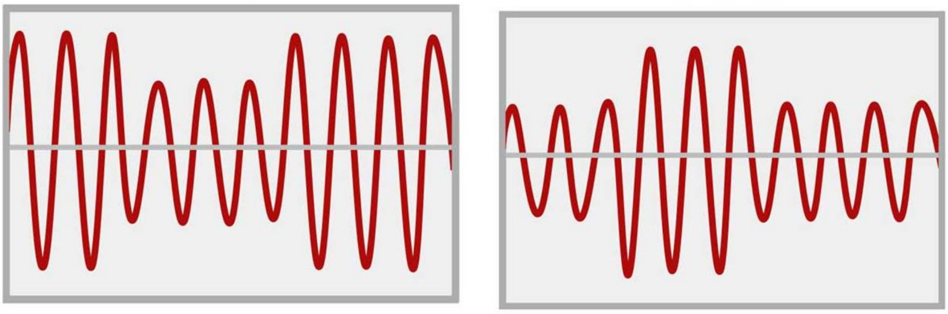

Fig. 2.1 (a) Voltage sag (b) Voltage swell

Momentary overvoltage, also known as voltage swells, are fluctuations in RMS voltage that are greater than 110 percent of the typical nominal voltage and last for less than one minute. It happens as a result of lightning, a tree falling on a live conductor, and single line to ground faults that cause the equipment to overheat and shorten its lifespan.

2.2 Harmonic Distortion

The main cause of fluctuations in sine waveforms is harmonics. Voltage and current distortion are integral multiples of the waveform's fundamental frequency. They are divisors of the frequency of 50 Hz. They are brought on by nonlinear loads in sensitive equipment, such as variable speed drives, heating controls, fluorescent lighting, and switched mode power supplies. They lead to transformer overheating, which increases iron losses in the transformer. Electronic and delicate devices will malfunction at higher harmonic levels. Total Harmonic Distortion (THD), which restricts distortion on the utility side of the metre, is the usual term used to refer to harmonic distortion. Where the disruption at PCC is coming from on the utility side. The perfect sine wave has almost 0% total harmonic distortion. The waveform's distortion grows in proportion to the waveform's magnitude.

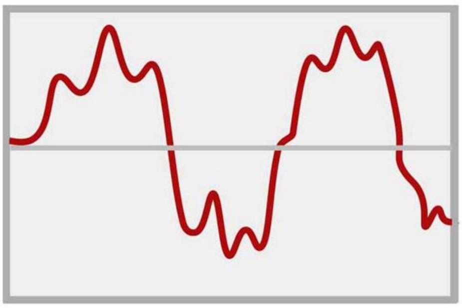

Fig. 2.2 Harmonic Distortion

2.3 Voltage Interruption

Total loss of voltage is referred to as voltage interruption. It is a voltage drop in the phase of the electrical system that is less than 10% of normal voltage. They are divided into three categories: brief interruptions, long-duration interruptions, and temporary disruptions [13]. For 8 ms, a momentary cause a total loss of voltage on the conductor phases. Voltage drops by 10% of the working voltage for 3 and 1 minutes during a temporary interruption.

Interruptions that persist more than a minute are referred to as long-duration interruptions. Such a loss causes industrial factories to produce less.

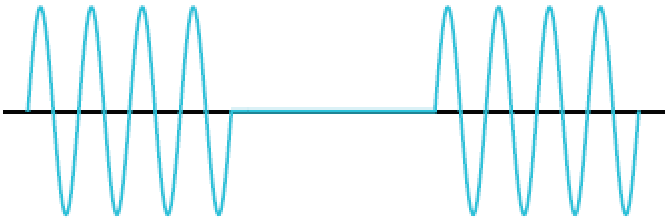

Fig. 2.3 Short and long duration interruption

2.4 Electrical Noise

On both sides of the grid system, high frequency signals are being conveyed. These lead to radio interference, which deteriorates telecommunications equipment. The diagrammatic representation of the signal, which has a high frequency and magnitude, is shown in the figure. According to the utility side, one of the significant noise examples is Corona, which generates a hissing sound that disturbs the customer.

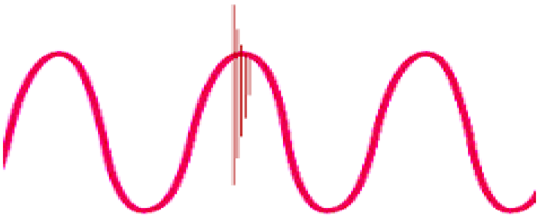

Fig. 2.4 Electric Noise

2.5 Voltage Unbalance

The term "voltage unbalance" refers to the phase voltage's variation. Most of the time, motors can handle a 2% voltage imbalance. Transformers, generators, and other site equipment overheat when there is a voltage imbalance of more than 2%.

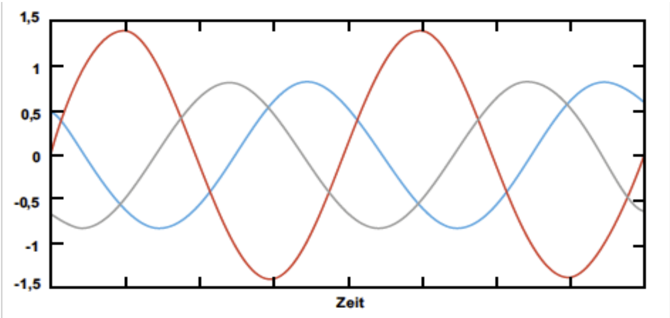

Fig. 2.5 Voltage unbalance

2.6 Flicker

The most frequent problem in wind systems is a continual and rapid shift in voltage magnitude. Its magnitude is between 0.95 and 1.05 times that of the average voltage [1]. Wind turbines send constant power to the output side during typical working conditions, however due to changes in wind speed, voltage fluctuations occur. Voltage (V) flicker is caused by intermittent loads, motor starters, and arc furnaces, and it irritates end users and utilities alike by causing light flickering. Static VAR system is the power conditioning component employed in this.

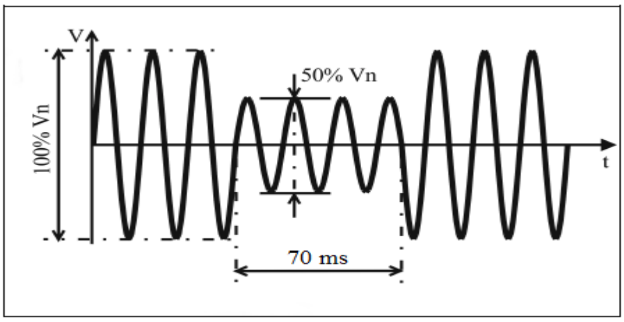

Fig. 2.6 Flicker

3. DFIG BASED WIND INTEGRATED SYSTEM

A diagrammatic illustration of a DFIG-based wind power system with two converters on each side, such as GSC and RSC, and a gearbox connected to the grid is shown in the image. An individual pitch control system is the mechanism employed for control [14]. The doubly fed induction generator, or DFIG, used by the variable speed wind turbine provides the stator winding while the rotor winding is supplied by RSC. Additionally, it employs vector control mechanisms to lessen flicker. The converters are used to supply energy with rectification utilising a DC common link and to supply the grid with the proper amount of AC power. The wind generating system's most often utilised generator is the DFIG.

The stator terminals are connected by GSC, and the rotor terminals are connected by RSC. Between the two converters, a DC link is attached. The RSC's primary control objectives are torque control and tracking wind power maxima (T). Maintaining constant grid current (I) and DC link voltage (V) is the GSC's control goal. It will enhance the mean wind speed to maintain production in light winds. Due to the increased wind speed in high wind conditions, the blades will pitch and the input and output of turbulence will be reduced. Due to its dependable functioning and functionality—we can use both of its sides of the grid—DFIG is used.

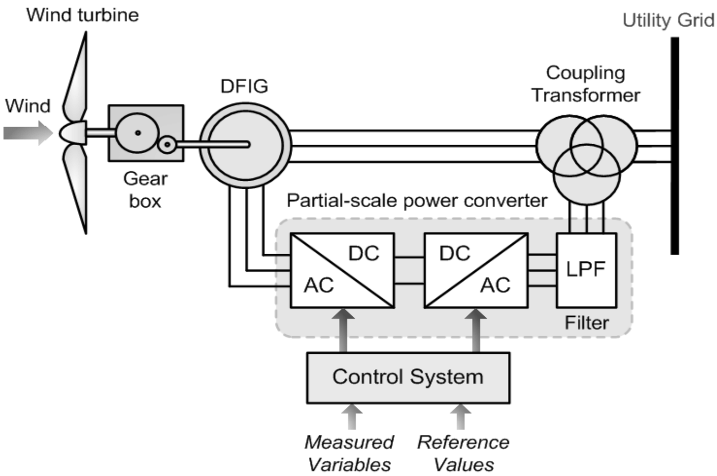

Fig. 3.1 DFIG based Wind Power System

3.1 Flicker Mitigation using STATCOM

Yaw inaccuracy and aerodynamic turbulence have an impact on voltage (V) level changes. Therefore, switching devices for power electronics are used to lessen the effects of output power fluctuations. A STATCOM can also be used to reduce voltage variations and enhance power quality. It is a FACTS device that is frequently used to lower the output power of a connected power system. A design of a STATCOM-based wind-generating system is shown in fig. 3.2. It consists of a collector system with a PCC between the grid side and the rotor side. STATCOM is employed in this methodology to eliminate or reduce output power fluctuations. The capacitor bank is used to decrease the size of STATCOM and to provide continuous output. On the output side of the collector system, an infinite bus bar is connected. To filter and keep the Power Quality concerns from becoming out of control, a capacitor bank and STATCOM are attached to the line.

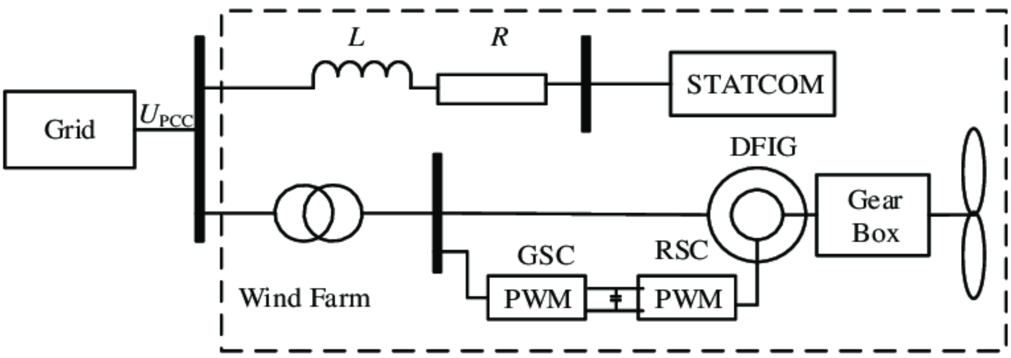

Fig. 3.2 STATCOM based Wind Generating System

CONCLUSION

The power quality, its numerous aspects, causes, impacts, and mitigation techniques are all discussed in this study. Additionally, it describes how different sources of power are integrated into the grid, along with the power quality problems they cause and potential fixes. Power electronic based switching devices and control system controllers are also the desired option to reduce flicker in wind power systems. Each topology varies in terms of complexity, price, and intended performance. Installing various power conditioning equipment in the power system is the best strategy to lessen and prevent problems with power quality.

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