CLASSIFICATION OF POWER QUALITY DISTURBANCE IN GRID CONNECTED WIND ENERGY SYSTEM

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ABSTRACT: The interconnection of the wind energy system based distributed generation (DG) system to the existing power system could lead to power quality (PQ) problems, degradation in system reliability, and other associated issues. This paper presents the classification of PQ disturbances caused not only by change in load but also by environmental characteristics such as change in the wind velocity. Various forms of sag and swell occurrences caused by change in load, variation in wind system, are considered in the study. This paper describes improved methodology of power quality at utility end in a grid system connected with renewable source of energy for power generation.

Keywords: power quality, wind energy system,

I. INTRODUCTION:

Wind-power technology is experiencing significant growth in developing countries like India. As a result of scientific assessments of wind resources throughout India, wind power has emerged as a viable and cost-effective option for power generation. Also studies shows that small-scale WECS are more efficient and cost effective. Therefore targeted technology development for power quality improvements of small-scale WECSs can make a significant overall contribution toward the national energy supply. Although India has made considerable progress in implementing technologies based on large scale renewable sources of energy, the dispersed energy technology applications are still few. PMG based power generation is one of the most favorable and reliable methods of power generation for small scale wind energy conversion systems since it has higher efficiency and smaller wind turbine blade diameter. To meet the amplitude and frequency requirements of conventional loads, the amplitude and frequency outputs of PMG require additional conditioning. The integration of wind energy into existing power system presents technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network. The issue of power quality is of great importance to the wind turbine. There has been an extensive growth and quick development in the exploitation of wind energy in recent years.

The individual units can be of large capacity up to 2 MW, feeding into distribution network, particularly with customers connected in close proximity [3]. Today, more than 28 000 wind generating turbines are successfully operating all over the world. In the fixed-speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations.

The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc. However the wind generator introduces disturbances into the distribution network. One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected. A proper control scheme in wind energy generation system is required under normal operating condition to allow the proper control over the active power production.

II. GRID CODE REQUIREMENTS FOR GRID CONNECTION

The voltage regulation in power systems is directly related to the control of reactive power. The recent grid codes require that the wind farms should provide reactive power control capabilities in response to the power system voltage in a manner similar to conventional power plants. The reactive power control requirements are related to the characteristics of each network. Reactive power control is an important issue for wind farms, because not all wind turbine technologies have the same capabilities, whereas wind farms are often installed in remote areas and therefore reactive power has to be transported over long distances resulting in power losses. The nominal voltages are 380, 220, 110 Kv for onshore wind farms and 155 kV for offshore wind farms in Germany and 400, 275 kV for Great Britain. The British code refers to wind farms with rated power above 50 MW. The German code specifies that wind farms may function in lagging or leading power factor in case of over voltages. According to the British code, power plants must be able to provide their full reactive power at voltages +5% around the nominal, for voltage levels 400 and 275 kV. According to the German code, the operating point for the steady-state reactive power can be defined in terms of power factor or reactive power level (Q in Mvar) or voltage level.

III. HARMONIC DISTORTIONS:

Widespread use of electronic equipment in today's commercial and industrial environments make harmonic distortion an important but complicated power quality issue. Simple electric devices like ac motors and incandescent lighting are a linear load, which means their impedance is constant whenever ac voltage is applied. The current waveform is the same as the voltage waveform, because linear loads do not switch on and off during one period of the voltage cycle. All of the energy provided by the ac supply is consumed. The resulting waveform of the load is a mirror of the voltage waveform. It is almost all 60Hz fundamental AC sine wave, and there is no visible distortion, on either the current or voltage.

In the United States, the fundamental frequency of electricity is 60Hz. This illustration shows one cycle of that frequency.

On the other hand, nonlinear loads such as personal computers, motor drives, electronic ballasts and office equipment switch on and off faster than the fundamental frequency of the supply voltage. Any power supply that converts AC to DC power will have a very distorted waveform at the supply. The current waveform is always a picture of the way a load reacts to the AC supply. When the return current from a distorted load reacts with the impedance of the switchgear back to the panel, an ohms law relationship exists. The distorted voltage created by the return current through the impedance of the cable and switchgear can cause the voltage waveform to distort. This voltage distortion will affect every device connected to the corrupted circuit.

By definition, a harmonic is an integer multiple of the fundamental frequency of the supply. In the USA the fundamental frequency is 60 cycles per second, or 60Hz. For example, the second harmonic of the fundamental frequency is 120Hz; the third harmonic is 180Hz and so on.

Notice that the second harmonic is half the length (or duration) of the fundamental and the third harmonic is one-third the length. The fundamental frequency is half the speed of the second harmonic and one-third the speed of the third harmonic.

A. Disturbances

The term "disturbances" is used to describe any kind of fluctuation in power. The most common types of disturbances are sags, swells, over-voltages, under-voltages, transients and interruptions.

B. Sags, Under-voltages and Interruptions*:*

Sags are momentary decreases in voltage. This decrease is typically 10 to 90% of the nominal voltage with duration between 0.5 cycles and 60 cycles. A sag in voltage lasting longer than a period of one minute is called an under-voltage and a complete loss of power is called an interruption. Sags occur commonly, and may be caused by any possible source including service failure, motor starts, or cycling machinery.

C. Swells and Over-voltages

Swells are the opposite of sags. They are momentary increases in voltage up to 110% of nominal lasting between 0.5 cycles and 60 cycles. This increase in voltage is more unusual than sag, but it is far more damaging. An increase in voltage lasting longer than a period of one minute is called an over-voltage.

D. Transients

Transients are short-duration, high-amplitude pulses superimposed on a normal voltage waveform. They can vary widely from twice the normal voltage to several thousand volts and last from less than a microsecond up to a few hundredths of a second.

Transients are caused by a rapid release of energy stored in an inductive or capacitive source in the electrical system, or from an external source such as lightning. While the duration of transients is unnoticeable to a human observer, their effect on power quality is still considerable. A single lightning strike can result in a transient large enough to destroy electronic devices.

E. Troubleshooting Power Quality Events

Voltage events tend to be periodic and they do repeat, but certain conditions may be required to see them. That means that a series of recordings will be needed, or perhaps you might want to leave a recorded on a circuit to record continuously until a failure occurs. Recording over time is the only way to successfully find a problem and diagnose it. The nature of disturbances in industrial settings can be irregular. By tracking a circuit over an extended period of time with the IDEAL Power Analyzer, data can be saved and analyzed later on a computer. This makes disturbances easier to pinpoint. Server power quality events that are causing complaints or failures need to be located and fixed quickly. The good news is that voltage events or disturbances are fairly easy to eliminate once they've been properly identified. The bigger the problem, the easier it is to track down, once you have a reliable recording power meter.

IV. VARIOUS APPROACHES FOR POWER QUALITY IMPROVEMENT BY SCES:

In 1996 Kazimierczuk and Cravens did the feasibility study for application of SCES in Aircraft Distributed Power Systems. In the experiment, under various operating conditions the **voltage regulation was improved for approximately 35 sec**, also provided emergency power at fix loads **as per military Standard MIL-STD-00704E(AS) [4].** Barrade did the simulations & implemented experimentally to improve profile of **transportation station, elevators and backup power for UPS** and found the suitable [12]. Barrade and Rufer did the simulations & developed a **Val-Vert**

prototype system based on SCES for voltage drop compensation for weak trolley busses sub-station distribution system and finds; voltage can be maintained with in standard limits. [22]

In 2001, Sels, Dragu, Craenenbroeck, and Belmans made a comprehensive study and predicted that flywheels and traditional batteries are best when there is need for emergency power for a very long time, while Supercapacitors can be used for **short duration** to improve the power quality. [6]

In 2002, Palma, Enjeti, and Aeloiza, made analytically a comprehensive work **to provide ride through** for ASD system with SCES & developed the compensator topology experimentally found that is capable of compensating voltage sags from zero to 99% for short voltage interruptions and maintained the dc link voltage constant during the transient period. Further, the simulations show the effectiveness of the proposed compensator and experimental results validated these results [7].

In 2004, Rufer, David and Barrade developed a prototype substation for **weak transportation network** to compensate voltage based on SCES and found it as alternative, promising and innovative results, also may prove economically competitive as the cost of Supercapacitors reduces.

In 2005 Zang did work on SCES to develop **PI control technique** for AC/DC-DC/AC power circuits for energy conversion in case of short duration and found that the reliability of the power supply and power quality are improved.

In 2006 Lu and Zhang did the simulations and experimental work for active-reactive power compensation based on SCES in distribution system in **the island mode, switching transients mode, grid connected mode** and found that the SCES system releases the stored energy to load and improved the reliability of power supply and power quality.

In 2006 Degobert, Kreuawan and Guillaud, worked; then simulation experimental result showed that by SCES system **undispatchable** power can be made dispatchable, fast fluctuations can be reduced in **standalone** as well as **in grid connected mode** for hybrid system composed of a photovoltaic and micro turbine.

V. CONCLUSION:

There are different processes to be used for power quality analysis of wind energy conversion system. STATCOM and DSTATCOM is powerful tool to analyze power disturbances in wind energy system. These tools increase the system performance and efficiency of the system.

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