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Design and Simulation of Reactive Power Compensator Using STATCOM for Wind Power Plant

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Abstract: ***Wind power has gotten the most central vitality source among the green sources in the course of the last not many decades. The fundamental situation that deflects the combination of this vitality into the matrix is the voltage fluctuation and low dependability of the breeze turbine engenderers (WTG). These troubles can be illuminated by using creations regularly kenned as FACTS (Flexible Alternate Current Transmission Frameworks), all the more solidly the Static synchronous compensator (STATCOM), which utilizes the guideline of receptive force infusion or assimilation into the framework Ride through flaw ability and minimization of voltage change using STATCOM. The STATCOM utilized is IGBT predicated PWM Cascade inverter that utilizes an early control framework which gives some extra progresses over the regular STATCOMs***

Keywords: Wind Energy, WTG, Facts, STATCOM, Reactive Power

1. Introduction

These continuous years, the economical force source age, particularly by the breeze turbines, taking progressively basic part in the electric framework. Wind essentialness has created as the speediest creating wellspring of vitality and is depended upon to see continued stable advancement in the prompt future. From as it were 4,800 MW in 1995, the world total presented limit has copied more than different occasions to arrive at more than 59,000 MW around the completion of 2005 . Close to the finish of 2016, the total presented limit accomplishes 486,790 MW .To seek after the creating enthusiasm for wind essentialness, the turbine advancements have ended up being continuously viable and realized a stepped decline in their apparatus costs. The breeze business is as of now planning into the supportable force source showcase and gives its expense per kWh that is for all intents and purposes indistinguishable from the expenses of ordinary essentialness age. As opposed to gas, coal and oil resources, later on, will turn out to be uncommon. The degree of wind imperativeness is plentiful, and a barely any redesigns were made to the streamlined highlights and power electronic gadgets. Later on, the formation of intensity from wind will unavoidably wind up more affordable than some other imperativeness source, especially than the customary sources available now . The job of STATCOM will be to alleviate the voltage issues like voltage hang voltage swell which for the most part happens in power framework during high voltage and low voltage condition. The majority of the cutting edge Wind turbines are generally employments fixed speed acceptance generators to create electrical vitality from its rotor yield. Enrollment generators are supported as curve generators for their insignificant exertion and low upkeep on account of brushless on the structure. Steady speed wind turbines outfitted with acknowledgment generators have the upside of not equipment ready, and they are used by and large in seaward wind ranches , and moreover, the breeze turbines are generally connected with feeble hubs or at course levels where the framework was not at first planned to move control into the network. This extends the necessity for dynamic responsive force backing to ride-through serious flaws . A striking typical for the settled speed enlistment generators is that this sort of generator constantly eats up responsive force. Shunt capacitor may be used for supply the required responsive force in the suffering state task; in any case, this framework exhibits a second rate execution in the midst of dynamic movement with capacitor bank related as just shunt contraption to the breeze generator. In this way, controllable responsive force (VAR) , for instance, Static synchronous Compensators (STATCOM) are once in a while important to give dynamic voltage support their adequately controllable VAR implantation, especially under voltage.

2. Existing System

Therefore, running control functions in power systems while facing phenomena like the flicker, imbalance, harmonic pollution, and transient behaviors will be more efficient and have a higher quality compared with the common compensators. One of FACTS devices, which has a positive and accurate function in regulating the voltage and compensating the flicker, is the synchronous static compensator (STATCOM). The STATCOM is a shunt connected FACTS family member that can regulate the system bus voltage at transmission or distribution levels. Furthermore, it can inject harmonic currents to enhance the power quality of the power networks. Such controller gains in fact a voltage-source-based converter that can operate in both modes injecting or absorbing the reactive power. In comparison with other shunt devices like thyristor controlled reactor, thyristor switched reactor, thyristor switched capacitor, and thyristor controlled reactor with fixed capacitor, which are identified as static Volt-Ampere Reactive (VAR) compensator, the STATCOM has some important advantages. For example, unlike other shunt-connected FACTS family, the maximum compensating current is not dependent on the system bus voltage. Therefore, the maximum reactive power injectable to the system by the STATCOM is decreased with decreasing of the system voltage linearly, while this reduction is

proportional to the square of voltage reduction in other shunt-connected devices. Moreover, the STATCOM is superior to others from viewpoint of exchanging the active power with the power system when it is equipped with an energy source. In spite of power quality, several functions such as power system stability and power system operation are carried out by using the STATCOM. Correction of transient state stability is one of the most important objects.

After 2000, two creditable and comprehensive reviews were published in the field of STATCOMs. In the first review, published by Jose Rodriguez et al. in 2002, the structures, usages, and control methods in multilevel converters have been investigated and reviewed. In this paper, the multilevel structures have been categorized in a way as follows: (i) diode-clamped inverter; (ii) capacitor clamped inverter; (iii) cascaded multi cell inverters; (iv) generalized multilevel cells; and emerging multilevel inverter topologies (mixed-level hybrid multilevel cells, asymmetric hybrid multilevel cells, and soft-switched multilevel inverters) which was firstly introduced in

In the structures of cascaded multicell inverters, some two-leg converters are put together in series in each phase, and the voltage of each phase s obtained through adding up the voltages of the converters of the same phase. This structure is much simpler than diode and capacitor-clamped inverter schemes. In generalized multilevel cells, the two-level, three-level, and four-level to N level ones are put next to each other. In this design, every level of voltage is balanced by itself and independent from the characteristics of the load. In other words, this topology provides a multilevel structure that can balance any level of DC voltage by means of specialized controls.

3. Operating principle of wind turbine generator

The general hypothesis of inciting electrical vitality from wind is to change over the dynamic vitality of wind into mechanical vitality by the turning cutting edges of the breeze turbine and later the mechanical vitality is changed over into electrical force by using an alternator. A fundamental arrangement of a breeze turbine generator is appeared in Fig. 1. So in the Figure, the turning edges changed over the dynamic vitality of wind into mechanical vitality. This mechanical vitality is applied to a pole which is equipped by the rigging system. The turn is utilized to An Air conditioning (Alternating Current) generator which changes over the mechanical vitality to electrical vitality. As the yield recurrence and the abundancy is variable, the air conditioner is at that point changed over into dc by an air conditioner to-dc converter and is utilized to charge a battery. The battery yield is then applied to an inverter which changes over the dc voltage into any longing air conditioning yield voltage and recurrence.

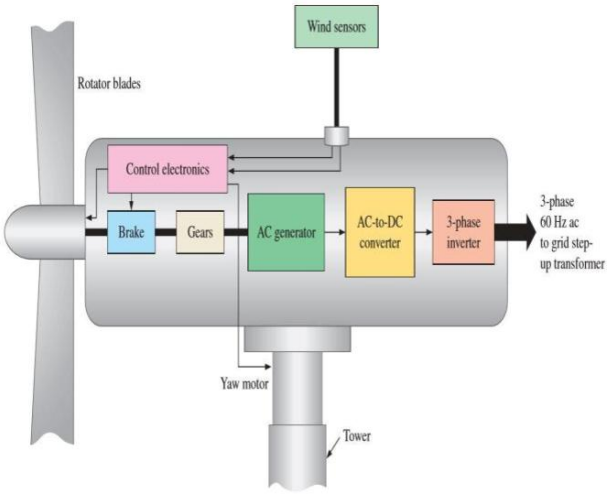

Figure 1: Basic wind Turbine generator Block diagram

Operation of STATCOM

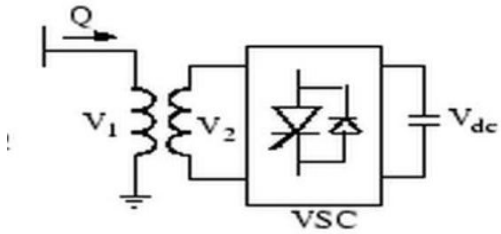

Figure 2: The simple block diagram of STATCOM

The STATCOM is a shunt creation of the family assigned FACTS using power gadgets to improve transient strength and control stream on power frameworks. The STATCOM is in a general sense a consistent state voltage source inverter joined with a transformer and fixing to a transmission line. By controlling the estimation of responsive force imbued into or acclimatized from the force framework, the STATCOM directs the voltage at its terminal. The assortment of dynamic force is performed by techniques for a Voltage Source Converter (VSC) related on the discretionary side of a coupling transformer showed up in Fig. 2. The STATCOM makes open force (STATCOM capacitive) at the point when structure voltage is low V2>V1. Exactly when structure voltage is high V1>V2, it acclimatizes responsive vitality (STATCOM inductive)

$$P = (V1\ V2)\ \sin\delta/X \ldots \ldots .. (1)$$

$$Q = (V1 - V2\cos\delta)/X \ldots \ldots \ldots \ldots (2)$$

These two are the force condition followed by the STATCOM. Where, V1 is the line voltage of the framework, V2 is the voltage of the STATCOM side, X is the Reactance of interconnection transformer and channels, Δ is the Phase edge of v1 as for v2

4. Block Diagram

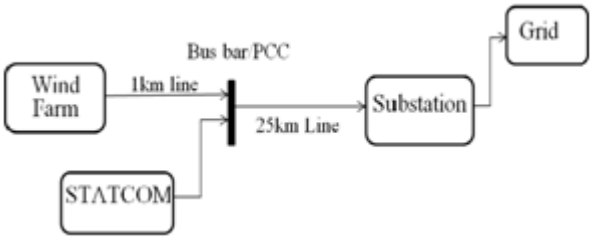

Figure 3: Simple Block diagram of the system

It shows a basic square graph of the entirety Framework to give a superior comprehension of our model (Fig. 3). In the following area, we will show the outcomes that coming up by running reenactment of the framework planned in MATLAB situations. The outcomes are separated into three sections for near voltage minimization, ride through Fault Capacity upgrade and dependability improvement.

5. MATLAB Environment

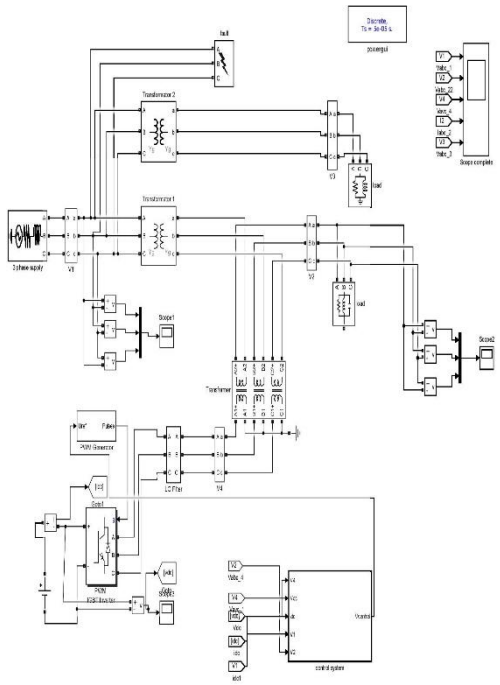

Figure 4: The full system design in MATLAB SIMULATION

6. Graphical Representation

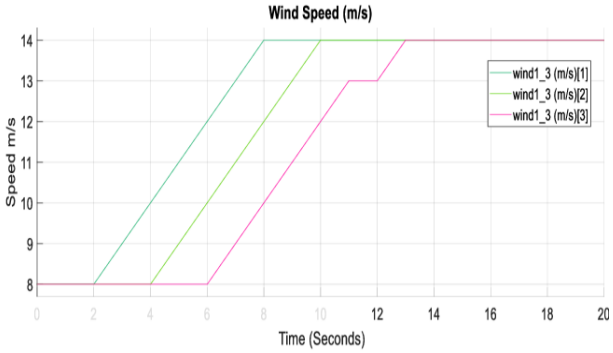

Figure 5: Wind Speed Input

To begin the reenactment and force age, we give singulexpands are breeze contribution to the three breeze turbines. As we can see from for WTG 1 and 2 we give an immediate breeze input which builds structure 8m/s to 14m/s and for WTG 3 we give a little bending in the information. Because of the Wind Speed builds, the WTGs its created power and arrives at its greatest limit which is appeared shows the voltage yields of the three WTGs without utilizing STATCOM. We see from the Figure the voltage level is diminished as a result of the high receptive force request of the enlistment generators of the WTGs. The voltage is about 0.72pu which can't be permitted to associate with the framework. In the wake of utilizing STATCOM. We can see that the voltage mutilation is just about zero and the voltage level is expanded to 0.99pu which would now be able to get the consent to associate with the network. For investigation, the capacity of the STATCOM in minimization of voltage variance we deliberately shift the voltage at the PCC utilizing the programmable voltage in the framework organize, appears in The most noteworthy voltage contortion is at time 12s 0.792pu. In the wake of utilizing STATCOM, the voltage twisting at time 12s diminished to 0.993, for example the STATCOM limited 96.63% of the happened voltage variance at PCC.

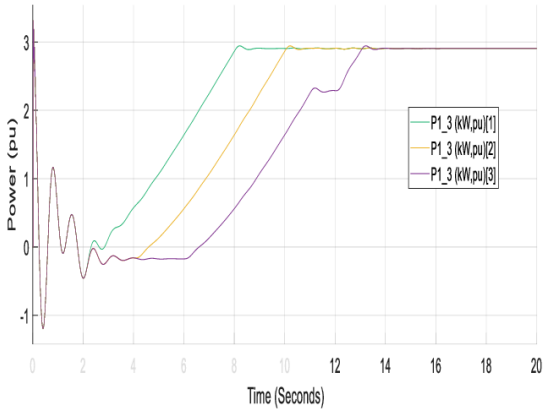

Fig. 6. Generated Active Power

B. Comparative Voltage Fluctuation Study

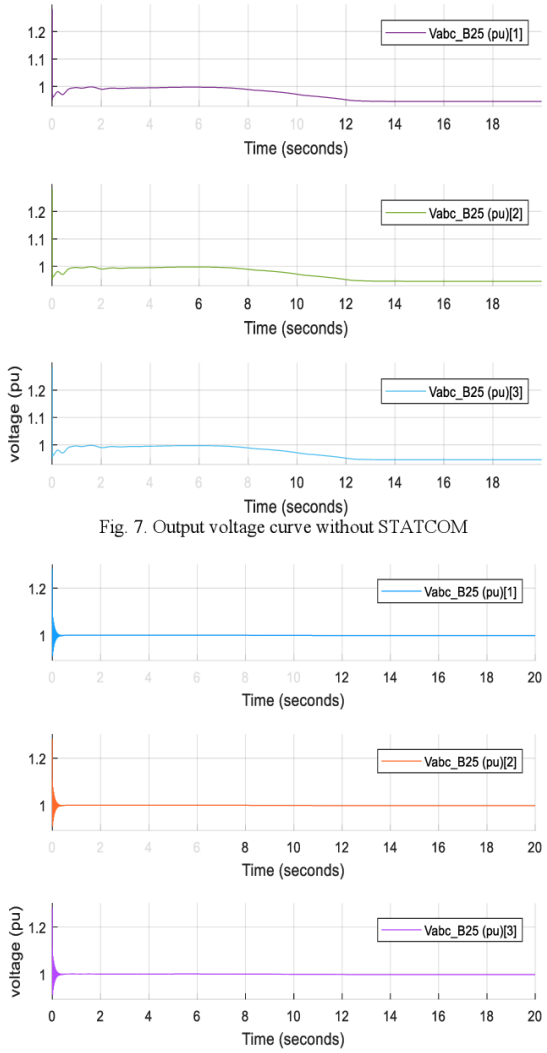

Fig. 7. Output voltage curve without STATCOM

Matlab Simulation Output

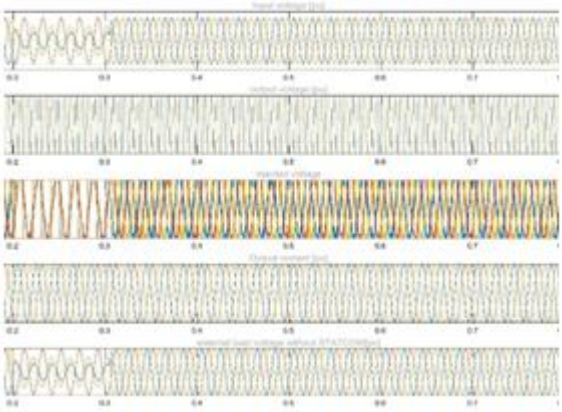

Figure 6: Simulation Output

Fault Analysis

Fault analysis is done to evaluate the improvement in the ride through fault capability of the WTGs by the STATCOM .We apply a double line to ground fault at time 15s to 15.1s in WTG 2 and analysis the conditions to keep up the association even in the hour of issue happen that is on the grounds that the STATCOM provided the immense measure of required responsive force during the shortcoming. Force bend at PCC with STATCOM In it shows the yield power bend at PCC during the Fault condition. We can see in the wake of applying deficiency at time 15s when the deficiency is clear the framework recuperates its past state rapidly. A similar circumstance is occurred in the voltage perusing in the wake of utilizing STATCOM. That demonstrates the improvement in soundness of the framework by the STATCOM

7. Conclusion

In the wake of breaking down the yield result, we have seen that the STATCOM lessens a colossal measure of voltage vacillation. The normal voltage variance was 20.8%, and subsequent to utilizing STATCOM, it slices to 0.7 %. By utilizing STATCOM, we can see it limited 96.63% of the happened voltage vacillation. There are a few restrictions, for example, The IGBT based STATCOM can't be utilized in high force producing power plant and to maintain a strategic distance from multifaceted nature we didn't switch connect up a level. So the STATCOM fills an incredible need to improve the general framework execution and to look after associations with the framework in any event, during a specific degree of a deficiency happening. Later on, the Government, just as numerous other private associations, should approach and take appropriate activities to grow wind turbine power plant at the inland and seaward territory by utilizing STATCOM for tackling wind vitality.

Prototype

In which the above prototype will be assuming the wind mill then the upper part will be consider us a wind mill. And the lower part will be consider as a STATCOM UNIT. If the fault will be created from the upper part and the reactive power injected to the statcom unit. Excatly in this prototype will 4-7 volt will be injected.

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