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Implementation of Grid System In Wind Farm

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Abstract*: This model serves as a simplified representation of the actual Zafarana wind farm, which holds the distinction of being Egypt's largest. We will use it for various simulations and show how different generators respond to the same operating conditions and power rating (700 kW). The second part of this paper explains the pitch controller simulation model, sometimes known as the transient fault controller, which enables the wind farm system to endure short-term malfunctions while maintaining turbine functionality. The controller's design is described, and simulation is used to assess how well it works. The turbine's behavior is examined, and the control methods are described. The system's response to a three-phase short circuit before the transient fault controller (TFC) was added and after the suggested controller was implemented will be contrasted. For simulating both static and dynamic electric, electromagnetic, and electromechanical systems, the model is made using MATLAB software.*
Keywords*: Ride through fault, Wind farm, Studies on the stability of transient and fault controllers*

I. Introduction

Combining models from several software programs and simulations helps ensure that an operation satisfies the numerous electrical system criteria. In several nations throughout the world, wind energy is growing and supplying a larger and larger portion of the electricity needed in those nations. However, if wind farms are to take the place of traditional power plants, they will need to take up a portion of the control activities that maintain the stability of the power system [1]. Riding through transient faults in power systems is one of the control issues caused by transients in power systems. Because transitory failures generate voltage excursions, it suggests that generation should be kept.

II. Wind Farm Model

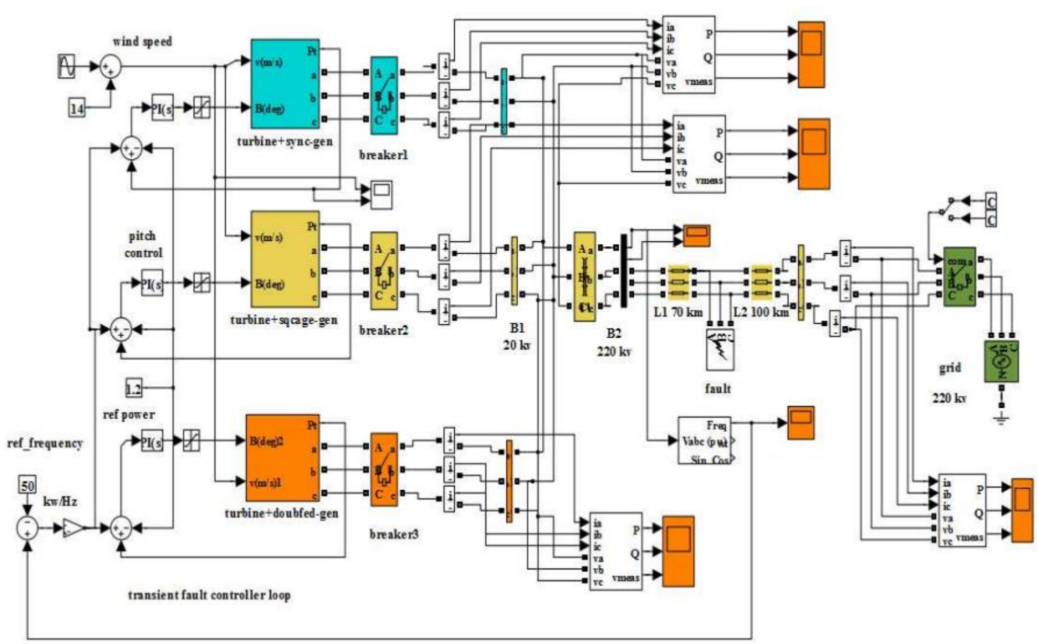

Fig 1: Design of Wind Farm Model

Figure 1 illustrates a wind farm model featuring wind turbines subjected to natural wind speed fluctuations and equipped with three distinct generator types: 3-phase synchronous, wound rotor induction and 3-phase squirrel cage induction. These generators are connected in parallel at the point of common coupling (pcc) and linked to the utility grid, with a combined power output of 500 kW. The model, created using MATLAB software, utilizes standard generator models from the MATLAB library to simulate both static and dynamic.

III. Transient Defects

The most severe fault in power system disruptions is a transient three-phase short circuit, which occurs frequently. This kind of fault short circuit will cause sub synchronous oscillations in the system, which need to be stopped before the system becomes unstable. A stabilizer is typically used to dampen such oscillations in conventional power plants with synchronous generators. Globally, synchronous generator-based power system stabilization is a well-established technique [2]. When the system's electrical generation is less than the sum of its electrical losses and electrical demand, the frequency in an AC power system remains constant. Grid frequency increases when generation surpasses demand and decreases when demand surpasses generation. The grid collapses into a new equilibrium when there is enough frequency-sensitive load in the system or when built-in governors that alter the primary move rave power bring the frequency back to its rated value. Governor controllers are currently used in all contemporary power systems to regulate the system's steady state frequency by managing the prime mover's mechanical power. If the generation or load changes gradually, so does the frequency deviation.

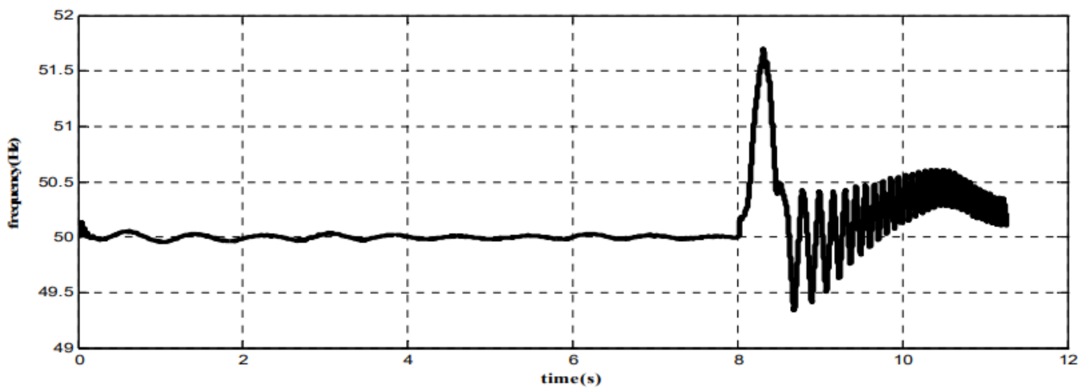

Fig 2: During short circuit frequency of power system

Wind farms must continue to be stable and connected to a three-phase fault under permanent fault isolation. In a three-phase fault, one would typically expect no auto rein to close. For a three-phase fault, the typical fault clearance time is 300ms. The voltage may momentarily decrease to 70% of the unaltered level for up to 10 seconds in the event of a three-phase fault (fig. 3). Even in these circumstances, the turbines must execute the control operations required to ride through this disturbance and restore steady operation. They must have the ability to regulate the electricity produced by the wind turbines.

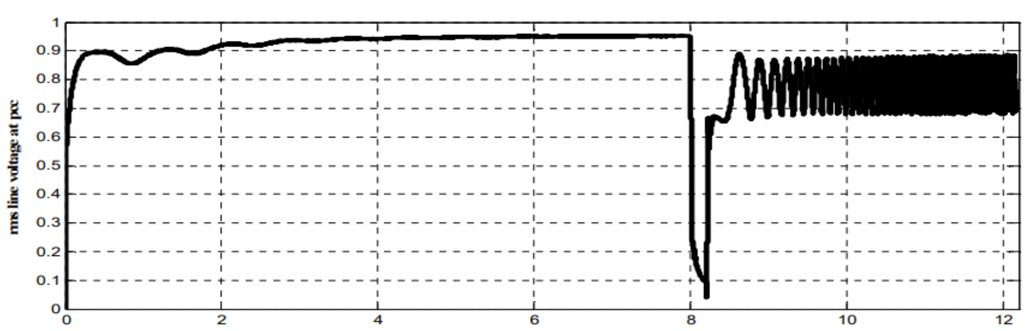

Fig 3: Fault clearance without controller at rms voltage

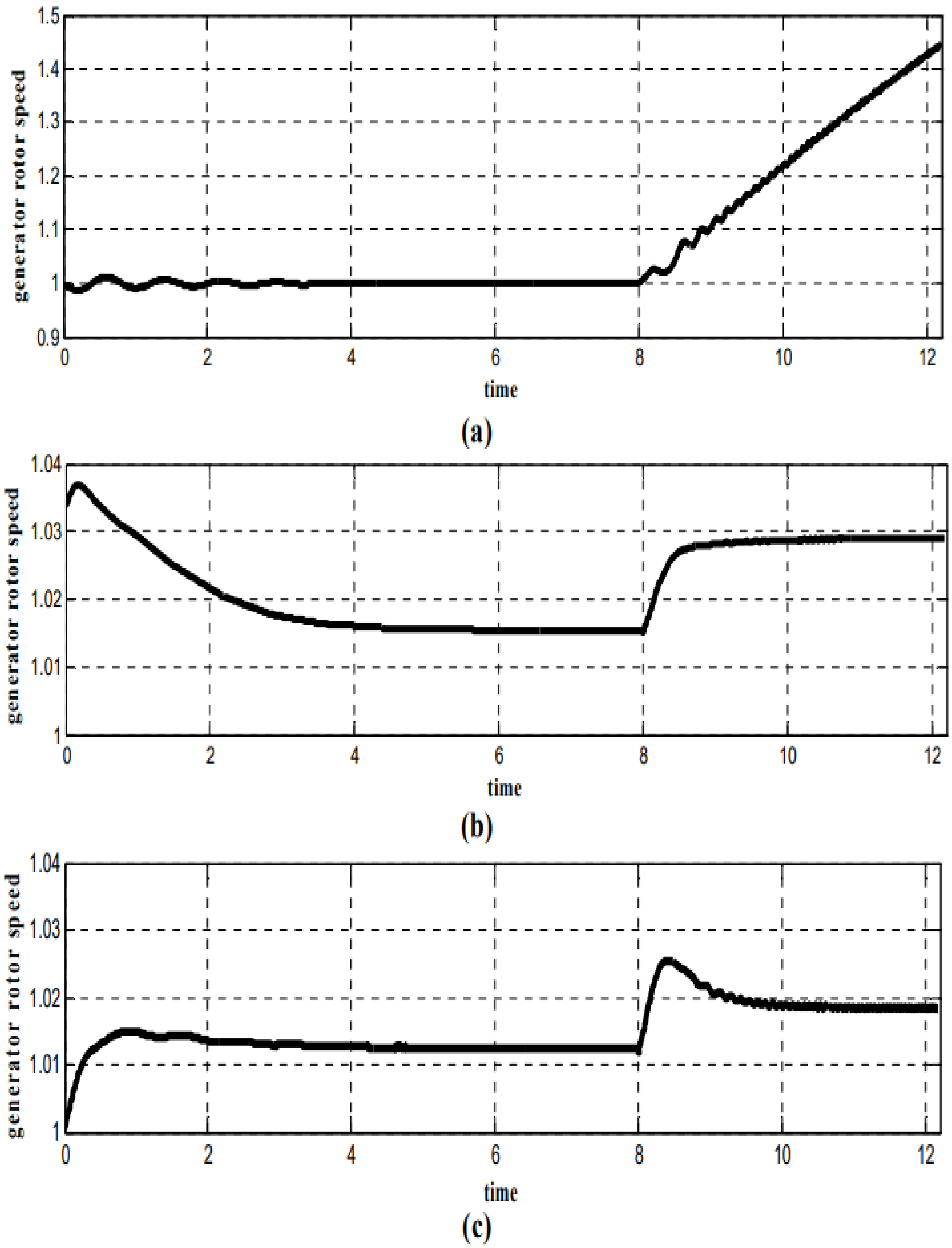

Fig 4: Fault clearance without at rotor speed (a) Double-Fed Induction generator
(b) Synchronous generator (c) Squirrel cage Induction generator

At any fault, the voltage of the generator terminal lowers, causing the active power to drop to almost zero. accelerate since there is no action taken by the wind turbine controller to lower the mechanical power input. Figure 4 shows that the speed of the generator increases rapidly and linearly in synchronous generators and steeply in induction generators. Two factors cause the generator to accelerate: The first reason is that the rotor continues to receive mechanical power throughout the failure, but it is unable to export power, thus the spinning energy builds up inside the rotor. The second issue happens when the fault occurs, the drive train starts reacting like a torsion spring. Now that it has raced much above its rated speed, the generator has greater than enough kinetic energy to break it. As a result, it is evident from Figs. 5, 6, and 7 that the generator's reactive power demand has significantly increased.

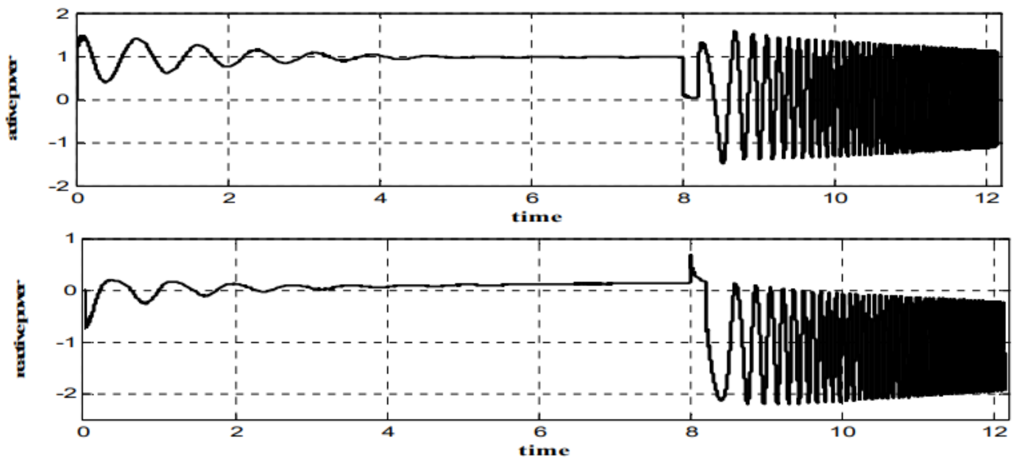

Fig 5: Without controller synchronous generator active and reactive power

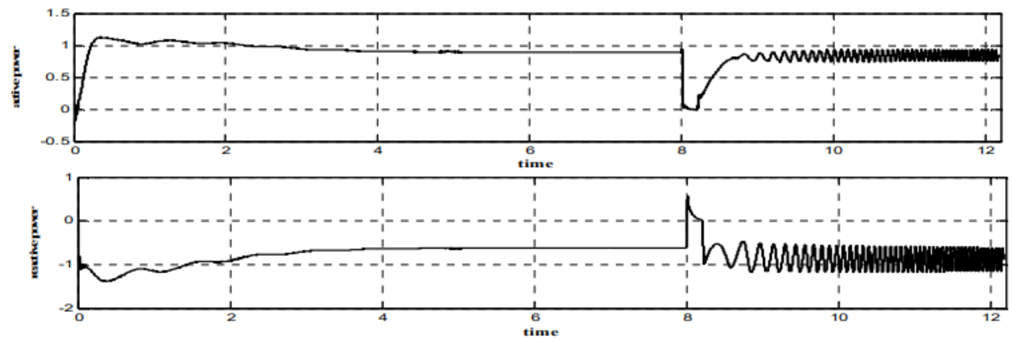

Fig 6: Without controller 3 phase squirrel cage induction generator active and reactive power

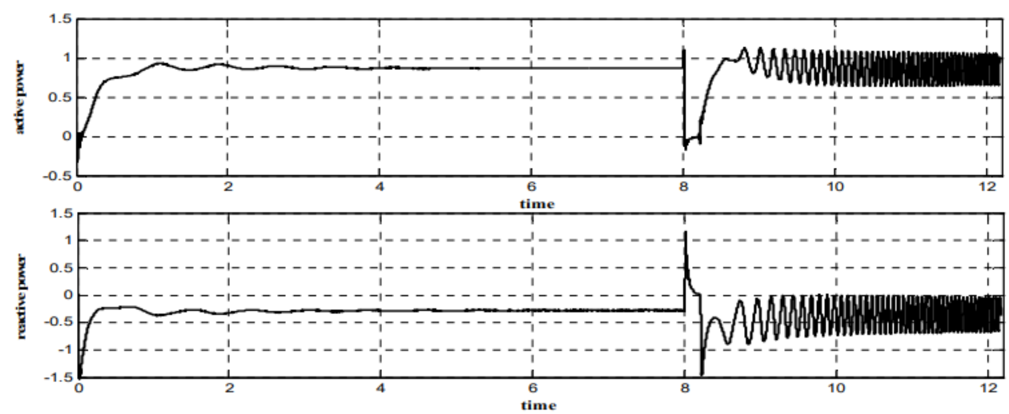

Fig 7: Without controller for double-fed induction generator active and reactive power

Because of its reactive power demand value, it permits a gradual recovery of the voltage. Currently undamped by the turbine drive train's torsion spring characteristic, Ge fluctuations in active and reactive power will result in increasing voltage oscillations. To prevent damage, a turbine overspeed protection mechanism would actually stop the turbine. The mechanical structure would eventually deteriorate due to the turbine's extensive speed oscillations. Put otherwise, this is a shift from the grid being a short circuit on the one hand (as in [5]), meaning that the grid is unable to provide enough reactive power and that the voltage r is therefore ineffective at suppressing the oscillations, to the grid being unstable on the other hand, meaning that the oscillations are unbounded due to a deficiency in reactive power.

III. Pitch Controller Design

As the generator decreases quite steeply the active power of each link is used to trace the grid health. Other signs of a problem will also be a decrease in voltage at the generator terminals. After a fault, the voltage is checked to see if the generator over speed up or if the system recovered. If you have no anomaly in voltage (or active power) it implies overspeed that islanding operation is taking place. Because of generator being excited by the compensating mechanism of the wind turbine even when it is being disconnected from the rest of the system voltage will remain constant. This means that the sharp drop in active power will occur only if the sharp drop in the dissipated power is followed by a sharp drop in the generator's active power, largely being a function of island size and turbine operating point. Once cleared of a fault, the transient fault controller must bring the speed back to a normal range before returning to normal operation. The creation of a PI controller and the control circuit block diagram to enable an active stall turbine to handle transient faults (Fig 8) are presented.

The voltage is tracked following a malfunction to see if the system has recovered. The generator overspeed's. Overspeed is a sign of islanding operation if neither the active power nor the voltage show any anomalies. Because the turbine's compensating mechanism keeps the generator excited, the voltage won't drop if a wind turbine is cut off from the rest of the system. Rather, the turbine will probably run into less power than it produces. The generator's active power may not be a clear sign of an islanding incident because a sharp decline in active power will only be seen if the system's dissipated power is However, this is contingent upon the island's size and the turbine's operating point. Before the transient fault controller tries to restart regular operation once a problem has been cleared, its activities must have returned the speed to its typical range. The control circuit block design is displayed in Fig. 8. A PI controller has been created to help an active-stall turbine handle transient faults.

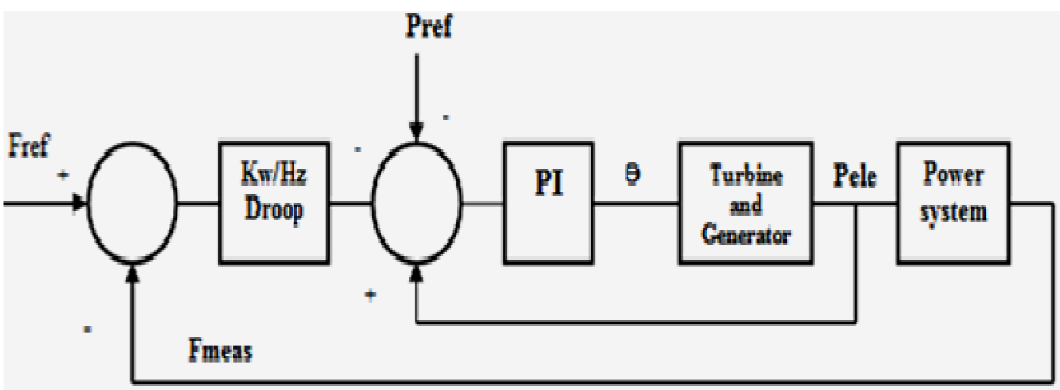

Fig 8: wind turbine pitch control system embedded with Transient fault controller

III. Sequence of Controller

The pitch system delivers the pitch angle with its maximum pitch rate to the transient fault control, which utilizes a pitch angle set point of this value and steps it to this value. The grid protection system will have to clear the fault when this pitch angle is attained, and the grid will need to recover so that the voltage and frequency normal is within range. Additionally, as shown in Fig. 9, the turbine's speed had to have dropped back to a level below the uppermost permitted limit. The entire sequence restarts if a new fault situation arises while the pitch angle is being restored to its typical state, with the pitch angle set point that is read instantly to the zero-power angle, spinning hardware that is connected to it, and so on (fig 9).

III. Short Circuit Simulation Three Phases

However, in this case, it is assumed that a 3 phase SC current occurs on the defect Bus (Figure 1) for 350 ms, followed by temporary isolation of the fault bus. The drive train is driven into tensional oscillations in the cleared fault. Speed and active power signals show oscillations. The speed of the train shaft of the drive train is necessarily has high frequency. The inherent oscillation frequency of the wind turbine rotor in the high inertia region of its high speed shaft, constituting the superimposed low frequency part. Fig. 9 and Fig. 10 identify a fault scenario and pitch angle regulation (or cutting off if so required) of a wind turbine that regulates it (or cuts it off if so required) during time window of the fault and reconnects it back as shown in the Fig 11.

By using pitch controller, the frequency angle is allowed to recover quickly and back to its natural value, as shown in Fig.14. The grid frequency versus time before and after fault clearing. Comparing the frequency response between Figures 2 and 14 is easy to determine whether the controller stabilized the system. As much as that, Fig. 15 plots the grid rms voltage at the site of common connection before and after fault clearance. Figures 3 and 15 can be used to conclude that the controller works fine and stabilize the system.

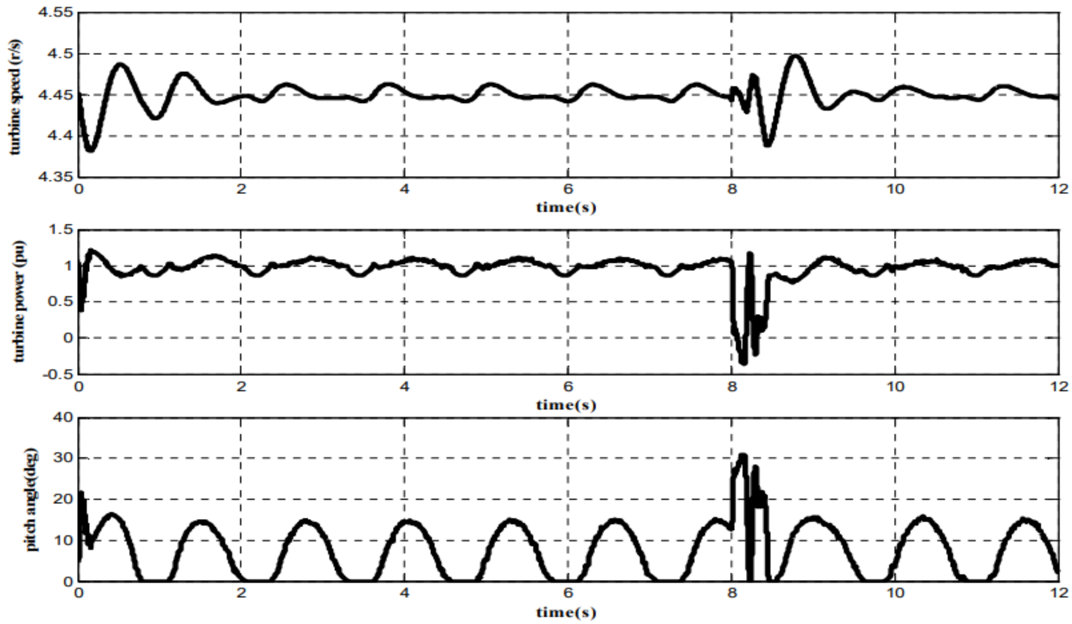

Fig 9: Transient fault controller of 3-phase turbine speed, turbine power, and pitch angle

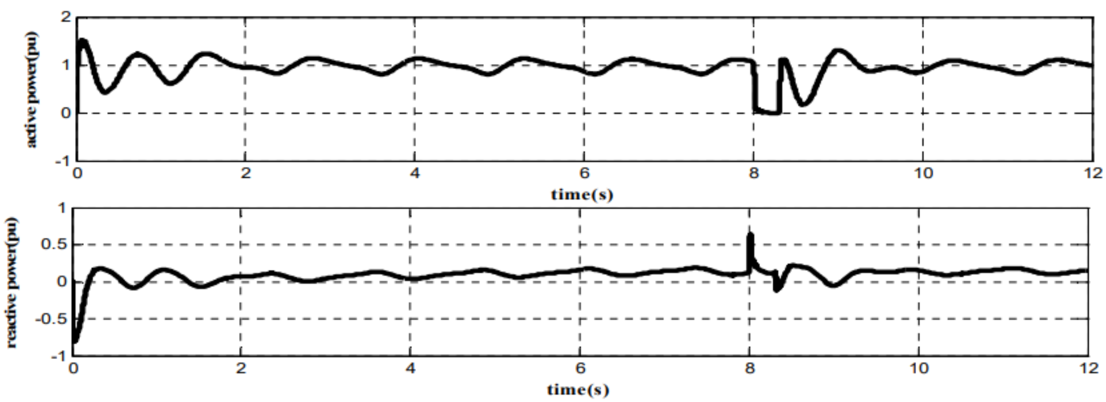

Fig 10: with transient fault controller reactive and active power of synchronous generator

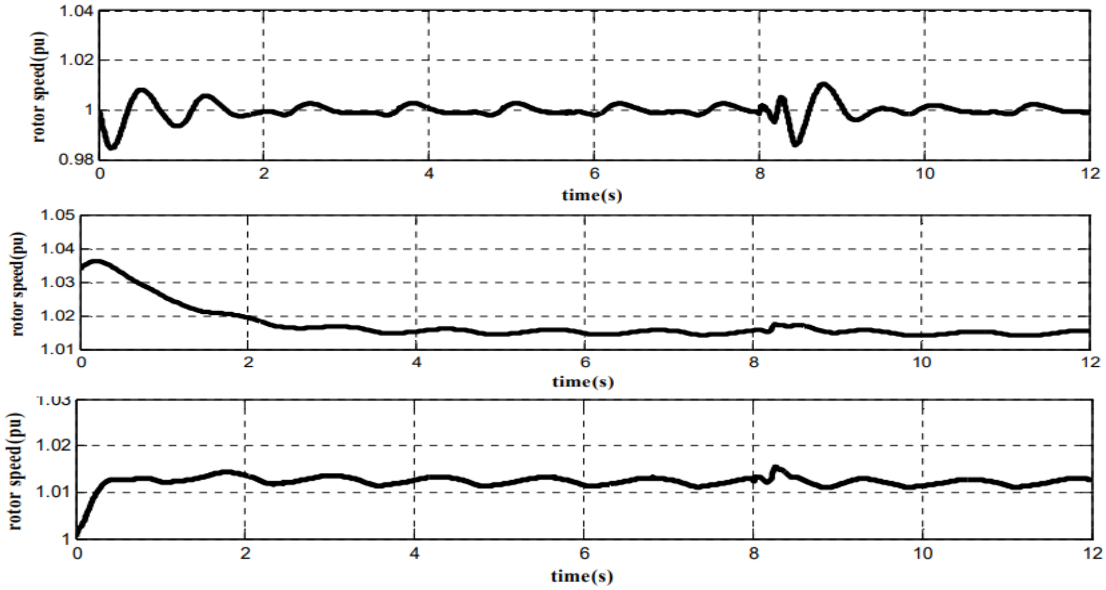

Fig 11: Pre and after fault clearance with controller, rotor speed of double-fed and squirrel cage

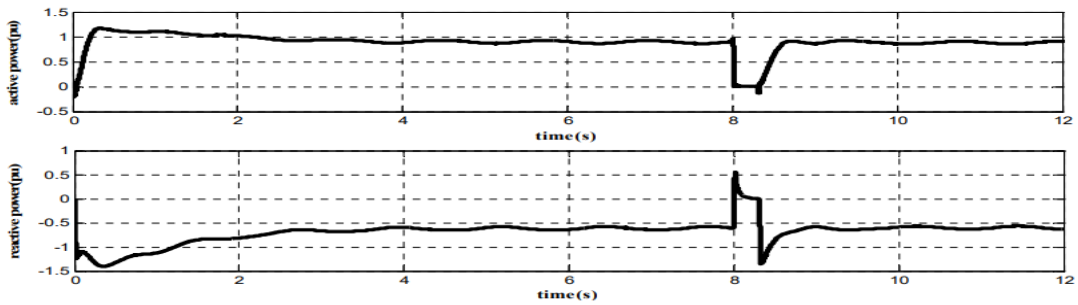

Fig 12: with transient fault controller reactive and active power of squirrel cage induction motor

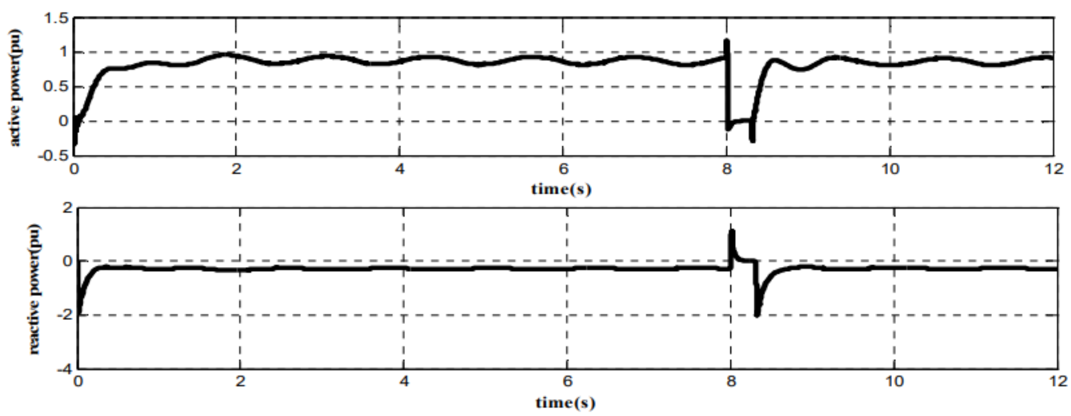

Fig 13: with transient fault controller reactive and active power of double fed induction motor

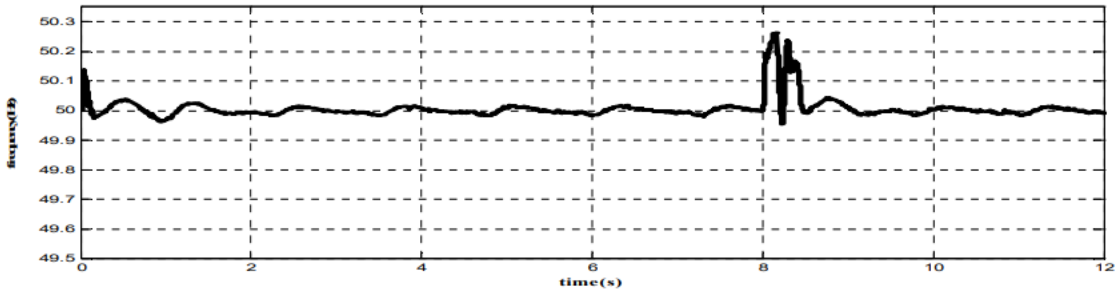

Fig 14: With a transient fault controller of frequency of 3 phase generators

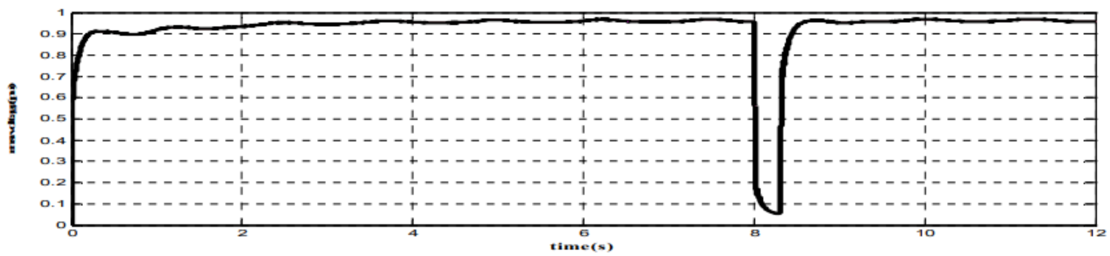

Fig 15: With a transient fault controller of rms of 3 phase generators

IV. Conclusion

This study demonstrates that a fixed speed active-stall wind turbine can assist in reducing power system oscillations by simply controlling its output power through its pitch mechanism. Grid frequency oscillations are chosen as the power system oscillations that require damping in this example simulation. Wind turbines operating at most winds speeds will be found to dampen grid frequency oscillations. Despite the limitations of the pitch mechanism, the wind turbine performance is improved to a high degree by the PI controller created here. In this study, the controller allows an active-stall turbine to ride through transient faults according to the grid connection criteria prescribed by Egypt's transmission system operators. With the proposed controller, it does not need any extra hardware to control the turbine pitch angle, but controls it itself and gets the frequency and voltage to normal. The turbine runs efficiently even with standard hardware. A transient fault does not overload the power system such that the voltage recovers. Also, the turbine itself is immune from mechanical damage resulting in sharp speed changes. This transient fault controller prevents the turbine from reaching a dangerous situation and maintain stability. It is shown that a doubly fed induction generator has smoother and more reliable characteristics than a synchronous generator and a squirrel cage induction generator, each with respect to its own characteristics being somewhat sophisticated.

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