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# Improvement of Grid Synchronization for DGS under grid disturbances

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***Abstract*-A new advanced conventional excitation controller using lead-lag-compensator is proposed in this paper for Grid Synchronization. The main goal of conventional excitation controller is to control the field voltage of the synchronous generators and aimed to provide an estimation of frequency between two power systems areas and to maintain synchronization of frequency under normal and faulty or distorted conditions. A wind turbine is operating in different speeds under both normal and faulty conditions. Simulation results are obtained by proposed control algorithm for normal and faulty conditions.**

***Keywords*-monitoring,synchronization, harmonicanalysis, frequency estimation, wind turbine, DGS.**

## I.INTRODUCTION

The connection of wind turbine to the grid is ainsubstantialissue. The stochastic power production of large-power wind turbines could create problems to the transmission line designed for constant power and to the power system stability this important issue justifies the concerns related to increasing penetration of wind energy within the power system [1].The Environmental friendly renewable vigor technologies such as wind and solar energy systems are among the fleet of new generating technologies driving the demand for dispensed generation of electricity. Power Electronics has initiated the next technological revolution and enables the connection of distributed generation (DG) systems to the grid. Thus the increasing power demand will be met by Distributed Generation (DG) system which are based on renewable energy sources such as solarpower,wind power, small hydro power etc.[2]-[3]. These systems need to be controlled properly in order to ensure sinusoidal current injection into grid. For the reliable operation of utility grid based on DG system, we should satisfy the grid code requirements such as fault ride through, grid stability, grid synchronization and power control etc. The major issue associated with DG system is their synchronization with utility voltage vector [3].

In this paper the focus is on the grid converter structures adopted in the WTS Dealing with grid regulations, grid monitoring and synchronization, grid converter control and control under grid faults. In power systems, the synchronous reference frame PLL (SRF-PLL) [4-6] is the most extended technique for synchronizing with three phase systems, despite the fact that the performance of SRF-PLL[7] is satisfactory under balanced conditions, its response can be inadequate under unbalanced, faulty, or distorted conditions. By using proposed algorithm that is conventional excitation controller that proposed algorithm overcome the disadvantage of the SRF-PLL technique. This proposed algorithm is satisfactory under both balanced and unbalanced conditions.

## II. CONTROL ALGORITHM

Mainly this type of controller is used to control the field voltage by using lead-lag compensator. In the below figure(fig.1) $V_d$ $V_q$ are the multiple inputs given to the multiplier when these signals are passed through the low pass filter then the filter reduces the harmonics in the signals .$V_d$ $V_q$, $V_{ref}$ and $V_{stab}$ are the signals passed through lead–lag compensator where lead compensator increases the stability of the system, then lag compensator reduces the steady state error. These signals are passed through the main regulator; it maintains voltage as constant and it reaches to saturation state. The system that are using in this paper is closed loop system so it maintains stability.

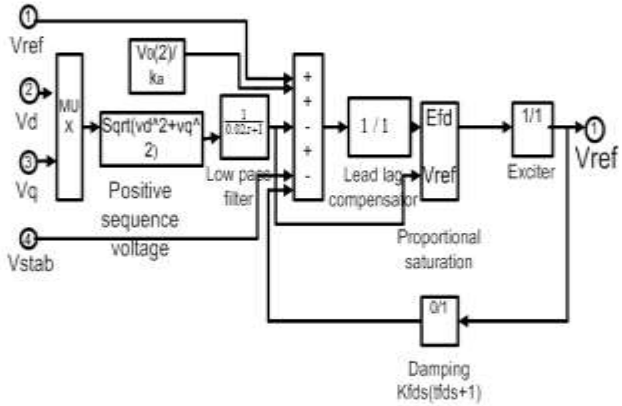


Fig.1: Excitation control algorithm using lead-lag-compensator

### III-SIMULINK DIAGRAM

In the Grid synchronization system, Area1 and Area2 are the two power systems considering for grid synchronization and Area1 is connected to the Bus1, where Area2 is connected through the Bus2.Two circuit breakers are using in between two areas to clear the faults that occur in two power systems, where Bus1 parameter is 230e3v, 1.062pu and power angle is -0.3732 and Bus2 parameter is 230e3v, 1.062pu and power angle is 17.12deg.

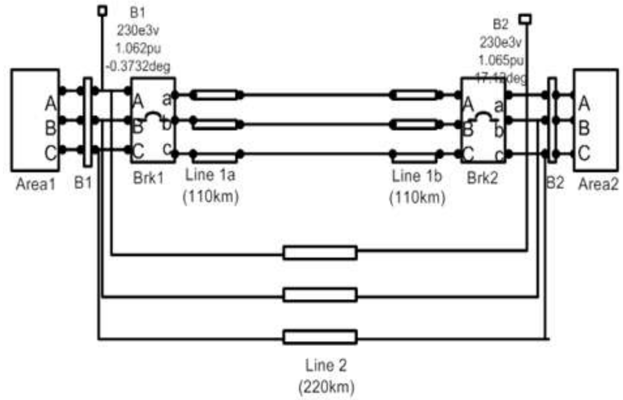


Fig.2: Grid synchronization system

In Area1 power system, the wind turbine type is doubly fed induction generator which generates power 575V.By using step-up transformer i.e. star-star-connection transformer step up the voltage 575V-20KV, its T/F rating is 1700MVA.By using delta-star-connection transformer, step up the voltage 20KV to 230KV and that voltage is giving supply through two π model transmission networks and their length are 25KM and 10KM.

In Area1, the synchronous generator generates a power of 900MVA, by using delta-star-connection transformer step up the voltage to 20KV to 230KV that voltage is integrated to 25KM transmission line,where the synchronous generator input is given i.e. field voltage and $V_{ref}$, $P_{ref}$ are given to machine 2 turbine and regulators to control both

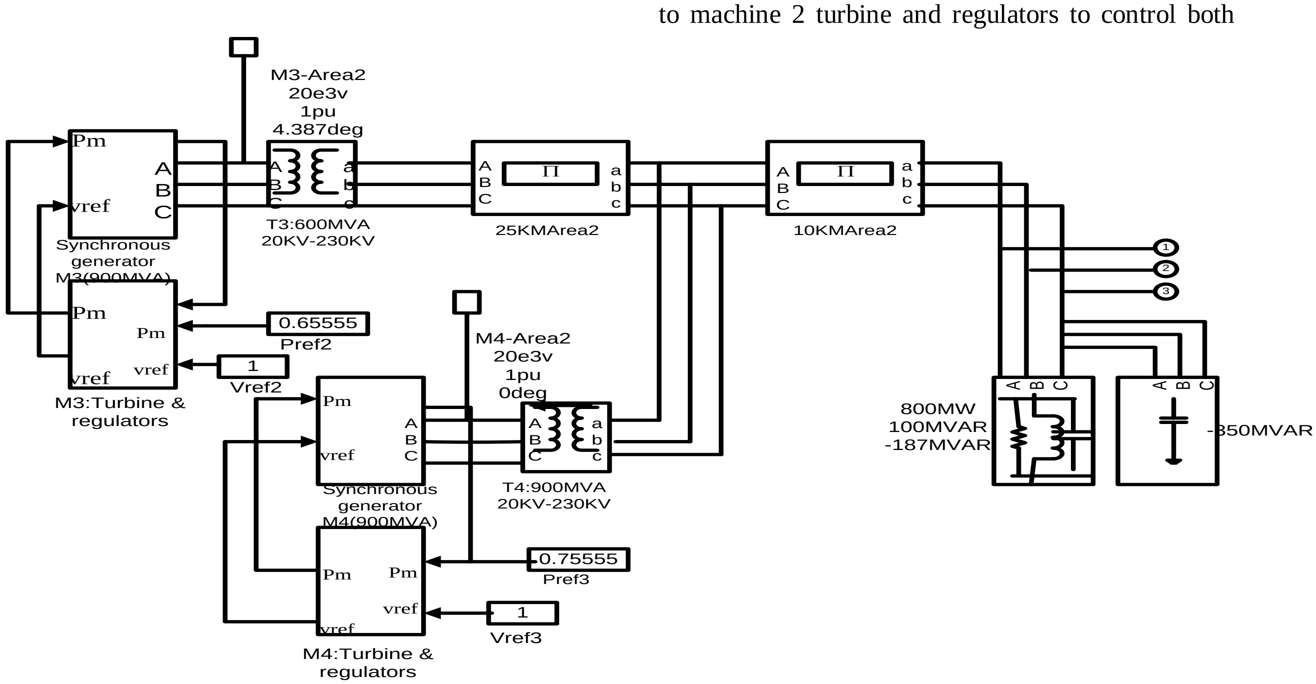


Fig.3: Area 1 power system

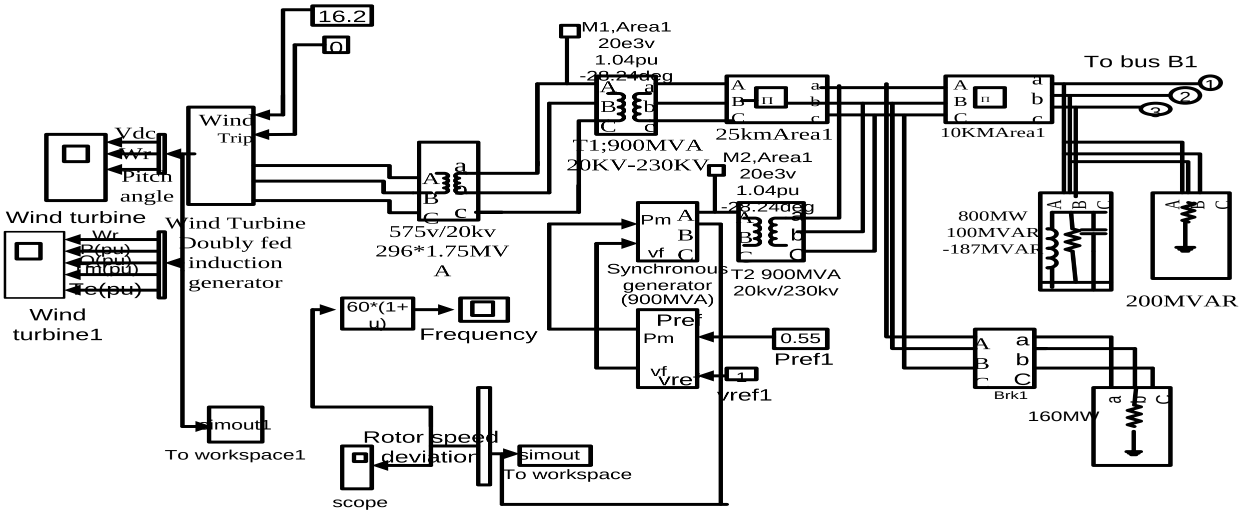


Fig.4: Area 2 power system

active power and field voltage and RLC loads are integrated at 10KM transmission line.

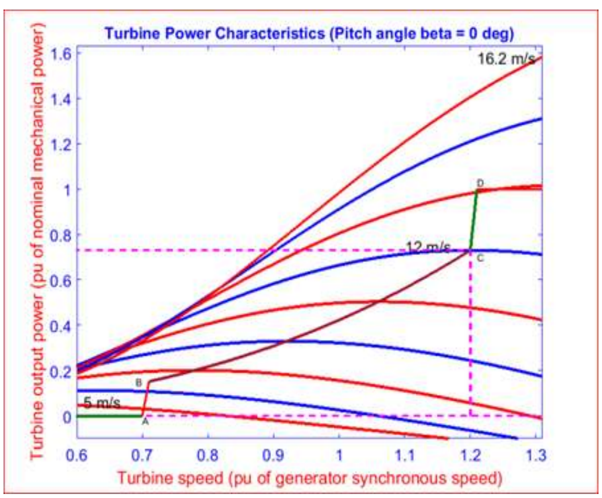


Fig .5: Turbine speed characteristics

In Area2 power system, two synchronous generators are present. These generators generate power about 900MVA each. By using delta-star connection transformer step the voltage 20KV to 230KV, through two π network transmission models voltage is transferred and line lengths are 25KM and 10KM.At 10KM, Area2 transmission line, RLC load is connected where active power is 800MW, inductive reactive power is 100MVAR and capacitive reactive power is 187MVAR.In the figure (5), the wind speed changes from 5m/s to 16.2m/s .In this paper, we are considering two values of wind speeds i.e. 12m/s and 16.2m/s.

## IV.SIMULATION RESULTS

**Case (1):**

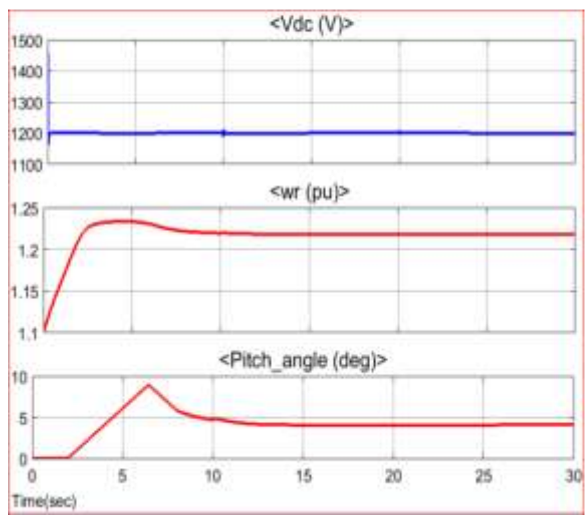


Fig 6: wind turbine parameters

At the Area1, when the wind turbine runs at speed 16.2m/s and the power reference value is given to the synchronous generator is 55% and at Area2, there are two synchronous generators and their power reference values are 65% and 75% and the fig (6) shows the DC voltage, rotor speed andpitch angle of the wind turbine at the condition when circuit breaker is closed.

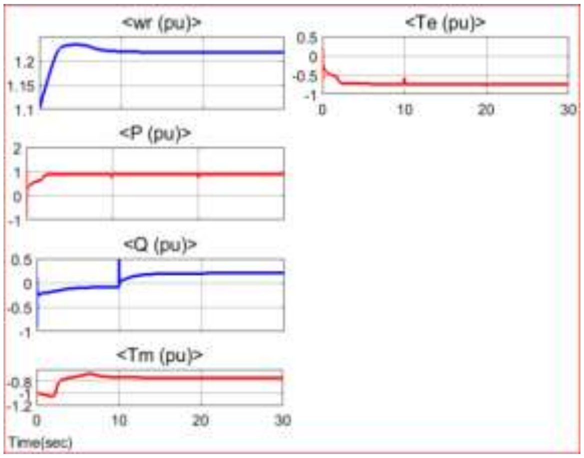


Fig 7: parameters of wind turbine

The above waveforms show the rotor speed, active power, reactive power, mechanical torque, and electrical torque.


Fig 8: Rotor speed deviation

**Case (2):**

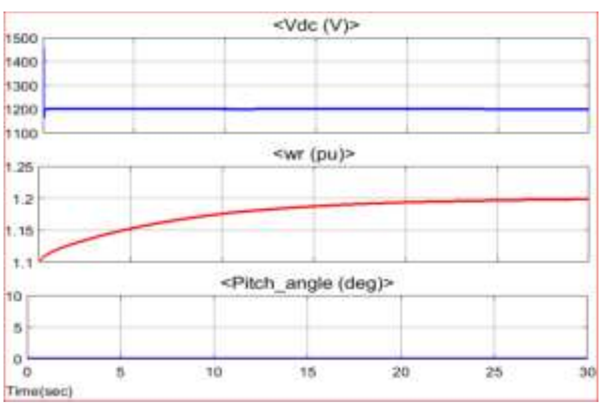


Fig9: Wind turbine parameters

In Area1 power system, the wind turbine speed runs at 12m/s and the power reference value given to the synchronous generator is 45% and in Area2 power system, there are two synchronous generators and their power references are 44% and 55%.The below outputs shows the Dc voltage, rotor speed, pitch angle and the speed, active power, reactive power, mechanical torque, electrical torque and rotor speed deviation at the condition when circuit breakers are closed.

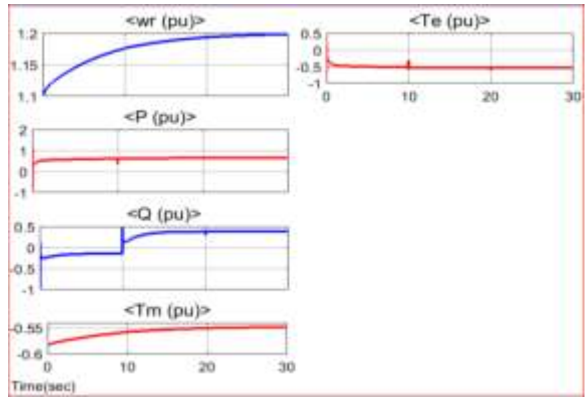


Fig 10: parameters of wind turbine

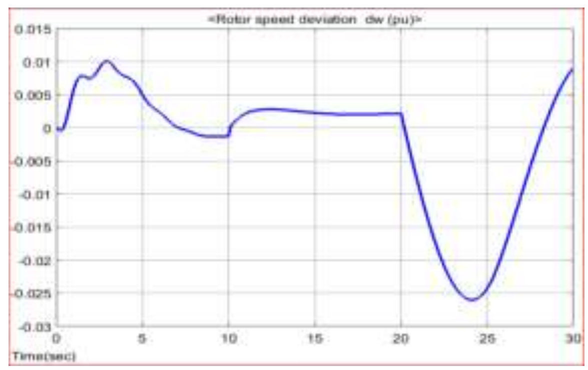


Fig 11: Rotor speed deviation

**Case (3):**

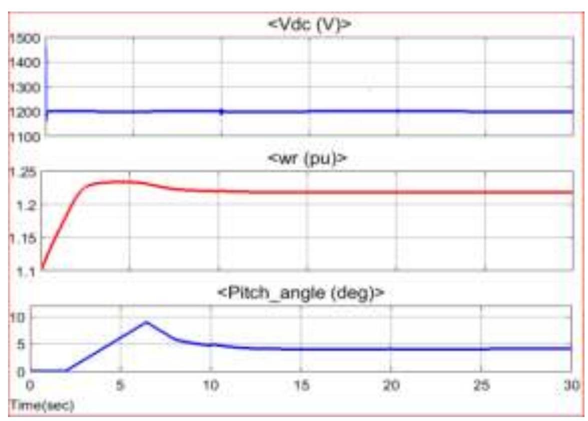


Fig 12: wind turbine parameters

In Area1, wind turbine runs at speed 16.2m/s and the power reference value given to the synchronous generator is 55% and in Area2 there are

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two synchronous generators and there power references are 65% and 75% and the below outputs shows the rotor speed, pitch angle, dc voltage, reactive power, active power, rotor speed deviation. When the phase A is open and the phases B,C are closed for the above condition the below outputs are shown below.

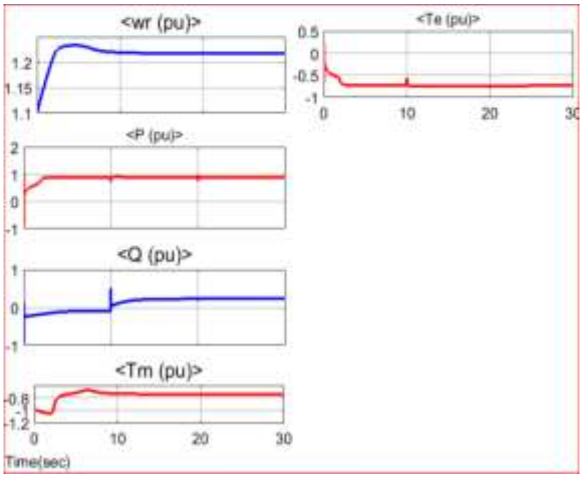


Fig 13: parameters of wind turbine

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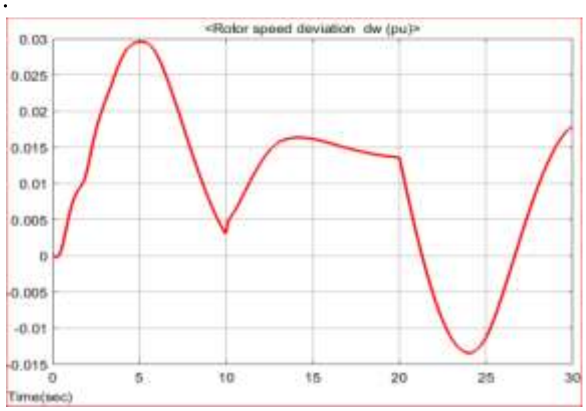


Fig 14: rotor speed deviation

**Case (4):**

In the Area1 power system, when the wind turbine system runs at speed 12m/s and the power reference value given to the synchronous generator is 45%. In the Area 2 there are two synchronous generators and their power reference values given to the synchronous generator is 44% and 55%, two circuit breakers are present near bus 1 and bus 2, when fault occur at phase A, at that condition phase A circuit breaker automatically open and the phases B, C are closed For the above condition the outputs are shown below.

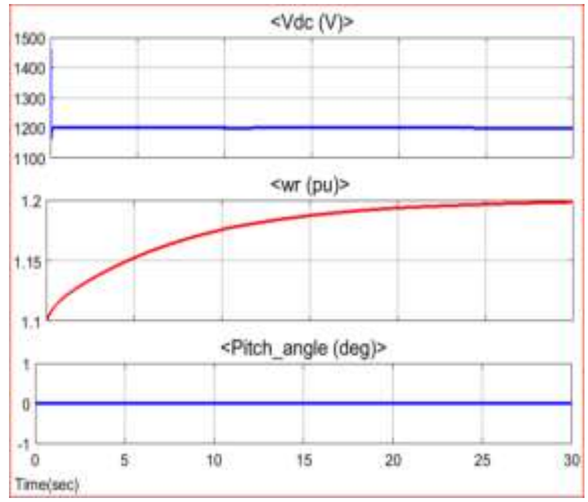


Fig 15: wind turbine parameters

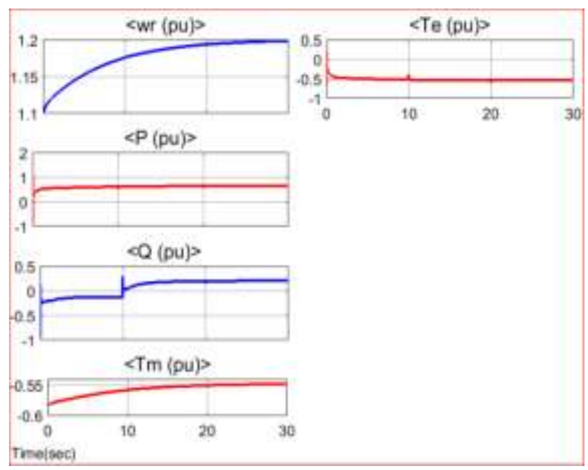


Fig 16: parameters of wind turbine


Fig 17: rotor speed deviation

## V.COMPARISION RESULTS OF FREQUENCY UNDER NORMAL AND FAULTYCONDITIONS

**Case (1):**

In the Area1, power system when the wind turbine runs at speed 16.2m/s and the power references given to the synchronous generator are 55% and in Area2 there are two synchronous generators and there power reference values are 65% and 75%.The below outputs shows the comparison of frequency at normal and faulty conditions

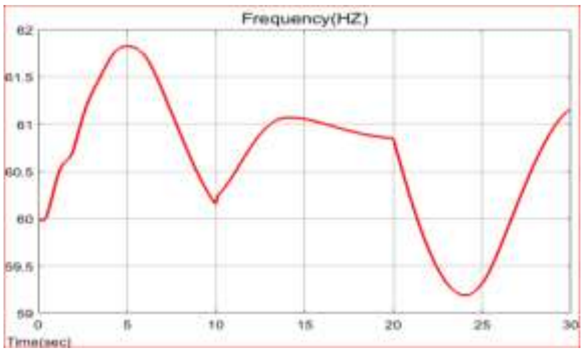


Fig 18: Frequency without fault

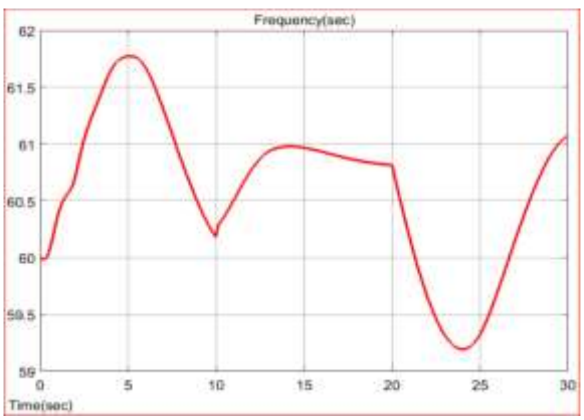


Fig 19: frequency with fault

**.Case (2):**

In the Area1 power system wind turbine speed runs at 12m/s and the power references given to synchronous generator is 45% and in Area2 there are two synchronous generators and there power reference values are 44% and 55% and the below outputs shows the comparison at normal and faulty conditions.

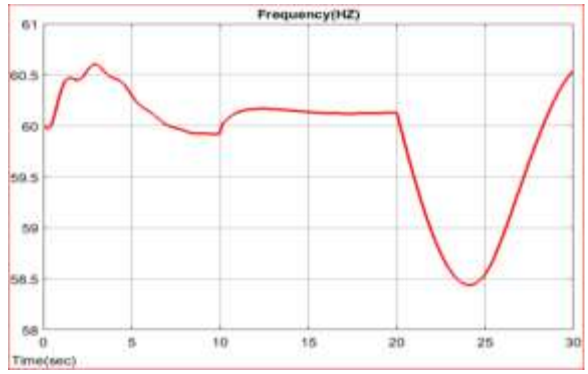


Fig 20: frequency without fault

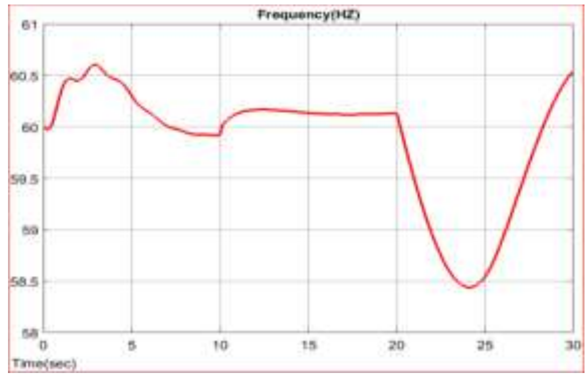


Fig 21: frequency with fault

**Comparison results of frequency under normal and faulty conditions for grid synchronization:**

| Cases | Wind speed(m/s) | Normal condition(F) | Faulty condition(F) |
|---|---|---|---|
| 1. | 16.2m/s | 61.2hz | 61.2hz |
| 2. | 12m/s | 60.5hz | 60.5hz |

The above table clarifies that the same frequency is maintained between two areas under normal and faulty conditions.

## VI.CONCLUSION

This paper has presented a synchronization algorithm aimed to provide an estimation of frequency between two areas are maintaining same frequency under normal and abnormal or faulty conditions. The existing system i.e. synchronous reference frame PLL is satisfactory under balanced conditions.By proposed algorithm that is by using conventional excitation control using lead-lag compensator is satisfactory under both normal and faulty conditions.A results obtained by the proposed algorithm maintains synchronization of frequency between two power systems has been proved.

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