DC Grid-Based Wind Power Generation System in a Poultry Farm Connected To AC Distribution Grid

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Abstract—In this paper the design of dc grid based wind power generation system connected to ac distribution grid is explained. It allows the adaptable operation of multiple parallel connected wind generators to reduce the need of frequency and voltage synchronization. This paper mainly explain about the operational capability of the dc grid based wind power generation in a poultry form under different cases like failure of one inverter during grid connected operation, connection of AC/DC converter during grid connected operation and islanded operation with fuzzy logic controller. With the use of fuzzy logic controllers the configuration of the system is simple.

Index Terms- DC grid, Wind power generation, Converter, Inverter, AC distribution grid.

I.INTRODUCTION

There is a current global need for clean and renewable energy sources. Fossil fuels are non-renewable and require finite resources which are dwindling because of high cost and environmentally damaging retrieval techniques. So, the need for cheap and obtainable resources to greatly needed more feasible alternator option is wind energy[1]. A poultry farm is where domesticated birds are raised. Poultry include chickens, turkey, ducks and geese. These animals are raised for both meat and eggs. There is a need to monitoring the conditions inside the poultry farms including temperature, humidity and air quality. In order to maintain the required temperature, cooling fans are installed at the poultry farms.

The power ratings of the cooling fans in poultry farm is tens of kilowatts. Cooling fans are not only used for the cooling purpose but also used by the wind turbines(WT) to decrease the grids demand. Generally the wind speed is variable in nature but in the poultry farms the wind speed is constant[2]. Wind speed variability is mainly depends on the weather and environmental conditions. The wind speed in the poultry farms is stable due to the use of the constant speed ventilation fans. In the poultry farm the power surging problems that affects the supply reliability which are nor presented. Now a days lot of researches takes place on dc grids due to technological improvements in the different power electronic devices.

So many research works have been completed on the DC micro grids to exhibits the combination of various energy storage system and distributed energy resources(DER). Wind form configuration based on the DC micro grid in which each wind energy conversion unit which consists of matrix converter, single phase ac/dc converter, a high frequency transformer is proposed the failure of one converter leads to the all wind turbines to be in out of the service is over come with the proposed system[3]. For achieving the decentralized control operation using with the local variables, different research works have been done.

II.DESCRIPTION OF THE SYSTEM

The configuration of the proposed DC grid based wind power generation in a poultry farm connected to ac distribution grid is represented in the figure1. The proposed system consists of four permanent magnet synchronous generators(PMSG) A,B,C,D each rating 10 kw which are driven by the wind turbine. Here the usage of PMSG is instead of any other generators, it does not require any dc excitation to the system which will the complexity of the designing of the system and control hardware.

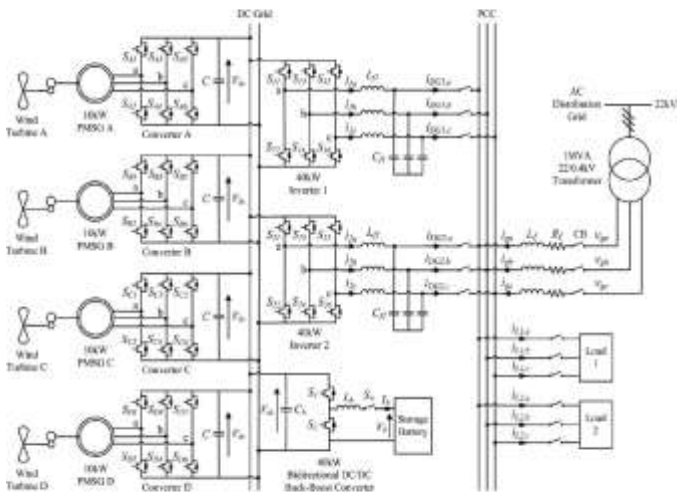


Fig.1: Over all configuration of the DC grid based wind power generation system in a poultry farm connected to AC distribution grid

The output of each permanent magnet synchronous generators A,B,C,D is given to the four converters A,B,C,D which converts ac to the required dc. The output dc is given to the dc grid. The total power at the dc grid is inverted by the inverters A,B with each rating of 40 kW. The usage of two inverters between the dc grid and ac grid instead of using the one inverter at the PMSG output. This eliminates the need of synchronization of voltage, phase and frequency which decreases the necessity of multiple inverters at the generator system side and gives the adaptable to the wind generators at the dc grid for play and plug connection. Point of common coupling is exists in between the inverters and ac distribution grid with the storage battery maintain the continuous and reliable power supply.

III. OPERATING MODES OF THE GRID

In this paper the operational capability of the system is tested through various test scenarios like failure of one inverter during grid connected operation, connection of AC/DC converter during grid connected operation and islanded operation[4].

i) Grid connected mode :

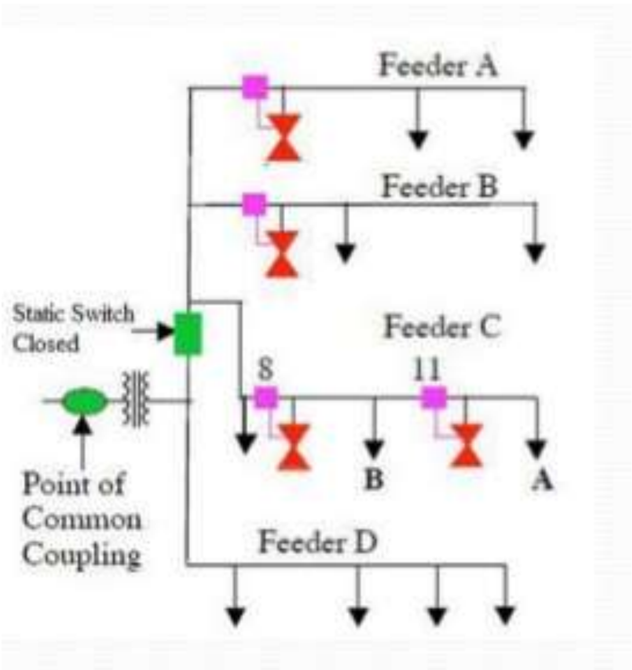
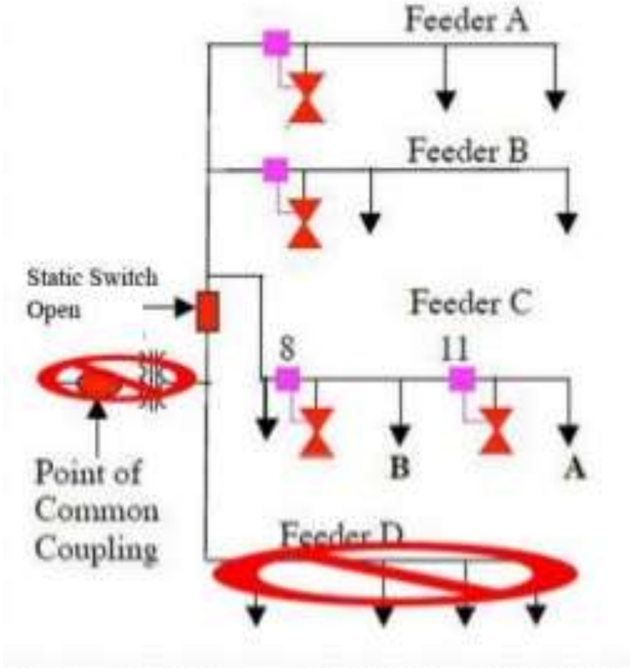


Fig.2: Representation of grid connected mode

In the grid connected mode the utility grid is active and static switch is closed as shown in the figure 2. In this mode the grid connected through point of common coupling and bidirectional power flow exists in the system. Economic is achieved by supplying excess power to the main grid. This mode reduces the cost using the power from main grid during low(night) load conditions. Here the feeders A,B,C,D are in the grid connected mode Feeders A,B,C are being supplied by the utility grid[5]. No problem of voltage and frequency management in the grid connected mode[6].

ii) Islanded mode:

The representation of the islanded mode of the grid is shown in the figure3. In the islanded mode, disconnected from the main grid due to abnormal conditions in the grid due to planned switching. Problem of voltage and frequency management in the islanded mode[7]. Utility grid is not supplying power in this mode. Static switch is in open condition. Feeders A,B,C are being supplied by the micro sources and the feeder D (not sensitive) in dead as shown in the below figure.



Problem of power quality management is also exists in this mode. There must be a communication among the motor generator components[9]. For multi customer system have to be well organize concerning contractual issues. Bidirectional power flow does not exists in the islanded mode.

IV. TIME DOMAIN SIMULATION RESULT ANALYSIS

The proposed simulation model is shown in the figure1 and it is implemented in the simulink/MATLAB. The operational capability of the proposed system under three different cases shown in the below figures.

Case i: Failure of one inverter during grid connected operation with fuzzy controller

Under this condition the micro grid is in the grid connected mode of operation and the proposed system supply the required power to meet the part of the demand on load. The total power generated by the PMSGs at the dc grid is converted by inverters 1 and 2 which will share the total power supplied to the loads Under normal operating condition.

When one of the inverters fails to operate and needs to be disconnected from the dc grid, the other inverter is required to handle all the power generated by the PMSGs. In this test case, an analysis on the micro grid operation when one of the inverters is disconnected from operation is conducted. With each PMSG generating about 5.5 kW of real power, the total power generated by the four PMSGs is about 22 kW which is converted by inverters 1 and 2 into 20 kW and 8 kVAr of real and reactive power respectively. Fig.4 and 5 show the waveforms of the real and reactive power delivered by inverters 1 and 2 for $0 \leq t < 0.4$ s respectively. For $0 \leq t < 0.2$ s, both inverters 1 and 2 are in operation and each inverter delivers about 10 kW of real power and 4 kVAr of reactive power to the load.

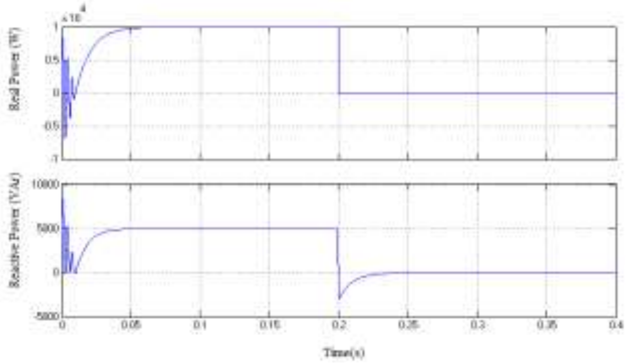


Fig.4: Real (top) and reactive (bottom) power delivered by inverter1

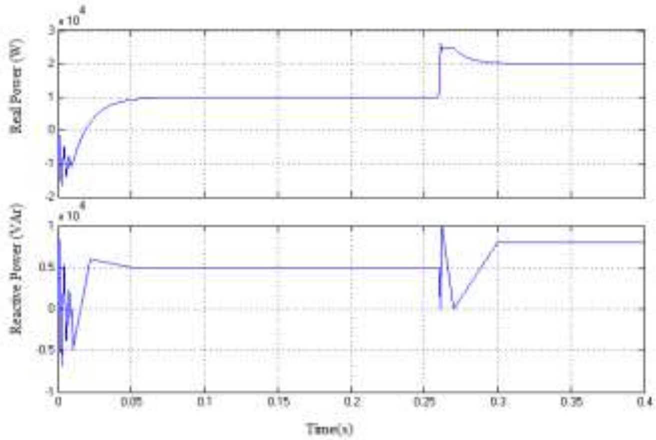


Fig.5: Real (top) and reactive (bottom) power delivered by inverter2

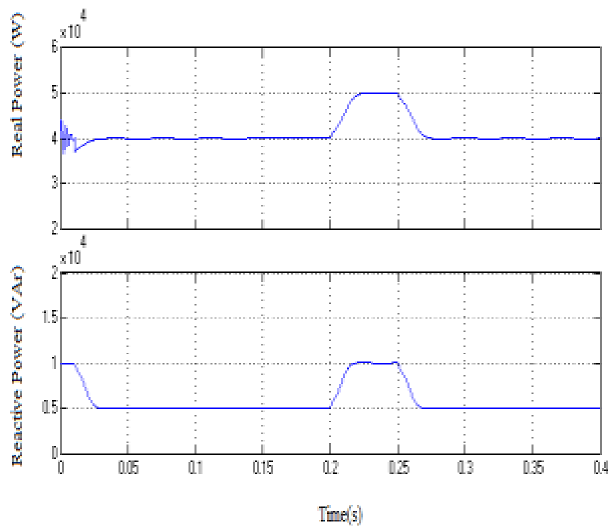


Fig.6: Real (top) and reactive (bottom) power delivered by grid

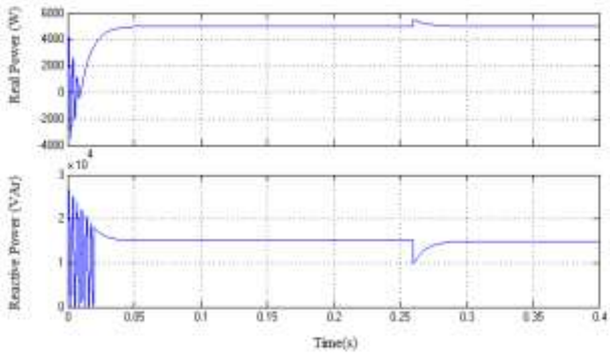


Fig.7: Real (top) and reactive (bottom) power consumed by loads

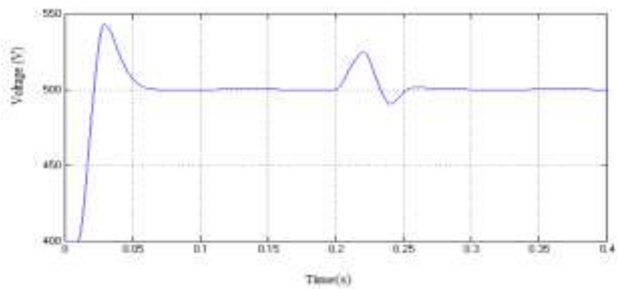


Fig.8: DC grid voltage

The remaining real and reactive power that is demanded by the loads is supplied by the grid which is shown in Fig.6 It can be seen from Fig. 6 that the grid delivers 40 kW of real power and 4 kVAr of reactive power to the loads for $0 \leq t < 0.2$s.The total real and reactive power supplied to the loads is about 60 kW and 12 kVAr as shown in the power waveforms of fig 7. The unsteady measurements observed in the power waveforms for $0 \leq t < 0.08$ s are because the controller requires a period of about four cycles to track the power references during the initialization period.

At t = 0.2 s, inverter 1 fails to operate and is disconnected from the micro grid, resulting in a loss of 10 kW of real power and 4 kVAr of reactive power supplied to the loads. As shown in Fig. 4.2, the real and reactive power supplied by inverter 1 is decreased to zero in about half a cycle after inverter 1 is disconnected. This undelivered power causes a sudden power surge in the dc grid which corresponds to a voltage rise at t = 0.2 s as shown in Fig.8 To ensure that the load demand is met, the grid automatically increases its real and reactive power generation to 50 kW and 8 kVAr respectively at t = 0.2 s, as shown in Fig. 7 At t = 0.26 s, the EMS of the micro grid increases the reference real and reactive power supplied by inverter 2 to 20 kW and 8 kVAr respectively.

Case ii: Connection of AC/DC converter during grid connected operation with fuzzy controller

The most significant advantage of the proposed dc grid based wind power genera2ion system is that it facilitates the connection of any PMSGs to the micro grid without the need to synchronize their voltage and frequency.

The micro grid operates connected to the grid and PMSG A is disconnected from the dc grid for $0 \leq t < 0.2$ s as shown in Fig.2.1. The real power generated from each of the remaining three PMSGs is maintained at 5.5 kW and their aggregated real power of 16.5 kW at the dc grid is converted by inverters 1 and 2 into 14 kW of real power and 8 kVAr of reactive power.

As shown in Figs. 9 and 10, each inverter delivers real and reactive power of 7 kW and 4 kVAr to the loads respectively. The rest of the real and reactive power demand of the loads is supplied by the grid as shown in Fig. 11. It can be seen from Fig. 11 that the grid delivers 46 kW of real power and 4 kVAr of reactive power to the loads. At $t = 0.2$ s, PMSG A which generates real power of 5.5 Kw is connected to the dc grid.

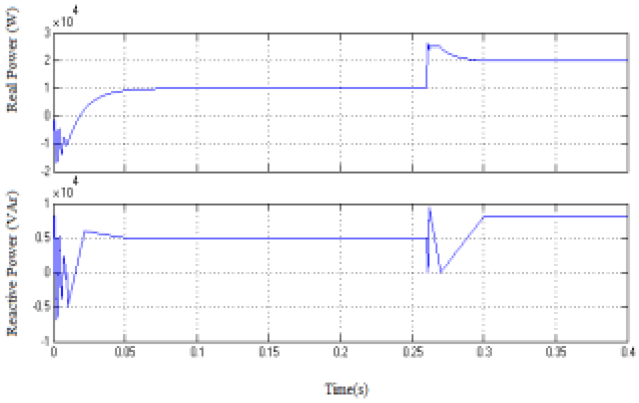


Fig.9: Real (top) and reactive (bottom) power delivered by inverter1

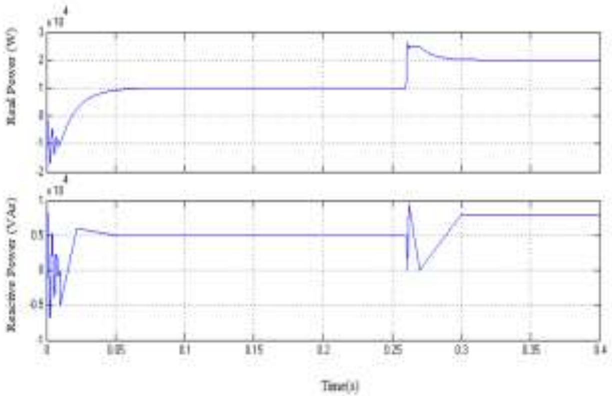


Fig.10: Real (top) and reactive (bottom) power delivered by inverter2

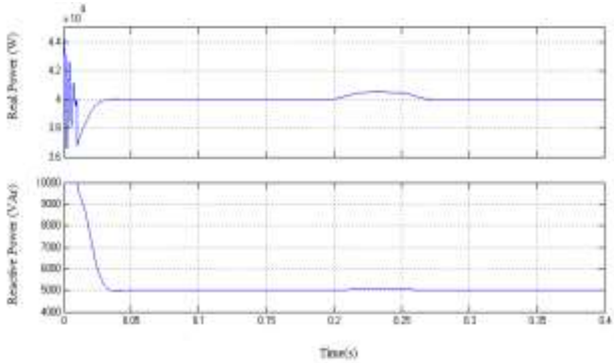


Fig.11 : Real (top) and reactive (bottom) power delivered by the grid

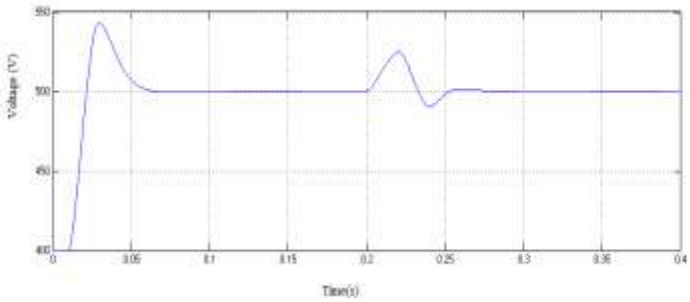


Fig.12: DC grid voltage

This causes a sudden power surge at the dc grid and results in a voltage rise at $t = 0.2$ s as shown in the voltage waveform of Fig.12. At $t = 0.26$ s, the EMS increases the real delivered by each inverter to 10 kW while the reactive power supplied by each inverter remains unchanged at 4 kVAr as shown in Figs. 9 and 10. This causes a momentarily dip in the dc grid voltage at $t = 0.26$ s as observed in Fig. 12 which is then restored back to its nominal voltage of 500 V for $0.26 \leq t < 0.4$ s. The grid also simultaneously decreases its supply to 40 kW of real power for $0.26 \leq t < 0.4$ s while its reactive power remains constant at 4 kVAr as shown in Fig.11.

Case iii : Islanded operation with fuzzy controller

When the micro grid operates islanded from the distribution grid, the total generation from the PMSGs will be insufficient to supply for all the load demand.

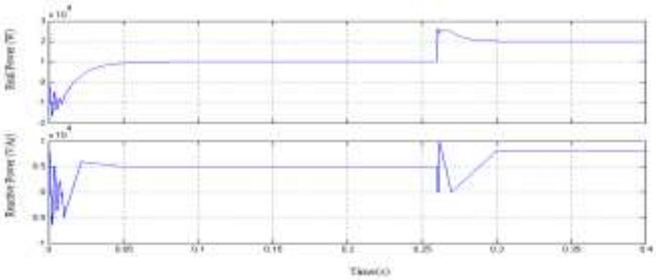


Fig.13: Real (top) and reactive (bottom) power delivered by inverter1

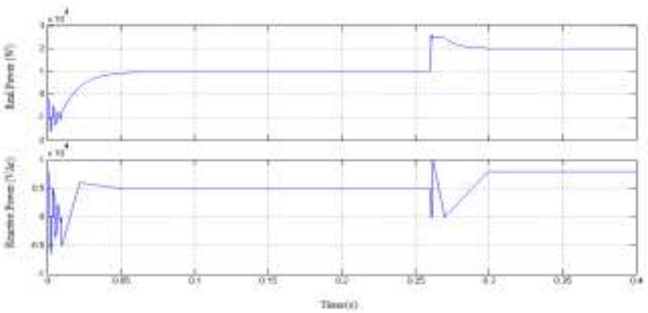


Fig.14: Real (top) and reactive (bottom) power delivered by inverter2

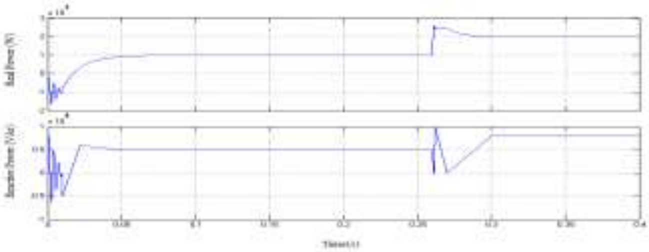


Fig.15: Real (top) and reactive (bottom) power delivered by the grid

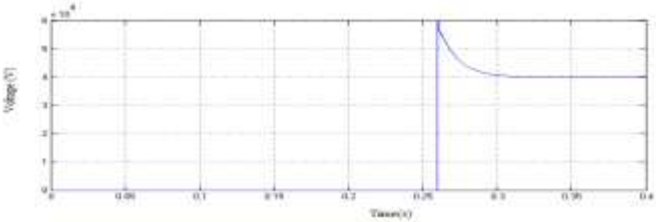


Fig16:Real (top) and reactive (bottom) power delivered by SB

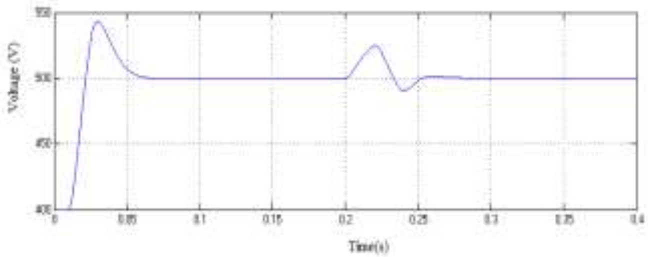


Fig.17: DC grid voltage

Under this condition, the SB is required to dispatch the necessary power to ensure that the micro grid continues to operate stably. The third case study shows the micro grid operation when it islands from the grid. The micro grid is initially operating in the grid-connected mode. The grid is supplying real power of 40 kW and reactive power of 4 kVAr to the loads for $0 \leq t < 0.2$ s as shown in Fig. 15 while each inverter is delivering real power of 10 kW and reactive power of 4 kVAr to the loads as shown in Figs.13 and 14. At $t = 0.2$ s, the micro grid is disconnected from the distribution grid by the CBs due to a fault occurring in the upstream network of the distribution grid. To maintain the stability of the micro grid, the SB is tasked by the EMS to supply real power of 40 kW at $t = 0.26$ s as shown in Fig.16. At the same time, the real and reactive power delivered by each inverter is also increased by the EMS to 30 kW and 6 kVAr as shown in Figs.13 and 14 respectively. Fig.17 shows the dc grid voltage where slight voltage fluctuations are observed at $t = 0.26$ s. The initial voltage rise at $t = 0.26$ s is due to the power supplied by the SB while the subsequent voltage dip is due to the increase in power drawn by the inverters.

V.CONCLUSION

In this paper, a dc grid based wind power generation system in a poultry farm connected to ac distribution grid design is discussed and it enables the several wind generators parallel operation. The proposed system eliminates the need of frequency and voltage synchronization, Due to this with minimal disturbances, the switching on and off of the wind generators is very adaptable. Operational capability of the system is verified through various test cases is observed with fuzzy logic controller. The obtained results indicates that the proposed design concept increases the flexibility and the reliability of the system.

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