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# Connect the Wind Farms to the Electrical Grid and Indicate Their Effect on Improving the Characteristics of the Network

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***Abstract*****—*This paper treats with one of the voltage quality problems when the wind farm is connected with the electrical distribution network and shows the positive effect of wind farms on voltage quality. Variance in voltage and frequency variables determines the quality the electrical grid. In the high and medium voltage grid, the sudden connection and disconnection of the dips. The results show that the connection of the wind farm with medium voltage grid has been increase the network stability and improve the voltage and frequency level for customers and electricity suppliers. During these changes, network stability can be secured through an additional active input. It is important to check whether the wind farm can contribute to improving the state of the network by simulating the system. Due to the change in wind speed, the energy available from the wind farm also vary, which provides volatile variables. This means that the direct connection of the wind farm can lead to network instability*

*In such circumstances, the separation of the variables of the wind farm and the main electric power grid is necessary. The application of power adapters in OTG makes it possible to separate the speed and format of the network frequency format. At the same time, state variables can be controlled independently. This paper provides compensation for voltage reductions by wind farm equipped with power transformers through models based on Matlab-Simulink. Many different sizes of the wind farms are formed and simulated with different nature of loads to get an over-all impression***.**

***Keywords***—*Public electrical grid; Voltage level; Simulation study.*

## I. Introduction

The study of linking the wind farms to the electrical grid and its positive effect on the improvement of the electric voltage of the electrical network and the compensation of the low voltages resulting from the heavy load connection through the laboratory experiments by using the Matlab / Simulink program to verify whether there is an impact on linking the wind farms to the electrical grid.

Changes in voltages and frequency levels usually determine the efficiency of the electrical grid. In medium voltage networks, sudden or heavy electrical loads, or the change in the power level generated by the generating units, lead to a low voltage level. The results showed the positive effect of linking the wind farms to the electrical network to improve the voltage and frequency levels that reach the users and their electrical equipment, especially during the low voltage period in the network.

In order to ensure the stability of the power grid, physical energy P and Q to the network is essential. The Feasibility Study of the wind farm has been verified to offset voltages in the grid and improve the state of the grid by simulating different virtual electrical networks with different strength and average tension with different wind farms.

On the other hand, due to changes in wind speed, the capacity of wind farms also changes, causing oscillations of voltages, which means that wind farms are connected to the grid making the latter unstable. Therefore, the use of electronic switches on wind farms makes it possible to control the torque and the ability of the rodent and also avoids wind generators separation cases when the changes in voltages and frequency in the event of network failures.

On the other hand, because of changes in wind velocity, the generating capacity of wind farms is also changing, causing unstable generated voltages, therefore, the use of electronic switches in wind farms makes it possible to control torque and generating capacity to avoid cases of wind generators failure when changing occur in voltages and frequency in network.

This study focuses on the potential of wind farms to compensate for low voltages and to verify this through the simulation described later using the Matlab / Simulink environment. The focus was also on the quality of the voltages due to merging the wind farm with the electrical grid and feeding various loads connected to the grid [1], [2].

## II. The Importance of Electronic Inverte in Wind Turbine

As a result of the rapid technological development in the power electronics sector and the desire to generate electricity from wind farms at large scale (greater than 1MW), the use of synchronous alternator in variable speed wind turbines with electronic switches has greater benefits than using induction generator in constant speed system, For different wind speeds, using electronic switches and the automatic voltages regulator, the voltages and frequency of the synchronous generator are independent of the grid.

Therefore, it is important in this study to know the effects of electronic switches used in wind turbines on the voltages produced by these turbines before connection to the electrical grid. The simulation was performed using the Matlab / Simulink program. The study was carried out in stepwise steps. Initially, a single wind turbine of 2MW was modeled to ensure that this turbine with electronic switches could keep the voltages fixed on both terminals of the generator with a regular pure sine wave in different loads. Thus, we have observed the effect of the use of electronic switches in the wind turbine to obtain a stable voltage wave suitable for load or electrical grid [3], [4].

## III. Simulation of Isolated Single Turbine Power (2MW) Using MATLAB

A single 2Mw wind turbine has been modeled to feed an isolated grid with different loads and a different power factor. The modelled system seen in figure 1. Where a load of 1MW + 0.2MV$_{Ar}$ has been connected with the wind turbine. The simulation results shown in figure 2 which shows the terminal voltages which remained constant by technique PWM, The first curve represents the resulting voltages of the wind generator, the second curve represents the form of continuous voltages on the bridge output, The third curve represents the voltages produced by the output of the transducer, which is a variable volt, whose signal is filtered using the LC filter. The final curve represents the average value of the Vrms on the load and its value is 380V$_{rms}$. These curves show the efficiency of the inverter system and the voltage regulator on the voltages level on the load [5].

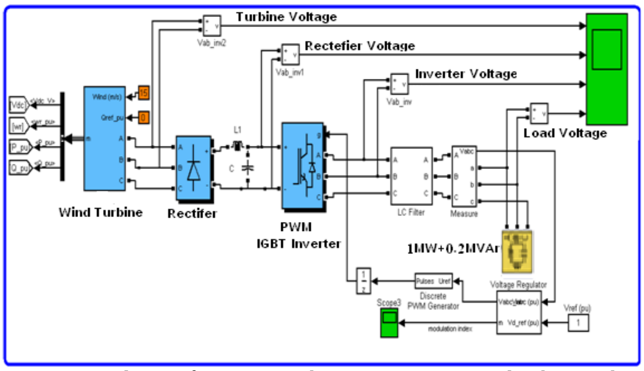


Fig. 1. Simulation of a 2MW synchronous generator wind turbine with electronic switches in Matlab-Simulink.

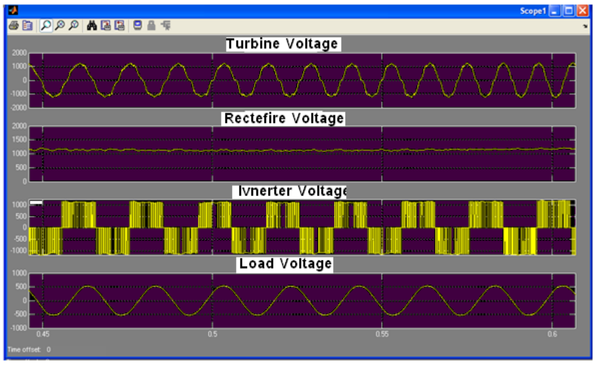


Fig. 2. Wind turbine performances with a synchronized 2MW power generator.

## IV. Simulation of Connecting a 20MW Wind Farm to the Electrical Grid Using MATLAB-SIMULINK

In this study, it is important to know the effects of wind turbines generated power on the electrical grid. The wind farm has been used to compensate for the low voltages in the electrical grid due to the continuous power of the network, so the wind farm can contribute to raising the network voltage reasonably [6], [7].

It is assumed that the electrical grid and the associated wind farm constitute an integrated electrical system that works in a stable state when the network voltage drop occurs. For any reason, the study was carried out in gradual steps. Initially a single wind turbine of 2MW was modeled to ensure that the turbine could keep the voltages constant on both ends of the generator with different loads.

Next step Many of these wind turbines have been linked together to form a wind farm. We then select different voltage virtual grid modeled by connecting different loads without connecting the wind farm, finally a wind farm linked to the grid. Thus, we observed the effect of the wind farm linkage on the high level of tension during voltage drop occurs [8], [9].

## V. Effect of Wind Farm on Upgrading Network Voltage

After simulating a single wind turbine with power of 2MW, we connect a 20 MW wind farm (combination of 10 single 2MW wind turbine) with different load connected to the main load bar as shown in figure 3. To show and understand the effect of wind farm linkage on raising the voltage level of the grid, we performed the following tests [10], [11]:

**The first test:** a 20MW wind farm connected to a 350MVA power grid with average voltage (11/33KV) feeding 90MW (and 16 M$_{var}$) loads at the far end of the grid at a distance of 23 km from the grid.

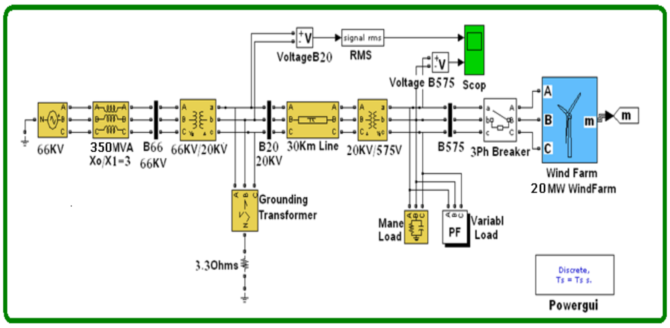


Fig. 3. Wind farm connected to an electric network using MATLAB-SIMULINK.

The total output power of the wind farm is (20MW). The voltages measured on the output terminals is (11KV), before attaching the wind farm where the tension was (10.91 KV$_{rms}$) and after the wind farm was connected, the tension at the same point is(11.10 KV$_{rms}$) increased by 1.7% as shown in figures 4 and 5 [12].

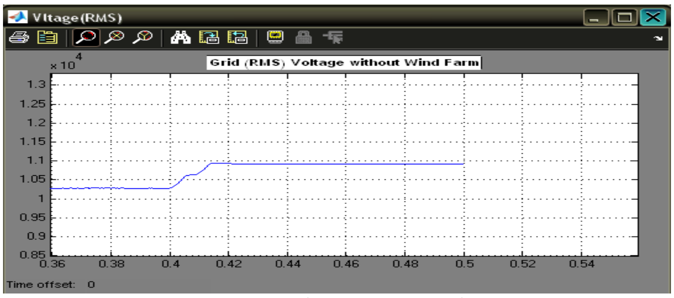


Fig. 4. Network voltage before 20MW wind farm connection.

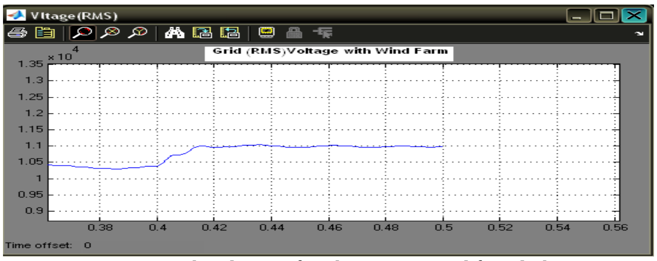

Fig. 5. Network voltages after the 20MW wind farm linkage.

Table I shows another module simulated by using Matlab-Simulink, using a network with output power of 350 MVA connected with a wind farm power of 20MW and loading the network with different loads. Different increases were obtained from 0.43% to 1.6% Shown in the table below:

TABLE I. Shows a summary of the results of a 350MVA grid connected to a 20MW wind farms for different loads type.

| Load type | Cos φ | P(MW) | V(KV) Without WF | V(KV) With WF | Percentage Increase % |
|---|---|---|---|---|---|
| Resistive | 1 | 40 | 18.65 | 18.73 | 0.43 |
| Resistive | 1 | 42 | 17.82 | 17.90 | 0.44 |
| Inductive | 0.9 | 34 | 18.59 | 18.80 | 1.1 |
| Inductive | 0.8 | 28 | 18.1 | 18.40 | 1.6 |
| Capacitive | 0.9 | 20 | 18.8 | 19.14 | 1.8 |
| Capacitive | 0.8 | 19 | 18.1 | 18.25 | 1.32 |

**The second test:** a 30MW wind farm connected to a 1000MVA power grid with average voltage (11KV). The wind farm consist of 15 wind turbines feeding 120MW omic loads, and capacitive inductive 40 $M_{var}$ load with power factor 0.9 the voltage has been measured at the output terminals before connection of the wind farm and it is 10 $KV_{rms}$, after the wind farm has been connected, the tension at the same point is 10.12 which means increasing by 1.2% as shown in figure 6 and 7 [13].

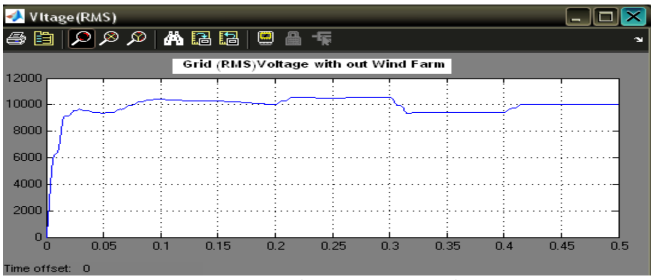

Fig. 6. Network voltages before 30MW wind farm connection.

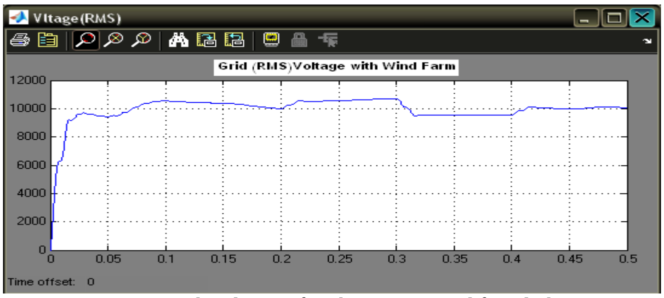

Fig. 7. Network voltages after the 30MW wind farm linkage.

Table II shows another module simulated by using Matlab-Simulink, using a network with output power of 1000 MVA connected with a wind farm power of 30MW (The wind farm consist of 15 wind turbine each with 2MW power) The grid is loaded with different loads, capacitive, inductive and resistive with different power factors. The results show the percentage of KV increases in voltage at 20KV where the increase ranged from 0.97% to 1.8% as indicated in the table II below:

TABLE II. Shows a summary of the results of a 1000MVA grid connected to a 30MW wind farms for different loads type.

| Load type | Cos φ | P(MW) | V(KV) Without WF | V(KV) With WF | Percentage Increase % |
|---|---|---|---|---|---|
| Resistive | 1 | 65 | 15.58 | 15.76 | 1.15 |
| Resistive | 1 | 70 | 15.0 | 15.28 | 1.8 |
| Inductive | 0.9 | 60 | 14.8 | 15.0 | 1.33 |
| Inductive | 0.8 | 64 | 14.20 | 14.35 | 1.0 |
| Capacitive | 0.9 | 63 | 18.32 | 18.50 | 0.97 |
| Capacitive | 0.8 | 65 | 17.47 | 17.60 | 1.0 |

## VI. Conclusion

In this study, a single wind turbine model and different wind farms were carried out in order to verify the positive effect of the wind farms on the network voltage during voltage drop.

These drops in voltages occur during the operation of heavy loads or because of the fluctuation of power by the generator units. In this study, it was verified that linking the wind farms to the grid could offset voltages which negatively affects loads especially sensitive loads such as factories and other loads that are affected by these reductions in voltages.

It was concluded that a wind turbine with power of 10MW of five turbines could increase network voltage by 0.5% to 1.7 KV depending on the loads connected to the grid.

The modeling of the wind farm and its connection to the electrical network or the electric grid demonstrate the mechanism and behavior of wind farms in the event of an emergency drop voltage of the network.

This allows us to study the possibility of connecting a group of to the Iraqi network grid with other international networks.

The issue of changing and drop voltages often results in the separation of the national grid from the rest of the international networks and the supporting of wind generating sets near these areas will contribute to supporting these linkage points and to avoid being separated from each other by the separation of emergency loads or connection of new loads.

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