IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Simulation of Smart Grid in MATLAB/Simulink

Durgesh S Pawar [1], Bhagyesh A Sonawane [2], Durgesh P Patil[3] , Prof.Dr. Harish.A. Patil[4]

[1,2,3,] UG Student

[4] Associate Professor

Department of Electrical Engineering, Godavari College of Engineering, Jalgaon, India, 425001

Abstract *– Energy Generation is a big problem in developing and developed countries. Its supply and demand is an issue as Energy Consumption is always higher than Energy production. Renewable Energy sources are playing a significant role in bridging the gap between energy generation and consumption. Photovoltaic Solar panels and wind generators are now widely available that can be used in order to conserve non-renewable resources. Wind Generator with Doubly-fed induction generator (DFIG) system is quite common in which the power electronic interface controls the rotor currents to achieve the variable speed necessary for maximum energy capture in variable winds. Exhaustion of Non-renewable Energy sources also leads to environmental problems. Therefore, there is the time to use renewable energy sources from non-renewable power sources such a way, which maximizes the use of power generated by renewable resources without affecting the power system. There should be an intelligent power system that can use the electrical power from renewable resources and only needs to use non-renewable power sources if renewable power is either not available or not fulfilling the required demand, which is the primary function of Smart Grid Power Network. Therefore, a smart grid is an electrical grid, which includes a vast variety of operations and energy measures, including smart meters, smart appliances, renewable energy resources, and energy-efficient resources. In this paper, different types of energy sources both non-renewable and renewable are connected and simulation is done with the help of MatLab Simulink Tool Box.*

INTRODUCTION

The Electrical power is the need of every person from day to day activities either for domestic purposes or for industrial purposes. A smart grid is an electrical grid, which includes a huge variety of operations and energy measures, including smart meters, smart appliances, renewable energy resources, and energy-efficient resources (Delamare, 2015). There should be an intelligent power system that can maximize the use of electrical power from renewable resources and only needs to use non-renewable power sources if renewable power is either not available or not fulfilling the required demand, which is the primary function of smart grid power network. A future smart grid power system network is a dynamic network for bidirectional energy flows, linking widely distributed small capacity renewable energy systems at consumer level (distribution network) and centralized higher-capacity power generators, facilitating active participation of customer choice for energy production/source and demand management, and providing real-time information on the

performance and optimal operation of the power system network. The smart grid is technically classified in three categories as below (Kumar, 2014): Smart Management System Smart Protection System Smart Infrastructure System Designing of the smart grid depends on various elements such as user-demand, centralized and decentralized energy production, storage elements, etc. A smart grid at the neighborhood level also involves several houses with a set of typical smart grid scenarios. Each house may have solar panels, a battery, etc. and its individual demand profile reallife gives insight into how the energy flows within a house and the neighborhood and thus can help in a smart grid design (Delamare, 2015).

LITERATURE REVIEW

The (Natsheh, 2011) have analyzed that performance optimization system reliability and operational efficiency are key characteristics of smart grid systems. The author represented a novel model of a smart grid-connected PV/WT hybrid system. It comprises a photovoltaic array, wind turbine, asynchronous generator, controller, and converters. The model was implemented using MATLAB/SIMULINK software package. Perturb and observe (P&O) algorithm is used for maximizing the generated power based on maximum power point tracker (MPPT) implementation. The (Benkhelil, 2012) has presented a technique to design and control of grid-connected PV generation system, identify its components, and describe how it works. To convert the solar energy efficiently, the MPPT algorithm for photovoltaic systems based on P&O algorithm has been presented and shown the control performance, and dynamic behaviour of the grid-connected photovoltaic system provides excellent results, show that the control system is robust, and efficient. (Kumar, 2014) has designed Smart Grid with MATLAB/SIMULINK for synchronization of Thermal and Wind power plants. Stability in terms of frequency deviation is also checked and analyzed of Active power and grid frequency since the standard frequency deviation is defined in the +3% range. The initial value of the inductive and active load is taken as 150 MVAR and 1100 MW at load bus bar B3 and 120 MVAR and 1900 MW at B6, respectively. At these load values, maximum and minimum frequencies obtained as 50.292 Hz and 49.90 Hz.

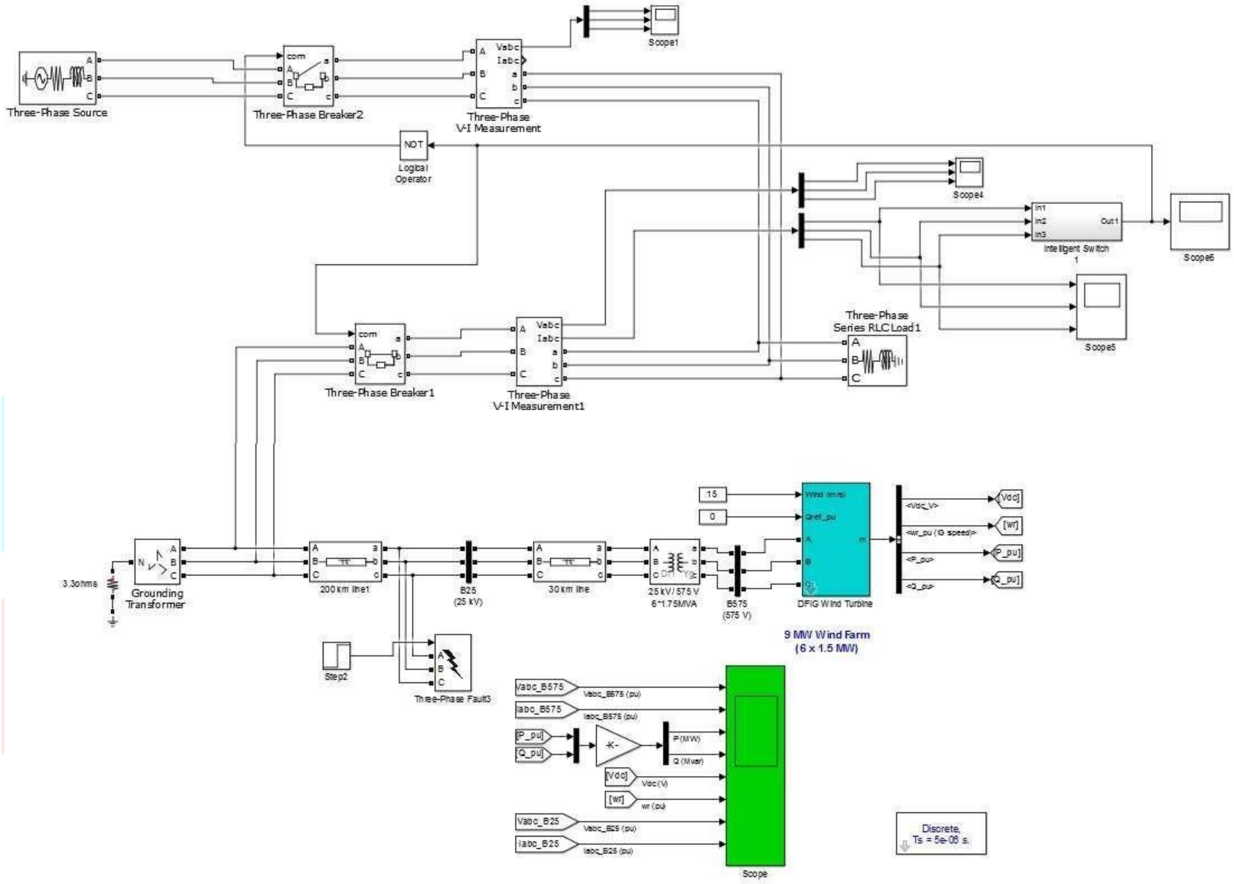

Fig. 1 - **Simulated model of smart grid power system using MATLAB / PowerSystem**.

A. SIMULINK MODEL :-

The Figure 1 shows the detailed block diagram of Smart Grid Work. In this work, two sources are modelled and evaluated in which one is non-renewable, and the other is a renewable energy source.

- Wind Turbine (DFIG)
- Electrical Energy Source

It consists of Wind Turbine, Step-up transformer, Three-phase measurement block, transmission Lines, Grounding transformer, Three-phase load with the three-phase breaker on one side and electrical power source, Three-phase measurement block with Three Phase breaker on another side. The three-phase load is common between the two sources of power, but it can also be different. For Fault generation, fault block is used along with trigger Generator. Scopes are also implemented for viewing and analysis of various waveforms.

Wind Turbine is used as a source of renewable energy. Wind energy is converted to Electrical energy once it connected to Generator called DFIG (Doubly Fed Induction Generator). The output of DFIG from the Wind turbine is fed to Step-up transformer. A step-up transformer is used to increase the level of voltage. Because the Wind Energy along with DFIG is quite far away, maybe in 100 or 1000 kilometres from actual consumption so two different transmission lines are inserted to make this model or work as practical as possible. Two three-phase measurement blocks are connected for analysis purposes. One is connected after both transmission lines towards the load with respect DFIG power line, and the other is connected in an electrical source power line towards the load. Grounding Transformer is used to provide the neutral in the Three Phase system.

Fault-block is used for creating various kinds of fault. Fault can be trigger on internal timing-based or external control to make it ON or OFF. The step function is used to specify the duration of time for the trigger. Three Phase Breaker is used to make or break contacts of all three phases. Same as Fault block, this block can also be controlled either internal timing control or by an external trigger.

The electrical energy source is connected three-phase breaker with an external controller and three-phase measurement block, then to the three-phase load.The three-phase breaker is normally open at the electrical sources side and The smart intelligent switch is responsible for the whole operation. It consists of comparator circuitry with a mathematical or digital operation that compares all three voltages with suitable constant values and gives an output that will be responsible for either switch “ON” or “OFF” DFIG or Electrical power source. A “NOT” or Inverter.

B. METHODOLOGY :-

- Setup priority according to Renewable resources.
- If the Renewable resource is not available, then select Non-Renewable sources. Like, solar power is not available, or wind is not available due to any reason.
- Select, Power line according to load.

RESULTS ACHIEVED

Figures 2 to Figure 5 show various waveforms of smart grid with or without faults.

The project **“Simulation of Smart Grid in MATLAB/Simulink”** was successfully completed using MATLAB and Simulink. The simulation model demonstrated the effective operation of a smart grid system under different operating conditions.

The obtained results showed that the smart grid system can efficiently manage power generation, transmission, and distribution while maintaining system stability and reliability. The integration of renewable energy sources such as .

DISCUSSION

The smart grid is a modern electric power grid infrastructure, which smoothly integrates automated control, advanced sensing and metering technologies, modern communication infrastructure, and modern energy management techniques into the electric power grid.

This research is based on the ideal conditions through MATLAB, but in real-life scenarios to implement this will be challenging. The algorithms which control different functions in a smart grid are complex and need to be studied through simulation before actual implementation to ensure proper operation in all scenarios.

In this paper, proper utilization of power is achieved with a smart grid system with a non-renewable and renewable resource depending on load. With its full implementation, smart grids will make renewable power feasible and equip the grid to meet increasing energy demands by reducing both the cost of energy consumption and production.

CONCLUSION

The demand for Electrical energy increases day by day. Fortunately, over the last decades, there has been an increase in the availability and affordability of Renewable Energy Sources in households, such as windmills and, primarily, solar panels. In addition, the capacity of electricity storage devices has risen considerably. Therefore, this renewable energy production will make up a large portion of the energy

The simulation of smart grid systems using MATLAB and Simulink provides an effective platform for analyzing and improving modern electrical power networks. Through simulation, various smart grid components such as renewable energy sources, microgrids, energy storage systems, electric vehicles, and intelligent control mechanisms can be modeled and tested efficiently. This study demonstrates that smart grid technology enhances power system reliability, efficiency, stability, and energy management. The use of simulation tools helps researchers and engineers evaluate system performance under different operating conditions and fault scenarios without affecting real-world infrastructure.

The project also highlights the importance of integrating renewable energy and advanced communication technologies into conventional power systems to achieve sustainable and intelligent energy distribution. Although challenges such as computational complexity, high implementation cost, and modeling limitations exist, MATLAB/Simulink remains a valuable tool for research, education, and practical smart grid development.

Overall, smart grid simulation plays a significant role in designing future energy systems that are more reliable, economical, environmentally friendly, and capable of meeting growing electricity demands.

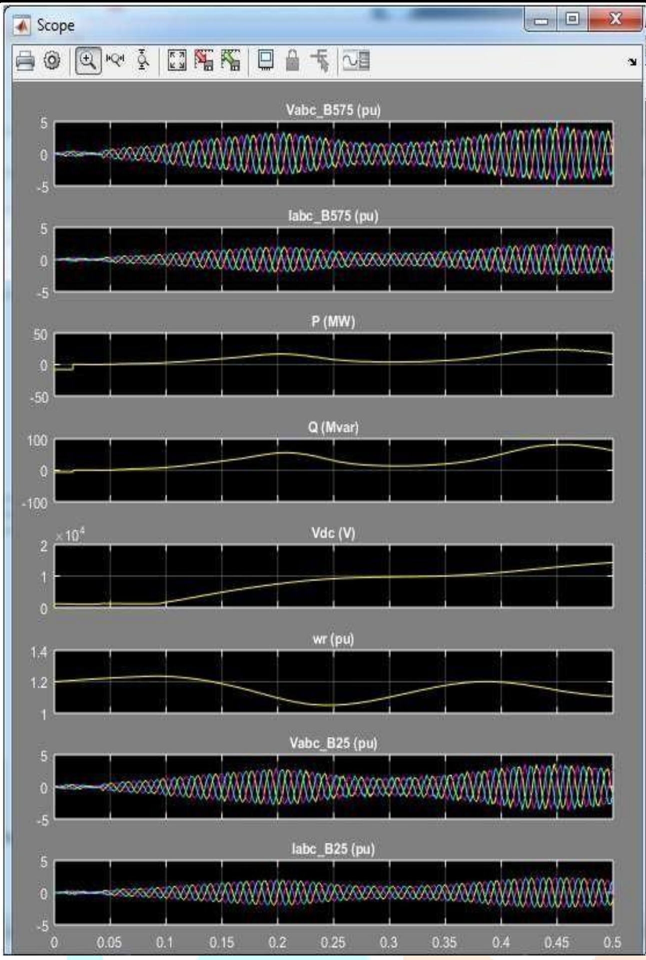

FIGURE 2. DFIG waveform without faults.

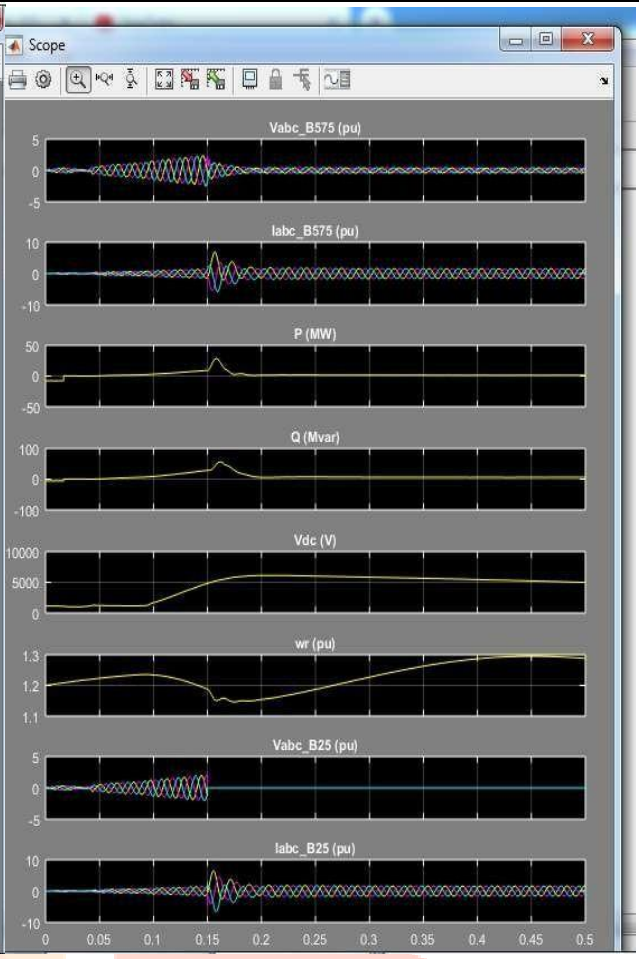

FIGURE 4. DFIG parameters and step time after creating faults

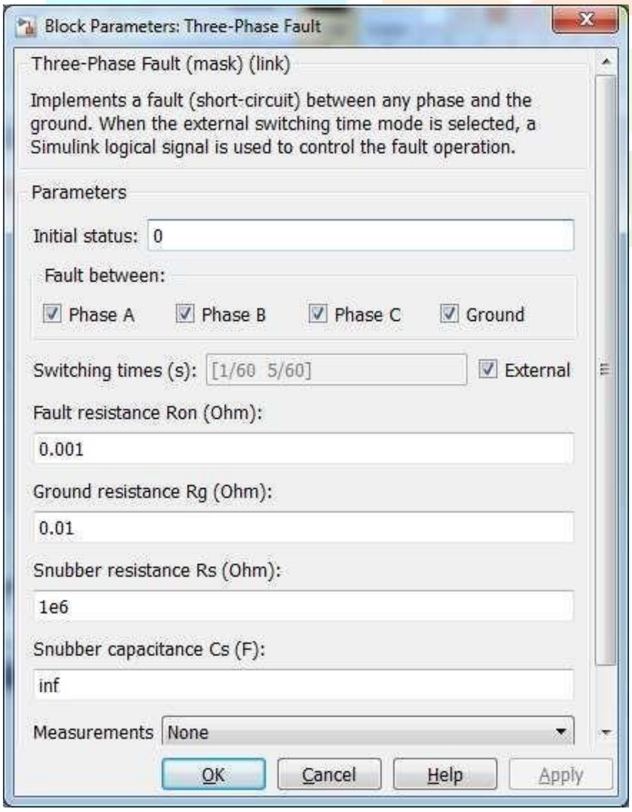

FIGURE 3. Fault generation block.

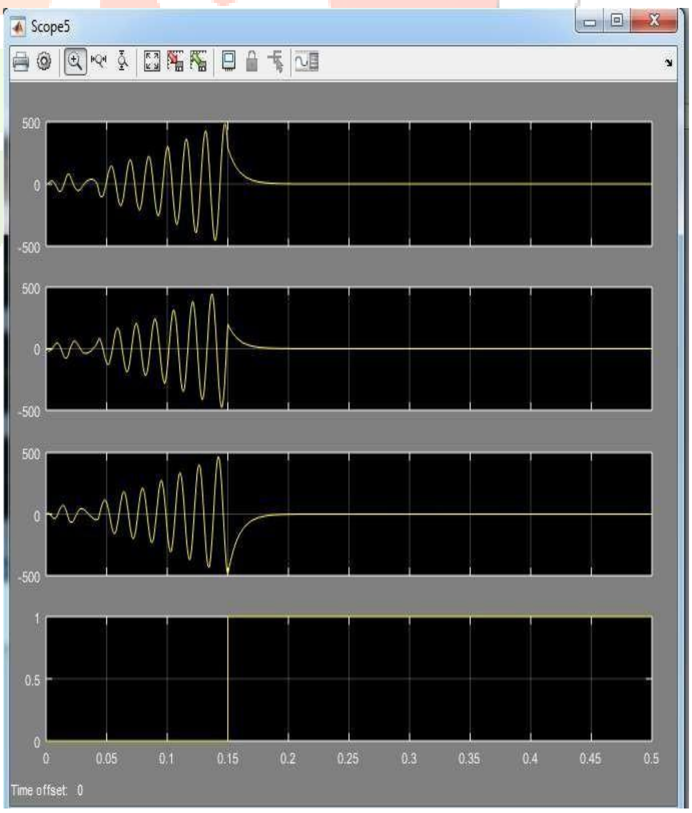

FIGURE 5. DFIG Waveform after faults

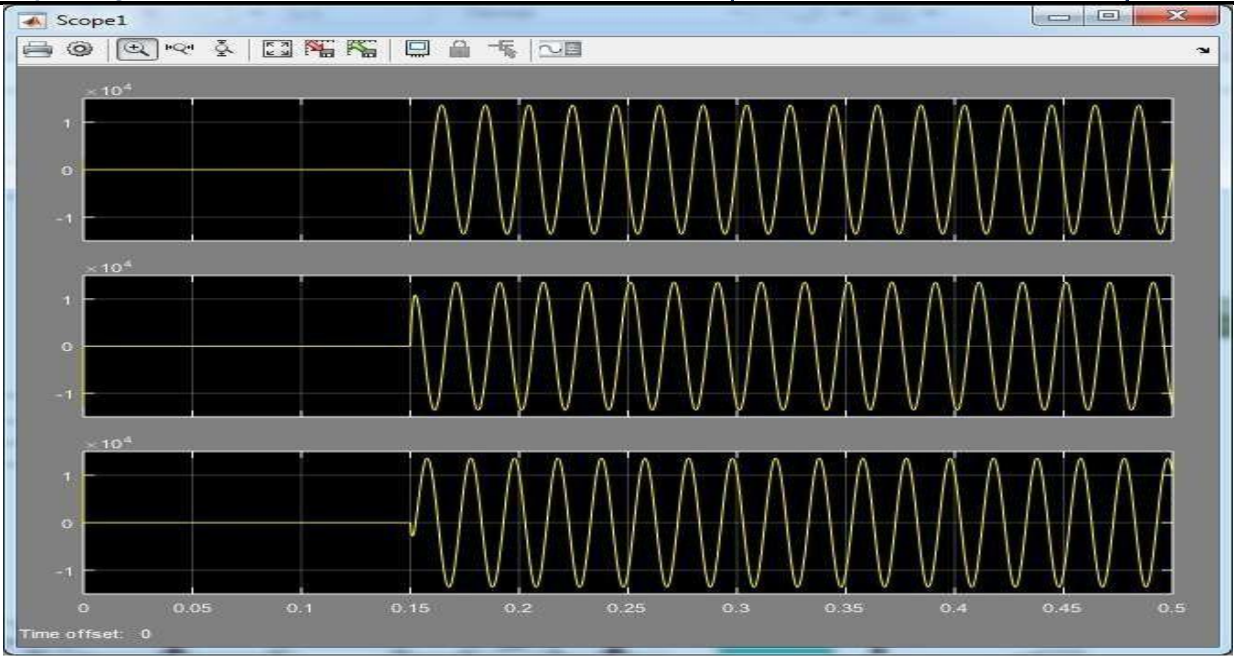

FIGURE 6. Electrical source parameters after creating faults.

uses wind energy as a renewable source and Three Phase Electrical Source as the non-renewable Electrical source. The faults are generated in between the transmission line towards the renewable source, the load received the supply from non-renewable Electrical Energy Sources, DFIG is disconnected with the help of three-phase circuit breakers respectively, and the load gets uninterrupted power suppl

APPLICATIONS AND LIMITATIONS

A. Applications

1. **Power System Modeling and Analysis**

MATLAB/Simulink helps engineers model complete electrical networks including:

- Generation systems
- Transmission lines
- Distribution networks
- Load systems

It enables analysis of:

- Voltage stability
- Power flow
- Fault conditions
- Load balancing

2. **Renewable Energy Integration**

Smart grids heavily rely on renewable energy sources such as:

- Solar photovoltaic (PV) systems
- Wind energy systems
- Hybrid renewable systems MATLAB/Simulink allows simulation of:

- Solar irradiance variations
- Wind speed fluctuations
- Grid synchronization
- Power quality issues

B. Limitations

1. High Computational Complexity

Large smart grid systems require:

- High processing power
- Large memory capacity
- Long simulation times

Problem

Real-time simulation becomes difficult for highly detailed models.

ACKNOWLEDGMENT .

I would like to express my sincere gratitude to everyone who supported and guided me during the completion of the project titled **"Simulation of Smart Grid in MATLAB/Simulink."**

First, I would like to thank my project guide and faculty members for their valuable guidance, encouragement, and technical support throughout the project work. Their suggestions and continuous motivation helped me successfully complete this study.

I am also thankful to my institution and department for providing the necessary facilities, resources, and learning environment required for the project.

Special thanks to MathWorks for providing powerful tools such as MATLAB and Simulink, which made the simulation and analysis of the smart grid system possible. Research survives on software ecosystems that are expensive, proprietary, and often inaccessible without institutional backing. Most projects quietly fail at this stage because tooling costs and model complexity compound faster than expected.

Finally, I would like to thank my family and friends for their constant support, patience, and encouragement throughout the completion of this project.

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