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Research Article

Design and Analysis of Hybrid Power System with Fault Detection and Removal Capability in Transmission Line

Manpreet Kaur† and Vikramjeet Singh†

†Student, Dept. of Electrical Engineering, Sri SAI College of Engineering, Pathankot, India

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Abstract

Renewable energy technologies are suitable for off-grid services, serving the remote areas without having to build or extend expensive and complicated grid infrastructure. Therefore standalone system using renewable energy sources have become a preferred option. The key reason for the deployment of the above energy systems are their benefits, such as supply security, reduced carbon emission, improved power quality, reliability and employment opportunity to the local people. Research work is carried out to simulate hybrid power system with wind energy, diesel power system and transmission line with fault detection using MATLAB SIMULINK software. Electrical parameters such as voltage, current, and power of the system are computed. Also the recovery time of the supply is observed. The simulated result shows the system works satisfactorily providing high electrical parameters.

Keywords: *Hybrid power system, diesel generator, transmission, wind generator.*

1. Introduction

India has an enormous renewable energy potential of about 100,000MW, which is mostly untapped. It is estimated that 40% of villages in the country are not electrified through grid electricity mainly due to capacity shortage and difficult terrain and environmental considerations. It becomes necessary to take up electrification of remote villages through non-conventional energy sources such as solar, micro-hydro and wind energy. A hybrid system is a combination of one or more resources of renewable energy such as solar, wind, micro/mini-hydro power and biomass with other technologies such as batteries and diesel generator (Muljad *et. al.* 2002). Particularly, the wind hybrid system developed with a combination of wind with battery and diesel generator. As an off-grid power generation, the hybrid system offers clean and efficient power that will in many cases be more cost-effective than sole diesel systems. As a result, renewable energy options have increasingly become the preferred solution for off-grid power generation (Wang and Nehrir 2008) (Hetzer *et. al.* (2008).

The ability of renewable energy working in tandem with diesel, contributes to high quality and dynamic electricity services for 24 hours/day while in a conventional system, the high diesel operating costs limits the power supply only to 12 hours/day (Mcgowan and Manwell 1999), (Elhadidy 2002). The cost of photovoltaic or wind power generation lies in the form of upfront capital expenditures whereby the operation and maintenance expenses are low. Therefore, the generating cost via photovoltaic or wind is marginally more than a conventional system with respect to the additional generating capacity, nevertheless promises customer satisfaction of a continuous electricity supply.

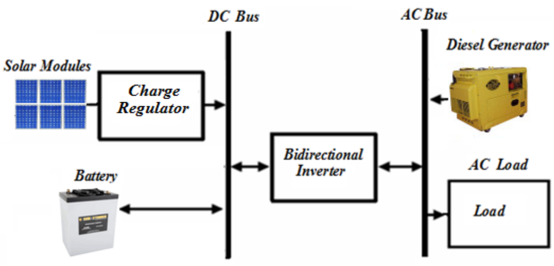

Fig.1 Hybrid power system.

Diesel generation and other fossil fuels emits air/water pollution agents as well as loud noise, proving the essentiality of renewable energy or diesel retrofits application in power generation which adopts an environmental-friendly technology. In fact, renewable energy system is also substantially quieter than other power generation system (Hiskens and Pai 2000), (Ismail *et. al.* 2013). Hybrid system promotes efficient use of power since renewable energy system could be configured to cope with base load whilst the peak load could be met via diesel generator. Renewable energy or

*Corresponding author **Manpreet Kaur** is a M.Tech Student and **Vikramjeet Singh** is working as Assistant Professor

diesel hybrid system act as the most cost-effective way of generating electricity with regards to savings on fuel consumption and lower maintenance cost. For a conventional diesel system at remote area, the fuel and transportation cost is typically very high, as well as the service and spare parts cost which grossly excessive to rural community (Dekker *et. al.* 2012), (Karakoulidis *et. al.* 2011).

2. Methodology

Research work is carried out to design hybrid system which is the combination of wind generating system, diesel system and transmission line having capability of fault detection in transmission line (block diagram shown in Fig. 2). If any fault occur on the transmission line due to bad weather or any other condition, wind generating system and diesel system are present to continue the supply. Also in any case if there is absence of wind then diesel system will be there to continue the supply. Initially the system with only diesel engine and transmission line tested with various combinations of faults on the phases. Diesel engine governor system governs the desired and actual speed of the diesel engine. The controller and actuator transfer function of the governor is as given below:

Controller transfer function,

$$H_c = k.(1 + T3.S)/(1 + T1.S + T1.T2.S^2)$$

Actuator transfer function,

$$H_a = (1 + T4.S)/[(S(1 + T5.S)(1 + T6.S)]$$

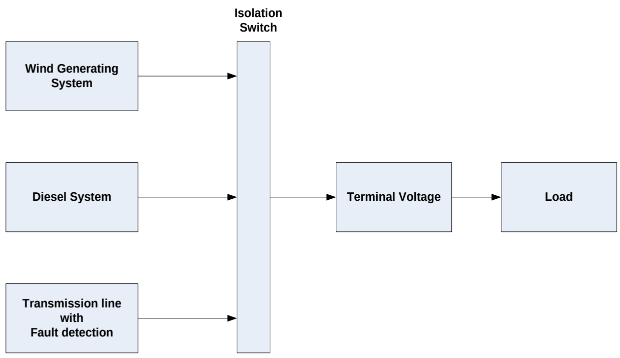

Fig.2 Block diagram of designed model

3. Results

A Simulink model of diesel generator with transmission line is simulated and then system is merged with wind power generator. Table 1 shows the fault sequence and rms voltage and current obtained from the system.

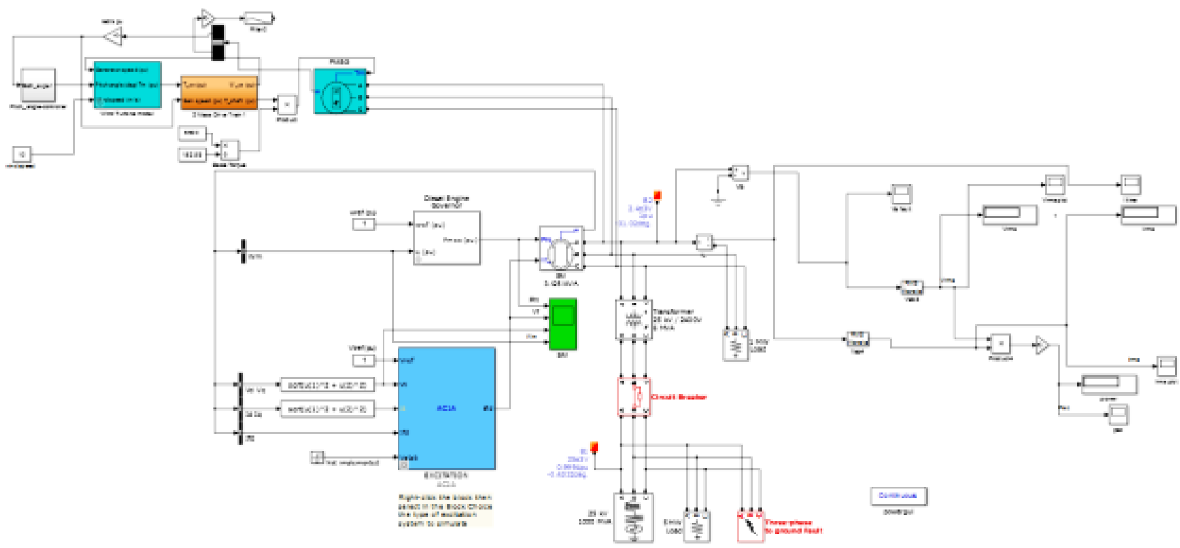

Fig.3 Snapshot of designed simulink model

Table 1 Experimental procedure parameters

Phase A	Phase B	Phase C	Vrms	Irms
0	0	0	1469	255.1
0	0	1	1439	249.8
0	1	0	1440	249.9
0	1	1	1412	245.2
1	0	0	1326	230.2
1	0	1	1296	225
1	1	0	1296	225
1	1	1	1351	234.5

Various output parameters are computed with respect to faults in three phases and constant wind speed. Table 2 represents various values of RMS voltage, RMS current and power with respect to various phase faults and a constant wind speed i.e.10 m/sec.

Table 1 Experimental procedure parameters

Phase A	Phase B	Phase C	Vrms	Irms
0	0	0	811.9	141
0	0	1	877.6	152.4

0	1	0	875.5	152
0	1	1	880.5	152.9
1	0	0	870.9	151.2
1	0	1	903.9	156.9
1	1	0	892.1	154.9
1	1	1	880.1	152.8

Fig. 5.15(a)-(d) illustrates various plots for output voltage, RMS voltage, RMS current and power when the fault is on all the Phases and with a constant wind speed of 10 m/sec. A large drop in output voltage can be observed in Fig. 5.15(a) and a corresponding change in other electrical parameters is observed.

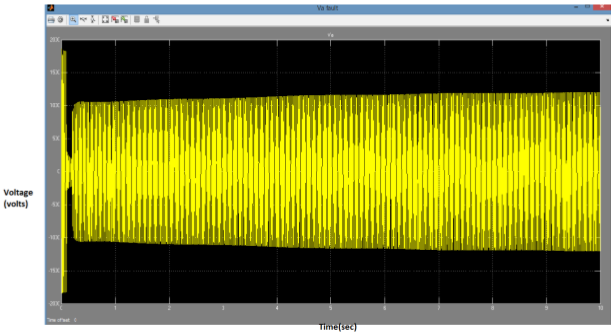

Fig.3 Output voltage of the system

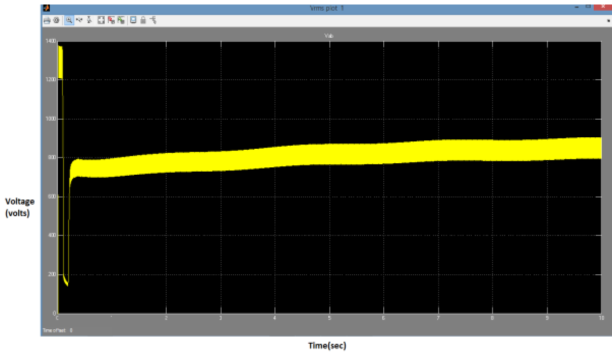

Fig.3 RMS voltage of the system

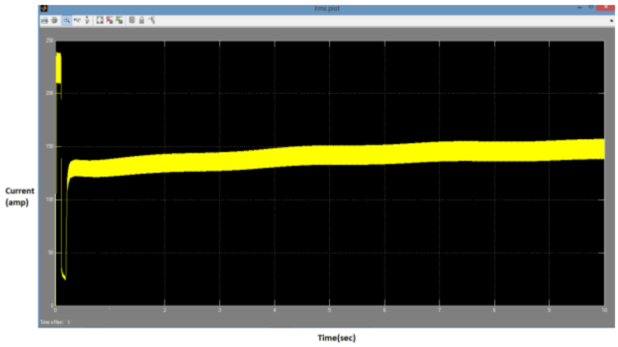

Fig.3 RMS current of the system

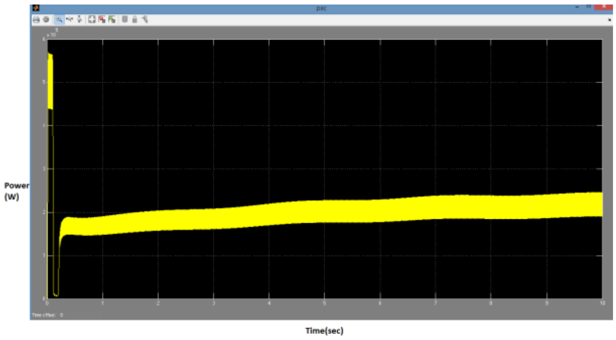

Fig.3 Power output of the system

Conclusions

The research work is carried out to simulate the performance of hybrid system. A hybrid model consisting of wind, diesel and transmission line is simulated to fulfil the load demand. In this experiment various values of RMS voltage, RMS current and power is obtained with respect to faults in the three phases and constant wind speed i.e. 10m/sec. The maximum values of RMS voltage, RMS current and power are 811.9V, 141A and 198200W respectively and minimum values of RMS voltage, RMS current and power are 880.1V, 152.8A and 232900W respectively. The recovery time after fault occurs is 0.1 sec.

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