CONTINUOUS WAVELET TRANSFORM FOR PV-CONNECTED HYBRID POWER SYSTEM FAULT DETECTION

Dhanurjaya Mahar[1], Smruti ranjan Nayak[2]
[1, 2]Gandhi Institute for Education & Technology, Bhubaneswar

Abstract- **In today's expanding world, access to consistent power and energy is a basic human necessity. The only way to do this is to use a renewable energy source. This research examines a model that includes a grid-connected photovoltaic system. The PV cell and other important characteristics are also covered. It also explains the various kinds of faults, such as L-L-L and L-L-L-G. Wavelet transform has also been employed by us to confirm the outcome. The Matlab Simulink file is used to illustrate the PV model that is explained below. The outcomes listed below were confirmed using Matlab software.**

Keywords- PV cell; Power system; Renewable energy; Hybrid distribution system; wavelet transform

I.INTRODUCTION

Some about of thousand years of electricity is being introduced people are fascinated by the use of electricity. But some people are there who thinks how electricity was first discovered. The electricity was first discovered by a Greek philosopher Thales of Miletus (624 BC to 546 BC). Some of his first writing tells us about principles of magnetism and static electricity. The more clear picture of static electricity came out around the 18th century when a scientist name Benjamin Franklin tested practically by flying kite using a metal string during lightning. When lightning struck the metal-strung he got a shock. By that means it was clear that electricity exists in nature. The earlier use of electricity was less so, using non-renewable source energy in the production of electricity was not a big deal. But in today scenario of a growing world, the demand for electricity is increasing day by day at its full phase. Due to the reduction or scarcity of non-renewable source of energy nowadays making it hard to produce electricity. Because most of our power production plants are based on using the non-renewable source of energy [1]. The basic way of power production. Electricity is by using fossil fuel like coal and natural gas the main problem in the non- renewable source of energy is that it takes millions of years to form and another big disadvantage is that it is extracted

land and sea. In this process of extraction of these fossil fuels, we exploit many living being which is becoming extinct. The most important point is that the production of electricity by this process produces a huge amount of pollution and release many harmful gases which may affect our living. So, if we are totally dependent on the source of energy in electricity generation than it will finish sooner or later, which would be a great disadvantage for us in terms of producing electricity for future use. Renewable energy is the energy that we get from the renewable source. They are constantly restored and they will never run out. In the past few years, we have been seeing the use of non-renewable resources like electricity generation from fossil fuel, others also caused harm to the environment greater than human activity [2]. So use renewable energy has a very important effect on today's world. The various types of renewable energy, i.e. wind energy, solar energy, Hydropower, biomass, geothermal power & other forms of energy. Wind energy is generated by wind turbines, converts wind energy into mechanical energy. It is one of the eco-friendly and safe energy sources. India surpassed Germany as one of the World's fastest growing markets for wind energy. Hydropower is the energy; we get from the flow of water. Most of the Hydropower is situated at the place major rainfall occurs. Biomass is a form of renewable energy produced from the organic matter. It includes forest waste and biodegradable waste from municipal waste. It is widely available and cheaper than fossil fuel. The main disadvantage is that it needs a huge amount of water & it is as efficient as others. Beside all renewable sources, solar energy is more efficient than other sources. It's the energy we can easily from the sun. It can easily be produced by solar heating, Photovoltaic cells & solar architecture [3]. Photovoltaic is the most commonly used methods. It is an element Technology which produces electricity from the sunlight without moving parts. It doesn't cause any harm to the environment. It can be easily available anywhere. India's average temperature throughout the year is 25-27.5 degree.

India has the huge solar potential. Due to the most efficient output PV cells are now used everywhere for electricity.

Hybrid Power systems have been designed to generate and use electrical power. It does not depend on the larger grid and more than one type of power source [4]. They deliver ac of fixed frequency for supplying electricity in remote locations. It normally contains AC diesel generators, DC diesel generator, an AC Distribution System. A hybrid distribution system consists of Photovoltaic (PV) combines solar energy collected from PV cells with other generating energy Source.

The Wavelet transform is a mathematical tool, basically it a type of signal processing algorithm which helps to detect the abnormal behavior of the signal of a different system. It requires various scaling method to calculate the highest or lowest frequency required. By comparing this paper with other paper, this paper only focuses on the fault analysis of different types while other papers deal with the thing like detection of islanding, protection of grid etc [11]. Mathematically, continuous wavelet transform is represented by

$$G(b, c) = \frac{1}{\sqrt{b}} T\left(\frac{t-c}{b}\right) \quad (1)$$

Where, b is the scale,
c is the translation,
T (t) is the mother wavelet, and
G is the 2D matrix of wavelet coefficients.

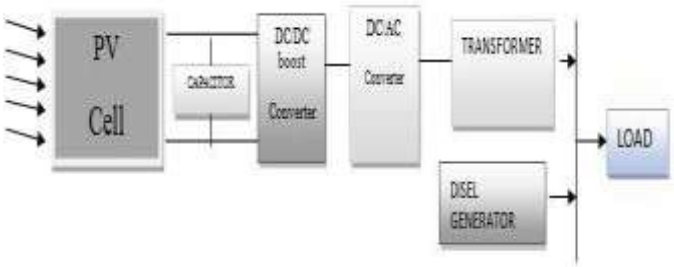


Fig 1. Block diagram of PV mode II.PV CELL

The first question which comes to our mind is that what is
PV cell? In general answer to this is PV cell is a device which converts sun heat energy into electrical energy for production of power. According to the renowned diode

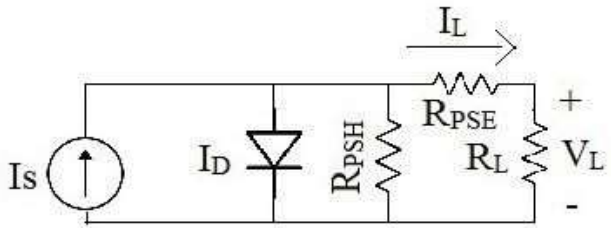


Fig 2. Equivalent model of PV cell

Where, $I_L = I_S - I_D$ (2)
Is=short circuit current by sunlight (Photon) ID= current through diode
IL=load current RL= load resistance
In the devices which are basically practically used PV cell has a parameter such
RPSE=Parasitic series resistance RPSH=Parasitic shunt Resistance
RPSE is a factor representing the resistance due to the presence of semiconductor. RPSH factor represents loss created by a small amount of leakage current which strikes through the resistor into the device [8].

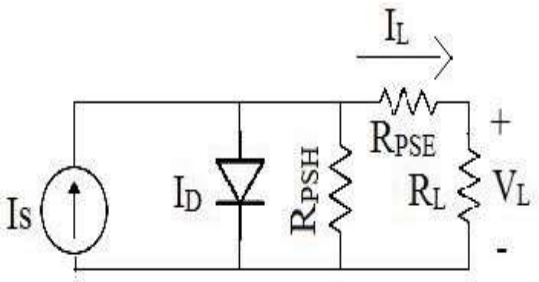


Fig 3. Practical model of PV cell
On the basis of the above model of PV cell, the output voltage can be described as,

$$V = \frac{n*K*T_{ref}}{q} \times \ln\left(\frac{I_S + I_{D0}}{I_{D0}}\right) - I_L \times R_{PSE} \quad (3)$$

equation, we are able to know the working operation of the PV cell [5]. This happens when the sun rays are focused on the PV cell which results the creation of current and "the remaining electron and hole left are forwarded to another direction due to the formation of an electric field in the depletion region [6,7].

Where k=Boltzmann constant ($1.381e^{-23}$ J/K) q=charge of electron($1.60 \times 10^{-19}e^{-23}$C)

Is=photocurrent which is due to irradiance level and temperature at the junction

Io=Reverse saturation current of the diode

TREF=Operating temperature (273K) RPSE= Series resistance of the cell

To obtain an output voltage of PV array the voltage should be multiplied with a number of PV cell connected in series. To get output current of PV array the current should be multiplied with a number of PV cell connected in parallel [9,10]. Due to the irradiance level of solar and temperature at the junction the output current gets changed. The effect of temperature & irradiance should be included in the PV model. Based on the Practical model let the effect represented by coefficient XtvL and XtvIL

$$XtvL=1+ \beta t \times(TREF-T) \quad (4)$$

$$XTIL=1+\gamma t \times (T-TREF)\times SREF \quad (5)$$

Here, $\beta t = 0.004$

$\gamma t = 0.066$

TREF=294K

Change in solar irradiance cans change the Is_{new} and T.Let change in solar irradiance is represented by ZsVL and ZsIL

ZsVL=output voltage correction factor

ZsIL=Correction factor of Is

$$ZsIL=1+(1/SREF) \times (S- SREF) \quad (6)$$

$$ZsVL=1+ \beta t \times \alpha \times (S- SREF) \quad (7)$$

After the correction the new output voltage,

$$VLnew= XtvL \times ZsVL \times VLold \quad (8)$$

$$Isnew= XTIL \times ZsIL \times Isold \quad (9)$$

III. PROPOSED MODEL

The Single line diagram shown below is derived and verified by MATLAB SIMULINK software

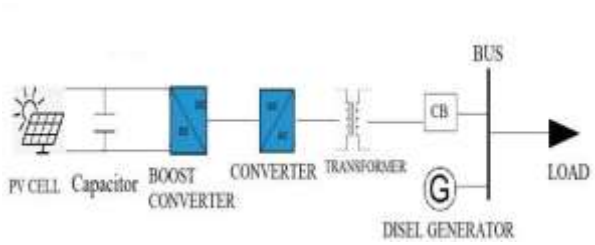


Fig 4. Single line diagram of the PV model

This paper deals with the significance of the PV farm and its connection with the utility grid. In this new world filled with new technologies, the installation of the PV system has increased. Due to safety and one time investment in this PV system, this has increased than the conventional method of power generation. The cost of grid connection and the data which is important for the installation of the PV system required can be through this simulation result .the electrical part model consists of converter, inverter, transformer, diesel generator A PV array is nothing but the collection of solar cell combined together to absorb more amount of heat from the sun. In PV array, solar cells are connected parallel, which is called as the string and each string has several solar cells connected in series. There is some PV array which is predefined and some are user-defined. The output of the PV array is fed to step up converter with parallel connected the capacitor to the converter. It is a converter with a simple circuit which boosts the output voltage. The use of a boost converter is that output voltage should be more than input voltage fed to the boost circuit. It basically was done by controlling the switching operations by proper selection of switching frequencies. In this switching device is a MOSFET. And a square wave pulse is provided to MOSFET to drive the circuit. Then the output of the boost converter is fed to the inverter. An inverter is a device which converts DC to AC. We used a converter in this model because the solar cell produces DC which need to convert to AC for further producing electricity. Then the output of an inverter is fed to the transformer.

The basic work of transformer is to increase or decrease the voltage required at the output or we can say in simple words that the mutual induction b/w the windings is the basic cause for the operation of the transformer. Here we have a three-phase transformer. In three-phase transformer, there are 3 primary winding and 3 secondary winding. Basically, we use the three-phase transformer because it is more economical and uses less conductor material than 2- phase transformer. Then the output of a transformer is fed to a bus bar. A bus bar is basically used to collect the power from a feeder and deliver the power to the output feeder which then feeds the power to the grid for further usage of power. The bus bar system consists of Circuit breaker and relay which is used in case of fault so that the grid is safe from the existing fault is the system. Also, a diesel generator is connected to the bus. It is used to give power supply in emergency condition when the grid fails. Then a load of constant

impedance is connected to the bus which draws constant current from the bus.

IV. RESULT AND ANALYSIS

The below described results are checked and verified by MATLAB/SIMULINK software to the best -suited value.

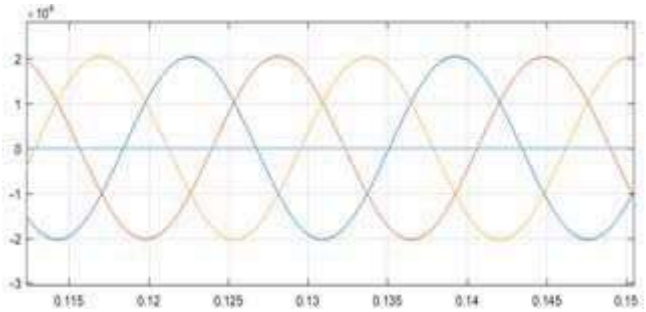


Fig 5. Voltage waveform during normally loaded condition

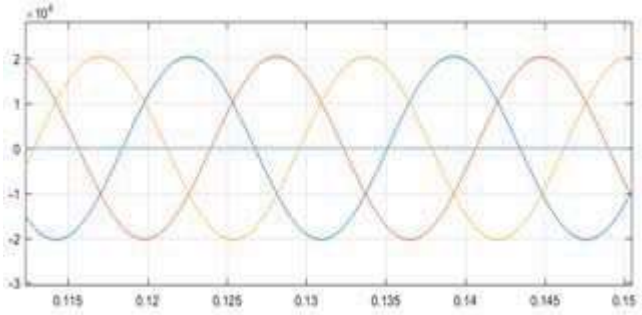


Fig 6. Current Waveform during normally loaded condition

The above fig[5][6] shows about the steady state of the system means when there was no fault occurred in the system, the system was at its steady state .

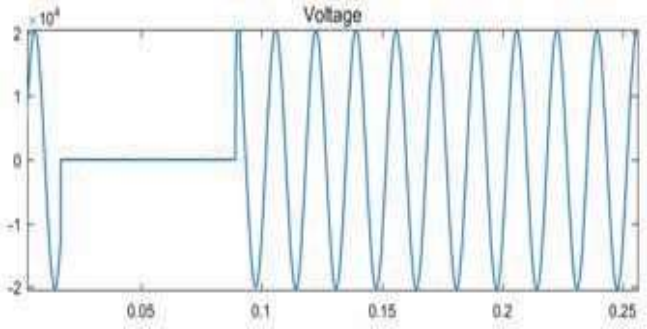


Fig 7(a). L-L-L-G Fault Signal

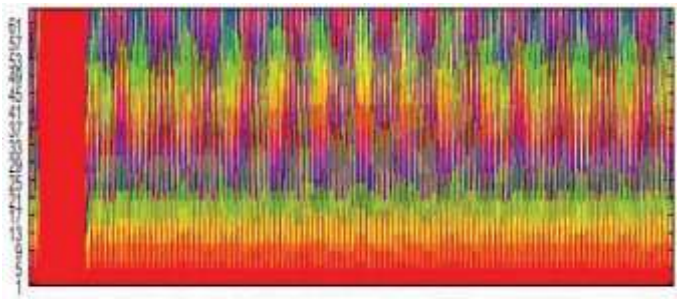


Fig 7(b). Detection of L-L-L-G fault using Continuous Wavelet

Fig 7(c). L-L-L-G fault Coefficients

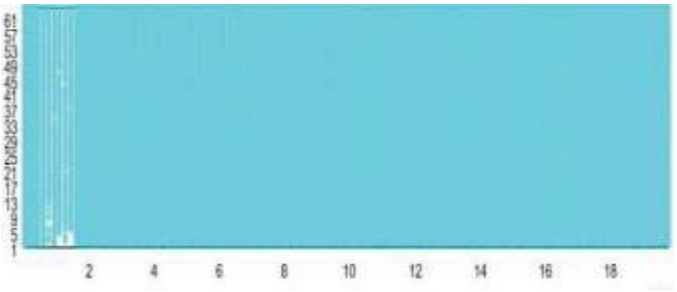


Fig 7(d). Local Maxima Lines of L-L-L-G fault

The above result is done using the fault block in the pv model .The system was in steady state, but at the instant when the L-L-L-G fault occurs in the system shown in fig 7(a) we can take a note that the voltage drops to zero for a period of time after that the system overcomes the fault then before coming to its steady state it produces a new peak voltage. The fig 7(b, c, d) discuss the fault in the system using wavelet transform. The blank space in fig 7(a) is the part when the fault has occurred and rest portion is when the system is in steady state.

Fig 8(a). L-L-L Fault Signal

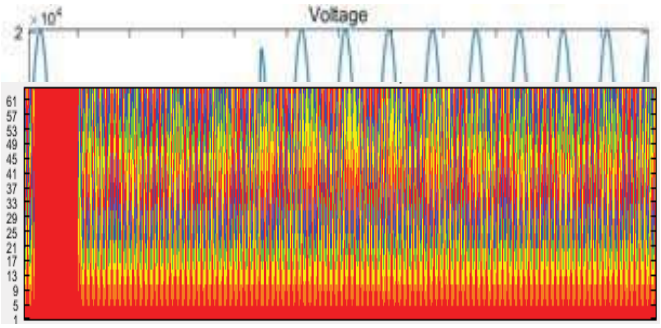


Fig 8(b). Detection of L-L-L fault using Continuous Wavelet

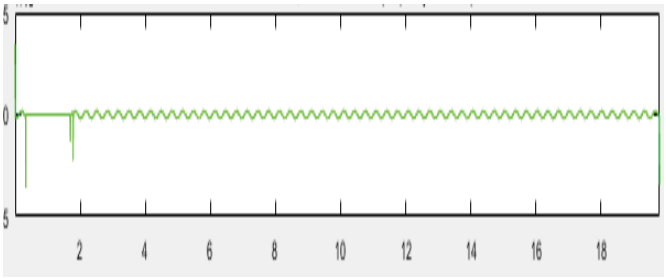


Fig 8(c). L-L-L fault Coefficient

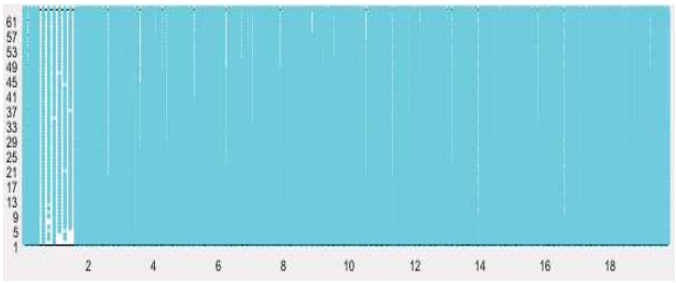


Fig 8(d). Local Maxima lines of L-L-L fault

The system was in steady state, but at the instant when the L-L-L fault occurs in the system shown in fig 8(a) we can take a note that the voltage drops to zero for a small period of time than the L-L-L-G fault after that the system overcomes the fault then the post fault result shows that the voltage is less than that of its steady state voltage. The fig 8(b, c, d) discuss about the fault in the system using wavelet transform. The blank space in fig 8(a) is the part when the fault has occurred and rest portion is when system is in steady state.

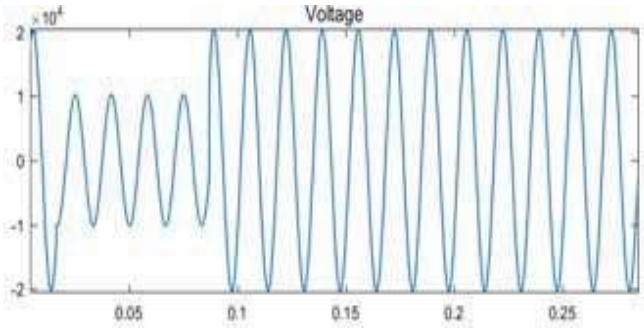
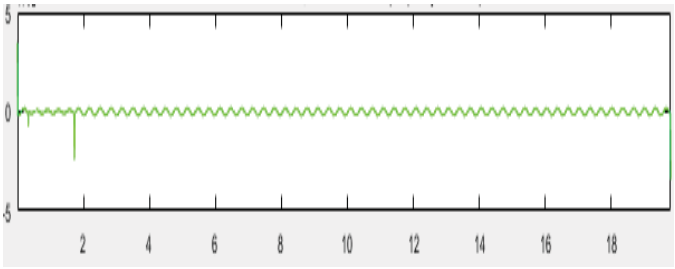


Fig 9(a). L-L Fault Signal



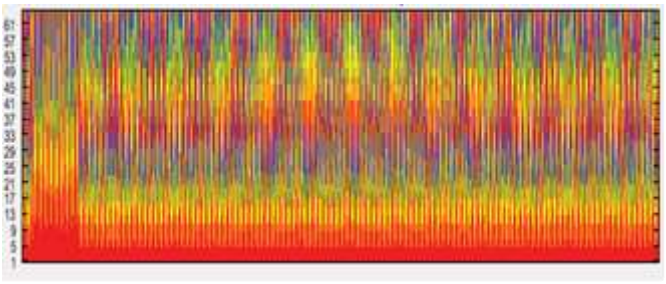


Fig 9(b). Detection of L-L fault using Continuous Wavelet

Fig 9(c). L-L fault Coefficients

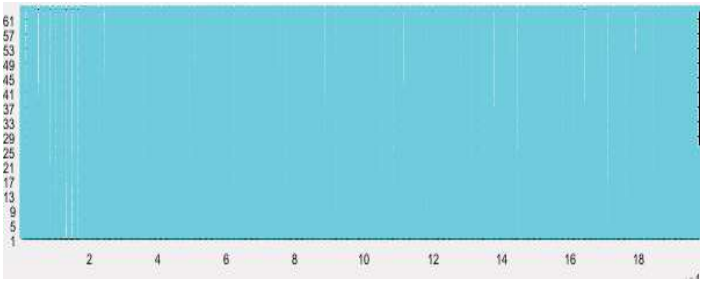


Fig 9(d). Local maxima lines of L-L Fault

Before the fault occurred the system was in its steady state, but when the fault occurred at phase A and B due this fault phase C also gets effected as shown in fig 9(a) we can observe that due to fault in A and B the magnitude of voltage in phase C gets affected . The fig 9(b, c, d) discuss the fault in the system using wavelet transform. The space in fig 9(a) where the wave is shorter than other is when the fault has occurred and rest portion is when the system is in steady state.

V. CONCLUSION

The enhanced PV cell and PV model, created with MATLAB/SIMULINK tools, are presented in this study. The outcomes stated above satisfied the paper's purpose. This work has several advantages over the prior model, including simplicity, precision, and—above all—the removal of flaws in some of the previous research. It also explains the many fault types, such as L-L-L-G, L-L-L, and L-L, and the results mentioned above are easy to comprehend. This essay discusses the benefits of renewable resources and the drawbacks of non-renewable ones. There is also a detailed discussion on using a hybrid system. Finally, we draw the conclusion that solar energy is the most reliable energy source currently in use.

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