Classification of faults in PV integrated Hybrid Power System using Artificial Neural Network

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Abstract*: Today in this growing world the basic need of people is to get continuous power supply. This can be only achieved by using a renewable source of energy as the alternative to meet the increase load demand. From all the available renewable source of energy PV cell Source is one of the most popular and widely used source. This work deals with the model consisting of a PV system connected to the grid. It also discusses the PV cell and various different parameters. In addition to that it describes the different type of fault like L-L-L, L-L-L-G. In this work Artificial Neural Network (ANN) techniques is used to verify the classification of fault accuracy. The PV model described below demonstrated the use of Matlab/ Simulink file. The results described in this work are verified by Matlab software.

Index Terms: PV cell,Renewable energy, Hybrid distribution system, Artificial NeuralNetwork.

I. INTRODUCTION

Some about of thousand years of electricity is being introduced people are fascinated by the use of electricity. 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 energy sources, it isdifficult to produce electric power. Because most of our power production plants are based on non-renewable source of energy [1].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 andrelease many harmfulgases which may affectour 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 get 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 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

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PV cells with other generating energy Source.

II. ARTIFICIAL NEURAL NETWORK

It is essential in the assurance plan to distinguish and group deficiencies dependent on transient voltage and additionally blame current flag. ANN is a numerical portrayal, reflected by natural neural systems. It is a versatile framework, changes its structure by learning stage. The analysts have been persuaded by the limit of ANN to learn convoluted nonlinear info or yield relationship and for applying ANNs to take care of nonlinear issues from a wide range of fields. This technique has the predominance of commendable commotion insusceptibility and heartiness and henceforth as for the changing working conditions ANN based methodologies are less influenced when contrasted with the conventional strategies in power framework designing [9]. ANNs have been effectively connected to control framework insurance and orders in light of its programming system and capacity to tackle nonlinear issue easily [8]. Fundamentally, the neural system can be built and prepared to take care of specific issues which are difficult to tackle by people or traditional computational calculation.

The information to the info layer with respect to yield encourages the framework to separate whether there is a fault and the accurate area where fault occurs. In Back Propagation Neural Network the output is feedback and compared with predicted output or input and the produced error is minimized by adjusting the weights.

The algorithm of BPNN is as follows:

1. Forward propagation

$$a_j = \sum_{i}^{m} w_{ji}^{1} x_i \tag{1}$$

$$z_j = f(a_j) \tag{2}$$

$$y_j = \sum_{i}^{M} w_{kj}^{2} z_j \tag{3}$$

2. Output Difference

$$\delta_k = y_k - t_k \tag{4}$$

3. Back Propagation for Hidden Layer

$$\delta_j = (1 - z_j^2) \sum_{k=1}^{K} w_{kj}\, \delta_k \tag{5}$$

The MSE for each output in individual iteration is represented mathematically by

$$MSe = \frac{1}{N} \sum_{1}^{N} (E_i - E_0)^2 \tag{6}$$

Where N is number of iterations E_i is actual output and E_0 is out of the model.

III. 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 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].

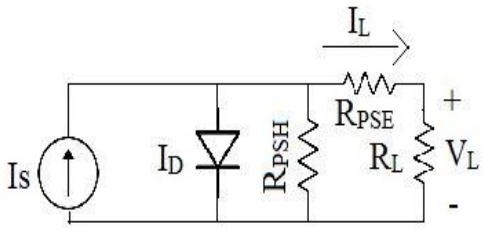

Fig.1. Equivalent model of PV cell

Where, $I_L = I_S - I_D$

Is=short circuit current by sunlight (Photon), I_D= current through diode

I_L=load current, R_L= load resistance

In the devices which are basically practically used PV cell has aparameter such as R_{PSE}=Parasitic series resistance,R_{PSH}=Parasitic shunt Resistance. R_{PSE} is a factor representing the resistance due to the presence of semiconductor. R_{PSH} factor represents loss created by a small amount of leakage current which strikes through the resistor into the device [3].

On the basis of the model of PV cell as shown in Fig.1, the output voltage can be described as,

$$V_L = \frac{n * K * T_{ref}}{q} \times \ln\left(\frac{I_S + I_{D0}}{I_{D0}}\right) - I_L \times R_{PSE} \tag{7}$$

Where k=Boltzman 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 atthe junction, Io=Reverse saturation current of thediode,T_{REF}=Operating temperature (273K), R_{PSE}= Series resistance of thecell

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 [4]-[5].Dueto the irradiance level of solar and temperature atthe 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 $Xtv_L$and Xtv_{IL}

$$Xtv_L = 1 + \beta t \times (T_{REF} - T) \tag{8}$$

$$XT_{IL}=1+\gamma_t \times (T-T_{REF}) \times S_{REF} \quad (9)$$

Here, βt=0.004,γ_t=0.066 and T_{REF}=294K
Change in solar irradiance canchange the Is_{new} and T. Let change in solar irradiance is represented by $Zs_{VL}$and $Zs_{IL}$where Zs_{VL}=output voltage correction factor andZs_{IL}=Correction factor of Is

$$Zs_{IL}=1+(1/S_{REF})\times(S-S_{REF}) \quad (10)$$

$$Zs_{VL}=1+\beta t \times \alpha \times (S-S_{REF}) \quad (11)$$

After the correction the new output voltage,

$$V_L new= Xtv_L \times Zs_{VL} \times V_L old \quad (12)$$

$$I_s new= XT_{IL} \times ZsIL \times Isold \quad (13)$$

IV. PROPOSED MODEL

The Single line diagram of the PV cell penetrated grid connected system shown below is derived and verified by MATLAB SIMULINK software

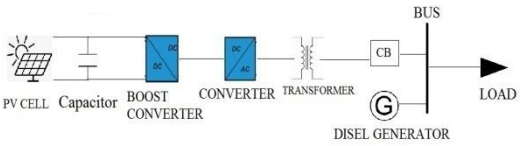

Fig.2. Single line diagram of thePV model

This work 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. 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 thebus which draws constant current from the bus.

V. RESULT AND ANALYSIS

The below described results are checked and verified by MATLAB/SIMULINK software to the best -suited value.In this PV model we have generated result on the basis of L-L-L-G fault. The value of voltage and current is taken as input data for ANN processing.

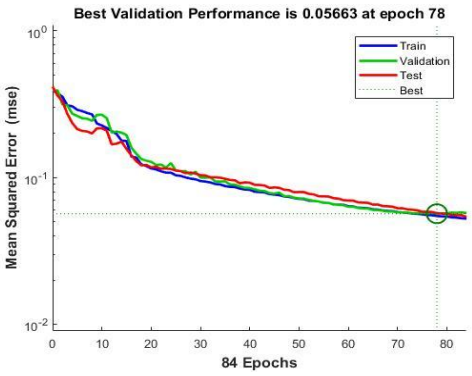

Fig.3. Performance plot

Then bytaking the training function (TRAINLM). After multiple trainings we got the best result which is showing performance is linear. The number of layers is two and the number of neurons is forty five. The Fig.3 shows the performance graph of the mean square error using ANN. The training of different ANN structures has done and corresponding overall performance have determined. The Fig.4 discusses about the gradient and val fail of the training state using ANN.

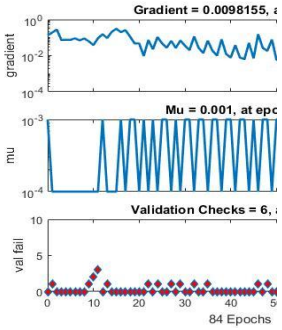

Fig.4. Training State

The data sets are created by creating different types of fault and then storing the data which is used later for training and testing purpose. The plots are given an indication that the system is effective. The correct percentage of classification of fault using the proposed method is 99%.

VI. CONCLUSION

This paper discuss about the improved model of PV cell penetrated to the grid. The model is done by using MATLAB/SIMULINK software. The objective of the paper to find out the classification of fault was fulfilled by the above-discussed results. It also describes the different type of faults like L-L-L-G and the resultsdiscussed above are satisfactory. In this paper the importance of renewable source and drawbacks of thenon-renewable source are discussed. The use of a hybrid system is also discussed in details. In comparison to the previous model this paper includes characteristics like simplicity, accuracy and most importantly its accuracy which is almost 99%.

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