Fault Prediction in Transmission Line in Presence of Wind DG Using Wavelet Transform

Anshuman Bhuyan, Basanta.K Panigrahi, S.Pati, S.K Gouda, P.K Sahoo, A.Sabat, A.Dash

Abstract*: For a reliable power system operation, protection is an important aspect. This is a very critical present day issue. The prediction of type of fault is very important for maintaining uninterrupted power supply in a power system network. In addition to that prediction of fault is also very important for rapid digital relaying operation on doubly fed transmission lines. Wavelet transform is one of the best methods for fault prediction analysis. Further selection of proper wavelet is necessary for extracting the dynamic features of the current signals at the instant of fault occurrence on a transmission line. This paper deals with the prediction of fault in a doubly fed transmission line in the presence of wind DG. The work done in this paper employs simulation of power system in MATLAB Simulink environment and pythonsoftware.

Index Terms*: Distributed Generator (DG), Wavelet Transform (WT). Fast Fourier Transform (FFT), Photovoltaic Cell (PV Cell).

I. INTRODUCTION

In our era electric power plays a very important part in our lives. Electricity has been acting like an elementary requirement hence we require a bulk production. Statistically in consuming electricity our country India has become the 3rd topmost consumer base in the world and to complete the requirement we have to reproduce a large quantity of electric power. To be brief about the countries and their power consumption, considering United States, it produces 49% of the power from the distributed generation. India has been sharing 81.9% of fossil fuel with merely 15.3% of renewable energy. This type of supremacy can be alarming for the coming time and we must be seeing renewable energy for the generation of electric power. So by linking distributed production having inexhaustible energy to power frame, we can possibly have it.

In the new era of employing different ways of electricity production, generation in distributed form is one of the latest technologies that serve the purpose. The latest tech consists mainly of standard and sustainable energy generators. Wind is considered to be the best available energy amongst all the sustainable energy available in the environment. Wind turbines can be used to generate electricity through wind. There is a very little chance of pollution. Also for land based utility this is the utmost potent energy source. Keeping in mind the electrical operations, wind is considered to be one among the best sustainable energy sources. DG has no concern over trustworthiness and guarantee of power. As it is very potent, when connected near the load it has the capability to reduce the losses to the minimum that occur in the circuit. A DG when embedded inside the system will provide us with certain effects on power quality, voltage, transient stability and also short circuit. But by embedding a DG it adds a fault current to the system. Wind farm, Solar PV, etc might be some forms that it can take. A modest scale of DG can have a maximum of 400 V of periphery. In some detracting cases, the distributed producers play a very crucial role in supplying energy when the power of the principal source is not enough to hold the load. The distributed producers are linked with the main grids. The distributed producers can affect the safety of the power grid. Consider some linear impedance elements like inductors, capacitors and also resistors that make up the power system. Usually this system is always energized and is carrying load unless a huge disturbance occurs as a result of some fault or any other huge perturbation. Therefore this is where the need for detection of the fault is needed. Hence devices like circuit breakers are placed in the supply grid and some other small grids for the protection from faults. These CBs secure the power system. CBs hold two key functions one being closed while at normal conditions and another opening the circuits during an event of fault protecting the system. Relays have a very important role to play in these functions. The Relay senses the abnormality from the current transformer in terms of switching, short circuit, lightning, and resonance and signals the CB to trip. By tripping we isolate the faulty circuit from the healthy one keeping the system run smoothly.

At times when there is scarcity of power and when the primary grid fails to compensate it, the load is often regulated by DGs to function smoothly and normally as they feed the power into the system that is required. But we should always know that the occurrence of a fault can happen at any point of time at any place such as near to a bus or at the bus. Hence it is better to prevent such faults and therefore to be able to detect and protect the system

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as soon as possible. There are numerous conventional procedures like methods based on impedance, travelling wave etc. The method based on impedance involves fault resistance along with ground resistance to compute the fault position [1]. Some current researchers have developed few techniques to detect, categorize and spot the fault using a wide range of methodologies such as Wavelet Singular Entropy, Fuzzy Logic, Linear Discriminant Analysis, S-transform(ST) and Support Vector Matrix, have been studied [2]-[4]. For analyzing the power quality, the voltage signals are used. For the detection of harmonics Fast Fourier Transform has been used [5]-[7]. Current Differential protection of transmission lines using the spectral energy information provided by Fast Discrete S-Transform. In the literature[8] recommended categorization of fault and prediction of its position in high voltage lines by means of Support Vector Matrix (SVM) and Wavelet Transform (WT) of the terminal voltage and current transient signal . The most important aspect of the process is to decrease the time in analyzing islanding. An attempt has been given for current differential protection using the spectral energy information provided by a new Fast Discrete S-Transform (to reduce the computational cost as well as to remove redundant information) [3]-[11]. As per the proposed fault locality algorithm, fault allocation is inessential before the location of fault estimation unlike some fault location method [6]-[9]. In this procedure the 3 phase current signals are recovered from the ends of the transmission line and processed through FDST to derive and detect the fault pattern. This technique detects and limits the quality of power problems and sudden changes in solar insulation in distributed network [10]. A detailed examination was completed using 16 wavelets to prove the superior performance of the Db4 wavelet for the process of fault classification.

II. WAVELETTRANSFORM

A wavelet is way alike wave vibration alongside an amplitude gearing up with a naught at first, rising to a level and returning down to zero again, can be seen to have an oscillation that is concise enough alike to that taped by a seismograph. Mostly the wavelets are knowingly designed so that they contain detailed holdings to be beneficial to deal with various signal transformations. To get data from the anonymous parts, the wavelets are mingled along with the acknowledged parts of the signal that is impaired applying an approach called convolution which contains reversal, integration, multiplication along with modification.

Distinct-time filter banks are used roughly by all the beneficial distinct wavelet transform being practically used. Namely the filter banks are known to be the wavelets and they might carry one or the two out of finite impulse response (FIR) and infinite impulse response (IIR) screen. The signal that is mentioned having a definite amount of energy being extrapolated over a consecutive group of the pulsation line belongs to continuous wavelet transforms. In discrete wavelet transform, it's mathematically impractical analyzing a signal utilizing all the coadjutant of the wavelet, so thinking to choose a distinct subgroup of the mentioned uppermost half being capable in reconstructing the signal amidst the recognized consecutive coadjutant of the wavelet. Affine system is a same kind of the system where a>1, b> .Usually a mother wavelet is preferred to provide a consecutively differentiable function along with a support which is quite condensed and essentially more applicable and efficient. In the texts out of many basic transforms the wavelet transform is very genuine and important one. One of the basic transforms out of the lot is the chirplet transform containing the CWT being a two-dimensional part of it.

The wavelet transform being widely utilized to transform given set of information, data lately encoding the 1st, finally which results in effectively compressing it.

III. WIND TURBINE

By the use of fossil fuel it enhances environmental pollution in the world and increasing of cost rate of the fossil fuel lead to the dangerous situation of power generation system. So the researchers choose for renewable source of energy which cost is very low and high efficiency. Power generated by much renewable energy like Solar, Wind, Geothermal, Tidal etc. The wind source renewable energy is stable, it's never ending and it is cost effective. So by the use of the wind turbine we can fulfill the demand of the consumer with fewer substructures and less area required for installation of wind turbines.

The wind turbine converts kinetic energy to electrical energy because of their nonlinear active system. Doubly fed generator used in WECS. Tower, blades and rotor are main parts of the wind turbine. In nacelle the blade like structure are connected and the blades are bounded by enclosure called nacelle. Also in electrical generator the nacelle is connected. The other equipment like power control equipment, mechanical equipment and electrical generator are inside the tower and these are produced kinetic energy to electrical energy. Rotor moving with high speed because of when wind flow between 4m/s to 30m/s the wind drives the rotor blades. So the rotor kinetic energy fed to the generator which is in tower through nacelle. The electrical voltage produced by the generator is fed to the substation by the transformer and that voltage is distributed to the consumer from the substation. The electricity produced in the generator as direct current is conducted through the entire to the tower to the banks. A converter transforms it into the alternating current which transform most commonly kind and the transformer transform the voltage into substations through the underground. To know the previous performance of the wind turbine, the following formula below required,

$$AEO = 0.01328 D_2 V_3 \quad (1)$$

Annual energy output measure in KWH per year is specified as 'AEO', the diameter of rotor measured in feet in 'D' and the average wind speed generated annually measured in mph is 'V'. The formula of output for maximum power is:

$$P = \frac{16}{27}\frac{1}{2}\rho v^3 A = \frac{8}{27}\rho v^3 A \quad (2)$$

Here effective area of the disk is 'A' the wind velocity is V and density of air is 'ρ' .

The power calculation

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formula is

$$Power = kC_p \, {}^{1}/_{2} \, \rho A V^3 \quad (3)$$

Here, the maximum power coefficient is 'C_p', range is 0.25 to 0.45 and 0.000133 is the value of 'K'.

In wind generator the electromechanical failure occurs that have an impact on the five sections of the turbine like stator, rotor, and the bearings the gear & the air gap. In periodic monitoring prevent degradation shows from recent studies. The stator currents governance &management conducted all studies of the present day. Especially lead out frequency inaugurate by the fault, the current spectrum is scrutinized. Wind turbine cost is very low as compared to other renewable energy source because it is a less costly energy pool. The maintenance of the wind turbines needed regularly to stay goods & stable.

Without any waste of fragment &greenhouse effect the non-polluting energy is developed by wind turbine 1500tons of $C0_2$ can be eliminated per year using 1MW of turbine instead of 1mw of crude oil. It environmentally better solution in now days. In wind connected hybrid system for fault detection purposes, here the different fault cases the fault analysis is being done. Shown below in the Fig.1 isthe single line diagram of the model shown in simplified analysis. The length of the transmission line is 30km.To reduce the transmission losses the transformer is connected to the generator is set up. The bus 1 is being connected from generator 1 the power is being fed to the transmission line. Hence this transmission line is depicted to be of pie-type. To reduce the voltage stepdown is required whose output is 575volts. The output voltage of 575volt bus the distributive generator is connected. On the distribution side the three phase series RLC load is connected.To the system the 6 wind turbines are connected of 9MW which given to the load & 575 volts is the nominal voltage of the turbines.

IV. PROPOSED MODEL

In wind connected hybrid system for fault detection purposes, here the different fault cases the fault analysis is being done.The length of the transmission line is 30km.To reduce the transmission losses the transformer is connected to the generator is set up. The bus 1 is being connected from generator 1 the power is being fed to the transmission line

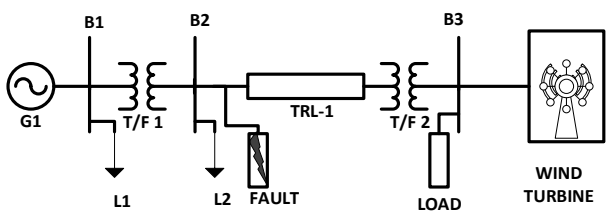

Fig.1. Single line diagram of the proposed model

Hence, this transmission line is depicted inπ type. To reduce the voltage step down is required whose output is 575volts. The output voltage of 575volt bus the distributive generator is connected. On the distribution side the three phase series RLC load is connected. To the system the 6 wind turbines are connected of 9MW which given to the load & 575 volts is the nominal voltage of the turbines.

V. RESULTS AND ANALYSIS

Authors of rejected papers may revise and resubmit them to the journal again.Here wavelet analysis has been used to extract the detail coefficient at level-4 of a faulty current signal for individual phase of a three phase transmission line. The obtained coefficients are further usedfor predicting the fault in the subsequent manner. The summation of wavelet coefficient for each is computed using the mean values. Let us assume R1, Y1, and B1 as the summation of level-4 detail coefficients of the transient current signal for first bus of R, Y, and B phases respectively. Correspondingly let us assume R2, Y2, and B2 as the summation of level-4 detail coefficients of the transient current signal for the second bus of R, Y, and B phase respectively. Using the preceding coefficients the subsequent values are derived.

$$R12=R1+R2 \quad (4)$$
$$Y12=Y1+Y2 \quad (5)$$
$$B12=B1+B2 \quad (6)$$

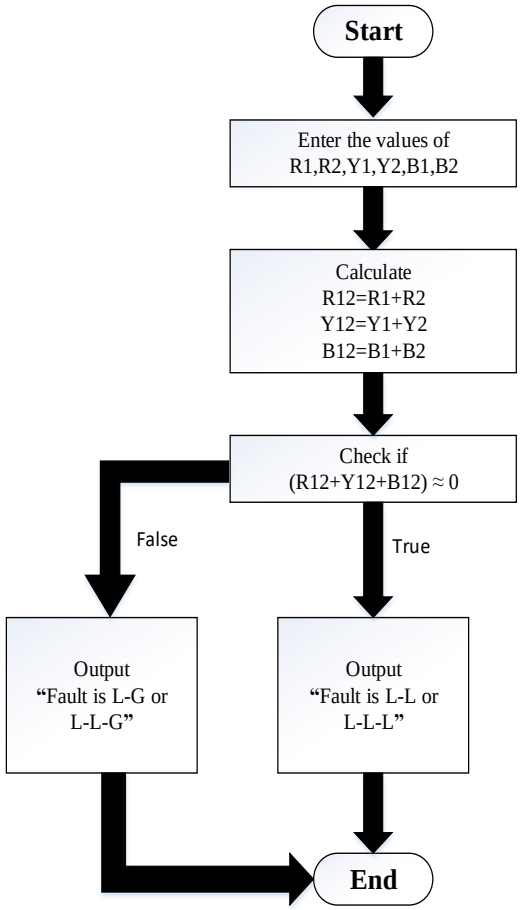

Fig.2. Flow chart of the proposed algorithm

The values of R12, Y12, and B12 are added and checked whether it sums up zero or not. If the sum nearly equalizes to zero, then we can say that the fault is either a double line fault i.e., L-L Fault or a triple line fault i.e., L-L-L Fault.

Bus	Phase	Mean	Summation
1	R	6.556e-07	0.2622406556
1	Y	1.614e-07	0.0645601614
1	B	-8.169e-07	-0.32767608169
2	R	1.319e-06	0.527601319
2	Y	5.166e-07	0.2066405166
2	B	-7.717e-08	-0.03086807717

Table1.Fourth Level Detail Coefficient of Current Signals during LG Fault.

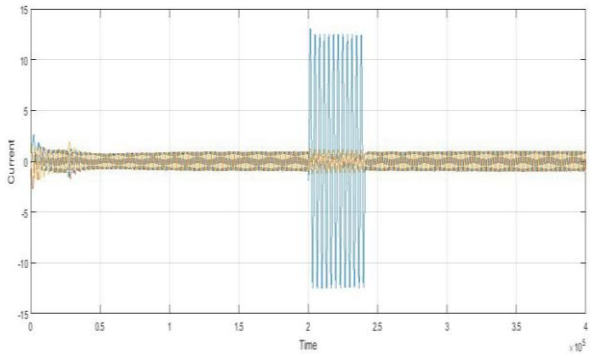

Fig.3. Current Signal of Bus 1 during LG Fault

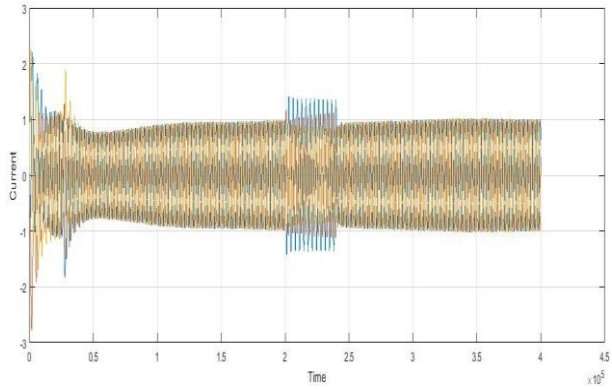

Fig.4. Current Signal of Bus 2 during LG Fault

If a single line to ground fault has occurred in either phase, tremendous current flows though the faulty phase due to the presence of a less resistive path. The magnitude of current in the remaining phases is negligible, indicating the absence of 2nd or 3rd harmonics (extracted by the summation of values of detail coefficients at level-4). This is valid for double line to ground faults i.e., L-L-G faults also where there is no harmonic content in the remaining phases which are healthy. If the addition of R12, Y12, and B12 doesn't sum up to zero, then we can say that the fault which has occurred is either a single line to ground fault i.e., L-G Fault or a double line to ground fault i.e., L-L-G Fault.

VI. CONCLUSION

A conclusion section is not required. Fault prediction is important for fast relaying action and protection of the power system. The fault prediction employing level four detailed coefficients of current signals is most reliable for the application of this algorithm in real time digital relays. This paper presents a detailed explanation of the stated algorithm, to know about the most likely faults that haveoccurred. In this paper the importance of renewable source and drawbacks of the non-renewable source are discussed. The use of a hybrid system is also discussed in details. The prediction of fault using python is very much satisfactory which reduces the time required to clear the fault in a wind connected power system network.

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