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Fault Location on Transmission Line in a system consisting of Distributed Generation Sources

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Abstract-In this paper, proposed an accurate and efficient method for fault distance calculation in electrical power transmission lines in a system consisting of Distributed Generation (DG) sources including a solar and wind farm .A fault produces a wide spectrum of signals that contains information about the fault distance. Fault location algorithms process the phasor of voltages and currents at both ends of the protection zone. Synchronized voltage and current samples at both ends of a line are used to calculate the location of the fault. The characteristic impedance and propagation constant of the line are determined by the line parameter. This project also proposes a new Discrete Fourier Transform (DFT) based algorithm (termed as Smart Discrete Fourier Transform, SDFT) to eliminate system noise and measurement errors such that extremely accurate fundamental frequency components can be extracted for calculation of fault location index. The simulations are carried out using MATLAB software. Simulation results of various types of faults on a typical transmission system demonstrate high efficiency and accuracy of the proposed method.

Keywords: Distributed Generation (DG); Microgrid; Smart Discrete Fourier Transform (SDFT); Transmission System; Phasor Measurement Unit (PMU) and Fault Analysis.

I.INTRODUCTION

In electrical utilities, transmission lines frame the spine of intensity frameworks. As to unwavering quality and upkeep expenses of intensity conveyance, exact fault location for transmission lines is of imperative significance in reestablishing power administration, and diminishing blackout time however much as could reasonably be expected. Numerous fault location procedures have been proposed in open writing [1]– [22]. Among these methods, particularly Takagi et al. [5], [6] connected the superposition standard to evaluate single-finished fault location calculations. The said creators' methodologies were exceptionally appealing as they didn't require correspondence to acquire comes about. Be that as it may, calculations in light of single ended information will influence exactness because of varieties in source impedances, fault frequency point, fault impedance, and stacking conditions. With the approach of worldwide situating framework (GPS)- based synchronously estimating units including phasor estimation units (PMUs) [23], advanced transfers, and computerized fault recorders in the mid 1990s, GPS-based fault location methods [2], [7]– [17] have turned out to be promising. The primary preferred standpoint of GPS-based methods is that fault location estimation precision is unaffected by varieties in source impedances and fault impedances because of the accessibility of two-terminal synchronized information. Kezunovc et al. [7], [8] utilized synchronized voltages and streams tests at two terminals to appraise the fault location. They received a period area demonstrate as reason for the calculation improvement. In any case, information must be gained at an adequately high inspecting rate to give sufficient estimation of the subsidiaries. As far as concerns them, Lee et al. [9] used synchronized phasors at the two terminals to get the fault location. Their calculation depended on positive and zero succession parts of post fault voltages and streams. Specifically, blunders will be given when managing three-stage faults where zero grouping segments are truant. In addition, their work just considered a short line demonstrate that proved unable mirror the idea of transmission lines. In the interim, our past works [10]– [14] proposed fault location/recognition strategies for transmission lines utilizing synchronized phasor estimations. The created fault location/recognition lists can be utilized for transmission line security also [15]– [17].

Be that as it may, because of the high establishment cost of PMUs, lion's share of utilities introduce PMUs just at key substations. Along these lines, the computerized estimations at two line terminals are gained non concurrently without GPS flag. In this way, fault location estimation in view of two-terminal information will endure in wording of exactness. Subsequently, fault locations in view of post fault information synchronization calculations were considered in a few papers. Girgis et al. [18] utilized an iterative strategy to accomplish time synchronization. The fault location strategy proposed by Dalcastagnê et al. [19] depended on voltage sizes. The proposed work [20] utilized the fanciful piece of the fault location record to synchronize the estimations. To accomplish a trade off between development cost and ecological insurance in Taiwan, overhead lines joined with underground links have been generally received by the Taiwan Power Company (Taipower) with 161 kV and 345 kV transmission frameworks. In any case, the created procedures [1]– [20] can't find the fault precisely utilizing these sorts of compound lines. Consequently, a two-terminal multi section line show must be considered to build up another fault location strategy. Gilany et al. [21] utilized synchronized estimations to distinguish/find a fault for a two-segment line joined an overhead line with an underground power link segment. Their work required recognizing the fault write before finding a fault. In the interim, their strategy is material just to two-segment compound transmission lines rather than more broad multi section compound lines. Yang et al. [22] embraced circulated parameter line models and the Newton-Raphson emphasis to find a fault for multi section underground links. Since the Newton-Raphson iterative activity is required, the plan experiences union issues. Additionally, their strategy did not consider all the more by and large consolidated overhead lines with control links, for example, the case considered in the present examination. This paper proposes a creative fault location system for two-terminal multi section compound transmission lines. The proposed plot gives a novel selector to recognize the interior fault of an intensified line from an outer fault as well as to recognize the exact fault line area of an inward fault. The proposed plan would thus be able to yield a correct answer for fault location estimation of a multi section line to maintain a strategic distance from the many-sided quality of multi solution calculations.

II. PROPOSED METHOD

A] POWER SYSTEM MODEL

Figure 2.1 shows the power system model designed in Simulink / Sim Power System including transmission and distribution power system. Newly developed micro grid model was designed by integrating a 10 MVA wind farm and a 200 kW solar farm with the distribution network. The power system is composed of a 100 MVA conventional power plant, composed of 3-phase synchronous machine, connected with 260 km long 154 kV distributed-parameters transmission line through a step-up transformer TR1. At the substation (TR2), voltage is stepped down to 22.9 kV from 154 kV. High power industrial load (6 MW) and low power domestic loads (1 MW each) are being supplied by separate distribution branch networks. The wind farm is directly connected with the branch network (B1) at bus B3 through transformer TR3 and solar farm with MPPT is connected at bus B4 through transformer TR7, are providing power to the domestic loads. The 10 MVA wind farm is composed of five fixed-speed induction-type wind turbines each having a rating of 2 MVA. At the time of fault, the domestic load is being provided with 3 MVA out of which 2.7 MVA is being provided by the wind farm.

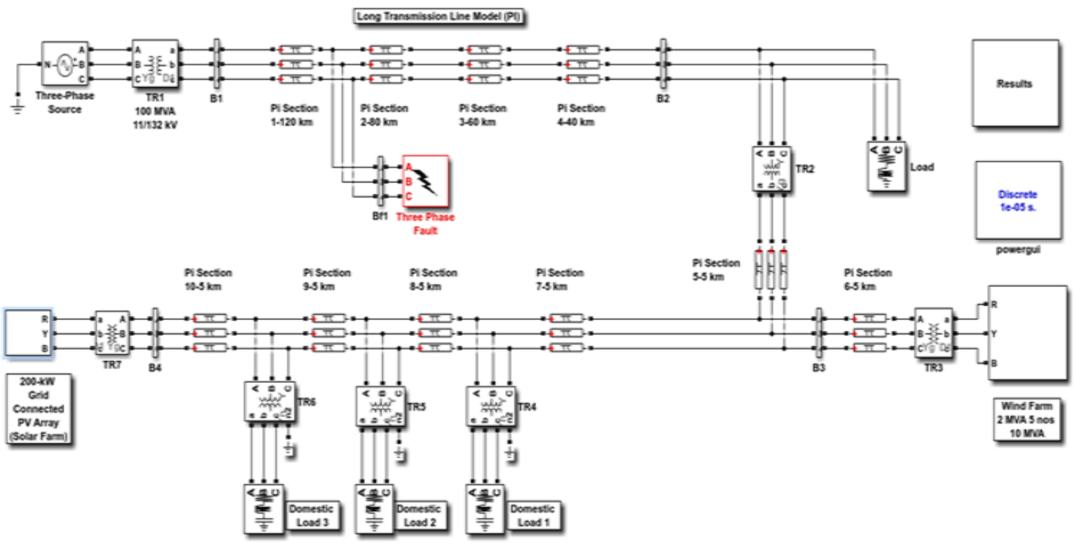

Figure 2.1: Smartgrid model with DG sources with transmission and distribution network in MATLAB / Simulink with SDFT based PMU for locating fault in distribution system.

B] SOLAR SYSTEM MODEL

A 200 kW solar farm is modelled in MATLAB/Simulink with two PV arrays each of 100 kW connected in parallel with varying solar irradiance and separated P and O based MPPT control as shown in figure 2.2. PV array consists of Npar strings of modules connected in parallel, each string consisting of Nser modules connected in series. The four PV model parameters (photo generated current Iph, diode saturation current Isat, parallel resistance Rp and series resistance Rs) are adjusted to fit the following four module characteristics measured under Standard Test Conditions (STC) (Irradiance 1 kW/m2 , cell temperature 25 degree celcius) and assuming a given diode quality factor (Qd) for the semiconductor:

Voc = open circuit coltage

Isc = Short circuit current

Vmp and Imp = Voltage and current at maximum power point.

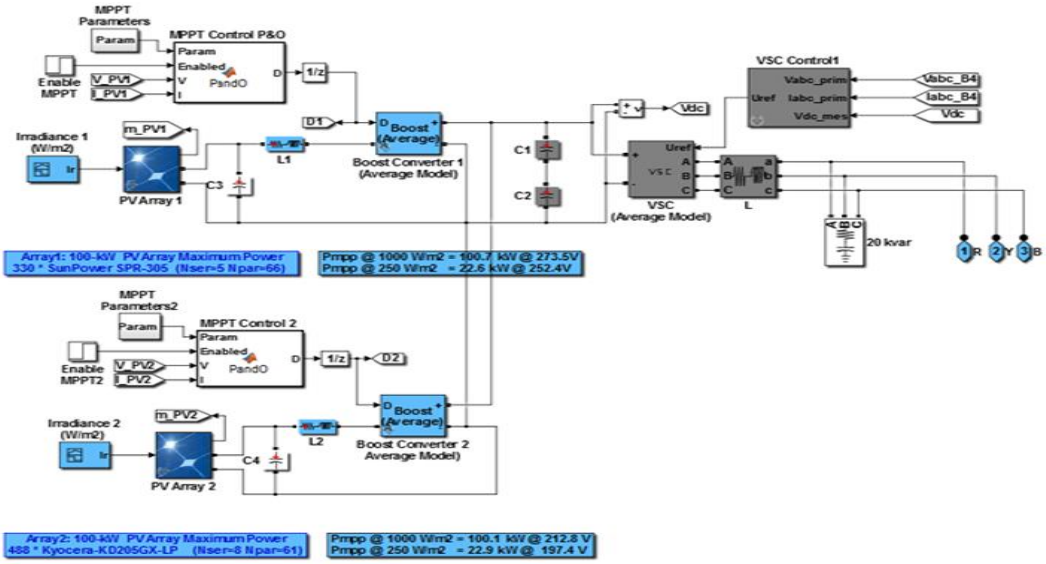

Figure 2.2: Solar plant (200 kW) model in Simulink with MPPT control

Module characteristics are extracted from National Renewable Energy Laboratory (NREL) system advisor model. PV Array1 is a 100-kW SunPower SPR-305 PV Array (Nser = 5 Npar = 66) with maximum power 100.7 kW with solar irradiation 1 kW/m2 at 273.5 V and 22.6 kW with solar irradiation 0.25 kW/m2 at 252.4 V

For several solar radiations varies between 0 to 1 kW/m2 in the steps of 0.25kW/m2 and for a constant temperature equal to 25 degree celcius, presented the I-V and P-V characteristic of PV Array1 (SunPower SPR-305-WHT) in figure for a module and in figure for a array. Current and power output decreases with the decrease in solar irradiance.

C] SDFT ON THE INPUT SIGNAL TO EXTRACT FUNDAMENTAL FREQUENCY, MAGNITUDE AND PHASE ANGLE.

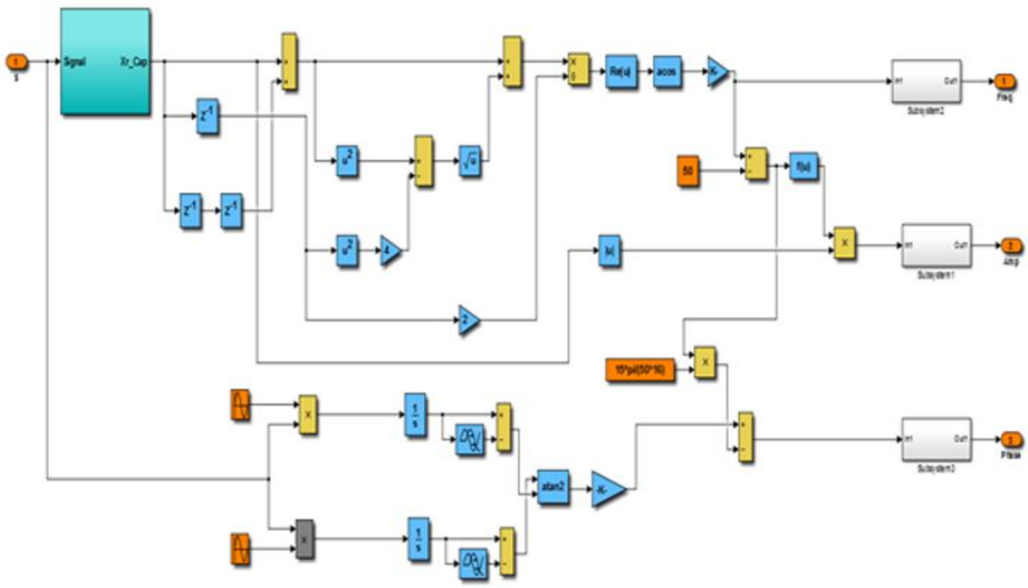

Figure 3.3: Modelling of SDFT.

The 10 MVA wind farm is composed of five fixed-speed induction-type wind tur bines each having a rating of 2 MVA. Five such Squirrel Cage Induction Generators (SGIG) each of following ratings is used. Figure implements a three phase synchronous machine (squirrel cage) modelled in a selectable dq reference frame (rotor). Stator and rotor windings are connected in star to an internal star point.

Table 2.1: Parameters of the SGIG

Wind speed	11 m/sec
Stator resistance	0.016 pu
Stator inductance	0.06 pu
Rotor resistance	0.016 pu
Rotor inductance	0.06 pu
Mutual inductance	7 pu
Inertia constant	5
Pole pairs	2

III.SIMULATION RESULTS

The above described system is simulated in healthy condition with DG sources and then it is simulated to observe the effect of different faults on distribution system fault location at different distances in the distribution network. For a severe kind of fault like three phase short circuit, observed waveforms for three phase voltage, current and power are given below.

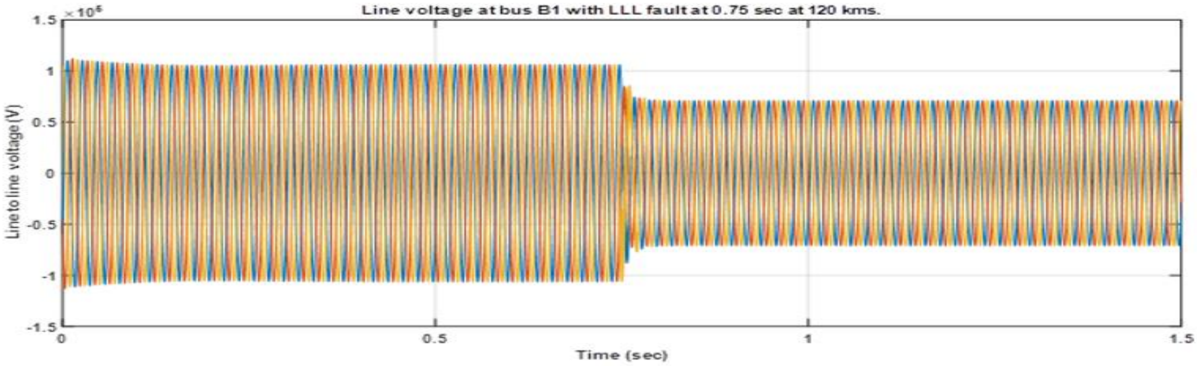

Figure 3.1: Three phase sending end line voltage in transmission circuit (V) at bus B1 with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

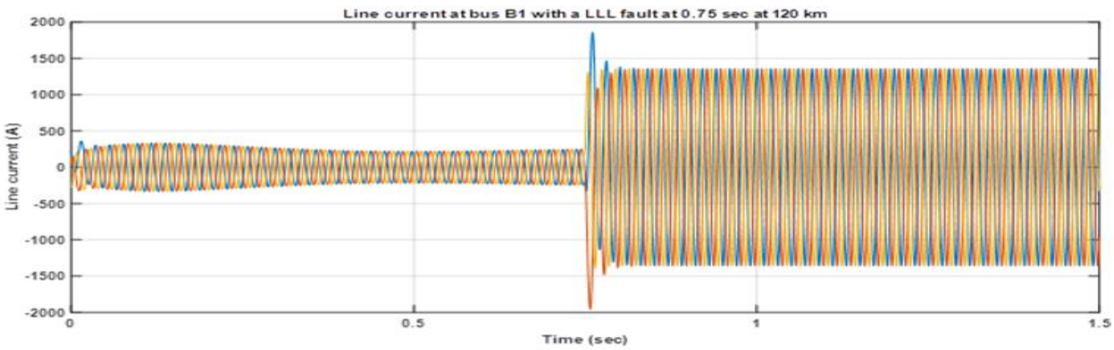

Figure 3.2: Three phase sending end line current in transmission circuit (A) at bus B1 with a LLL fault in transmission circuit at 0.75 sec at 120 kms

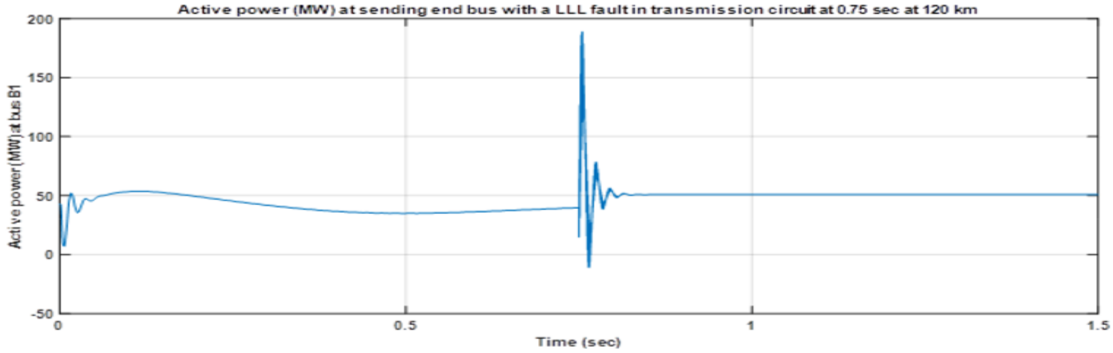

Figure3.3 : Three phase sending end active power in transmission circuit (MW) at bus B1 with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

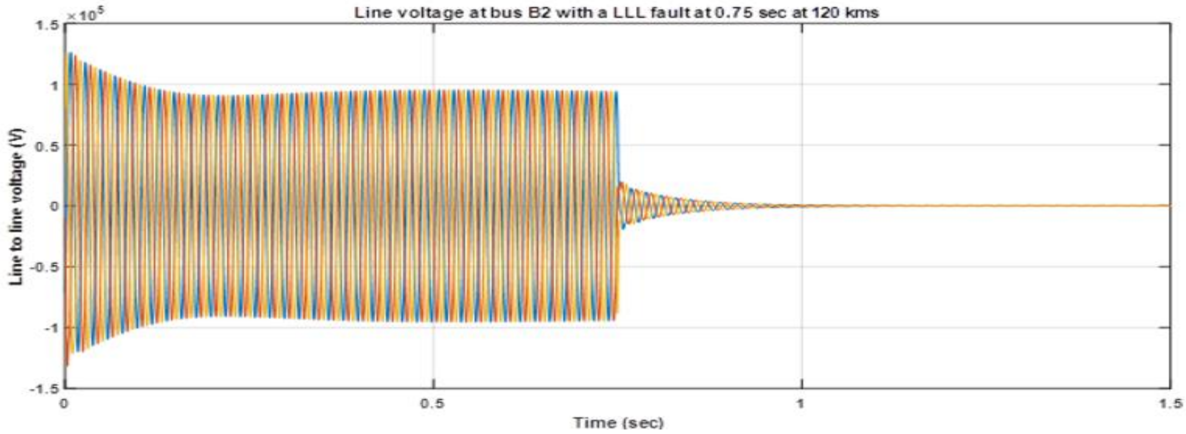

Figure 3.4: Three phase receiving end voltage in transmission circuit (V) bus B2 with a LLL fault in transmission circuit at 0.75 sec at 120 km.

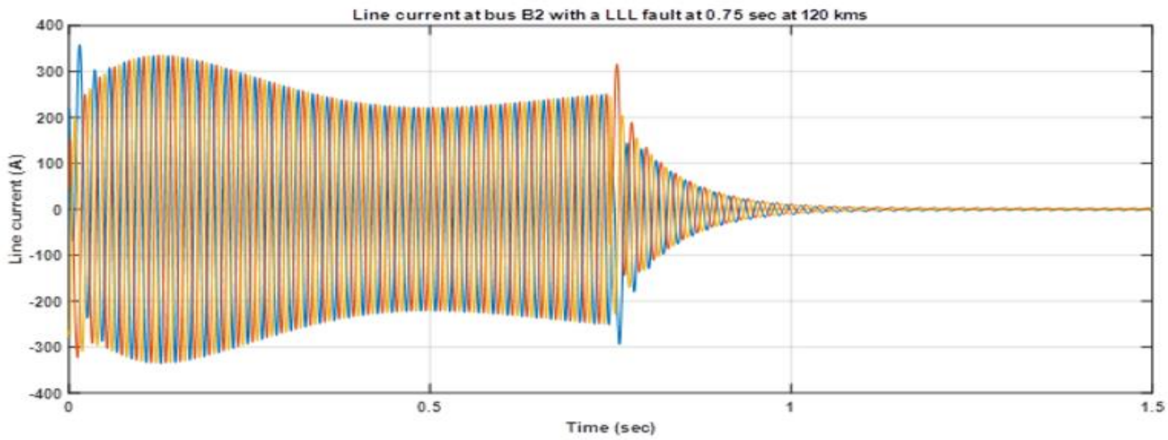

Figure 3.5: Three phase receiving end line current in transmission circuit (A) at bus B2with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

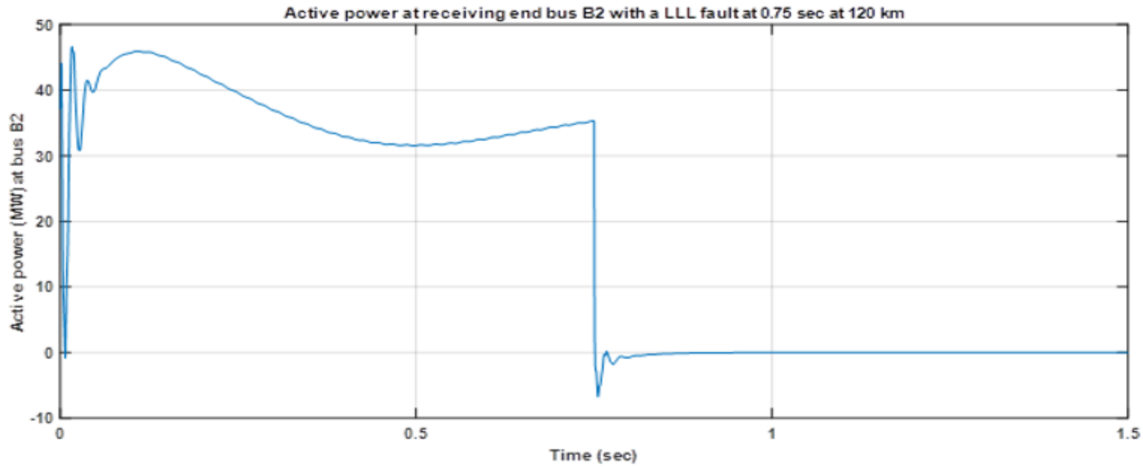

Figure 3.6 : Three phase receiving end active power in transmission circuit (MW) at bus B1 with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

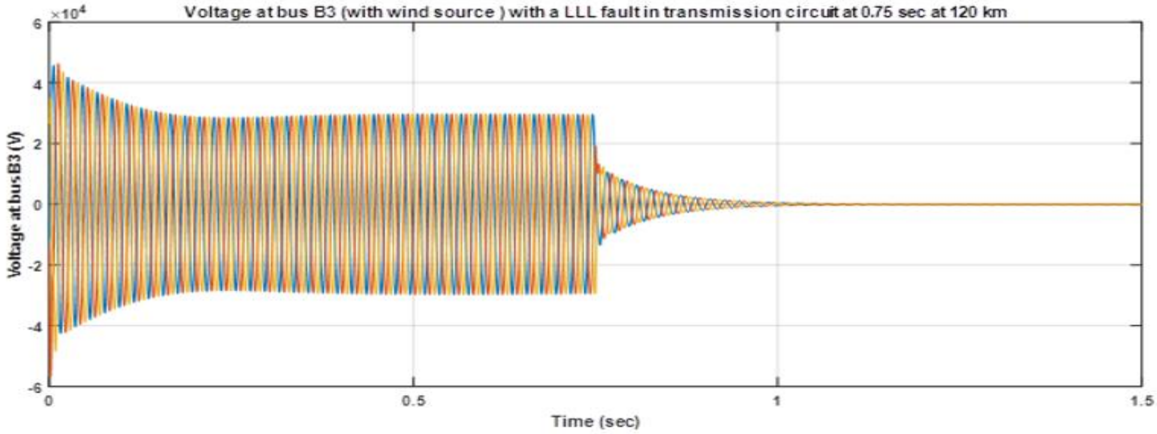

Figure 3.7: Three phase line voltage (V) at bus B3 to which wind farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

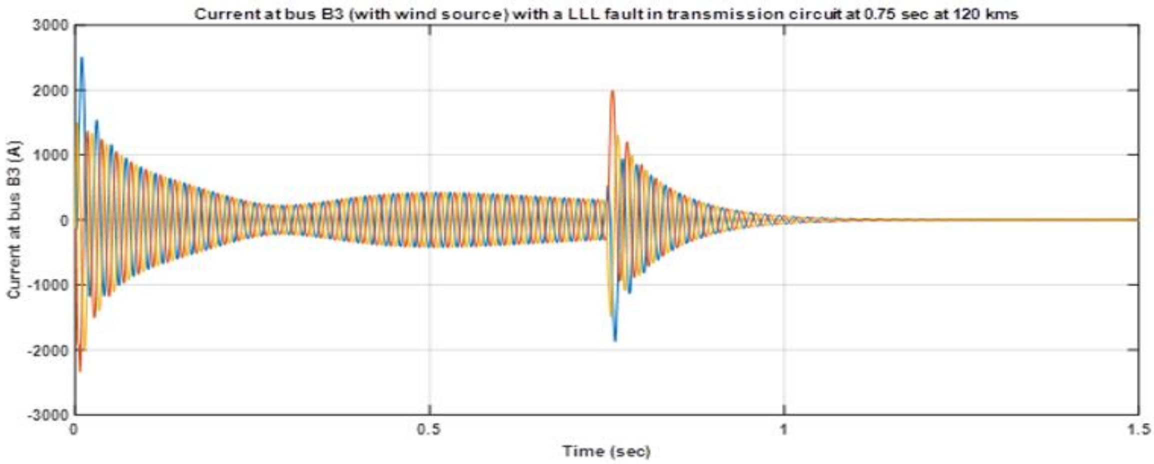

Figure 3.8: Three phase current (A) at bus B3 to which wind farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

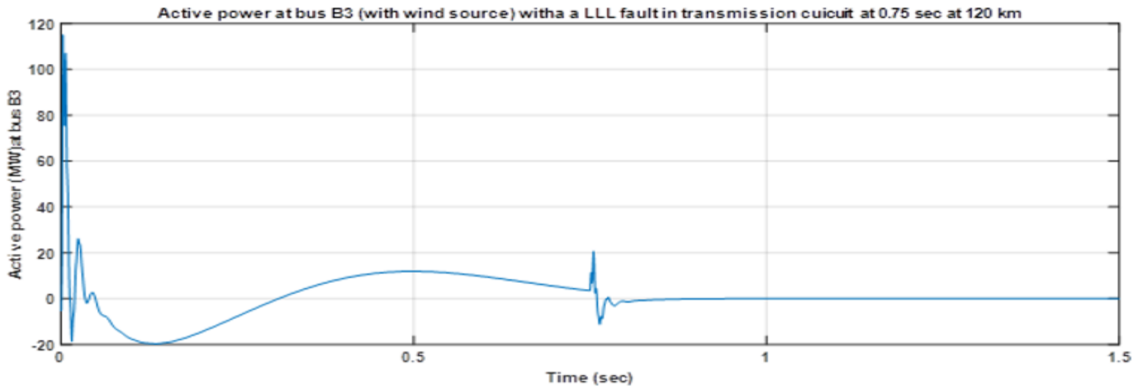

Figure 3.9: Three phase active power (MW) at bus B3 to which wind farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

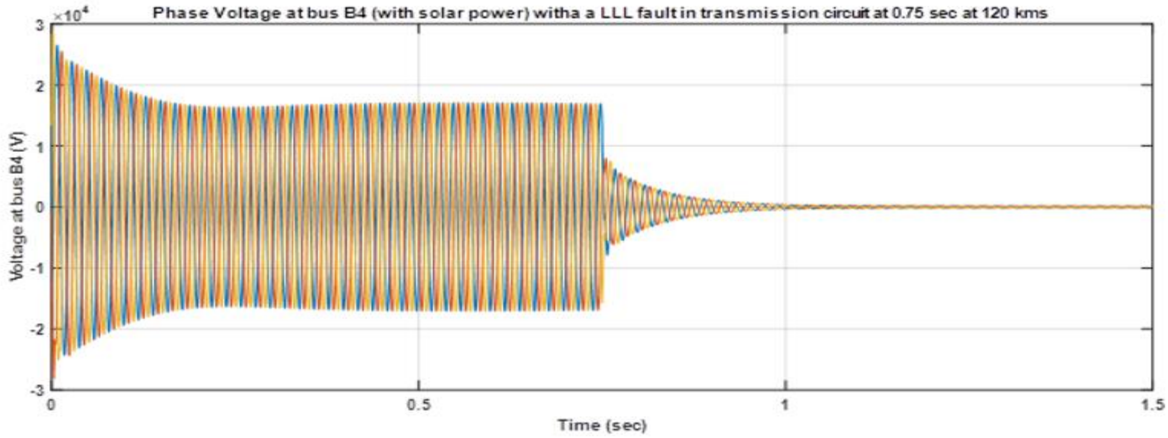

Figure 3.10: Three phase voltage (Vphase) at bus B4 to which solar farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

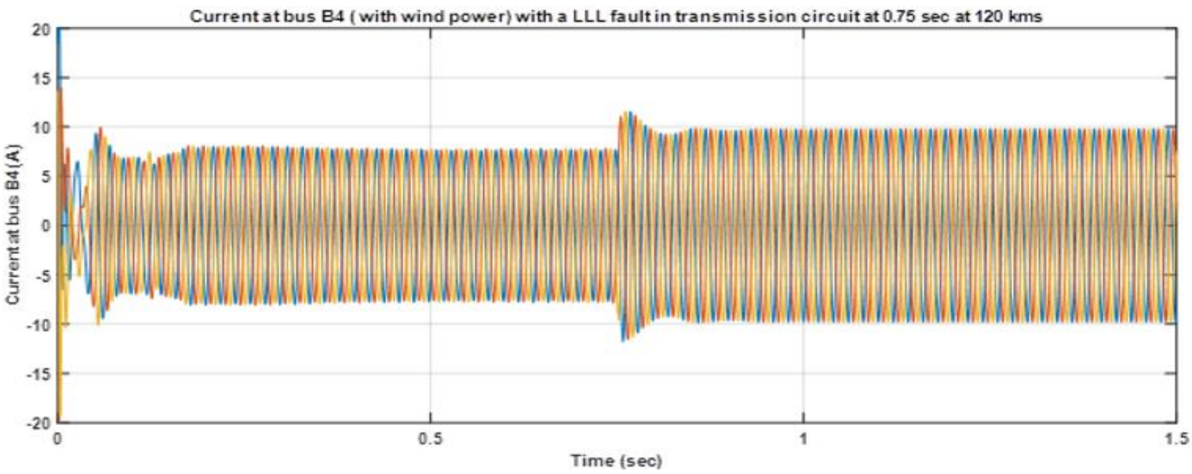

Figure 3.11: Three phase current (Iphase) at bus B4 to which solar farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

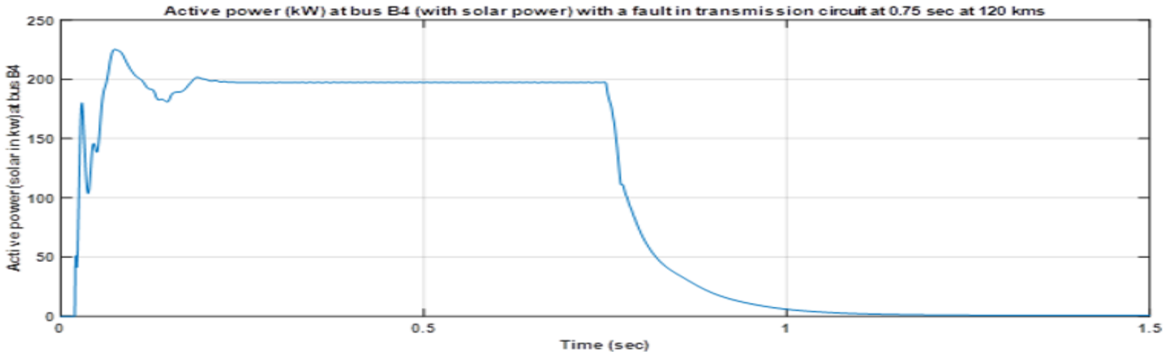

Figure 3.12: Three phase active power (kW) at bus B4 to which wind farm is connected with a LLL fault in transmission circuit at 0.75 sec at 120 kms.

The voltage and current phasors are obtained by Smart Discrete Fourier Transform (SDFT). We assumed that a line-to-ground fault with fault resistance of 0.001 ohm. The voltage and current phasors are obtained by Smart Discrete Fourier Transform (SDFT) We assumed that a line-to-ground fault with fault resistance of 0.1 ohm occurs at various locations along the line and applied the proposed method to each case. Simulation results are tabulated in Table 3.1with estimation error . Three phase fault (LLL), Three phase to ground (LLLG), Double line to ground (LLG) and Line to ground fault (LG) at different distances. It can be found that the errors range from -1.6317 to 15.7346% and minimum error is 0.0118 which is nearly zero, which means the suggested method is quite useful in fault location problem. Actually, in finding the phasors of voltage and current, it is inevitable to have some error due to DC offsets.

Table3.1 : Located distance for different faults at various locations and % distance error.

Actual Fault Distane (km)	LLL(SC)Fault		LLL-G Fault		L-G Fault		LL-G Fault	
	Located Distance (km)	Error %	Located Distance (km)	Error %	Located Distane (km)	Error %	Located Distance (km)	Error %
0	0.0353	0.0118	0.0353	0.0118	0.0353	0.0118	0.0353	0.0118
120	120.18	0.0603	120.18	0.0603	120.18	0.0603	120.18	0.0603
200	200.47	200.4754	200.47	200.4754	200.47	200.4754	200.47	200.4754
260	260.89	260.8942	260.89	260.8942	260.89	260.8942	260.89	260.8942
300	301.24	301.2496	301.24	301.2496	301.24	301.2496	301.24	301.2496

CONCLUSION

In this paper, we have run a great deal of MATLAB simulations. These simulation data are utilized to evaluate the performance of the proposed algorithm under the various fault events. A special filtering technique so called the SDFT method has been develop to solve such problems mentioned above. The performance of the SDFT method for extracting true system frequency and fundamental phasors has been verified. Combining robust fault location index, parameter estimation algorithm, the SDFT method, and the well-designed PMU, the proposed technique will be an adaptive, high performance, and low cost fault detection/location technique. Simulation results are tabulated in Table 5.8 with estimation error for different faults like Three phase fault (LLL), Three phase to ground (LLLG), Double line to ground (LLG) and Line to ground fault (LG) at different distances. It can be found that the errors range from -1.6371 to 15.7346% and minimum error is 0.0118% which is nearly zero, which means that the suggested method is quite useful in fault location problem.

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