International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com ǁ PP. 140-144

Identification Faults on Transmission Line by using Phasor Measurement Unit (PMUs)

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Abstract: The phenomenal growth of power system network both in terms of geographical sprawl as well as technological advancements, it requires tools for dealing with the system, wide disturbances that often cause widespread catastrophic blackouts in power system networks. When a major disturbance occurs, protection and control measures play the most important role to prevent further degradation of the system, to restore the system back to a normal state and minimize the impact of the disturbance. Continuous technological innovations in information and communication technology, novel sensors and measurement principles in general have promoted the advent of Phasor Measurement Units (PMUs). This paper describes the modelling and testing of Phasor Measurement Unit for two bus transmission line system for identification faults(like LG fault) using MATLAB/Simulink. Since PMUs are costly device therefore module wise testing and analysis are essential. For such modelling and testing, software based analysis is the best approach. This has been done through MATLAB and the results were analysed.
Keywords: PMU, LG Fault, MATLAB.

I. INTRODUCTION

The complexity of Indian power system is increasing rapidly due to factors like demand growth, increasing machine size, long distance power haulage, integration of renewable energy sources, increased competition in electricity market and Large seasonal load variations. The skewed availability of energy resources, the load pockets over large geographical regions in the country results in transmission of power over long distances. The power grids are expected to operate closer to their limits in order to maximize utilization of the network. In such a scenario, the role of the system operator has become very critical and a judiciary balance has to be struck between the market and margins towards security of the interconnected Power System.

The decision of system operator in Sub-Load Dispatch Centers, Regional Load Dispatch Centers (LDC) and National Load Dispatch Center greatly depends on the data or information available to them in real time. The existing (SCADA) Supervisory Control and Data Acquisition System or (EMS) Energy Management system acquire analog and digital information such as voltage, frequency, active and reactive power flows and circuit breaker status through RTU's/SAS spread throughout the system. This information is updated once in every 4-10 seconds at respective LDCs. This information is not time synchronized. Lack of an accurate coordinated time stamp for the data recorded, makes reconstruction of a time line difficult and time consuming. In addition, the lack of coordinated time stamping of data may lead to suspect the recorded data when it is used to reconstruct a timeline of events among Disturbance Recorders (DR) and Event Loggers (EL).

Synchrophasor Measurement Technology comprises of Phasor Measurement Units (PMUs), Phasor Data Concentrators (PDCs), Historian, Communication Network, real time visualization and offline tool boxes with following distinct features

- Phasor measurement units reports 25 to 50 samples of power system data in a second with synchronized time stamp. This is much faster as compared to existing conventional technology.
- Phasor data concentrator collects the data from PMUs and aligns this data with corresponding time. In addition to that the PDC also checks time alignment, synchronization quality and feed this data to Historian.
- Historian archives the PMU data for a period of few years depending on the storage capacity. The data can be retrieved in user readable format and can be used for post-disturbance and postmortem analysis. This data can also be exported or imported in required standard format.
- Communication networks consist of high speed wide band communication infrastructure (optical fibers) from substation to control centers.

- Real time visualizations and common trends graphs of voltages, currents, frequency, angular separation of voltages or currents between the nodes, MWs, MVARs and rate of change of frequency. Based on these trends, alarms can be raised for decision making.
- Offline toolboxes consist of Signal Analysis Methods, Oscillation Monitoring Systems and Voltage Stability Analysis etc.

II. PHASOR MEASUREMENT UNIT (PMU)

A constant phasor implies a stationary sinusoidal waveform, in practice it is necessary to deal with phasor measurements which consider the input signal over a finite data window. In many PMUs the data window in use is one period of the fundamental frequency of the input signal. The phasor diagram shown in Fig: 1.

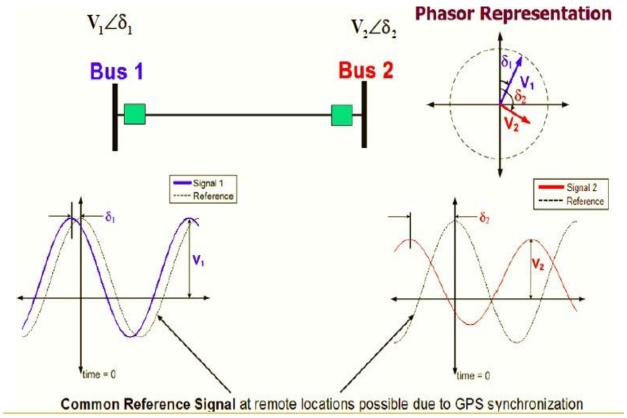

Fig: 1 Phasor Representation

If the power system frequency is not equal to its nominal value (it is seldom), the PMU uses a frequency-tracking step and thus estimates the period of the fundamental frequency component before the phasor is estimated. It is clear that the input signal may have harmonic or non-harmonic components.

The task of the PMU is to separate the fundamental frequency component and find its phasor representation. The most common technique for determining the phasor representation of an input signal is to use data samples taken from the waveform, and apply the Discrete Fourier Transform (DFT) to compute the phasor. Since sampled data are used to represent the input signal, it is essential that anti-aliasing filters be applied to the signal before data samples are taken. The anti-aliasing filters are analog devices which limit the bandwidth of the pass band to less than half the data sampling frequency (Nyquist criterion). It should also be noted that the normal output of the PMU is the positive sequence voltage and current phasor. In many instances the PMUs are also able to provide phasor for individual phase voltages and currents.

III. CASE STUDY: SIMULATION RESULTS

The case study is done for a simple two bus system subjected to common LG fault. The output and input wave forms are shown with and without LG fault. The following data used for simulation.

Voltage Rating: 220kV System
Frequency: 50 Hz
Line Constant: R0 = 0.01273 (Ohms/Km);
R1 = 1 0.3864 (Ohms/Km)
L0 = 0.9337mH (H/Km);
L1 = 4.1264 mH (H/Km)
C0 = 12.74 nF (F/Km);
C1=7.751 nF (F/Km)
Transmission Line Length: 100km
Filter: Type: Butterworth Low Pass Filter Order: 8;
Pass band edge frequency: 380 rad/Sec
ADC: Sample Time: 50 μs
Transformer rating – 13.8/220 kV
Primary: 13.8 kV, R1=0.002 p.u, L1=0.08p.u
Secondary: 220 kV, R2 =0.002 p.u, L2=0.08p.u

Individual modules of PMUs are modeled to determine module wise output. The results of the output of both the PMUs are compared to analyze the synchronization process. Simulink includes various basic power system components, which can be utilized for modeling of all kinds of power system network simulations. Since all the electrical parts of the simulation interact with the Simulink's extensive modeling library, it provides a platform not only to easily draw the power system network, but also enables its interactions with every electrical component.

The 3- phase input voltages from P.T during modeling is stepped down to ±10V and fed to the low pass filter which filters the high frequency noise and results in the output as shown in Fig 2. The 3- phase outputs are well balanced with no noise present in it. Thereafter the filtered output available is sampled. The sampling process produces discrete output. Discrete Fourier Transformation (DFT) is performed on the discrete output to obtain phasor estimation of the fundamental voltage component and transmission line LG faults. This is illustrated in Fig. 3 to Fig. 9.

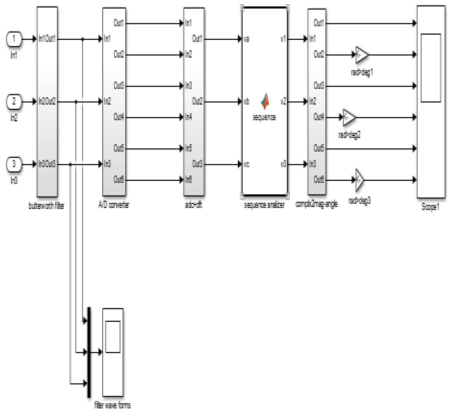

Fig: 2 PMU Simulation Block

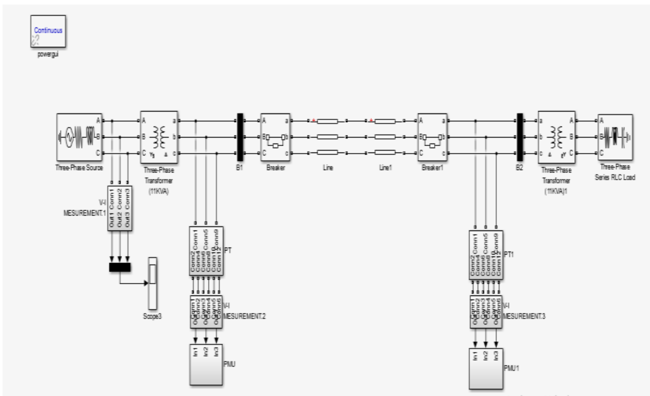

Fig: 3 Two Bus System Without Fault

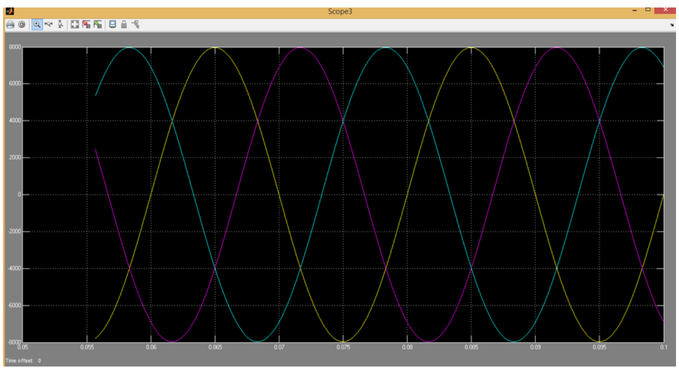

Fig: 4 input wave form

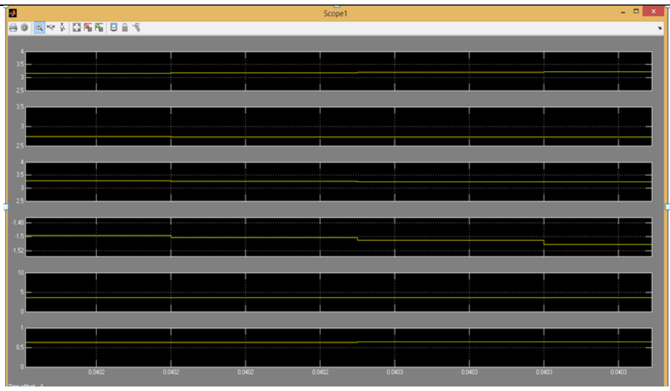

Fig: 5 output of PMU1

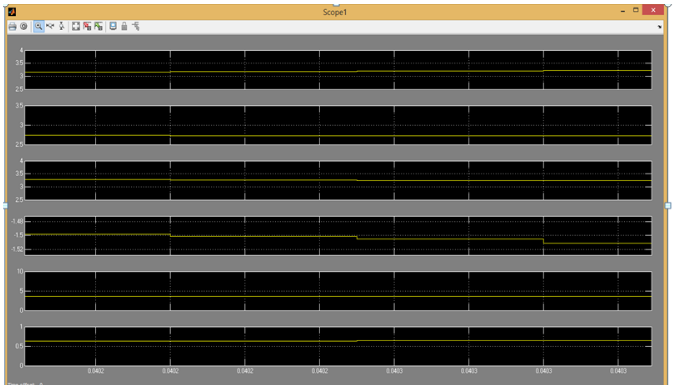

Fig: 6 output of PMU2

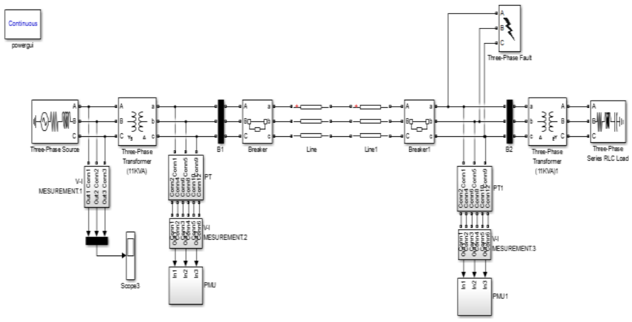

Fig: 7 Two Bus System With Fault

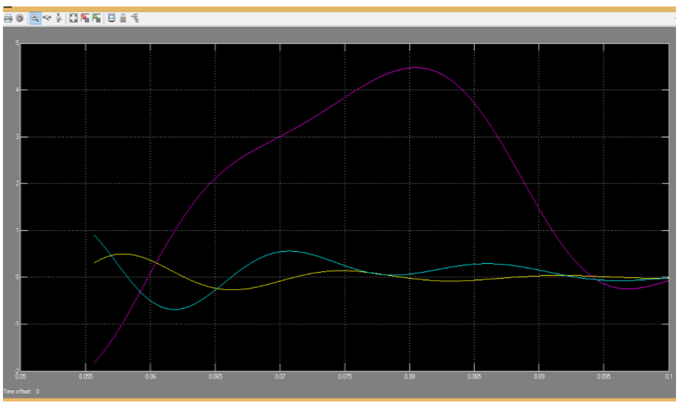

Fig: 8 output wave form butter worth filter under LG fault

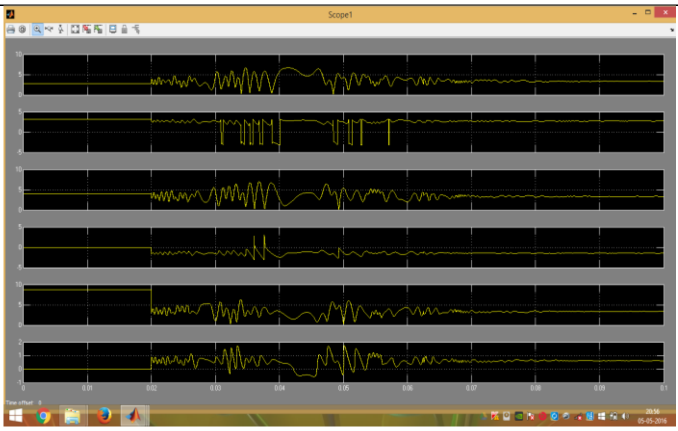

Fig: 9 output of PMU 2 under LG fault

IV. CONCLUSION

The PMUs are edifice for wide area monitoring and control of modern power system. The PMUs are costly equipment, analysis by actual hardware testing of its module involves considerable cost and also time. To avoid these complications, an approach using software based analysis performed in this paper. The simulated performances of the PMUs validate the efficacy by being verified through analytical approach.

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