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Fault Analysis with PMU Data in a Interconnected Network Transmission System with STATCOM

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***Abstract*— With the phenomenon growth of power system in terms of both technological advancement and geographical sprawl has lead to introduction of new unit for eradicating the disturbances that often cause calamitous, widespread catastrophic blackouts in power system networks. So phasor measurement unit (PMU) has become defensive system for tripping such failures in the system. This paper allows identification of various faults by utilizing real time data collected from various Phasor measurement unit(PMU)s and develop the backup protection for wide area systems using phasor measurement units (PMUs) and static synchronous compensator (STATCOM). This paper describes the modelling and testing of PMU based protection for 14 bus system using STATCOM and this has been done through MATLAB/ Simulink for analysing the results.**

***Index Terms*— Phasor Measurement unit (PMU), Static Synchronous Compensator (STATCOM), Synchronised Measurement Technology (SMT)**

I. INTRODUCTION

Phase angles and magnitudes of voltages and currents are important parameters in electrical network system,any disturbance in the two parameters creates major blackouts for the entire network system. Discharges due to lighting, reduction in the clearance of insulation by undergrowth, variations of various loads due to unpredictable natural calamities, overloading of lines, swinging of generator rotors which in turn contributing transmission lines swings, cascading voltages, power swings, maloperation of various protective relays, reduction of reactive power at various load centres, increase in reactive power consumption etc. are some of the important parameters for the major blackout of the network system. Previously, measuring technology was mainly concerned about measurement of voltage difference and real power flow during planning and construction of network system. Later direct measurement of phase angle difference in the network was used, along with some of the satellites and radio transmission networks, like GOES, HBG, and LORAN-C, Where the accuracy was about 40µs. Then comes the microprocessor based relays which also failed due to insufficient storage of unmanageable calculations of the faulted system. Finally new technology was introduced for the wide area measurements with little moderation to the concept of symmetrical components. Symmetrical components are used for performing various fault calculations in one equation, later symmetrically based algorithm was introduced along with synchronised measurement technology for protecting the various interconnected network system from various dangerous faults.
For high voltage transmission line, line charging current causes significant deviation in phase angle from

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one end to another.[1]B Kasztenny et al proposes a method for phase angle comparison with the help of compensation of line charging currents using synchronized measurements[2].V.Terzija et al highlights on phase angle monitoring (PAM) that it allows early identification of potential problem both locally and regionally. Pam assist in real time operation by monitoring angle separation or rate of change of angle separation between two buses to determine the stress on the system.[3]E.Martinz et al used positive sequence voltages magnitudes and angles for wide area protection, control to improve the reliability of generator shedding schemes.[4]M.Eissa et al proposes philosophy of the protection scheme depends on comparing positive sequence voltage magnitudes at each bus during fault condition inside a system protection centre to detect the bus nearest to the fault.

Phasor measurement Unit plays a vital role in wide area measurement system .PMU with WAMS is the new proposed technology that has been introduced for providing backup protection for the third zone of network system in order to keep the system secure from various blackouts.PMU receives real time data that are available from interconnected network system and it also receives real time data available from GPS .Data available in PMU is compared for obtaining synchronized time samples. The synchronised data for various faults are collected from various PMUs at different locations of power systems. Detects the internal and external faults and thereby system is protected using STATCOM.

II. ZONE -3 OUTAGES

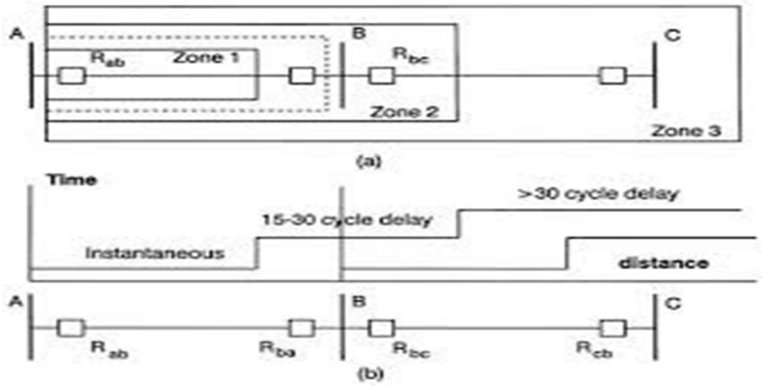

Fig 2.1 Zones of protection

Zone 3 is used as back up protection for entire network system. Settings of zone 3 is adjusted such that it covers zone1,zone2 with 25%of the next line. This zone is longest protective zone covering primary zone transmission line, secondary protective zone i.e large transmission line of zone 2 with 25%of further transmission line in zone3. Zone3 has operating time delay for about 0.4 to 4 sec. Although it is being a major back up protection fails due to damage of transmission lines, substations, overloading of electrical equipments and distribution system parameters. Because of the failure of zone3 three different types of outages are created.

- Permanent outages
- Brown out
- Black out

Permanent outages are seen in transmission lines which are responsible for major power loss, Once faults are cleared power is automatically restored. Brown out seen in lightening discharges voltage sags, dip or drop of voltage in electrical supply. It causes bad performance of equipments an in accurate operation of a network system. Black out is most severe and serious outage that causes heavy loss of power in the network system. Black out is due to tripping of lines, power swings, rotor swings etc. This type of outage may last fo few minutes to few hours or even few days. In order to avoid total collapse of the system new unit is introduced i.e Phasor measurement unit(PMU).PMU consists of synchronised measurement technology and it is used for analysing faults detecting the faults, identifying faults ,clearing faults and finally it makes the system secure and reliable using STATCOM.

III. Block Diagram And Protection Scheme For Proposed System

A major blackout in many of the power system network has given rise for introduction of new technology called synchronised measurement technology (SMT).

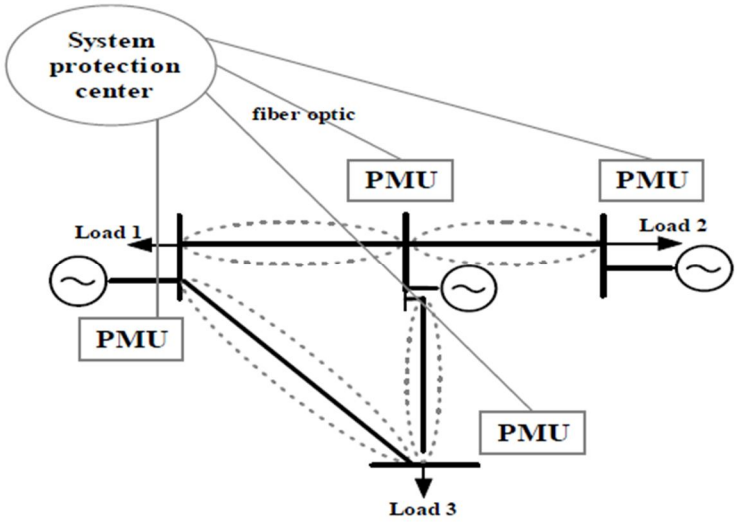

Fig. 3.1. Block diagram representation of proposed system

PMUs are installed in distribution system for wide area measurements and are interlinked with global positioning system. Datas that are available from interconnected electrical network system are sent to PMUs.PMUs along with GPS are helpful in getting voltage and current signals from local network centres for further analysis. Using synchronised measurement technology, the obtained signals are compared to identify the dangerous faults, later magnitudes and phase angles of the faulted signals are calculated to obtain sequential components .sequential components of faulted signals are fed to STATCOM a FACTS device, there by system is protected.

Iv Synchronised Measurement Technology

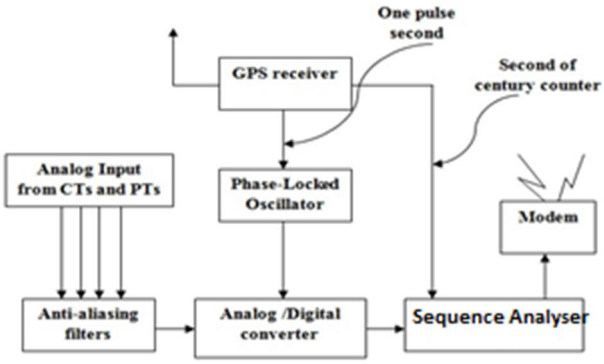

Fig.4.1. Elements of Phasor measurement unit

WAMS consists of PMU. PMU uses SMT technology for converting the faulted signal to positive sequence voltage magnitudes. PMU consists of following components:
Anti- aliasing filters, Analog to digital converters, GPS receiver, Phase locked oscillators, Phasor micro processor, communication links and modem. Three phase current and voltage signals are obtained from secondary windings of current and voltage transformers. Obtained signals are converted into voltage with

appropriate shunts and instrument transformers within the range of ±10 V, so that they are matched to requirements of analog to digital converters. This ensures that all the analog signals have same phase shift and attenuation. This ensuring that phase angle difference and relative magnitudes of the different signals are unchanged. GPS clock pulses are phase locked with sampling clock pulses in satellite.GPS receives the rate of samples in the range of 96 to 128 periodic samples within 1μs are sent to phase locked oscillators were detector detects and compares the phase of corrected signals with respective phase of input signals and finally both the signals are matched for their phases and frequencies. This phenomenon useful in obtaining synchronised signals from PMUS and GPS. These synchronised signals from PMUS and GPS are sent to A/D converters for obtaining digital signals and sent to sequence analyzer.Sequence analyzer is used for calculation of positive sequence components by the following equation:

$$V1=1/3(Va+aVb+a^2Vc)$$

where a=1∟120,Positive sequence voltage magnitudes will be calculated without any change in frequency.

V. Results And Discussions

The following 14 bus network is taken for the case study. MATLAB/Simulink package software is used for the simulation and implemented.

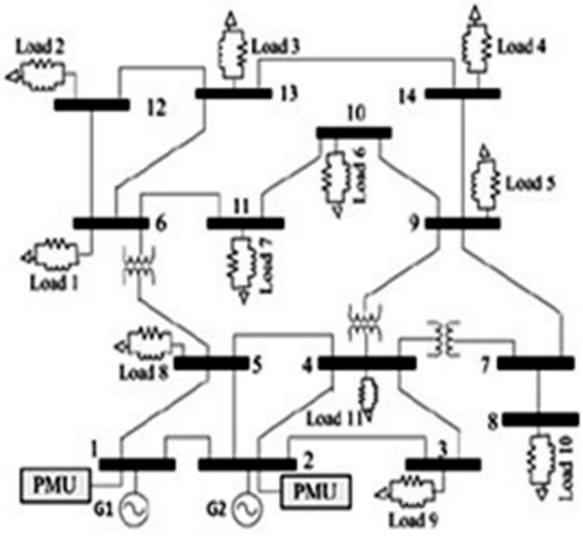

Fig:5.IEEE standard 14 bus system.

Generating station is on one side and on the other side is the load is connected through 220 KV ,100km transmission line is as shown in fig 5. 3-ϕ fault condition is simulated near 14 bus using MATLAB software.

PMUs are installed in the interconnected network system measures the 50/60 Hz AC waveforms at the rate of 48 samples per second. Global positioning system and PMU together which are linked together synchronises the samples of the various voltage and current phasors from different intersecting locations on the grid. Synchronised samples are analysed and compared for various conditions such as frequency changes, MW, MVARs, KV in order to detect faults that have been raised in the network, later various voltage levels are converted to positive sequence voltages to detect the most appropriate and nearest faults which are responsible for the disturbance of the system.

For obtaining synchronized time samples at different locations of power networks, PMUs collect real time datas of voltage and current of power networks and compares with signals obtained from GPS. Faulted voltage signals are converted to positive sequence voltage magnitudes with the help of PMUs. From Fig. 6.5 positive sequence magnitudes, are compared and nearest faults are identified.

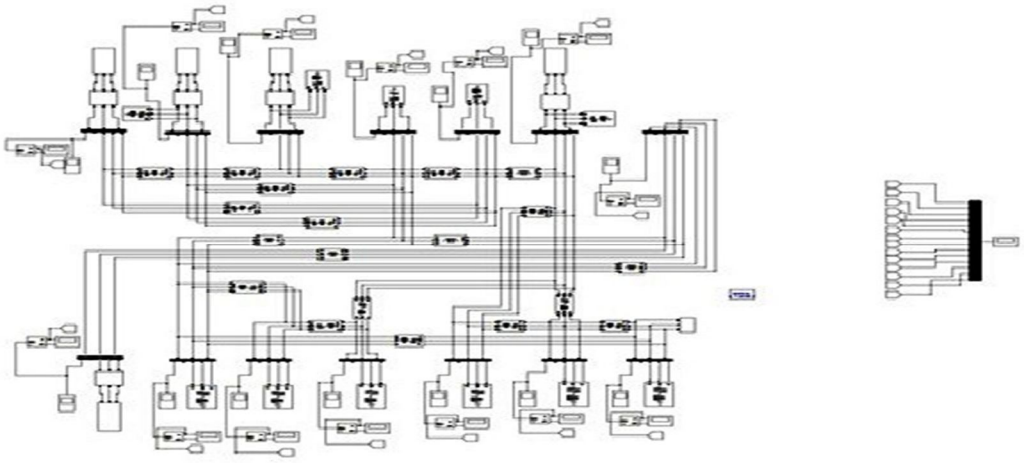

Fig.6.Positive sequence magnitudes

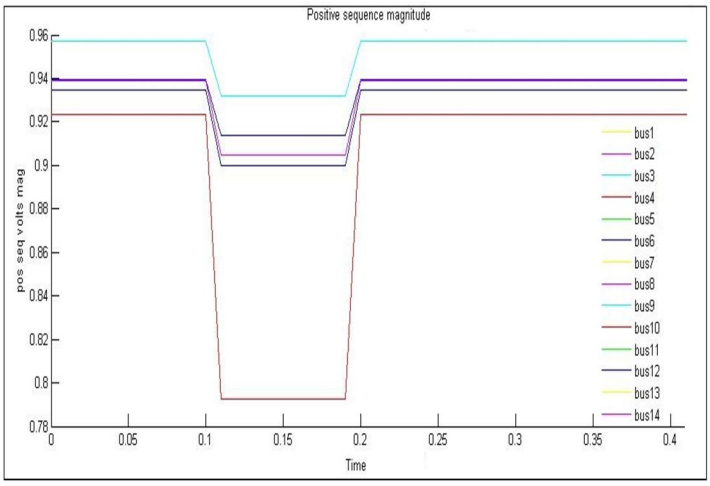

Fig. 7.Graph of positive sequence voltage magnitudes

Protection using STATCOM:

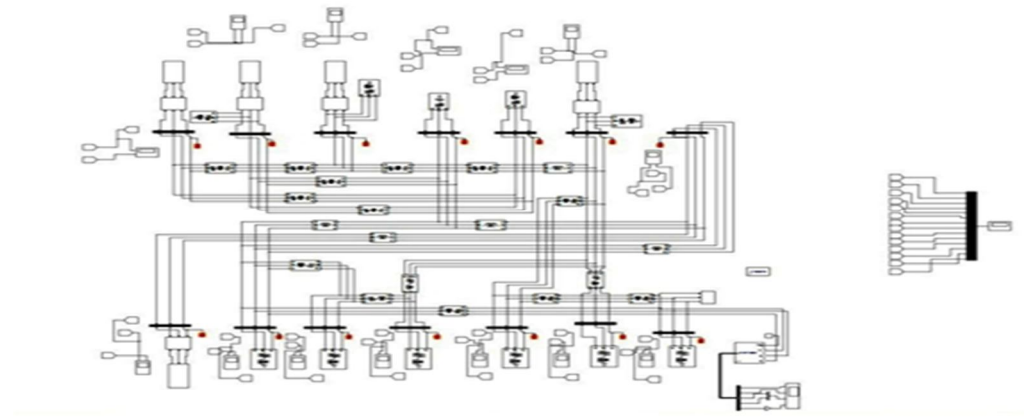

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Fig.8.Simulink Model of 14 bus system connected to STATCOM

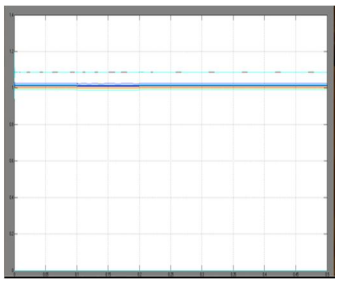

Fig. 9.Graph showing corrected voltage signals

STATCOM is connected to transmission line for providing rapid supply of dynamic VAR's during system faults for voltage support and voltage stabilization. As illustrated in Fig. 8 and Fig. 9. STATCOM is connected to faulted area injects the rective power and there by trip the STATCOM and hence system is protected.

VI. CONCLUSION

PMU is used as main protection for WAMS. The proposed system reduces the chances of blackouts. Simulation results for various faulted conditions are illustrated. The proposed scheme is suitable for protecting the transmission line for various network conditions as a backup protection; it also indentifies and isolates the faulted line for providing protective measures and to make the system secure and reliable.
The scheme outlines the idea of detecting and classifying the faults using PMUs interconnected system. The main idea of proposed system is to create the backup protection for collecting and storing the data and forwarding the tripping signals for small faults also. Test results from MATLAB simulation are satisfactory, which are useful to overcome the problems of blackouts.

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