International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2763
Issue 12, Volume 2 (December 2015) www.ijirae.com

ANALYSIS OF ASYMMETRICAL FAULTS IN 220/400 KV LINES USING FFT

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I. INTRODUCTION

An electrical power system comprises of generation, transmission and distribution of electric energy. Transmission lines are used to transmit electric power to distant large load centers. The rapid growth of electric power systems over the past few decades has resulted in a large increase of the number of lines in operation and their total length. These lines are exposed to faults as a result of lightning, short circuits, faulty equipment, mal-operation, human errors, overload, and aging. Many electrical faults manifest in mechanical damages, which must be repaired before returning the line to service. The restoration can be expedited if the fault location is either known or can be estimated with a reasonable accuracy. Faults cause short to long term power outages for customers and may lead to significant losses especially for the manufacturing industry. Fast detecting, isolating, locating and repairing of these faults are critical in maintaining a reliable power system operation. When a fault occurs on a transmission line, the voltage at the point of fault suddenly reduces to a low value.

II. FAULTS

The faults in power system are basically divided into two types:

a. SYMMETRICAL FAULT
b. ASYMMETRICAL FAULT

a. Symmetrical fault: Symmetrical faults are those types of faults in which all the three phases gets involved simultaneously. For example: triple line fault (L-L-L), triple line to ground fault (L-L-L-G). A symmetric or balanced fault affects each of the three phases equally. In transmission line faults, roughly 5% are symmetric. This is in contrast to an asymmetrical fault, where the three phases are not affected equally.

b. Asymmetrical fault: In this type of faults, the fault occurs mainly in one or two phases and are categorizes as unbalanced fault.

For example: single line to ground (L-G), double line to ground (L-L-G). An asymmetric or unbalanced fault does not affect each of the three phases equally. Common types of asymmetric faults, and their causes:

- *Line-to-line - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator.*
- *line-to-ground - a short circuit between one line and ground, very often caused by physical contact, for example due to lightning or other storm damage*

III. NUMERIC RELAY

The first and foremost driving force for advances in relaying systems is the need to improve reliability. In turn, this implies increase in dependability as well as security. This need to improve reliability propelled the development of solid state relays. Solid state relays have inherent self checking facility which was not available with electromechanical relays. This feature is also available with numerical relays. For example, when the computer is booted, it goes through a self checking phase where it checks RAM, hard disk, etc. Also, with the reduced cost of computer hardware, and an exponential growth in processing capability, numerical relays can provide high performance at moderate costs. Since, numerical relays are based on digital technology; they are more or less immune to variation or drift in parameters of individual components like OP-AMPS etc. due to changes in temperature, ageing etc. Numerical relays also help in reducing burden (volt-amperes) of Current Transformer (CT) and Voltage Transformer (VT). This is desirable because ideally sensors should not consume any power. If a sensor consumes energy from the measure and, it will automatically distort the signal. This problem is further aggravated in CTs due to non-linearity of iron core. Numerical relays offer very low impedance to the secondary of CT and hence reduce burden on CT. Numerical relaying along with developments in fiber optic communication have pioneered development of automated substations.

Once, the analog signals from CTs and VTs are digitized, they can be converted to optical signals and transmitted on substation LAN using fiber optic network. With high level of EMI immunity offered by fiber optic cable, it has become the transmission medium by choice in substation environment. Numerical relays can be nicely interfaced with a substation LAN. Further, a single fiber optic LAN permits multiplexing of multiple analog signals which is not possible with legacy arrangement

Numerical relays also permit development of new functions as well as development of *adaptive* relaying schemes. Traditionally, relaying systems are designed and set in a conservative manner. They represent compromise between: economy and performance, dependability and security complexity and simplicity, speed and accuracy, credible and conceivable. Few distinct features of numerical for it`s wide popularity are discussed below:

Cost: The processing power measured in Floating Point Operations per Seconds (FLOPS) has been steadily increasing. This is because of the technological advances in VLSI. Today, general purposes as well as high speed Digital Signal Processors (DSP) are available at reasonable cost. As such, cost of numerical relays is competitive with traditional electromechanical and solid state relays.

Self Checking and Reliability: A numerical relay just like a PC can check the health of its components periodically. In case of a failure, it can raise an alarm. No amount of periodic maintenance can provide this facility, which goes a long way in improving the reliability of digital relay.

System Integration and Digital Environment: Transmission systems were automated first to improve the reliability of the overall transmission system by use of SCADA and setting up of energy control centers.

Functional Flexibility and Adaptive Relaying: Numerical relays are programmable. A multi-purpose hardware can be programmed with many relaying schemes. With the emergence of the DSP based numerical relays, it is possible to incorporate a number of features in a relay. Further, such relays can be equipped with communication facilities thereby, opening the possibility of adaptive relaying.

IV. METHODOLOGY

1. *Data was collected from three different locations where numerical relay are use.*
2. *From the collected data various faulty signal were separated i.e L-G or L-L-G*
3. *FFT analysis of the faulty signal was done in Matlab platform.*

V. RESULT

The waveform recorded by the numerical relay during L-G fault and L-L –G is shown in figure 1-2

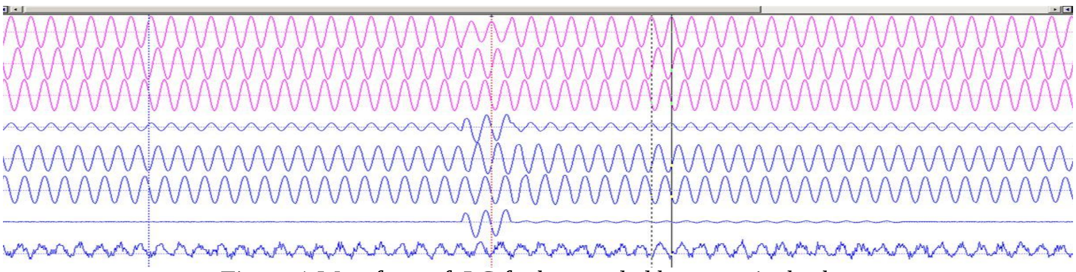

Figure 1 Waveform of LG fault recorded by numerical relay

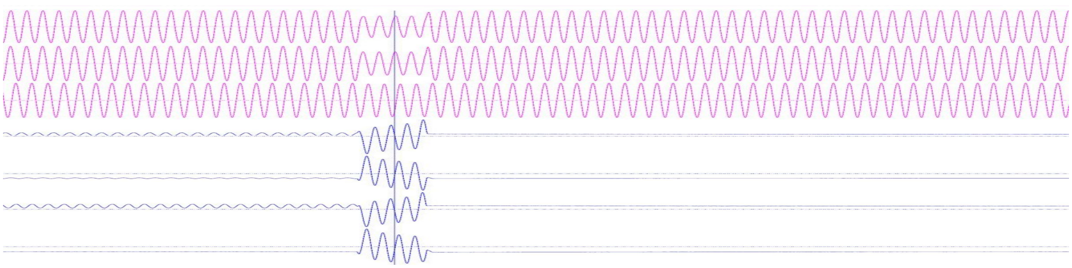

Figure 2 Waveform of L-L-G fault recorded by numerical relay

VI. CONCLUSION

On the basis of the results obtained from the numeric relay few important conclusion drawn are which are listed below separately for LG and LLG fault: The FFT analysis of the faulty signal recorded by the numeric relay are shown in figure 3-6 **in** form of bar graph.

FOR L-G FAULT:

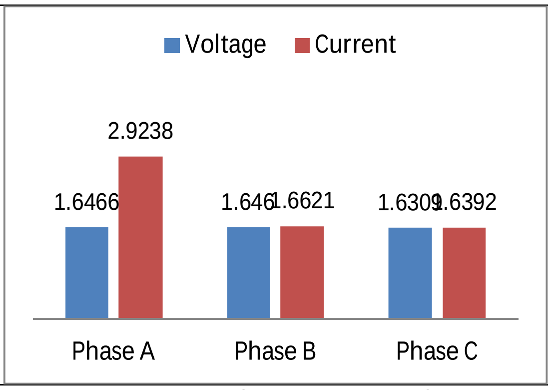

Figure 3 Comparison of Kurtosis value of Voltage and Current during LG

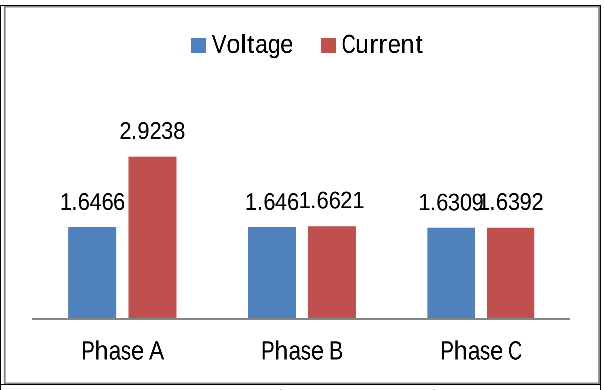

Figure 4 Comparison of RMS value of Voltage and Current during LG

- Significant increase in Kurtosis value of current in faulty phase has been observed whereas nominal increase in the kurtosis value of the voltage in the faulty phase only. During faulty condition the magnitude of current in faulty phase increase by factor 2-15 times (approximate)
- During L-G fault significant increase in the value of neutral current (I_N) is found.
- These are no change in the RMS value of voltage and current during LG fault.

FOR L-L-G FAULT:

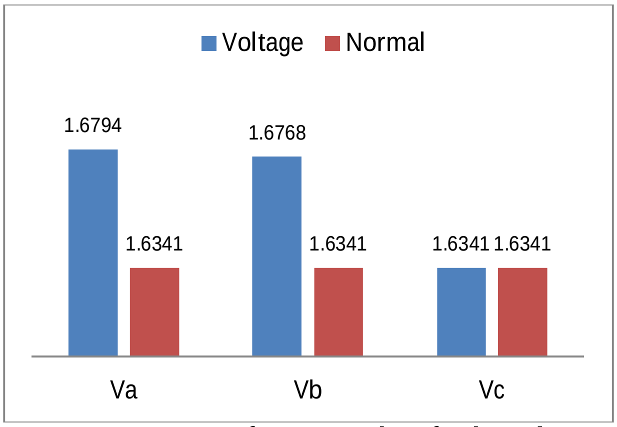

Figure 3 Comparison of Kurtosis value of Voltage during L-L-G

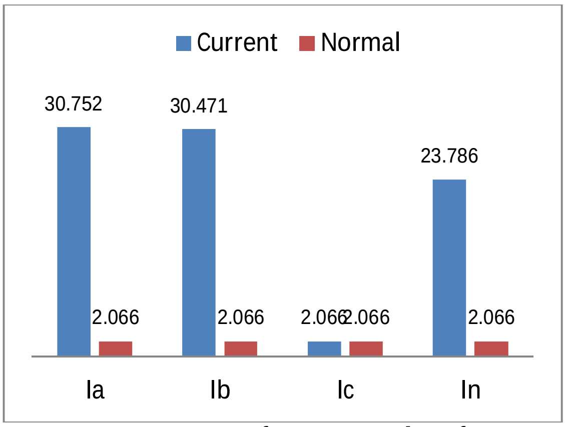

Figure 3 Comparison of Kurtosis value of Current during L-L-G

- Changes (Increment) in Kurtosis value of current is observed in the two faulty phases
- During L-L-G fault condition kurtosis value of neutral current I_N also increases.
- In case of fault, current in faulty phases increase by factor 2-10 times (approximate).

Finally it is concluded that on the basis of the FFT analysis of the recorded signal by numerical the asymmetrical fault in the power system can be determined.

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