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Power System Fault Detection and Analysis Using Numerical Relay in Power grid Corporation Limited, Shoolagiri

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Abstract: *The faults in a power system may be of various nature and they may affect the stability of the power system by causing outage of the line, there by overloading other connected lines and also causing cascading effect in the system. In order to access the nature of fault and analyze the impact of the same in a power system, fault analysis is required to be carried out as the same will be useful for the system operation and to take quick decisions in securing the system. In this paper we discuss the various types of faults in EHV system that may occur in line or substation. These faults are identified by Numerical relays which use IEDs [Intelligent Electronic Device]. The faults identified includes symmetrical and unsymmetrical faults in power system. Further in this project, we have taken into consideration the theoretical and practical study of the fault analysis through Numerical relays. In case of occurrence of Transient faults, Auto re-closure works with dead time of 1 sec. Current, voltage, Breaker status (open, close) are graphically represented by Disturbance Recorder. Events are recorded by Event logger. The above mentioned project for faults and analysis of faults in line or substation were carried out at Power grid Corporation Limited, 400 / 230kv Sub-Station Shoolagiri.*

1. INTRODUCTION

During Electrical Power System (EPS) is divided into several parts and each part classified as a system. Generation, Transmission and Distribution systems. Transmission line considered one of the main parts of EPS networks. However, EHV Transmission Line is prone to the fault. Fault in power system affect the stability by causing the outage in line by overloading other connected lines and also cascading effect in the system. In order to access the nature of the fault and analyze the impact of the same in power system, analysis is useful for the system operation to take the quick decisions in securing the system. In this paper we discuss the various types of faults in EHV system that may occur in line or substation. The faults identified includes symmetrical and unsymmetrical faults in power system. The symmetrical fault consists of line-line- line fault, it is also called three phase fault. The unsymmetrical fault consists of line to ground, line to line, line - line to ground. Earlier these faults were being sensed by electromagnetic relays and static relays, currently Numerical relays are being used.

The electromagnetic relay controls and allows electrical current to flow through a conducting coil that opens are closes the switch. It works as one relay- one function. The direction features is absent, it requires periodic maintenance. In electromagnetic relay improper fixing of plunger contacts are the major disadvantages, high burden level instruments transformers are required. The static relay is a type of relay, with an electrically operated switch, it has no moving parts. The output is obtained by the static components like magnetic and electronic circuit. It is easily affected by the high voltage surges. The working of the relay depends on the electrical components and it has less overloading capacity. As the technology evolved, several improvements from a standard fuse to the circuit breaker have also been made to the safety devices. We have been using static relays and magnetic relays for years to secure an electrical network and now the safety systems have also changed as the microprocessor have evolved.

In the present era Numerical relays which make use of Microprocessor controls & IEDs are used, so we are going to concentrate more on Numerical relay. The formed type of a static and electromagnetic relay is numerical relay. They are a system used in an electrical network to calculate electrical parameters and transform them into numerical data that is mathematically and logically interpreted to determine whether to activate an electrical network. Numerical relays have various protection functions which includes Distance relay, Directional relay, Differential relay, Over current relay, Over voltage relay. In case of occurrence of Transient faults, Auto-recloser works with dead time of 1 sec. Data collected from various parameters like Current, Voltage, Breaker status (open, close) are fed into Disturbance Recorder were all the parameters are graphically represented. Time stamping events are recorded by Event logger.

objective

- With the present trend of Renewable energy, Power system is growing at a very fast pace and it very much essential to maintain the stability of the Power system for which study on Fault & fault analysis in the power system based on which improvements can be made to ensure maximum availability of the system.
- To analyse the reliability & Speed of the numerical relays in clearing the faults in a system by comparing the Theoretical values and practical conditions by stimulating the fault.

Block Diagram: The inputs from the Instrument transformers (Current transformer & voltage transformer),is fed to the numerical relay [Intelligent Electronic Device]. Here, the numerical relay is used for automated protection. In case of a fault occurring in the transmission line the numerical relay senses the fault / type of fault. Numerical relays have the facility to detect / sense the faults which includes distance, directional, differential, over current, over voltage and accordingly protect the system by tripping the system.

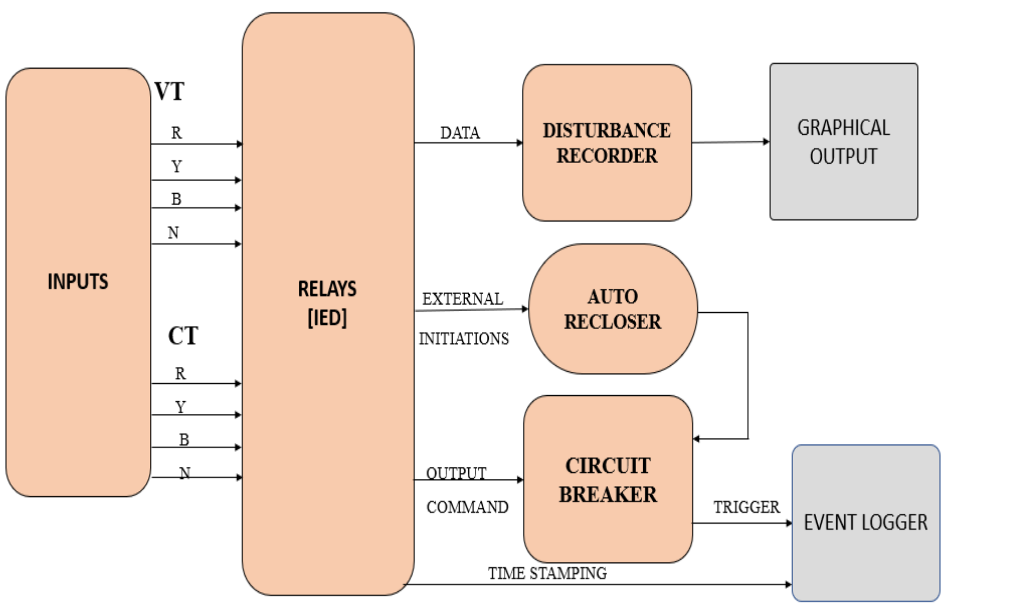

Figure 1. Block Diagram

In case of occurrence of transient fault external initiations from the relay are fed into the Auto re-closure, works with the dead time of 1 sec. In case of occurrence of permanent fault the output command from the relay are fed to the tripping circuit of the circuit breaker, thereby operating the breaker that is opening the breaker. Data from the numerical relay is fed into the Disturbance recorder for getting the graphical representation of the fault details and the parameters during the fault viz., phase wise current / Voltage etc.,. This data will be used for analyzing the fault. Time stamping events from the relay and circuit breaker triggering events are recorded and stored in the

Event logger for reference and for anlaysing the fault.

2. TRANSMISSION LINE PROTECTION

The **Introduction to Distance Protection:** Distance relays are one of the most important protection elements in a Transmission line. Distance relays respond to the voltage and current, i.e., the impedance, at the relay location. The impedance per mile is fairly constant so these relays respond to the distance between the relay location and the fault location. As the power systems become more complex and the fault current varies with changes in generation and system configuration, directional over current relays become difficult to apply and to set for all contingencies, whereas the distance relay setting is constant for a wide variety of changes external to the protected line. Unlike an over-current protection scheme, which does not have built-in backup protection, in a distance protection scheme backup is provided by arranging three sets of distance protection zones operating in tandem. In its basic form is a non-unit system of protection offering considerable Economic & Technical advantages. Unlike over current protection, the key advantage of distance protection is that its fault coverage of the protected circuit is virtually independent of source impedance variations. Distance protection is comparatively simple to apply and it can be fast in operation for faults located along most of a protected circuit.

Principles of Distance Relays: Distance protection is so called because it is based on an electrical measure of distance along a transmission line to a fault. The impedance of the transmission line is distributed uniformly along the transmission line length this provides the basis for the principle of the distance relay. Distance relaying is considered where over current relay is so slow to adopt or is not selective. Since the impedance of a transmission line is proportional to its length, for distance measurement it is appropriate to use a relay capable of measuring the impedance of a line up to a predetermined point (the reach point). Such a relay is described as Distance relay and is designed to operate only for faults occurring between the relay location and the selected reach point, thus giving discrimination for faults that may occur in different line sections. The basic principle of distance protection involves the division of the voltage at the relaying point by the measured current. The apparent impedance so calculated is compared with the reach point impedance. If the measured impedance is less than the reach point impedance, it is assumed that a fault exists on the line between the relay and the reach point. The reach point of a relay is the point along the line impedance locus that is intersected by the boundary characteristic of the relay. Since this is dependent on the ratio of voltage & current and the phase angle between them, it may be plotted on an R/X diagram. The loci of power system impedances as seen by the relay during faults, power swings and load variations may be plotted on the same diagram and in this manner the performance of the relay in the presence of system faults and disturbances may be studied.

Relay Performance: Distance protection relays are comparatively very simple to implement and it is faster in operation in the fault location in protection zone. Distance relays can also be utilized in primary and remote back-up protection in a single protection scheme. Distance relay performance is defined in terms of reach accuracy and operating time. Reach accuracy is a comparison of the actual ohmic reach of the relay under practical conditions with the relay setting value in ohms. Reach Accuracy particularly depends on the level of Voltage fed to the relay under fault conditions. The impedance measuring techniques employed in particular relay designs also have an impact. Operating times can vary with fault current, with fault position relative to the relay setting, and with the point on the voltage wave at which the fault occurs. Depending on the measuring techniques employed in a particular relay design, measuring signal transient errors, such as those produced by Capacitor Voltage Transformers or saturating CT's, can also adversely delay relay operation for faults close to the reach point. It is usual for electromechanical and static distance relays to claim both maximum and minimum operating times. However, for modern digital or numerical distance relays, the variation between these is small over a wide range of system operating conditions and fault positions.

Distance Relay characteristics: Some numerical relays measure the absolute fault impedance and then determine whether operation is required according to impedance boundaries defined on the R/X diagram. Traditional distance relays and numerical relays that emulate the impedance elements of traditional relays do not measure absolute impedance. They compare the measured fault voltage with a replica voltage derived from the fault current and the zone impedance setting to determine whether the fault is within zone or out-of-zone. Distance relay impedance comparators or algorithms which emulate traditional comparators are classified according to their polar characteristics, the number of signal inputs they have, and the method by which signal comparisons are made. The common types compare either the relative amplitude or phase of two input quantities to obtain operating characteristics that are either straight lines or circles when plotted on an R/X diagram. At each stage of distance relay design evolution, the development of impedance operating characteristic shapes and sophistication has been governed by the technology available at that point of time. Distance relay characteristics may be Mho, quadrilateral, Off set Mho etc.

Zones of distance protection: The figure below shows a three-zone step distance relaying scheme that provides instantaneous protection over 80–90% of the protected line section (Zone 1) and time-delayed protection over the remainder of the line (Zone 2) plus backup protection over the adjacent line section. Zone 3 also provides backup protection for adjacent lines sections.

3. HARDWARE REQUIERMENTS & SPECIFICATION

The high-performance, low-power Atmel 8-bit ATMEL 16A RISC-based microcontroller combines 16KB ISP flash memory, 1KB SRAM, 512B EEPROM, an 8-channel/10-bit A/D converter (TQFP and QFN/MLF), and debug WIRE for on-chip debugging. The device supports a throughput of 20 MIPS at 20 MHz and operates between 2.7-5.5 volts.By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

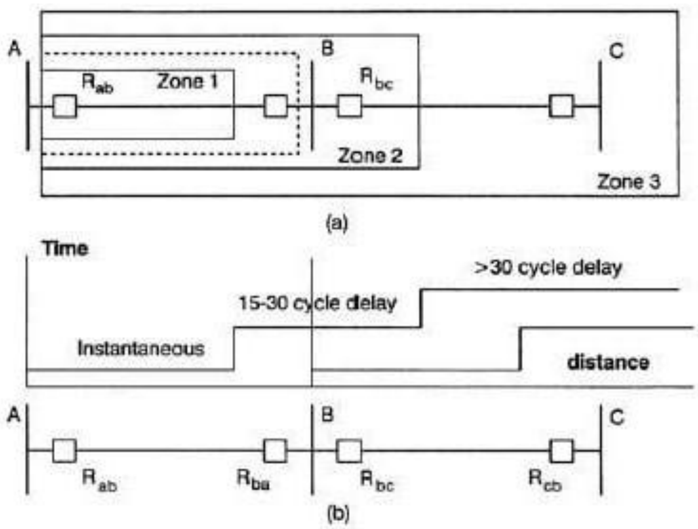

FIGURE 2. Zone 1, Zone 2 and Zone 3

Zone 1

- Zone I is mainly intended to cover the entire length of the Protected Line Length and set to operate instantaneously.
- Distance is set at 80 to 90 % of the Line and not 100% as such set to Under-reach.
- The Safety Margin of 10 to 20 % is kept for Relay / CT / PT Errors, Infeed/ Outfeed Effects and inaccuracies in line Impedance parameters.

Zone 2

- Zone II is mainly intended to cover the remaining 10 % to 20 % of the Protected Line and provide Backup for the Adjoining Lines. It set to cover Remote End Busbar and as such set to Over-reach.
- The Operating Time of Zone 2 is Delayed by 15 - 45 cycle time, so as to be selective with Zone 1 of the Adjacent Line i.e. The Zone 1 Relays that are supposed to Trip get a chance to do their job first. For a 220KV Feeder, the operating Time of the Zone 2 it is about 400ms.
- Zone II should not overlap.

Zone 3

- Zone III is primarily intended to provide Backup against External Un- cleared Faults and hence set to cover the Longest Adjoining Line.
- It covers Full Protected Line Length and Full Adjacent line plus the Safety Margin of 20 %
- The Operating Time of Zone III should be slightly more than the Zone II Operating Time. For a 220 KV Line, it is about 700 ms. In case of Long Heavily Loaded Line, the Zone III Settings should be checked for possible Load Encroachment.

In the case of parallel lines, the mutual coupling / compensation of these lines can cause distance relays to under reach and over reach. For this reason the relay setting must consider this effect, some relays have algorithms to compensate, but it is necessary to use the current of the parallel line which adds complexity to the installation.

In a three phase Power System the following faults are possible:
1. Phase to Ground Fault.
2. Phase to Phase (Double Phase) to Ground Fault.
3. Three Phase Fault
4. Three Phase to Ground Fault

Differential Protection:
Differential protection relay is a unit protection used for protection of Transformers / Bus bars / Alternators. The differential relay actually compares between primary current and secondary current of power transformer, if any unbalance found in between primary and secondary currents the relay will actuate and inter trip both the primary and secondary circuit breakers of the transformer. Differential protection schemes are mainly used for protection against Phase – to Phase faults and Phase to Earth faults. Differential Protection is generally used for Power Transformer exceeding 2 MVA rating and is based on Merz – Prize circulating current principle. The phase currents on both sides of the transformer to be protected is compared. If the differential current of the phase currents in one of the phases exceeds the setting of the stabilized operation characteristic or instantaneous protection stage of the function, the relay provides an operating signal. Over-current protection is used as a backup for differential protection. Differential protection protects the transformer from
1. Winding short circuit faults.
2. Inter-turn faults.

The theory of differential protection action: The working theory of differential relays is based on the Merz - Price principle. Simply if the current entering the protected unit is equal to the current coming out of it, this means that there is no fault in the protected area and the Relay / protection is not working. On the other hand, a difference between the current entering the protected area and outside the protected area indicates a fault, and the Relay / protection in this case works to separate the fault current as quickly as possible.

Types of Differential Relays: For the operation of the differential relay, it should have, two or more similar electrical quantities and these quantities should have phase displacement (normally approx 180°). There are two types of differential relays, namely,
1.Current differential relay 2.Voltage balance differential relay
3.Percentage differential relay or biased beam relay.

Current Differential Relays: Circulating current differential relay protection is also called Merz-price differential protection. It works on the principle that, when there is a fault within the protected zone, then there will be a difference in the current entering and current leaving of that protected zone. Thus by comparing the entering and leaving currents of the protected zone either in magnitude or in phase or both we can detect the fault in the protected zone.

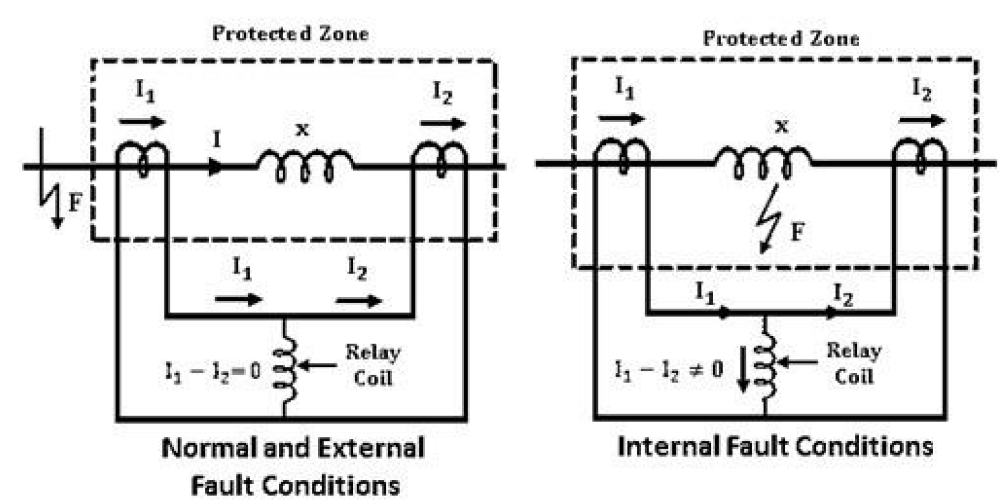

FIGURE 3. Current differential relay

The relay compares the two currents and sends a trip signal to the circuit breaker if the difference exceeds a predetermined set value. The circuit connections of differential relay protection for external fault or normal condition and during internal fault are shown in the figures (1) & (2) above respectively.

Disadvantages of current Differential Relay: Under heavy flow of currents, the accuracy of the relay gets affected due to the capacitance of the pilot cable. Due to heavy currents under short circuit conditions, it may saturate the current transformer and results in the unequal flow of currents in the secondaries of CTs. These unequal currents cause inaccurate operation of the relay. The current transformers used here cannot have 100% similar ratings or characteristics due to constructional errors and pilot cable impedances. This causes a sensitive relay to operate inaccurately. These disadvantages can be overcome by modifying the current differential relay and is known as percentage differential relay or biased differential relay.

Voltage Balance Differential Relay : In this type of protection, two CTs are connected at either end of the element to be protected i.e., alternator winding as shown in the below figure. This relay compares the two voltages, either in magnitude or in phase or both, and trips the relay circuit if the difference exceeds a predetermined set value. In order to maximize performance and parallelism, the ATMEL 16 BIT uses a Harvard architecture – with separate memories and buses for program and data. Instructions in the program memory are executed with a single level pipelining. While one instruction is being executed, the next instruction is pre-fetched from the program memory. This concept enables instructions to be executed in every clock cycle. The program memory is In-System Reprogrammable Flash memory.

The ALU supports arithmetic and logic operations between registers or between a constant and a register. Single register operations can also be executed in the ALU. After an arithmetic operation, the Status Register is updated to reflect information about the result of the operation. Program flow is provided by conditional and unconditional jump and call instructions, able to directly address the whole address space. Most ATMEL 16BIT instructions have a single 16-bit word format. Every program memory address contains a 16-bit or 32-bit instruction. Program Flash memory space is divided in two sections, the Boot Program section and the Application Program section. Both sections have dedicated Lock bits for write and read/write protection. The SPM instruction that writes into the Application Flash memory section must reside in the Boot Program section. The memory spaces in the ATMEL 16BIT architecture are all linear and regular memory maps. A flexible interrupt module has its control registers in the I/O space with an additional Global Interrupt Enable bit in the Status Register. All interrupts have a separate Interrupt Vector in the Interrupt Vector table. The interrupts have priority in accordance with their Interrupt Vector position. The lower the Interrupt Vector address, the higher the priority. The I/O memory space contains 64 addresses for CPU peripheral functions as Control Registers, SPI, and other I/O functions. The I/O Memory can be accessed directly, or as the Data Space locations following those of the Register File, 0x20 - 0x5F. In addition, the ATmega48/88/168 has Extended I/O space from 0x60 - 0xFF in SRAM where only the ST/STS/STD and

LD/LDS/LDD instructions can be used.

Voltage And Current Sensor: Sensors are basically a device which can sense or identify and react to certain types of electrical or some optical signals. Implementation of Voltage and Current Sensor and current sensor techniques has become an excellent choice to the conventional current and voltage measurement methods.

Advantages of Sensors over Conventional Measuring Techniques

- Small in weight and size.
- Personnel safety is high.
- Degree of accuracy is very high.
- It is non-saturable.
- Wide dynamic range.
- Eco-friendly.
- It is possible to combine both the voltage and current measurement into a single physical device with small and compact dimensions.

In this article, we can discuss in detail about Voltage and Current Sensor. A Voltage and Current Sensor can in fact determine, monitor and can measure the supply of voltage. It can measure AC level or/and DC voltage level. The input to the Voltage and Current Sensor is the voltage itself and the output can be analog voltage signals, switches, audible signals, analog current level, frequency or even frequency modulated outputs. That is, some Voltage and Current Sensors can provide sine or pulse trains as output and others can produce Amplitude Modulation, Pulse Width Modulation or Frequency Modulation outputs. In Voltage and Current Sensors, the measurement is based on the voltage divider. Mainly two types are of Voltage and Current Sensors are available- Capacitive type Voltage and Current Sensor and Resistive type Voltage and Current Sensor.

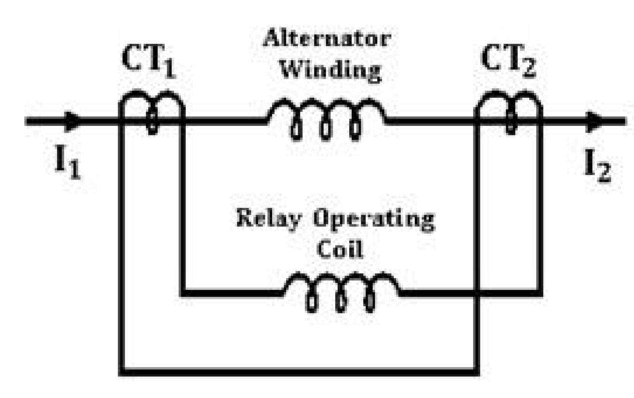

FIGURE 4. Sensors

The primary windings of CTs having the same current ratios are connected in series with the pilot wire. Pilot wires are always connected by joining two ends of the circuit as shown in the figure and secondary winding of CTs to the relay operating coil. At normal operating conditions the same amount of current will flow in both the primary windings of CTs. Since the current being the same, the voltage in the secondary winding remains the same. Therefore, zero current flows in the relay operating coil. Under the faulty conditions, there exists a phasor difference in the currents of the primary coil. Therefore, there is an imbalance in voltage at the secondary winding. Now there exists a phasor difference in voltage of secondary coil and this voltage is fed to the relay operating coil, connected in series with the secondary winding. Due to this current flows through the relay operating coil and the relay operates.

Disadvantages of Voltage Balance Differential Relay:

The construction becomes complex for achieving the perfect balance between CT pairs. Under heavy flow of currents, the accuracy of the relay gets affected due to the capacitance of the pilot cable.This type of differential relay protection can be effectively used for shorter length lines.

Percentage Differential Relay: The schematic arrangement of percentage or biased differential relay is shown below. It consists of two coils, a restraining coil, and an operating coil. The operating coil is connected to the midpoint of the restraining coil. The operating coil produces the operating torque which makes the relay operate, while the restraining coil produces a restraining torque (bias force) which is opposite to the operating torque.

The relay is designed in such a way that it operates to the differential current in terms of its fractional current flowing through the protected zone. When there is no fault in the protected zone (alternator winding in the above case) or there is a fault outside the protected zone the restraining torque will be greater than the operating torque. This makes the trip circuit open and hence relay will be inoperative.

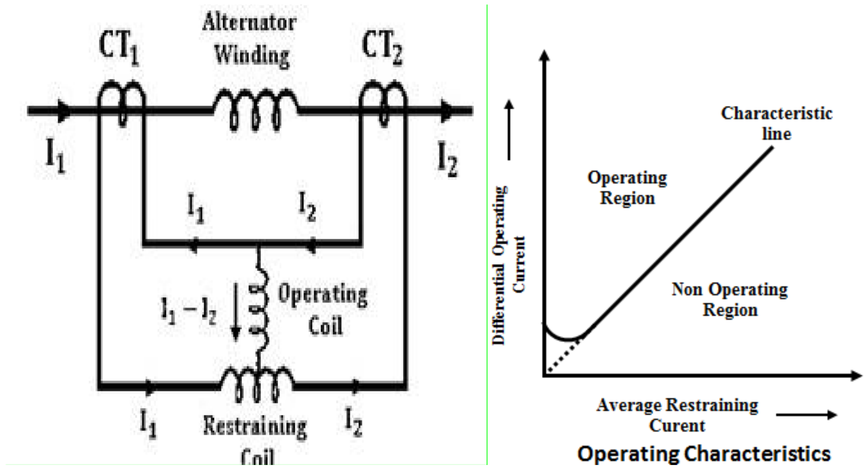

FIGURE 5.

But when there is a fault in the protected zone the operating torque will be greater than the restraining torque. Due to this, the beam closes the trip circuit thereby initiating a trip signal by the relay to the circuit breaker. In the above equivalent circuit, the differential current within the operating coil is i2 – i1 whereas the restraining coil is i1 + i2/2 because of the middle connection of the operating coil. So the ratio of i2 – i1 (differential operating current) to the (i1 + i2)/2 (restraining current) has a fixed percentage always. Therefore, this relay is known as a percentage differential relay. To operate this relay, the differential current should be higher as compared to this fixed percentage. The operating characteristics of the percentage differential relay is shown above, from which it can be seen that the characteristics are a straight line except at low currents.

Advantages :

The advantages of differential relay include the following. Digital signal handling is completely possible with a 16-bit microprocessor. This is the most significant protection within the power system. Measuring accuracy is high on all the ranges of settings because of a precise 16- bit analog-to-digital conversion method.These are very simply adaptable to different alarm & substation systems. These relays are very responsive because they cannot differentiate between minor faults & heavy loads. These relays avoid malfunctions within a network.

Disadvantages :

The disadvantages of differential relay include the following. The current differential relay accuracy in heavy current flow will get affected because of the pilot cable's capacitance. The current transformers in this relay cannot have similar characteristics or ratings because of the pilot cable impedances & constructional errors. So this causes a relay to operate incorrectly. The construction of a voltage balance type relay becomes complex to achieve the perfect balance between CTs. The protection of this relay can be used effectively for shorter-length lines. However, the following factors affect the differential current in transformers and should be considered while applying differential protection. These factors can result in a differential current even under balanced power in & out conditions

1. Magnetising inrush current – The normal magnetizing current drawn is 2 – 5% of the rated current. However during Magnetising inrush the current can be as high as 8 – 30 times the rated current for typically 10 cycles, depending upon the transformer and system resistance.

2. Over excitation – This normally of concern in generator – transformer units. But it can also be of concern in certain transmission transformers where line capacitance is dominant and light load conditions can lead to high voltage on the transformer. Transformers are typically designed to operate just below the flux saturation level. Any further increase from the max permissible voltage level (or Voltage / Frequency ratio), could lead to saturation of the core, in turn leading to substantial increase in the excitation current drawn by the transformer.
3. CT Saturation – External fault currents can lead to CT saturation. This can cause relay operating current to flow due to distortion of the saturated CT current. Alternatively the harmonic current present in the saturated CT can cause a delay in the operation of the differential relay during internal faults. Proper selection of CT ratios is essential to minimize problems due to the saturation. CT selection is discussed later
4. Different primary and secondary voltage levels, that is the primary & secondary CT's are of different types and ratios.
5. Phase displacement in Delta-Wye transformers. Transformer Protection 7 of 12.
6. Transformer voltage control taps
7. Phase shift or voltage taps in regulating transformers.

Over Current Protection: Over current protection scheme is based on the intuition that, faults typically Short circuits, lead to currents much above the load current. We can call them as **Over- currents.** Over current relaying and fuse protection uses the principle that when the current exceeds a predetermined value, it indicates presence of a fault (short circuit).

Fault current is fed from only one end of the feeder

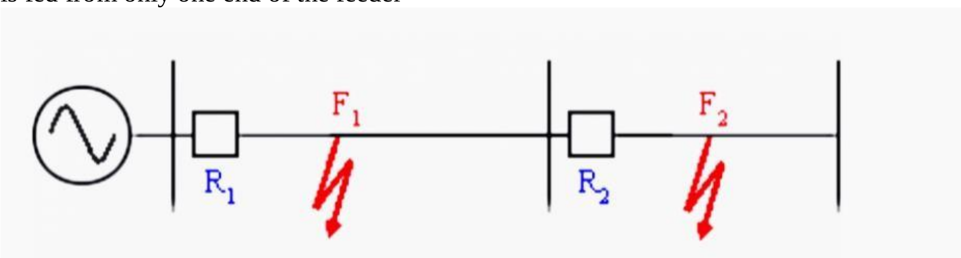

FIGURE 6.

STUB Protection: STUB Protection is simple overcurrent protection it is used to protect the power system transmission line when the line isolator is in open condition. The distance protection needs line voltage and current inputs to operate. As the line is under shutdown and the line isolator is in open condition, there is no voltage in the distance relay. In this case, to protect the area as marked in the diagram, we need STUB Protection.

4. TRANSFORMER

The main objective of transformer protection is to detect abnormal conditions and protect to Transformer from internal faults and external faults nothing but through faults.

Over Current Protection: Overcurrent relays are used as primary protection if differential protection is not used. If differential protection is used Overcurrent protection is used as backup protection. Overcurrent relays should not trip in the following conditions.

1. During the period of Magnetising current inrush– During switching of load, the load take sudden surge of magnetising inrush current.
2. Short time Load- Cold load pickup- To avoid tripping during switching on Circuit Breaker.
3. Through Faults- For load side faults usually 3-phase short circuit OC relay should not pick up before operating any other protection relays.
4. Three phase over load– For permitted values of three phase overloads the Over current rely should not pickup.

Over Fluxing Protection: Over Fluxing or Over Excitation leads to transformers overheating and getting damaged. A V/Hz Over excitation relay is used for transformers that are likely to operate at a too high voltage or at a too low frequency. Generator transformers can be overexcited during acceleration or deceleration of the turbine. The maximum allowable V/F ratio is 1.1 times the rated V/F ratio.

Differential Protection: Differential protection relay compares the phase currents on both sides of the transformer to be protected. If the differential current of the phase currents in one of the phases exceeds the setting of the stabilized operation characteristic or instantaneous protection stage of the function, the relay provides an operating signal.
Over-current protection is used as a backup for differential protection. Differential protection protects the transformer from
1. Winding short circuit faults.
2. Inter-turn faults

Distance Protection: Over current protection is not suitable for providing backup protection for transformers connected to networks. In this case Under Impedance or Distance relay protection is required when there is a large difference between the maximum and minimum Short circuit fault MVA.

5. FAULTS

Fault in Power System: Power system faults may be defined as any condition or abnormality of system which involves in electrical failure, insulation failure resulting in short circuit or conducting path failure resulting in open circuit condition, the former being by far the more common type of failure. The major type & causes of failure are:
1. Insulation – design defect or errors, improper manufacturing, improper installation, aging of insulation, contamination.
2. Electrical – lightning surges, switching surges, dynamic over voltages.
3. Thermal – coolant failure, over current, over voltage, ambient temperature.
4. Mechanical – over current forces, earthquake, foreign object impact, snow or ice.

The above Faults in a Power system may involve:- (i). Fault in the Generation System.
(ii). Fault in the Transmission system (including Transmission lines / Transformers) and (iii). Fault in Distribution system.
As a part of the protection system Relays are used and these relays must operate for several types of faults viz.,:

Three phase fault Phase to phase fault
Two phase to ground fault Phase to ground fault
Open circuit fault (single phase, two phase & three phase) Over Current / Over voltage / Over flux etc.,

The Principle kind of power system faults and system variables used to detect them:

1. Phase fault in general- phase current, current difference, difference of phase angle, difference of phase voltage, difference of power direction, difference of impedance.
2. As-symmetric faults (phase-ground, phase-phase, phase-phase-ground) – Positive / negative and zero sequence components of current, voltage and the power directions.
3. Ground faults - zero sequence components of current, voltage & power direction.
4. Over load-phase current temperature.
5. Real power deficit-frequency, rate of change of frequency.
6. Real power excess-frequency.

Types Of Fault Occurance : The fault may occur in three forms transient, permanent and intermittent faults.

1. Transient Fault
2. Permanent Fault
3. Intermittent Fault

6. THEORITICAL ANALYSIS OF FAULTS

In order to provide the information for choosing the right switchgear, selecting appropriate materials such as Conductors / Insulators / other switchgears or other equipments and for designing a power Transmission system ensuring utmost stability, the level of fault and fault analysis is very much essential. Selection of the equipments must be to see that the equipments work with maximum / optimum level of fault current (presently designed in EHV systems of 400 kV and above for 40 kA - 60 kA) that may flow through the system during abnormal condition or severe fault.

Short Circuit Fault: A short circuit is an abnormal connection between two nodes of an electric circuit intended to be at different voltages. This results in an electric current limited only by the Thevenin equivalent resistance of the rest of the network which can cause circuit damage, overheating, fire or explosion. Although usually the result of a fault, there are cases where short circuits are caused intentionally, for example, for the purpose of voltage- sensing crowbar circuit protectors.

Short circuit fault are of two types:

- Asymmetrical Fault
- Symmetrical Fault

Asymmetrical fault: In the field of electrical engineering an asymmetrical fault is the condition in which the load in a 3 phase power supply becomes unequal on all the three phases. Asymmetrical fault thus gives rise to a situation that contradicts the properties of three phase power supply that is the load should be equal on all the three phases. Asymmetrical fault mandate the calculation of positive, negative& zero sequence components separately. Asymmetrical faults are as follows

- Single line to ground fault
- Line to line fault
- Double line to ground fault

Symmetrical Faults: Symmetrical faults do not give rise to zero sequence or negative sequence components because they are perfectly balanced, symmetrical faults only have positive sequence values.

7. RESULTS

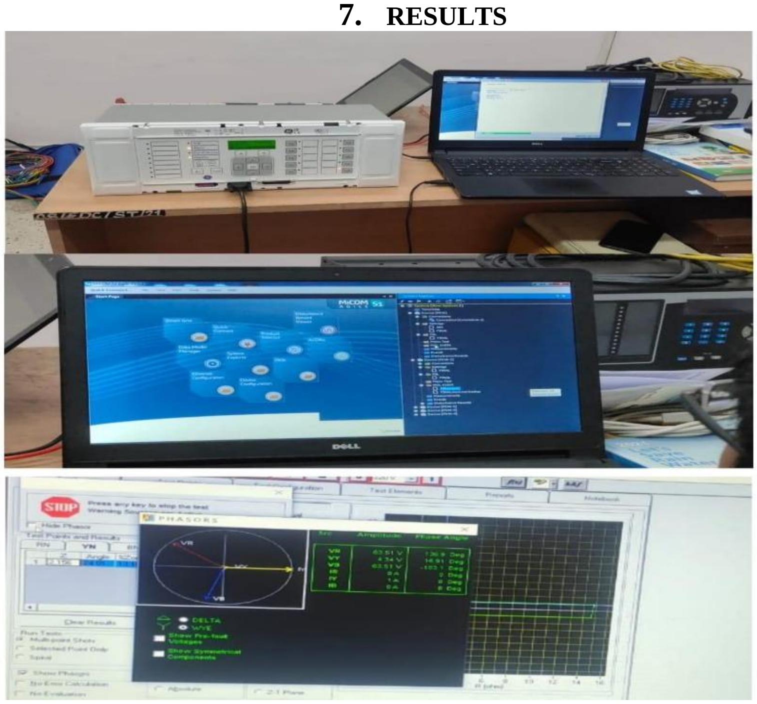

FIGURE 7. Analysis for software

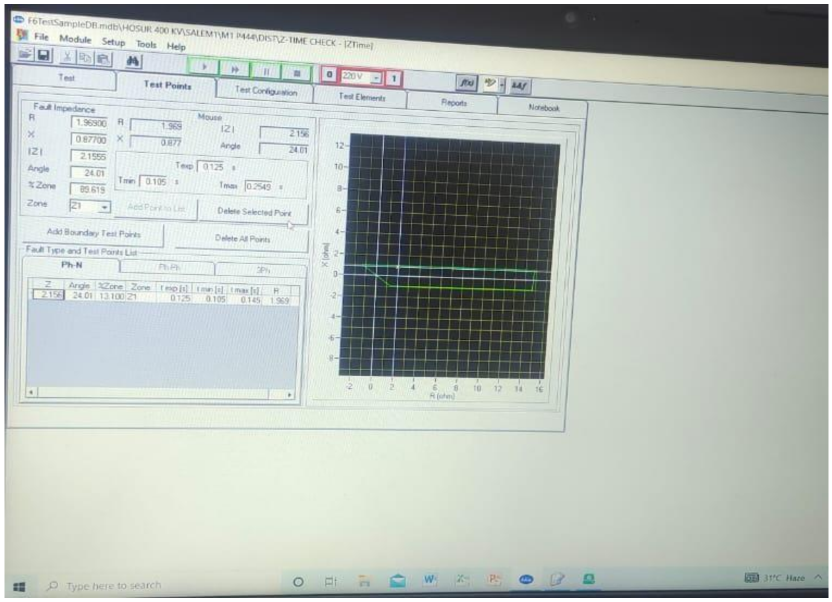

FIGURE 7.

It may be noted that the Impedance as per the Simulated relay for testing purpose is IZI = 2.155 ohms (shown in the above photo) and that calculated theoretically is also 2.155 ohms.

FIGURE 8.

As the zone of defect is depended on the impedance, it is confirmed that the fault as per the simulation as well as theoretically is under Zone 1, that is under 80% of the line length

8. CONCLUSION

As a conclusion, this project is to understand the concept and practical analysis of fault occurrence in Transmission lines and transformers. From the above results, we can conclude that the Numerical relays [Intelligent Electronic Device] which are being used for Transmission line protection & Transformer Protection at 400/230 kV Sub-station POWERGRID, are highly effective & efficient in sensing the fault and thereby making it most appropriate for using in Power line protection and analysis of faults. As an added advantage we can also get the Circuit Breaker open / Close status and all the parameters in the Disturbance recorder and the Time stamped event from the Event logger the data for which are taken from the Neumerical relay. Only point of concern is that the accuracy of the relay depends upon the parameters like current, voltage fed from CT / CVT, however, with specific & stringent quality requirements imposed by POWERGRID on the manufacturers the issues related to accuracy CT / CVT are also addressed and got rid off.

REFERENCES

[1]. Power engineers handbook; published by TNEB engineers association.
[2]. Warrington, A.R. Van C., protective relays-their theory and practice, vol.1, 1968, chapman and hall, London.
[3]. Ellis, N.S, distance protection of feeders, pamphlet No.1301, reyrolle and co.
[4]. Warrington, A.R. van C., “graphical method for estimating the performance of distance relays during faults and power swings”, trans A.I.E.E., 1949, p. 608.
[5]. Humpage, W.D. and kandil, M.S., “measuring accuracy of distance protection with particular reference to earth fault conditions on 400kv. Looped circuit interconnections”. Ibid., vol.117, feb.1970, p.431.
[6]. Roy, S.N., “power line faults- a statistical analysis of their types duration and causes”, J. of the inst. Of engrs.(india),elec.engg.div.,june 1968,p.732..
[7]. Developments in power system protection IEE conference publication 125.(11-13 march 1975, savoy palace).
[8]. Majid Jamil, Sanjeev Kumar Sharma and Rajveer Singh, Fault detection and classification in electrical power transmission system using artificial neural network, Springer Plus, 2018.
[9]. Halil Alper Tokel, Rana Al Halaseh, Gholamreza Alirezaei, Rudolf Mathar, A new approach for machine learning-based fault detection and classification in power systems, IEEE Power & Energy Society Innovative Smart Grid Technologies Conference, 2018.
[10]. Tamer S. Abdelgayed, Student Member, IEEE, Walid G. Morsi, Senior Member, IEEE, and Tarlochan S. Sidhu, Fellow, Fault Detection and Classification Based on Co-training of Semi supervised Machine Learning, IEEE Transactions on Industrial Electronics (Volume: **65**, Issue: 2, Feb. 2018), Page(s): 1595–1605, 2018. https://doi.org/10.1109/TIE.2017.2726961.
[11]. Teng Xiuyi, Gong Yuxia, Research on Application of Machine Learning in Data Mining, IOP Conf. Series: Materials Science and Engineering **392**, 2018
[12]. Rekha Nagar, Yudhvir Singh, A literature survey on Machine Learning Algorithms, © 2019 JETIR April 2019, Volume **6**, Issue 4, 2019.