

CHAPTER ONE

INTRODUCTION

The purpose of an electrical power system is to generate and supply electrical energy to consumers. The system should be designed and managed to deliver this energy to the utilization points with both reliability and economy. Many items of equipment are very expensive, and so the complete power system represents a very large capital investment. To ensure the maximum return on the large investment in the equipment, which goes to make up the power system and to keep the users satisfied with reliable service, the whole system must be kept in operation continuously without major breakdowns and also to reduce the impact of fault on the other parts of the system.[1]

1.1 Protection Importance

The importance of the protection lies in two basic points :

- 1- Detect faults and identifies how serious they are and where are their places.
- 2- Isolate the affected elements faults and opening the appropriate cutouts.

Protection System: a complete arrangement of protection equipment and other devices required to achieve a specified function based on a protection principal.

Protection Scheme: a collection of protection equipment providing a defined function and including all equipment required to make the scheme work (i.e. relays, CT's, CB's, batteries, etc).

Relays are the devices, which monitor the conditions of a circuit and give instructions to open a circuit under unhealthy conditions .

The basic parameters of the three-phase electrical system are voltage, current, frequency and power. All these have pre-determined values and/or sequence under healthy conditions. Any shift from this normal behavior could be the result of a fault condition either at the source end or at the load end .

Transformers are a critical and expensive component of the power system. Due to the long lead time for repair of and replacement of transformers, a major goal of transformer protection is limiting the damage to a faulted transformer. Some protection functions, such as over excitation protection and temperature-based protection may aid this goal by identifying operating conditions that may cause transformer failure. The comprehensive transformer protection provided by multiple function protective relays is appropriate for critical transformers of all applications. [1]

1.2 Protection relays

A protective relay is the device, which gives instruction to disconnect a faulty part of the system. This action ensures that the remaining system is still fed with power, and protects the system from further damage due to the fault. Hence, use of protective apparatus is very necessary in the electrical systems, which are expected to generate, transmit and distribute power with least interruptions and restoration time. It can be well recognized that use of protective equipment are very vital to minimize the effects of faults, which otherwise can kill the whole system. Relays may be classified according to the technology used :

1.2.1 Electromechanical relay: They work on the principle of a mechanical force causing operation of a relay contact in response to a stimulus. The mechanical force is generated through current flow in one or

more windings on a magnetic core or cores, hence the term electromechanical relay and this relay can be classified into several different types as follows: attracted armature, moving coil, induction, thermal, motor operated, mechanical .

1.2.2 Static relay: This term implies that the relay has no moving parts, Their design is based on the use of analogue electronic devices instead of coils and magnets to create the relay characteristic. Early versions used discrete devices but advances in electronics enabled the use of linear and digital integrated circuits

1.2.3 Digital relay: In this type Microprocessors and microcontrollers replaced analogue circuits used in static relays to implement relay functions .

1.3 Statement of problems

Faults occur in substation will eliminate the services from the units for this reason effective protection action is required to minimize damage and repair costs where it senses fault, Ensure safety of personnel.

1.4 Objective

The main objectives of this research are to develop and investigate protection system used in high power transformer rating protection.

1.5 Methodology

The first stage in this project; numeric relays from ABB techniques used to obtain protection transformer. This protection using ABB REF615 which protect over current, restricted earth fault and differential protection.

On second stage selected setting of numerical According to IEEE Standers and ABB Technical guides.

On final stage run simulation to test the setting.

1.6 Project layout

The thesis is organized as follow :

Chapter one gives brief introduction about relay in protection in electrical network and summarized research objectives and problem.

Chapter two contains introduction about electrical section. Also contains detailed understanding to protect the transformer.

Chapter three contains the of numeric relay Hardware ,Relay interfaces and algorithms.

Chapter four testing of numerical relay with simulation before and after connection to transformer.

Chapter five conclusion and recommendations.

CHAPTER TWO

TRANSFORMER

The transformers are static devices without having any rotating part and are totally enclosed. Hence the chances of faults occurring in transformers are much rare as compared to the faults occurring on generators. Similarly possibilities of running on abnormal conditions are also less in transformers compared to generators. But though the fault possibility is rare, if fault occurs, the transformer must be quickly disconnected from the system. The rare faults if not cleared quickly can get developed into the major faults which may be very serious for the transformers. Hence the protection must be provided to the transformers against possible faults.

The use of series fuses is very common in case of small distribution transformers instead of circuit breakers. Hence it is not necessary to install any automatic protective relaying equipment with the distribution transformers. But the power transformers having large ratings need some type of automatic protective relaying equipment, to give protection against the possible faults.

The protection scheme for a power system should cover the whole system against all probable types of fault. Unrestricted forms of line protection, such as over current and distance systems, meet this requirement, although faults in the bus bar zone are cleared only after some time delay. But if unit protection is applied to feeders and plant, the bus bars are not inherently protected. Bus bars have often been left without specific protection, for one or more of the following reasons:

- 1- The bus bars and switchgear have a high degree of reliability, to the point of being regarded as intrinsically safe.
- 2- It was feared that accidental operation of bus bar protection might cause widespread dislocation of the power system, which, if not quickly cleared, would cause more loss than would the very infrequent actual bus faults.
- 3- It was hoped that system protection or back-up protection would provide sufficient bus protection if needed.[1]

2.1 General transformer protection

Generally transformer protection can be divided into two main types:

(i) Self-Protection:

This is already installed in transformer such as temperature detector, pressure detector, gas detector and current detector.

(ii) Relay Protection:

This is installed outside transformer such as differential protection, over current protection, restricted earth fault protection relay, over current relay and phase/earth over current protection. [1]

2.2 Faults in transformers

Transformers are subject to a variety of faults. The most common being the winding to core faults because of weakening of insulation. Phase faults inside the transformer are rare. However, such faults may take place outside the transformer. On the transformer terminals, which fall within the transformer protection zone, the type of connection will effect in the variation of fault current with respect to fault location within the transformer and method of grounding the transformer neutral.

A transformer may develop inter-turn faults and inter-turn faults are difficult to detect by electrical means these are best detected by non-electrical methods. Over flux also will effect in transformer. And it rise from the over voltage, and under frequency operation at rated voltage. Over flux can be dangerous and needs immediate protection.

2.3 Transformer protection

Transformers are provided with over current protection against fault, only, when the cost of differential relaying cannot be justified. However, over current relays are provided in addition to differential relays to take care of through faults. Temperature indicators and alarms are always provided for large transformers. Small transformers below 500KVA installed in distribution system are generally protected by drop-out fuses, as the cost of relays plus circuit breakers is not generally justified.

The resistance-earthed star-connected winding, a winding –to-earth fault will give rise to a current dependent on the value of the earthing resistor and the distance of the fault from the neutral end of the winding.[1]

2.4 Differential protection

Differential protection, as its name implies, compares currents entering and leaving the protected zone and operates when the differential current between these currents exceed a pre-determined level. The type of differential scheme normally applied to a transformer is called the current balance or circulating current scheme as shown in Figure 2.1

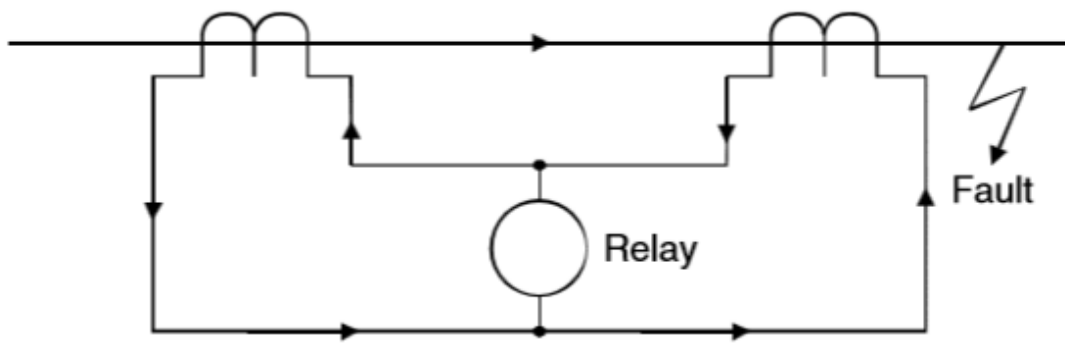


Figure 2.1: Differential protection using current balance scheme (external fault condition)

The CTs are connected in series and the secondary current circulates between them. The relay is connected across the midpoint where the voltage is theoretically nil, therefore no current passes through the relay, hence no operation for faults outside the protected zone. Under internal fault conditions (i.e. faults between the CTs) the relay operates, since both the CT secondary currents add up and pass through the relay as seen in Figure 2.2

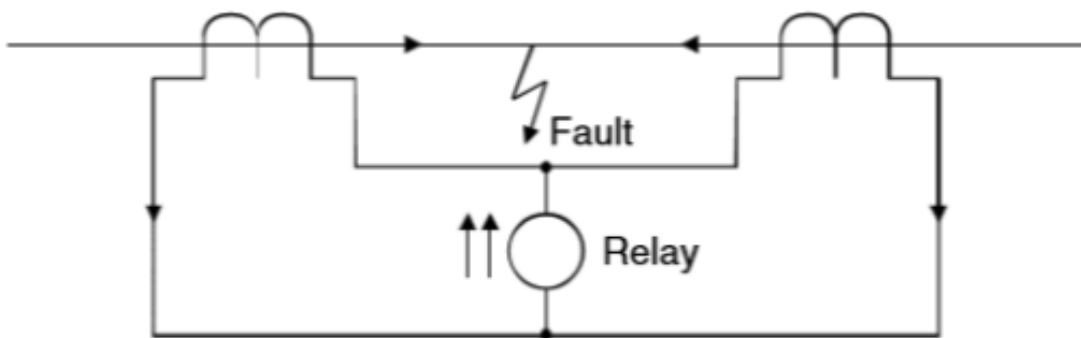


Figure 2.2: Differential protection and internal fault condition

This protection is also called unit protection, as it only operates for faults on the unit it is protecting, which is situated between the CTs. The relay therefore can be instantaneous in operation, as it does not have to coordinate with any other relay on the network.[2]

2.5 Over current protection

There are some faults that cannot be discovered by differential relay such as external load which cause excess heat. Such faults are not detected using only over current protection as some serious faults have over current relay is the fastest in the separated. In this type of protection must take into account the time difference separating relay voltage protection on the side of high voltages for it on the side of low voltages, which should be the fastest.

The pickup value of the phase fault over current units is set such that they don't pick up on maximum permissible over load, but are sensitive enough to pick up on the smallest phase fault. The pick up on the earth fault relay, on the other hand, is independent of the loading of transformer. The neutral current under load condition is quite small 3rd harmonics as zero sequence current and though the neutral, in the ground over current relay.

2.6 Restricted earth fault

A simple over current and earth fault relay will not provide adequate protection for winding earth faults. Even with a biased differential relay installed, the biasing desensitizes the relay such that it is not effective for certain earth faults within the winding. This is especially so if the transformer is resistance or impedance earthed, where the current available on an internal fault is disproportionately low. In these case, it is often necessary to add some form of separate earth fault protection. The degree of earth fault protection is very much improved by the application of unit differential or restricted earth fault systems as shown in figure 2.3

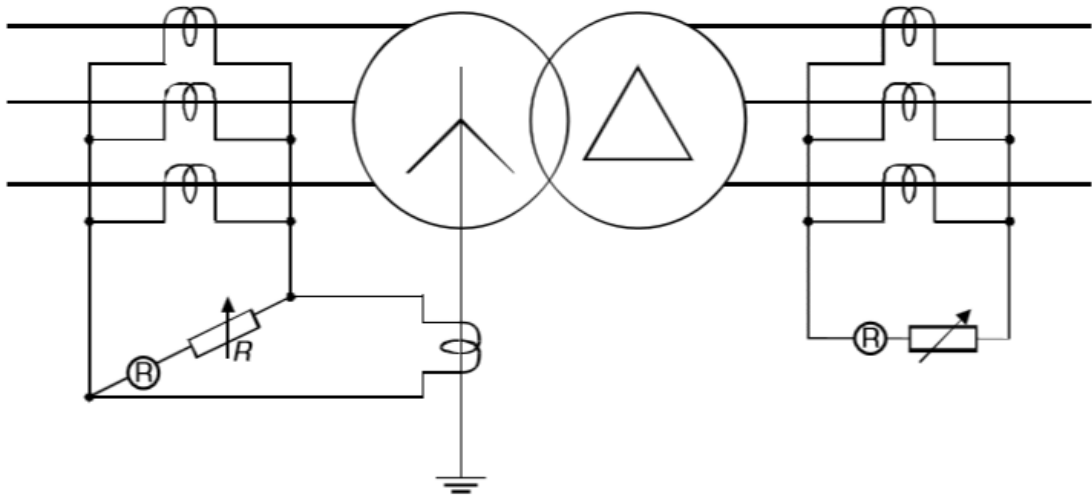


Figure 2.3: A restricted earth fault system

On the HV side, the residual current of the three line CTs is balanced against the output current of the CT in the neutral conductor, making it stable for all faults outside the zone. For the LV side, earth faults occurring on the delta winding may also result in a level of fault current of less than full load, especially for a mid winding fault which will only have half the line voltage applied. HV over current relays will therefore not provide adequate protection. A relay connected to monitor residual current will inherently provide restricted earth fault protection since the delta winding cannot supply zero sequence current to the system. Both windings of a transformer can thus be protected separately with restricted earth fault, thereby providing high-speed protection against earth faults over virtually the whole of the transformer windings, with relatively simple equipment. The relay used is an instantaneous high-impedance type, the theory of which is shown in figure 2.4. [2]

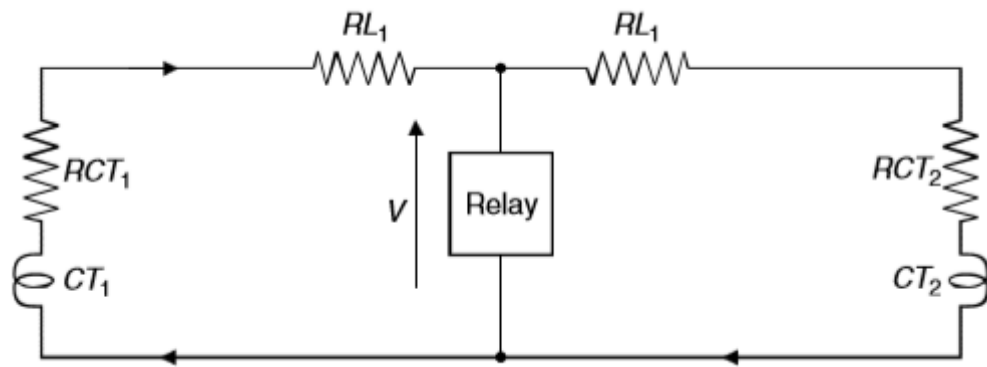


Figure 2.4: Basic circuit of high-impedance current balance scheme

Where:

V : voltage through the relay.

CT_1 :Current transformer 1.

CT_2 :Current transformer 2.

RL_1 : Resistance load 1.

R_{CT_1} : Resistance of current transformer 1.

R_{CT_2} : Resistance of current transformer 2.

CHAPTER THREE

NUMERICAL RELAY

Numerical relay are natural developments of digital relays due to advance in technology. They use one or more digital signal processors (DSP) optimized for real time signal processing, running the mathematical algorithms for the protection function. The relay function such as over-current or earth fault are referred to as 'relay elements' Each relay element is in software so with modular hardware the main signal processor can run a vast variety of relay elements.[3]

Figure 3.1 shows the general hardware outline of a numeric protection relay. Relaying voltages at 110V or 50V and currents, at 5A or 1A, are first passed through isolation transformers. Since analogue to digital conversion is usually performed on voltages, the current signals are converted to representative voltage signals by, for example, passing the current through a known resistance value. All the signals are then filtered using very simple analogue filters. Since Analogue to Digital Convertor are expensive it is common to find only one used in a digital relay, thus an analogue multiplexer, under microprocessor control, is used sequentially to select the required signal into the ADC. Because the ADC takes a finite conversion time, typically 25 μ s, it is necessary to hold the incoming signal for the duration of the conversion; this is achieved with the sample and hold amplifier. Having been converted by the ADC, the signals can now be manipulated by the microprocessor. It is common to find more than one microprocessor used, The relaying program will be located in the read only memory (ROM), and the random access memory (RAM) will be used for storing sampled quantities and intermediate products in the relaying algorithm. Relay settings are stored

in the electrically erasable programmable read only memory (EE-PROM). Relays are powered from the station batteries which are typically 50 V. Since the battery voltage is prone to variation depending on its state of charge, a power supply is incorporated in the relay to provide regulated, constant power rails for the relay electronics. These are typically $\pm 5V$ and $\pm 12V$. Switched mode power supplies are normally used in relays since they are more efficient, dissipating less power, and can work with a wider variation in supply voltage than more conventional series regulator types. In addition, switched mode power supplies also allow isolation between the station batteries and the relay electronics. [2]

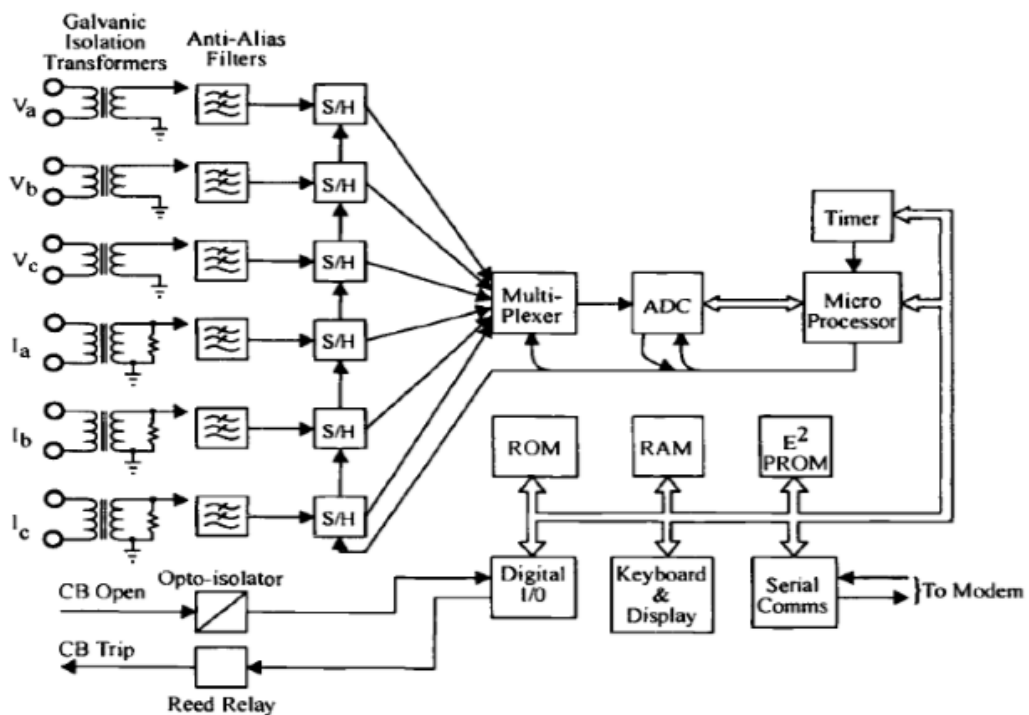


Figure 3.1: Numeric relay hardware

3.1 Relay interfaces

Communication with a relay is necessary for three reasons. First, a facility must exist for programming settings into the relay, secondly, unit type relays must communicate with their counterparts and thirdly, the relay must issue trip and alarm signals under emergency conditions. Unlike

electromechanical or static relays, numeric relays have few or no case mounted controls for adjusting settings. Settings are normally associated with the relaying program and have consequently to be entered into the software. Hence, some form of interface is required to allow the user to communicate with the relay. This form of communication can usually occur on two levels. Firstly, it is common for contemporary numeric relays to have liquid crystal displays (LCD) and keypads incorporated on the relay front panel. To enter settings, the user manipulates the keypad to display and alter numbers appearing on the LCD display. Note that some numeric relays do not use K factors (The percentage setting) to specify the settings, instead actual values, e.g. sequence impedance values, are used. However, manufacturers that do use K factors are now supplying users with programs, to run on personal computers, which allow easy computation of the K factors. Secondly, a visual display unit (VDU) maybe connected to the relay via a serial communications link. This may occur in the substation or it may occur remotely if the serial link can be connected to a modem which allows transmission of the serial information over, for example, a telephone line. Thus, it is possible to dial up a relay and alter its settings from a control centre. Communication via a VDU is similar to the LCD and keypad approach except that the VDU screen and keyboard are used. Unit-type relays, such as digital differential relays, communicate digitally with their counterparts using a form of serial communication. Although some types are designed to use existing communication media such as voice frequency communication links, others use a completely digital approach and are designed for 64 k bit/s pulse code modulated (PCM) systems. In general, digital communication is superior to analogue communication due to its ability to check for, and to some extent correct, errors in transmission. The circuitry required for digital communication is integrated into the relay hardware and is under control of the relay microprocessor, see Figure 3.1. Digital relays need some method of issuing trip signals and alarm signals. Since these signals are essentially

binary, it is relatively simple to decode some part of the microprocessor address space for this use. This occurs in the block marked digital output in Figure 3.1. Ironically, despite the advanced technology found within a digital relay, the trip and alarm signals are commonly connected to the outside world via electromechanical reed relays. [2]

3.2 Relay operating environment

The substation is an electromagnetically hostile environment for a numeric protection relay due to its close proximity to transmission lines, isolators and circuit breakers. Under fault and switching conditions it is essential that external noise does not enter the relay and prevent normal relay operation. Disturbances in this category are classed as electromagnetic interference (EMI). There are essentially two causes of EMI in substations: first, as a result of switching operations and line surges, which may also couple onto low voltage relay input signals and, secondly, due to external causes such as lightning strikes to power system equipment and spurious radio interference. It should be stressed that, because of the high-speed operation of the microprocessor, numeric relays are especially prone to EMI effects. Thus, it is imperative to ensure that a numeric relay has electromagnetic compatibility (EMC) with its environment. To ensure digital relays meet EMC requirements, a variety of approaches are taken. These range from encasing all relay electronics within a steel faraday cage to isolating all connections to the relay galvanically. Increasingly, relays are tested to rigorous IEC specifications to ensure greater quality control for the user. It is worth noting that electromechanical relays were largely unaffected by EMI and so introducing digital technology into the substation environment has created some problems as well as benefits. [2]

3.3 Numeric relay algorithms

Numerical relay 4th edition of relays. The functions of numerical relay:

3.3.1 Differential relays

A current differential relay performs a Kirchhoff Law current summation of the currents entering a multi-ended circuit. By comparison of the residual components of the summation it is possible to detect faults. Differential relays perform the comparison on each phase. In the following description, only one phase of a three phase system is considered, but a practical relay contains three separate channels to evaluate faults on each phase or between phases. In a numeric differential relay, the sampled current values need to be filtered and converted into a form suitable for comparison at the line ends. A simple and effective approach for achieving this is based on a Fourier technique. It will be recalled 'Spectral analysis', that the discrete Fourier transform (DFF) is a method for evaluating the frequencies contained within a series of N sampled data values at a frequency resolution of $(1/NT)$ where T is the sampling interval and N the number of samples. Unlike the fast Fourier transform, it is possible with the DFF to evaluate only one frequency of interest; for example, for a sampling rate of 400 Hz, if $N=8$ and $m=1$, then $X(1)$ will represent the 50 Hz content of the sampled signal. Note also that $X(1)$ is a complex quantity and contains a real and imaginary component of the 50 Hz content. This thus provides a basis for both filtering and converting the current into a form suitable for a Kirchhoff current summation. For a sampling frequency of 400 Hz, typical for a numeric current differential relay, the equations used to evaluate the real and imaginary components of the sampled current waveform are:

$$I_s = \left(\frac{2}{N}\right) \sum_{n=0}^{N-1} i(n) \sin(nT\omega) \quad (3.1)$$

$$I_c = \left(\frac{2}{N}\right) [i(0) + i(N) + \sum_{n=1}^{N-1} i(n) \cos(nT\omega)] \quad (3.2)$$

where:

I_s = sine or imaginary component of the current samples.

I_c = cosine or real component of the current sample.

T = time of cycle.

ω = speed in rad/s.

$i(n)$ = sampled current value at time n .

N = number of samples per power system frequency cycle = 8.

There are small differences that enhance the frequency responses. The group delay associated with the formation of I_s and I_c is one cycle of power system frequency and, thus a numeric current differential relay of this type does not give ultra-high-speed operating times. [2]

3.3.2 Over current relays

Over current relays are the least complex type of relay to be implemented by numeric means. Due to the relative slow operation of an over current relay compared with, say, a distance relay; there is little performance benefit to be gained from a numeric implementation. The main benefit of numeric over current relays is lower cost and the ability to provide a full range of characteristics in one product, the required characteristic being selected by switches on the relay front panel. With respect to the hardware of a numeric over current relay, the outline is essentially as given in Figure 3.1 excepting the following points:

*Only one current input is provided per relay.

*The processing requirements are far less demanding for an over current relay than the other types described in this chapter.

*By virtue of above two points it is possible to integrate the data acquisition and microcomputer components within one chip, thus reducing printed circuit board space within the relay

* Some relays use a bridge rectifier on the current input to avoid using bipolar analogue to digital converter.

Operation of over current

The operation of a typical numeric over current relay will be described. The signals within the relay are shown in Figure 3.2. The current into the relay is firstly rectified and then passed through a resistor network, selected by switches on the front panel, to provide a voltage proportional to the incoming current. The switches are the equivalent of the plug setting multiplier found in electromechanical over current relays and serve to scale the input current. The scaling is such that, irrespective of the current setting, input current at the setting level will produce the same internal voltage in the relay. This voltage is then digitised by an analogue to digital converter. Sequential samples are then compared to find the peak values of the rectified sine wave. These peak values are stored in peak registers within the microprocessor; four peak registers are used to store the preceding four peak values. Every time a new peak value is added, all the peak registers are compared to find the highest peak value over the last four peaks. The highest peak value is then referred to a look-up table (table of coefficients stored in memory) which produces an increment number.

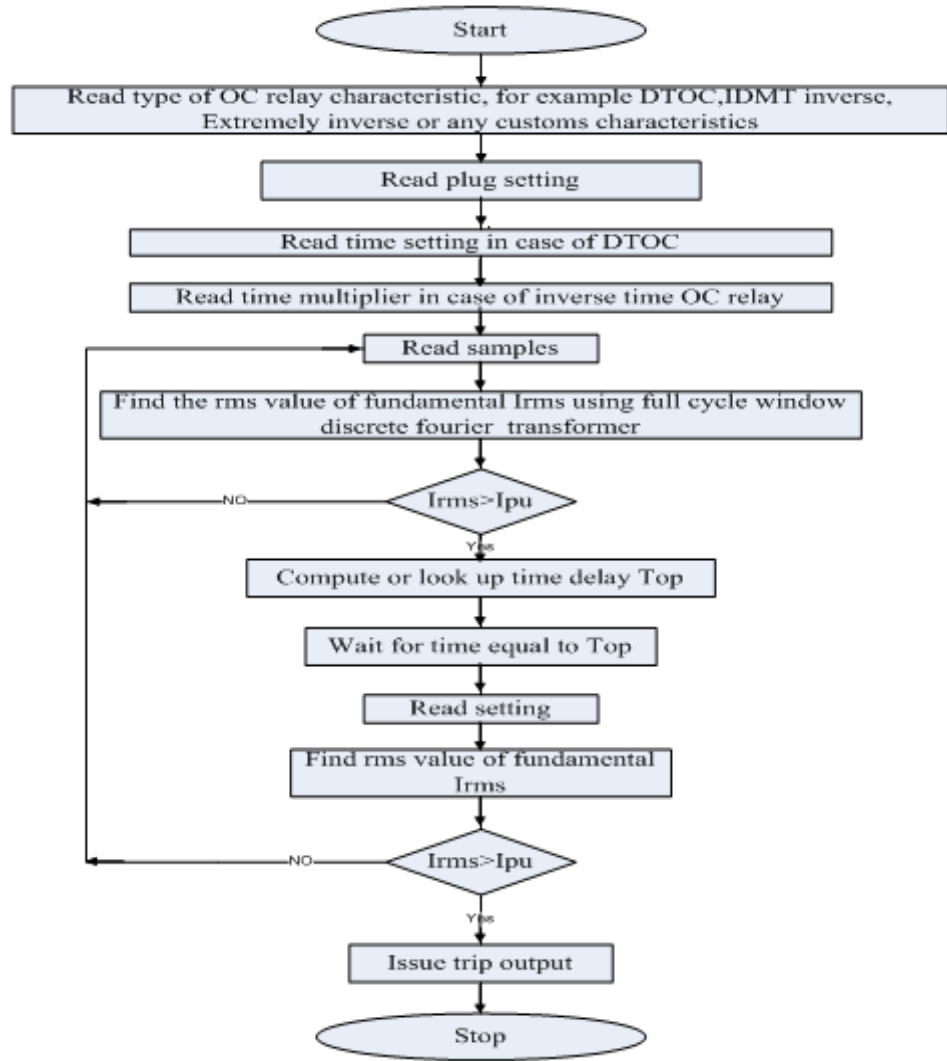


Figure 3.2 : A numerical over-current relay algorithm flow chart

3.3.3 Relay characteristic

The relay calculates differential and bias current values in a similar fashion to a conventional current differential relay. For a two-ended line with ends R and S, the equations are, for say the 'a' phase:

$$|I_{diff}| = |I_{Ra} - I_{Sa}| \quad (3.3)$$

$$|I_{bias}| = 1/2(|I_{Ra}| + |I_{Sa}|) \quad (3.4)$$

where:

I_{di} : differential current.

I_{bi} : Bias current.

I_{Ra} : output current.

I_{Sa} : Input current.

absolute value $|I|$ of current vector I is given by The evaluation of a square root is time-demanding task for a microprocessor to perform and is thus better avoided. In place of a square root, one approach is to use a least squares approximation technique or, alternatively, since the absolute values are required, the fault evaluation can be performed using the squares of the signals.

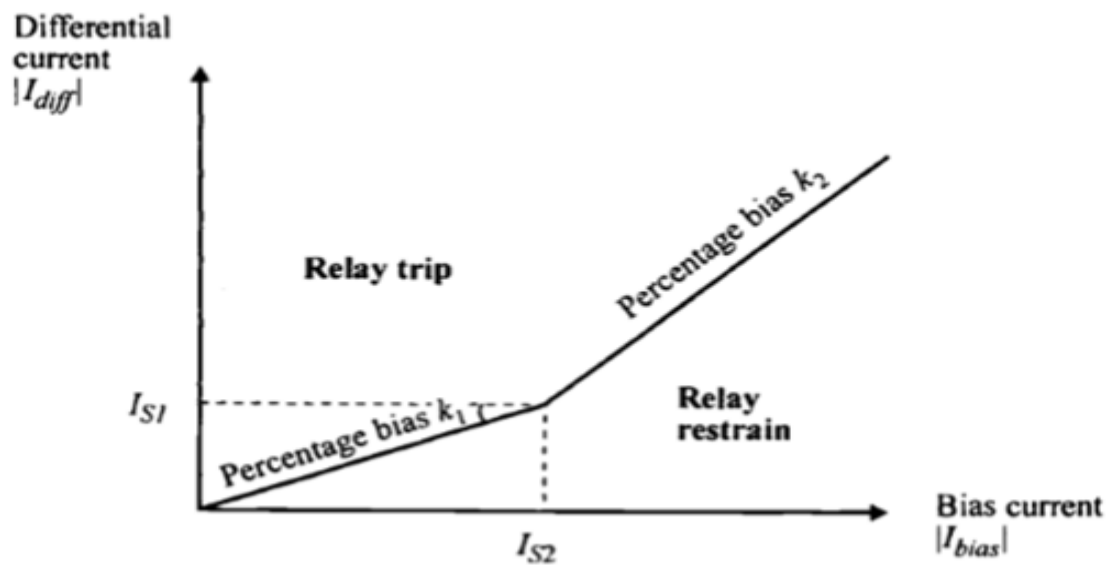


Figure3.3: Baised differential characteristic

Thus, a standard percentage bias characteristic may be implemented as shown in Figure 3.4 where the lower percentage bias tripping criterion is:

$$|I_{diff}| > K_1 |I_{bias}| + |I_{S1}| \quad (3.5)$$

$$|I_{bias}| > I_{S2} \quad (3.6)$$

$$\text{is: } |I_{diff}| > K_2 |I_{bias}| - (K_2 - K_1) I_{S2} + I_{S2} \quad (3.7)$$

where:

K_1 & K_2 : The percentage bias setting .

I_{S1} : The minimum differential current .

I_{S2} : The minimum bias current setting.

Different implementations of numeric differential relays use different sampling frequencies. However, if a low sampling frequency is used, e.g. 400 Hz, then the requirements for a counting strategy, that is deciding how many consecutive samples of indicated fault should cause the relay to trip, are less demanding than in the cases of the numeric distance and directional comparison relays where sampling frequencies in the kHz range needed careful consideration. As with all differential relays, numeric implementations have no independent operating mode and so are entirely reliant on the digital communications path between relays. [2]

CHAPTER FOUR

OPERATION OF NUMERICAL RELAY

4.1 Relay testing system

Relay testing is intended primarily for secondary injection testing of protective relay equipment. Virtually all types of single-phase protection can be tested. You can also test three-phase protection that can be tested one phase at a time, and also a number of protective relay systems that require phase shifting. Moreover, automatic reclosing devices can be tested.[3]

4.2 Type of relay test system

There are many type of relay test system such as following:

4.2.1 Omicron cmc 356

The CMC 356 is the universal solution for testing all generations and types of protection relays. Its powerful six current sources (three-phase mode: up to 64 A / 860 VA per channel) with a great dynamic range, make the unit capable of testing even high-burden electromechanical relays with very high power demands.

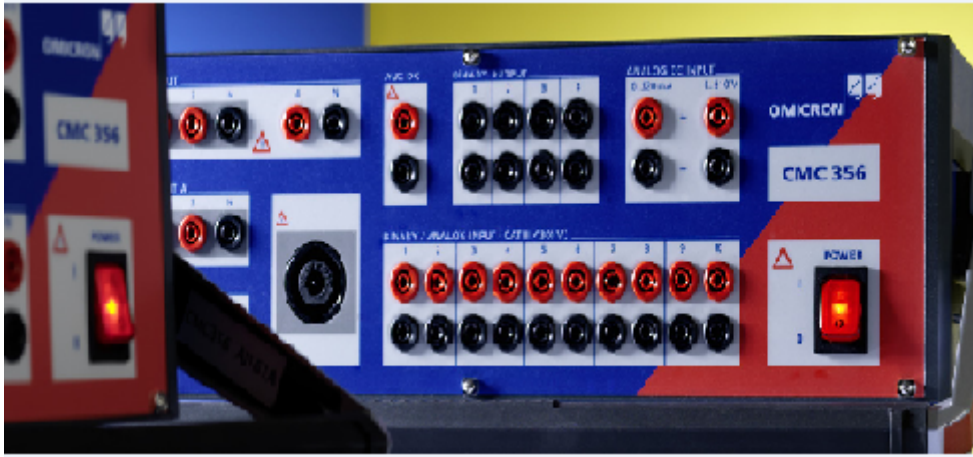


Figure 4.1: omicron cmc 356.

4.2.3 Freja 300

The FREJA™300 relay testing system is a computer-aided relay testing and simulation system. The weight of FREJA 300 is only 15 kg. The rugged hardware design is built for field use over a wide temperature range, with the possibilities of intelligent software to perform rapid testing. FREJA 300 can be operated with or without a PC. After being put into the Local mode, FREJA 300 can be used stand-alone without a PC. Using the Local mode is easy. The function of each key is described on the display, which also presents the settings and measured values. The very accurate (typically 0.01%) low level analogue inputs are designed for transducer measurements. The high level inputs can be used as a normal volt- and ammeter. FREJA 300 can generate 4x150 V (82 VA) and 3x15 A (87 VA) or 1x45 A (250 VA). Each output can be varied independently. Both static and dynamic testing can be performed, such as prefault and fault generation, simultaneous ramping of several quantities and wave form editing. FREJA 300 can also be used as a disturbance simulator and create and generate simulated disturbances, or import actual recorded disturbances from e.g. EMTP or COMTRADE files (and edit the wave forms), by using the FREJA SIM Disturbance

DC source you can directly supply Simulator Software. With the built-in to the protective relay.[4]

Table 4.1: Application Relay Testing

Examples of what FREJA 300 can test	ANSI® No.
Distance protection equipment.	21
Synchronizing or synchronism-check relays.	25
Under voltage relays.	27
Directional Power relays.	32
Undercurrent or underpower relays.	37
Negative sequence overcurrent relays.	46
Overcurrent-/ ground fault relays.	50
Inverse time overcurrent-/ ground fault relays.	51
Power factor relays.	55
Overvoltage relays.	59
Voltage or current balance relays.	60
Directional overcurrent relays .	67
DC overcurrent relays.	76
Phase-angle measuring or out-of-step protective relays.	78
Automatic reclosing devices.	79
Frequency relays.	81
Differential protective relays.	87
Directional voltage relays.	91
Voltage and power directional relays .	92

4.3 Operation of freja

There are two method:

4.3.1 Local Mode - without PC

Using the dial by turning and clicking it is easy to make the settings. All settings are saved automatically when you exit, but if you prefer you can assign the settings a name and save them separately for convenient access when you conduct your next test. The display can also show the measured value that is being generated. This feature is equivalent to three voltmeters and three ammeters that present RMS values for all generators.[4]

4.3.2 With a PC - FREJA Win FREJA Win

In control center There are a number of instrument programs. You start the different programs at the Control center, where you also save and recall results. Since the test set-ups/results are saved via a regular Microsoft® Explorer display.[4]

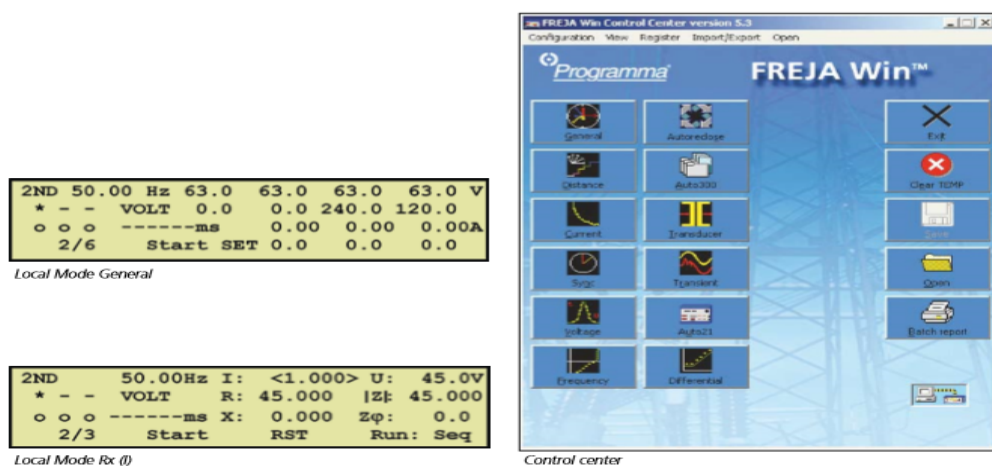


Figure 4.2: freja monitor.

4.4 Freja 300 components



Figure 4.3: freja300 relay test system.

The component of Freja 300 is:

1. Binary inputs
2. Binary outputs (normally-closed and normally-open).
3. Display and buttons used in the Local Mode.
4. Dial, press to Enter.
5. Multiconnector for voltage (L1U, L2U, L3U, NU) and current (L1I, L2I, L3I, NI).
6. Current and voltage outputs.
7. Switch, PC to Freja 300 or relay.
8. DC-supply, connect to (10) to read the values (in General mode page 5/6 on the display).
9. Analog inputs, LOW, for measurement transducers.
10. Analog inputs, HIGH, for volt- and ammeter.

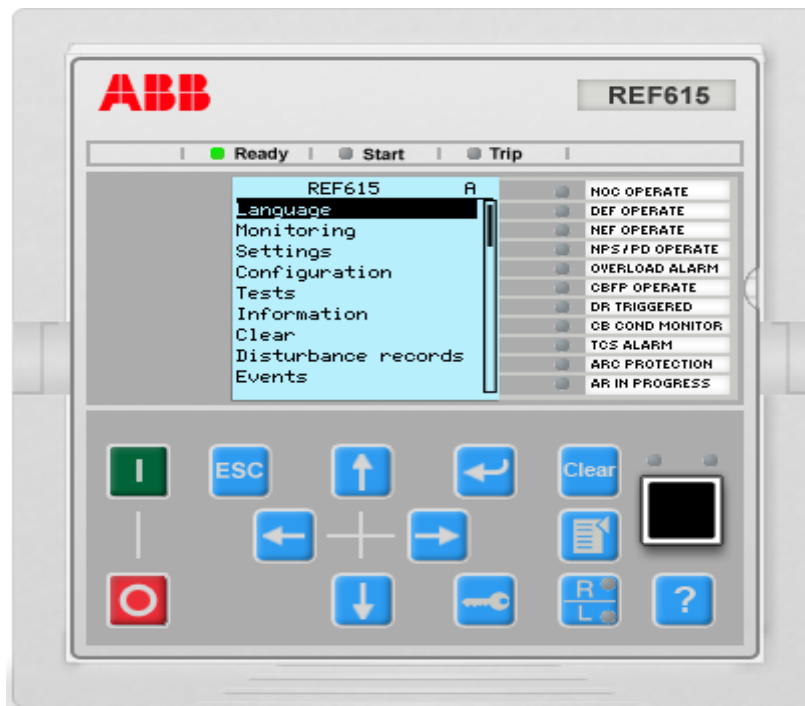


Figure 4.4: Main menu of relay.

The figure show the main menu of relay which include:

1. language of system.
2. Monitoring .
3. Settings.
4. Configuration.
5. Tests.
6. Information.
7. Clear.
8. Disturbance recoder.
9. Events.
10. Measurement.

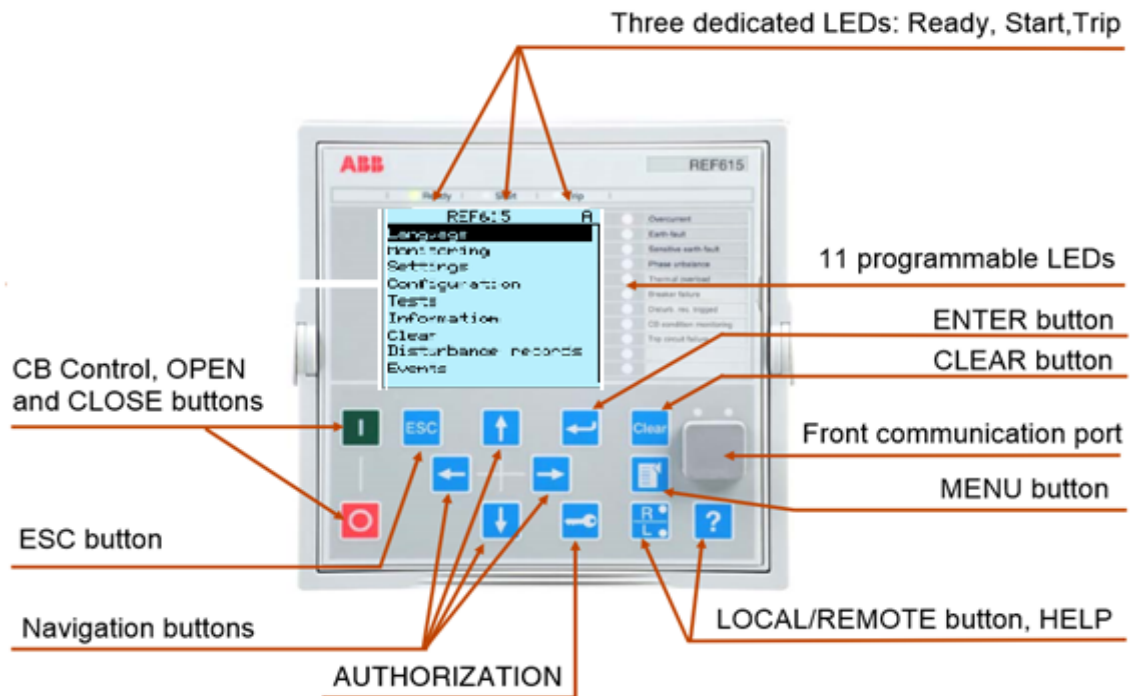


Figure 4.5: 615 series panel HMI .

4.5 Setting

Enter setting and select setting group to activate group of protection for various cases for example two group of protection group1(G1) for day load and group2(G2) for night load.

Select setting for example G1 and activate protection which need to set time and current trip.

Operation of freja:

Select Three-phase non-directional over-current protection, low stage, instance 1 [IEC 61850 naming, “classic” IEC symbols or ANSI codes: (PHLPTOC1, 3I>, 51P-1)].

4.5.1 Setting guidelines

Transformer data:

100MVA,primary/secondary=220/110KV

Calculation:

$$I_{\text{ref primary}} = (100 \times 1000) / (\sqrt{3} \times 220) = 262.432 \text{ A}$$

$$I_{\text{ref secondary}} = (100 \times 1000) / (\sqrt{3} \times 110) = 524.864 \text{ A}$$

CTs ratio:

For primary side = 300/1 A , ($I_{\text{nominal}}=300\text{A}$),

For secondary side = 600/1 A , ($I_{\text{nominal}}=600\text{A}$)

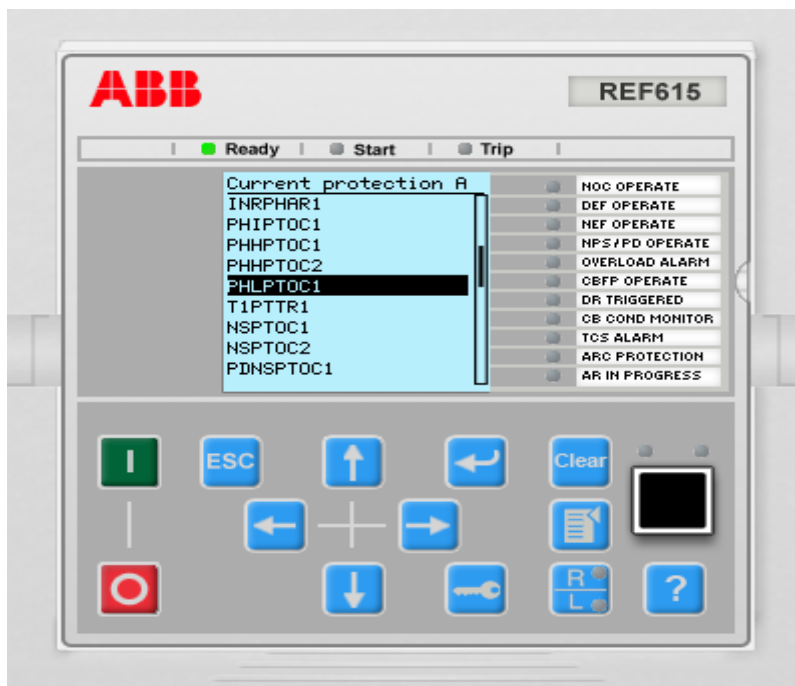


Figure 4.6: Select type of protection.

Activate operation then set current = $1.2 \times I_n$ & time = 7sec for trip as shown figure 4.8



Figure 4.7: Activate operation set current.

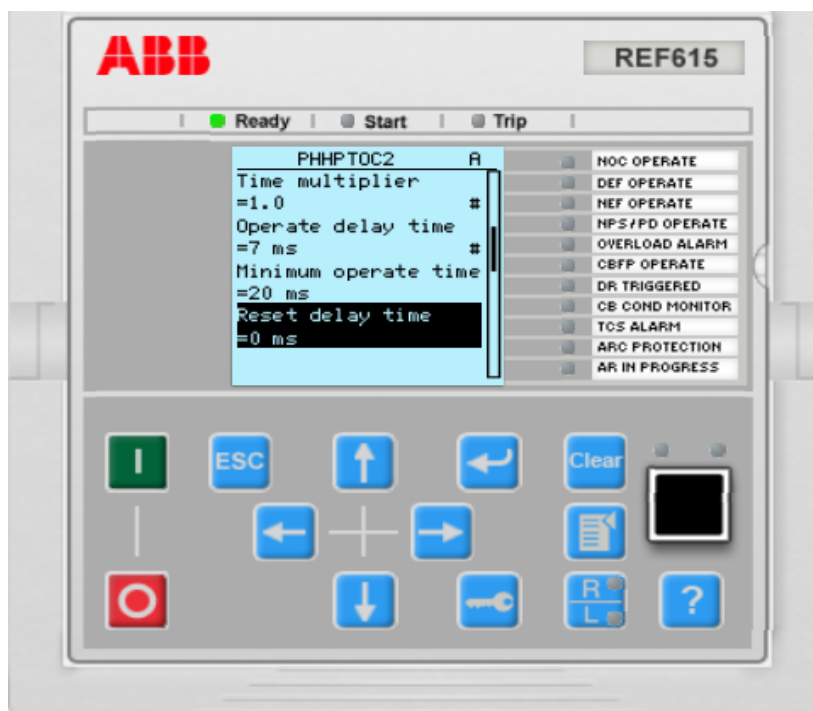


Figure 4.8: Activate operation set time.

Measurements:

Currents:

1 out of 3

When the current of phase1 reach $I_{L1}=300A$ the relay will operate.

Historical data.

Number of auto-reclosures (ARs) etc .

Fault indications.

Four fault recordings with time stamp.

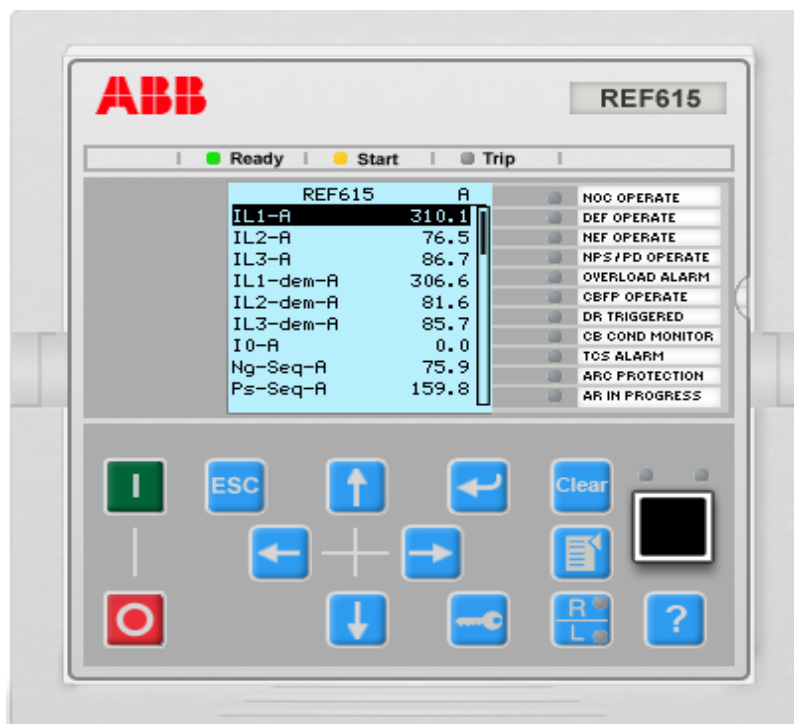


Figure 4.9: Measurements phase current.

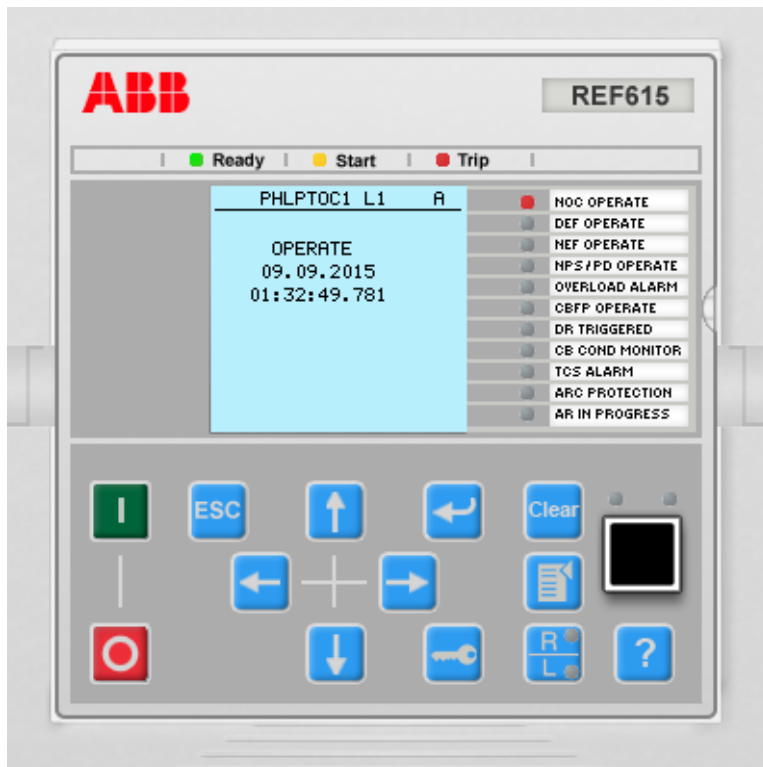


Figure 4.10: Type of fault and the time of trip.

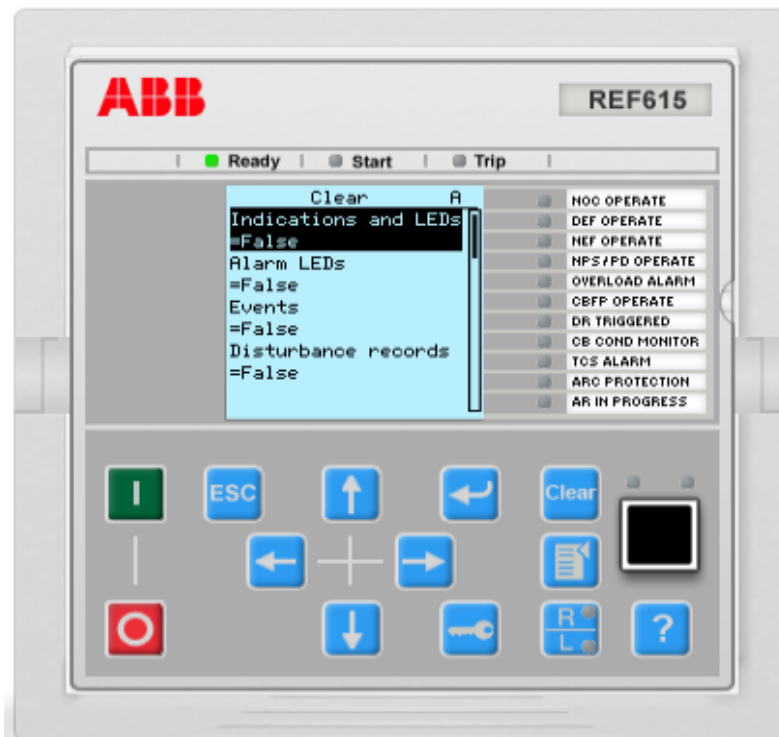


Figure 4.11: Clear fault.

Table 4.2: Functions included in the standard configuration

Function	IEC 61850	IEC	ANS I
Protection			
Three-phase non-directional over-current protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional over-current protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional over-current protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional over-current protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
++Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> - >	67N-2 A
Negative-sequence over-current protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence over-current protection, instance 2	NSPTOC2	I2> (2)	46 (2)

Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3I _{th} >F	49F
Three-phase inrush detector	INRPHAR1	3I _{2f} >	68
Transient / intermittent earth-fault protection	INTRPTEF1	I _o > -> IEF	67NIEF
Phase discontinuity protection	PDNSPTOC1	I ₂ /I ₁ >	46PD
Non-directional (cross-country) earth fault protection, using calculated I _o	EFHPTOC1	I _o >> (1)	51N-2 (1)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Through out the project it's clear that numerical protection is the best type of protection used compared to the other types due to its rapid fault detection, fast fault locating (LCD display screen) and extremely rapid fault clearance in such accuracy as in mille-seconds.

The numerical relay is avery easy device to handle and setting changing is as simple as possible (personal computer, control center or manually through relay front panel) according to the equipment protected, also it's quite easy to conduct tests to check its capability of doing the wanted work. The numerical relay is considered to be quite economical due to containing several protections in a single size suitable relay.

From the advantages listed above its seen that the numerical relay has helped in maintaining continuity of supply and keeping all different divisions in synchronism.

During the tests conducted it's seen that the time delay of tripping from the pre-set time is estimated to be in mille-seconds which indicates the high speed of response.

The numerical relay is not only well known to be easily remotely controlled, but also easy to change the setting remotely.

The numerical relay is highly secure because it doesn't allow unauthorized personnel to access and change the setting through a password only given to authorized personnel.

From the previous study done it was able to manufacture a prototype that simulates the operation of the numerical relay and three different inserted within (differential, reverse and over current protection) which are the main needed in the refinery protections.

5.2 Recommendations

- 1.The university should be availability requirement of projects.
- 2.Using programmer to analysis station to know the situation .
- 3.Work in numerical relay need the data sheet of relay to be available because it very helpful.
- 4.Take harmonics influence in operation of numerical relay.