Final Year Project Report

“Designing of Transformer and Implementation of a Digital Scheme for its Protection against Over Fluxing, Over Loading and Over Heating”

UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

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“Designing of Transformer and Implementation of a Digital Scheme for its Protection against Overfluxing, Over Loading and Over Heating”

Project Report submitted to the Department of Electrical Engineering, University of Management and Technology in partial fulfillment of the requirements for the degree of

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Certificate

It is to certify that the project & research work done under my supervision by this group titled, **“Designing of Transformer and Implementation of a Digital Scheme for its Protection against Overfluxing, Over Loading and Over Heating”** is original and not copied unlawfully from any source. The document submitted is error free and in preparation of this dissertation, the guidance/help taken from the work already published has been cited properly as per IEEE format.

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Dated: 19-07- 2012

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ABSTRACT

In this modern age the protection of electrical system has been a challenging problem for all protection engineers. The transformation from analogue world to digital world has created vast scope of study for all protection engineers and has moved to more economical techniques for implementation as well.

With advancement of microchips we were also attracted towards protection of transformer using microcontroller. Here we have chosen PIC microcontroller due to its special features like reprogram ability, built in Analogue to digital convertor (ADC). The transformer is backbone of every electrical power system. The various application of transformer has lead to its wide usage including substations to mini house household appliances. Thus protection has been compulsion.

In this project, microcontroller based protection system of transformer has been designed and explained. The main purpose of this project is to provide protection against different faulty conditions in transformer such as Internal Faults, Short circuit, Overloading Overheating.

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Chapter 1

Importance of Protection

The modern society has come to depend heavily upon continuity and reliability of electricity. Computer and telecommunication networks, railway networks, banking and post offices networks, continuous process industries and life support systems are just a few applications that just cannot function without a highly reliable source of electric power. And add to this, the mind boggling number of domestic users of electricity whose life is thrown out of gear in case the electric supply is disrupted. Thus, the importance of maintaining continuous supply of electricity round the clock cannot be overemphasized. No power system can be designed in such a way that it would never fail So, one has to live with failures

Protection of electrical systems is very important in the modern age and this goes on increasing with every incoming day. Today the situation is much different from the old days when electrical customers as well as electrical supplier companies were limited in number. More-ever the continuity of electric supply was not so critical as in the modern age..People were simple and satisfied with the electrical energy supplier. But now the situation is quite different. A man living in this civilized society knows much about his rights .HE wants to get the best in return that he pays for it. He needs reliable and continuous suuply from supplier, or he selects another supplier. So these electric companies are much curious about reliable and continuous supply of electrical power.

One thing should be remembered at this stage that no protection scheme can prevent any type of fault from occurring any way. It can however sense the fault and isolate faulty section, as soon as possible helping in reducing losses.

1.1 Characteristics of Protection Schemes

The protection schemes whichever is used must have some characteristics upon which there is no compromise.The higher these characteristics a scheme attains the better it is for the protection purpose.

1.1.1. Sensitivity

One of these is the sensitivity. The protection scheme must be alive to the presence of the smallest fault current. The smaller the fault current it can detect, the more sensitive it is. This is because if fault is not cut at start it will lead to a big fault within no time. So nip the evil in the bud.

1.1.2. Selectivity

The second important property is the selectivity. In detecting the fault and isolating the faulty element, the protective system must be very selective. Idealy, the protective system should zero-in on the faulty elements and isolate it, thus causing minimum interruption to the system**.**

1.1.3. Speed

The third property is the speed.The longer the fault presists on the system, the larger is the damage to the system and higher is the possibility that the system will lose stability.Thus it helps a lot if the entire process of fault detection and removal of the faulty parts is accomplished in as short a time as feasible. Therefore, the speed of the protection is very important. It must however, be mentioned that speed and accuracy bear an inverse relationship. The high-speed systems tend to be less accurate.This is for the simple reason that the high speed systems has lesser amount of information at its disposal than a slow speed system. The protection engineer has to strike a balance between these two incompatible requirements.

1.1.4. Reliability and Dependency

Fourth important property is the Reliability and Dependency. A protective system is of no use if it is not reliable. There are many ways in which reliability can be built into the system.Good engineering judgement plays a great part in enhancing the reliability of the protective system.In general,it is found that simple system are more reliable.Systems which depend upon locally available information, tend to be more reliable and dependable than those that those that depend upon the information at the remote end.However inspite of best efforts to make the system reliable we cannot rule out the possibility of failure of the(primary) protection system.therefore we add features like backup protection to enhance and dependability of the protective system.

1.2 Components of Protection Schemes

The main objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault, whilst leaving as much of the network as possible still in operation. Thus, protection schemes must apply a very pragmatic and pessimistic approach to clearing system faults. For this reason, the technology and philosophies utilized in protection schemes are often old and well-established because they must be very reliable.

Protection systems usually comprise five components:

1. Current and voltage transformers to step down the high voltages and currents of the electrical power system to convenient levels for the relays to deal with;
2. Relays to sense the fault and intiate a trip, or disconnection, order;
3. Circuit breakers act to limit the current in a single circuit in most household applications. Typically a single circuit is limited to 20 amperes, although breakers come in many sizes. This means that 20 amps of current will heat the bimetallic strip to bend it downward and release the spring-loaded trip-lever. Since the heating is fairly slow, another mechanism is employed to handle large surges from a short circuit. A small electromagnet consisting of wire loops around a piece of iron will pull the bimetallic strip down instantly in case of a large current surge. Circuit breakers to open/close the system based on relay and autorecloser commands;
4. Batteries to provide power in case of power disconnection in the system.
5. Communication channels to allow analysis of current and voltage at remote terminals of a line and to allow remote tripping of equipment.

1.3 Current Transformer

A current transformer (CT) is a type of instrument transformer designed to provide a current in its secondary winding proportional to the alternating current flowing in its primary. They are commonly used in metering and protective relaying in the electrical power industry where they facilitate the safe measurement of large currents, often in the presence of high voltages. The current transformer safely isolates measurement and control circuitry from the high voltages typically present on the circuit being measured.

1.3.1 Design

Depending on the ultimate clients requirement, there are two main standards to which current transformers are designed. IEC 60044-1 (BSEN 60044-1)[17] & IEEE C57.13 (ANSI), although the Canadian & Australian standards are also recognised. The most common design of CT consists of a length of wire wrapped many times around a silicon steel ring passed over the circuit being measured. The CT's primary circuit therefore consists of a single 'turn' of conductor, with a secondary of many hundreds of turns.The CT acts as a constant-current series device with an apparent power burden a fraction of that of the high voltage primary circuit. Hence the primary circuit is largely unaffected by the insertion of the CT.Common secondaries are 1 or 5 amperes. For example, a 4000:5 CT would provide an output current of 5 amperes when the primary was passing 4000 amperes. The secondary winding can be single ratio or multi ratio, with five taps being common for multi ratio CTs[12].

1.3.2 Usage

Current transformers are used extensively for measuring current and monitoring the operation of the power grid. The CT is typically described by its current ratio from primary to secondary. Often, multiple CTs are installed as a "stack" for various uses (for example, protection devices and revenue metering may use separate CTs).

1.3.3 Connections

For IEC (BSEN) typically, the secondary connection points are labeled as 1S1, 1S2, 2S1, 2S2 and so on, or in the ANSI/IEEE[17] standard areas, X1...X5, Y1...Y5, and so on. The multi ratio CTs are typically used for current matching in current differential protective relaying applications.For a three-stacked CT application, the secondary winding connection points are typically labelled X_n, Y_n, Z_n.

1.3.4 Safety Precautions

Care must be taken that the secondary of a current transformer is not disconnected from its load while current is flowing in the primary, as the transformer secondary will attempt to continue driving current across the effectively infinite impedance. This will produce a high voltage across the open secondary (into the range of several kilovolts in some cases), which may cause arcing. The high voltage produced will compromise operator and equipment safety and permanently affect the accuracy of the transformer.

1.3.5 Accuracy

The accuracy of a CT is directly related to a number of factors including:

- Burden
- Burden Class /Saturation Class
- Rating factor
- Load
- External electromagnetic fields
- temperature and
- Physical configuration.

For the IEC stnadard, accuracy classes for various types of measurement are set out in BSEN /IEC 60044-1[12] , Class 0.1, 0.2s, 0.2, 0.5, 0.5s, 1 & 3. It will be seen that the class designation is an approximate measure of the accuracy, e g , Class 1 current transformers have ratio error within 1% of rated current Class 0.5 within a ratio error of 0.5% etc.

1.3.6 Burden

The burden in a CT metering circuit is essentially the amount of impedance (largely resistive) present. Typical burden ratings for IEC CTs are 1.5VA, 3VA, 5VA, 10VA, 15VA, 20VA, 30VA, 45VA & 60VA with ANSI/IEEE B-0.1, B-0.2, B-0.5, B-1.0, B-2.0 and B-4.0[11]. This means a CT with a burden rating of B-0.2 can tolerate up to 0.2 Ω of impedance in the metering circuit before its output current is no longer a fixed ratio to the primary current. Items that contribute to the burden of a current measurement circuit are switch blocks meters and intermediate conductors. The most common source of excess burden in a current measurement circuit is the conductor between the meter and the CT. Often, substation meters are located significant distances from the meter cabinets and the excessive length of small gauge conductor creates a large resistance. This problem can be solved by using CT with 1 ampere secondaries which will produce less voltage drop between a CT and its metering devices.

1.3.7 Rating Factor

Rating factor is a factor by which the nominal full load current of a CT can be multiplied to determine its absolute maximum measurable primary current. Conversely, the minimum primary current a CT can accurately measure is "light load," or 10% of the nominal current (there are, however, special CTs designed to measure accurately currents as small as 2% of the nominal current). The rating factor of a CT is largely dependent upon ambient temperature. Most CTs have rating factors for 35 degrees Celsius and 55 degrees Celsius. It is important to be mindful of ambient temperatures and resultant rating factors when CTs are installed inside pad-mounted transformers or poorly ventilated mechanical rooms.

1.3.8 Saturation Problem of CT

Well-established engineering practice exists for CT selection to ensure saturation free-operation of protection CTs at a given short circuit level, CT burden, X/R ratio and assumed residual flux. In the context of this paper, it is assumed that this engineering technique is not applied, and severe saturation will occur for short circuits within the protected zone (motor, feeder, cable or bus)

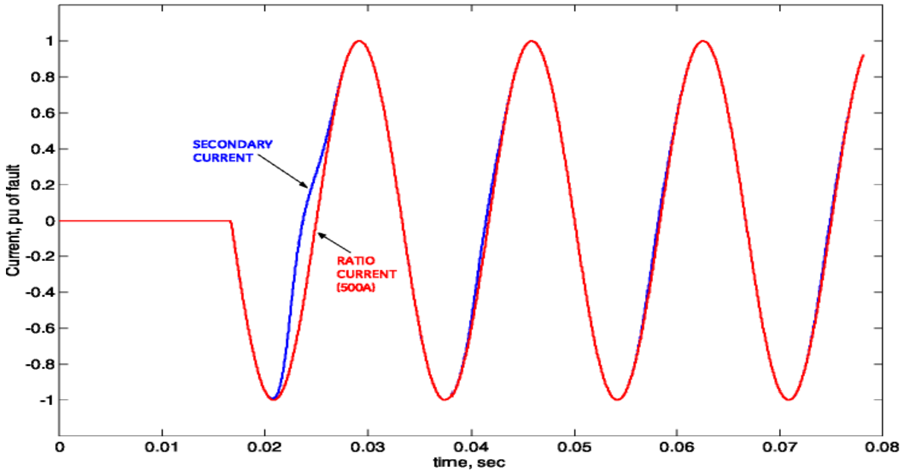

Fig.1.1 CT with a burden of 0.2ohms under fault current of 500A (symmetrical)

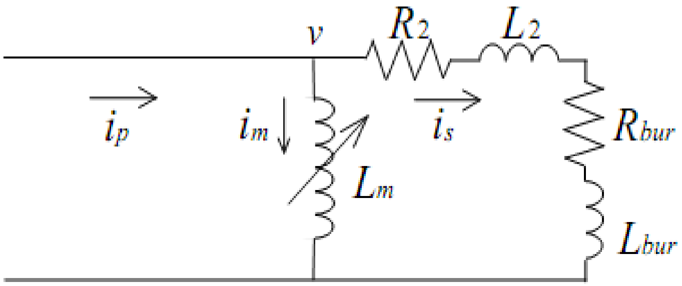

Fig.1.2. Equivalent circuit of CT

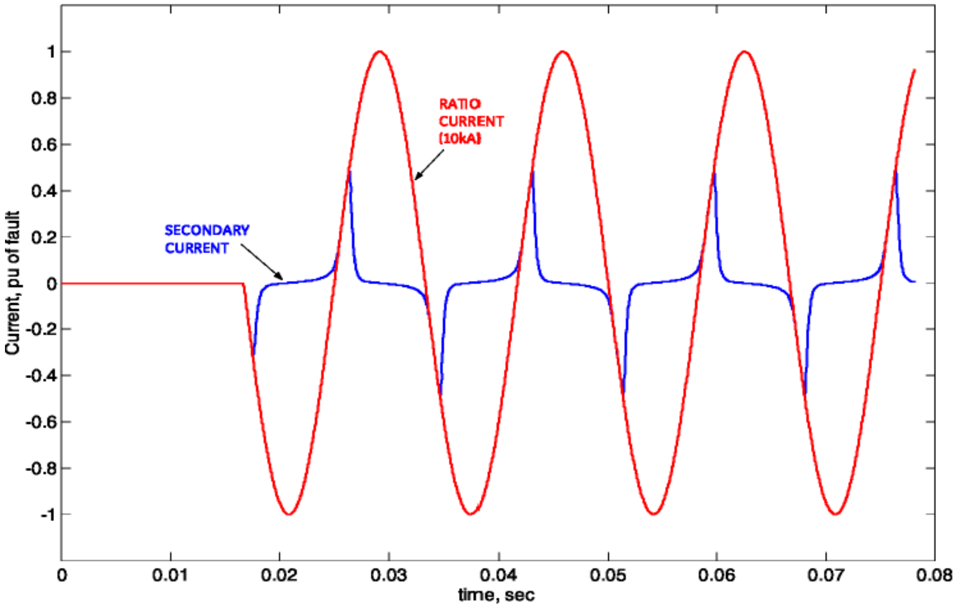

Fig.1.3. CT with a burden of 0.2ohms under fault current of 10kA (symmetrical).

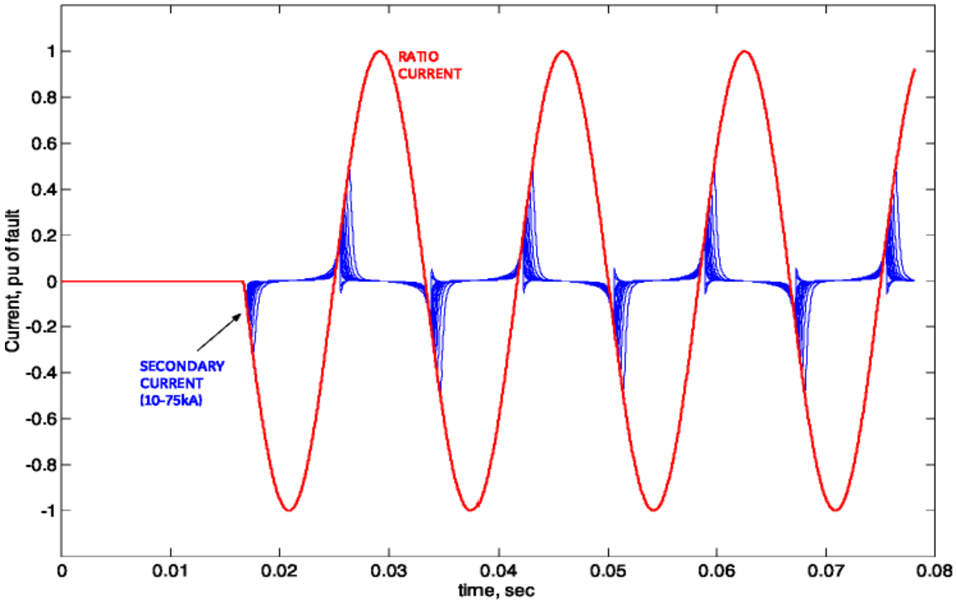

Fig.1.4. CT with a burden of 0.2ohms under fault current up to75kA (symmetrical)

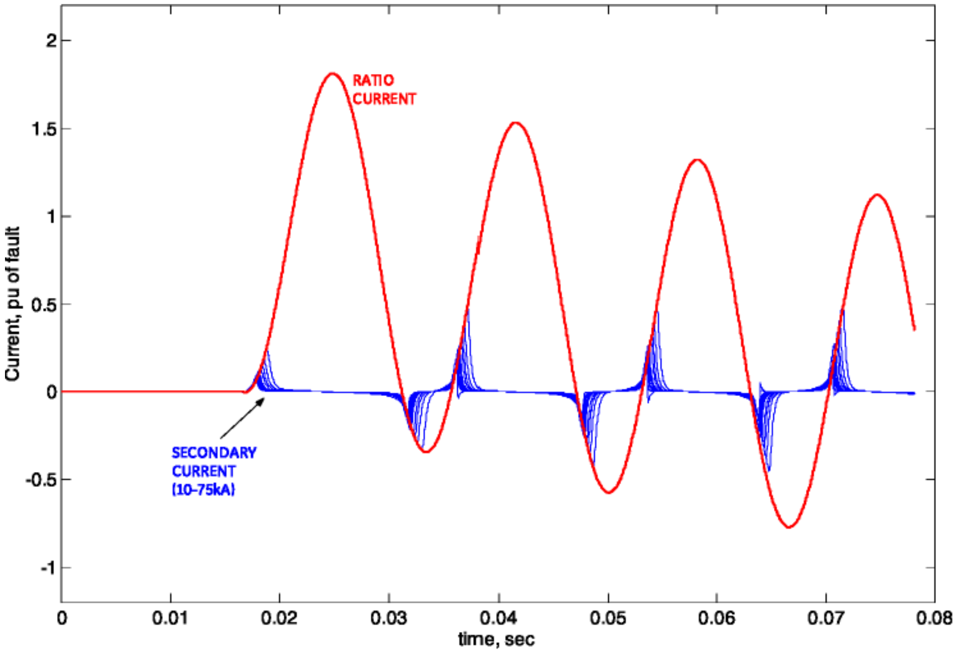

Fig.1.5. CT with a burden of 0.2ohms under fault current up to75kA (fully offset).

1.3.8.1 Impact of Relay on Current Transformers

In general, the relay input CTs may saturate adding to the complexity of the analysis, and to the scale of the problem. However, saturation of relay input CTs may be neglected for the following reasons:

The secondary current is substantially reduced under severe saturation of main CTs. Moreover, saturation of the main CT makes the secondary current symmetrical eliminating the danger of exposing the relay input CT to decaying dc components. And thirdly, the secondary current has a form of short lasting spikes. This limits the flux in the cores of the relay inputs CTs.For example, consider the case of Figure 5. Under say 75kA of symmetrical fault currentthe secondary current is approximately a series of triangular peaks of about 0.08*75kA*/ (50:5) = 848A secondary, lasting approximately 0.5-1ms. Assuming 1ms duration of these spikes, the true RMS of this secondary signal is only 120A, or 24 times the 5A rated of the relay input.In reality, the relay input CT would have some impact on the response of the relay. Frequency response, i.e. ability to reproduce the short lasting input signal, may play a role.The theoretical analysis of this paper neglects the impact of relay input CTs it is believed to be small. This is confirmed through testing of actual relay hardware.

1.3.8.2 Impact of the Analog Filter

Analog filters are implemented in order to prevent aliasing of higher frequencies on the fundamental frequency signal. Typically, a second order filter is used with a cut-off frequency of about 1/3rd of the sampling rate.

Analog filters have a positive impact on the response of the relay to heavily saturated current waveforms. Due to its intended low-pass filtering response, the analog filter reduces the peak values of its input signal and lengthens the duration of such spikes. In a way, the analog filters smoothes out the waveform by shaving its peaks and moving the associated signal energy into the area of lower magnitude. This phenomenon is illustrated in Figure 9. Given the fact that the peak magnitude of spikes is well above the conversion level of the relay, and as such it is not used by the relay when deriving the operating quantity, the operation of shifting some signal energy from the peaks into the low magnitude area would increase the operating signal, and improve the overall response of the relay.

1.3.8.3 Impact of the A/D Converter

The impact of the A/D converter is twofold. First, any converter has a limited conversion range where signals above a certain level are clamped. This is similar to the response of the analog filter in front of the A/D converter (saturation of the amplifiers). The conversion range of today’s relays is typically in the 10-50 span. For example, the GE 469 Motor Management Relay clamps the inputs at 28.3* 2 *5A = 200A secondary peak, assuming the 5A rated current.

.1.3.8.4 Impact of the Magnitude Estimator

Microprocessor-based relays calculate their operating signals, such the current magnitude for the IOC function, from raw signal samples. This process of estimation can include digital filtering for removal of the dc offset that otherwise would result in an overshoot. Typically a Fourier-type or RMS-type estimators are used.

The former extract only the fundamental component from the waveforms (60Hz) through a process of filtering. This would result in a much lower estimate of the magnitude if the waveforms were heavily distorted.

The latter extracts the total magnitude from the entire signal spectrum yielding a higher response under heavily saturated waveforms. The difference can be tenfold in extreme cases such as the ones considered in this paper.

1.4 Voltage Transformer

Voltage and potential transformers are used to measure voltage in electric circuits. Their main role is to condition (step down) the voltage to be measured to levels suitable for the measuring instrument. Voltage and potential transformers have a secondary voltage that is substantially proportional to the primary voltage, but differs in phase by an angle that is approximately zero for an appropriate direction of the connections. A low voltage transformer converts normal line voltage (120 VAC) to low voltage (typically 12 VAC). This lower voltage can then be used to power an incandescent low-voltage lamp. A dimmer is specifically designed for an electronic low-voltage transformer. A low voltage lighting transformer converts 120-volt currents to a relatively safe and energy efficient 12-volt (low-voltage) current for many outdoor lighting applications.

1.4.1 Types

There are many different types of voltage and potential transformers. A high voltage transformer operates with high voltages. Typically, these voltage transformers are used in power transmission applications, where voltages are high enough to present a safety hazard. A medium voltage transformer can be connected directly to a primary distribution circuit and generally has the most load diversity. These voltage and potential transformers have installation practices that are generally in accordance with application recommendations from the Institute of Electrical and Electronic Engineers (IEEE). Voltage transformers such as a constant voltage transformer maintain a relatively constant output voltage for variations of up to 20% in the input voltage. A transformer and voltage regulator is a transformer whose voltage ratio of transformation can be adjusted. A variable voltage transformer is a transformer that changes voltage, such as changing the ratio between primary and secondary coils. These voltage and potential transformers usually provide automatic adjustment controls to maintain "constant" (regulated) voltage output.

1.4.2 Selection

Selecting voltage and potential transformers requires and analysis of performance specifications such as single-phase or three-phase primary configuration, primary frequency, maximum primary voltage rating, maximum secondary voltage rating, maximum power rating, and output type. The size and cost of a single-phase voltage transformer increases with the number of leads. A five-lead primary requires more copy than a quad or 2+2 primary. A ladder is the least economical primary configuration. Three phase voltage and potential transformers are connected in delta or wye configurations. A wye (Y) - delta transformer has its primary winding connected in a wye and its secondary winding connected in a delta. A delta - wye (Y) transformer has its primary winding connected in a delta and its secondary winding connected in a wye.Two types of voltage transformer are used for protective-relaying purposes, as follows: (1) the "instrument potential transformer," hereafter to be called simply "potential transformer," and (2) the "capacitance potential device." A potential transformer is a conventional transformer having primary and secondary windings. The primary winding is connected directly to the power circuit either between two phases or between one phase and ground, depending on the rating of the transformer and on the requirements of the application. A capacitance potential device is a voltage-transforming equipment using a capacitance voltage divider connected between phase and ground of a power circuit.

1.4.3 Accuracy of Potential Transformer

The ratio and phase-angle inaccuracies of any standard ASA accuracy class of potential transformer are so small that they may be neglected for protective-relaying purposes if the burden is within the "thermal" volt-ampere rating of the transformer. This thermal volt-ampere rating corresponds to the full-load rating of a power transformer. It is higher than the volt-ampere rating used to classify potential transformers as to accuracy for metering purposes. Based on the thermal volt-ampere rating, the equivalent-circuit impedances of potential transformers are comparable to those of distributin transformers.The "burden" is the total external volt-ampere load on the secondary at rated secondary voltage.

1.5Relays

Relay is a simple electromechanical switch made up of an electromagnet and a set of contacts. Relays are found hidden in all sorts of devices. In fact, some of the first computers ever built used relays to implement Boolean gates.

In general, the point of a relay is to use a small amount of power in the electromagnet -- coming, say, from a small dashboard switch or a low-power electronic circuit. For example, you might want the electromagnet to energize using 5 volts and 50 milliamps (250 milliwatts), while the armature can support 120V AC at 2 amps (240 watts).Relays are quite common in home appliances where there is an electronic control turning on something like a motor or a light. They are also common in cars, where the 12V supply voltage means that just about everything needs a large amount of current. In later model cars, manufacturers have started combining relay panels into the fuse box to make maintenance easier.

In places where a large amount of power needs to be switched, relays are often cascaded. In this case, a small relay switches the power needed to drive a much larger relay, and that second relay switches the power to drive the load Relays are amazingly simple devices. There are four parts in every relay.

- Electromagnet
- Spring
- Armature
- Set of electrical contacts

A relay consists of two separate and completely independent circuits. The first is at the bottom and drives the electromagnet. In this circuit, a switch is controlling power to the electromagnet. When the switch is on, the electromagnet is on, and it attracts the armature (blue). The armature is acting as a switch in the second circuit. When the electromagnet is energized, the armature completes the second circuit and the light is on. When the electromagnet is not energized, the spring pulls the armature away and the circuit is not complete. In that case, the light is dark.

1.6 Circuit Breaker

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city

All circuit breakers have common features in their operation, although details vary substantially depending on the voltage class, current rating and type of the circuit breaker.

The circuit breaker must detect a fault condition; in low-voltage circuit breakers this is usually done within the breaker enclosure. Circuit breakers for large currents or high voltages are usually arranged with pilot devices to sense a fault current and to operate the trip opening mechanism. The trip solenoid that releases the latch is usually energized by a separate battery, although some high-voltage circuit breakers are self-contained with current transformers, protection relays, and an internal control power source.

Once a fault is detected, contacts within the circuit breaker must open to interrupt the circuit; some mechanically stored energy within the breaker is used to separate the contacts, although some of the energy required may be obtained from the fault current itself. The stored energy may be in the form of springs or compressed air. Small circuit breakers may be manually operated; larger units have solenoids to trip the mechanism, and electric motors to restore energy to the springs.

The circuit breaker contacts must carry the load current without excessive heating, and must also withstand the heat of the arc produced when interrupting the circuit. Contacts are made of copper or copper alloys, silver alloys, and other materials. Service life of the contacts is limited by the erosion due to interrupting the arc. Miniature circuit breakers are usually discarded when the contacts are worn, but power circuit breakers and high-voltage circuit breakers have replaceable contacts.

When a current is interrupted, an arc is generated - this arc must be contained, cooled, and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit. Different circuit breakers use vacuum, air, insulating gas, or oil as the medium in which the arc forms. Different techniques are used to extinguish the arc including:

- Lengthening of the arc
- Intensive cooling (in jet chambers)
- Division into partial arcs
- Zero point quenching
- Connecting capacitors in parallel with contacts in DC circuits

Finally, once the fault condition has been cleared, the contacts must again be closed to restore power to the interrupted circuit.

1.6.1 Arc interruption

Miniature low-voltage circuit breakers use air alone to extinguish the arc. Larger ratings will have metal plates or non-metallic arc chutes to divide and cool the arc. Magnetic blowout coils deflect the arc into the arc chute.In larger ratings; oil circuit breakers rely upon vaporization of some of the oil to blast a jet of oil through the arc. Gas (usually sulfur hexafluoride) circuit breakers sometimes stretch the arc using a magnetic field, and then rely upon the dielectric strength of the sulfur hexafluoride (SF_6) to quench the stretched arc.Vacuum circuit breakers have minimal arcing (as there is nothing to ionize other than the contact material), so the arc quenches when it is stretched a very small amount (<2-3 mm). Vacuum circuit breakers are frequently used in modern medium-voltage switchgear to 35,000 volts.Air circuit breakers may use compressed air to blow out the arc, or alternatively, the contacts are rapidly swung into a small sealed chamber, the escaping of the displaced air thus blowing out the arc.

1.6.2 Short Circuit Current

Circuit breakers are rated both by the normal current that are expected to carry, and the maximum short-circuit current that they can safely interrupt.Under short-circuit conditions, a current many times greater than normal can exist (see maximum prospective short circuit current). When electrical contacts open to interrupt a large current, there is a tendency for an arc to form between the opened contacts, which would allow the current to continue. Therefore, circuit breakers must incorporate various features to divide and extinguish the arc.The maximum short-circuit current that a breaker can interrupt is determined by testing. Application of a breaker in a circuit with a prospective short-circuit current higher than the breaker's interrupting capacity rating may result in failure of the breaker to safely interrupt a fault. In a worst-case scenario the breaker may successfully interrupt the fault, only to explode when reset, injuring the technician.Miniature circuit breakers used to protect control circuits or small appliances may not have sufficient interrupting capacity to use at a panelboard; these circuit breakers are called "supplemental circuit protectors" to distinguish them from distribution-type circuit breakers.

1.6.3 Types of Circuit Breaker

Front panel of a 1250 A air circuit breaker manufactured by ABB. This low voltage power circuit breaker can be withdrawn from its housing for servicing. Trip characteristics are configurable via DIP switches on the front panel.Many different classifications of circuit breakers can be made, based on their features such as voltage class, construction type, interrupting type, and structural features.Low voltage (less than 1000 V_{AC}) types are common in domestic, commercial and industrial application, include[18]:

MCB (Miniature Circuit Breaker) rated current not more than 100 A.Trip characteristics normally not adjustable. Thermal or thermal-magnetic operation. Breakers illustrated above are in this category [17].

- MCCB (Moulded Case Circuit Breaker)—rated current up to 1000 A. Thermal or thermal-magnetic operation. Trip current may be adjustable in larger ratings.
- Low voltage power circuit breakers can be mounted in multi-tiers in LV switchboards or switchgear cabinets.
- Vacuum circuit breaker—with rated current up to 3000 A, these breakers interrupt the current by creating and extinguishing the arc in a vacuum container. These can only be practically applied for voltages up to about 35,000 V, which corresponds roughly to the medium-voltage range of power systems. Vacuum circuit breakers tend to have longer life expectancies between overhaul than do air circuit breakers.
- Air circuit breaker—rated current up to 10,000 A. Trip characteristics are often fully adjustable including configurable trip thresholds and delays. Usually electronically controlled, though some models are microprocessor controlled via an integral electronic trip unit. Often used for main power distribution in large industrial plant, where the breakers are arranged in draw-out enclosures for ease of maintenance.

1.7 Causes Of Faults

A fault current is an abnormal current in an electric circuit due to a fault (usually a short circuit or abnormally low impedance path).In terms of installation wiring, the prospective short-circuit current must be known as it influences the choice of protective device. If a circuit is to be properly protected, the fault current must be high enough to operate the protective device within as short a time as possible; also the protective device must be able to withstand the fault current and extinguish any resulting arcs without itself being destroyed or sustaining the arc for any significant length of time.

Fault current comes in three varieties: Phase to neutral, phase to phase and phase to earth. These differ widely depending on the type of earthing system used, the installation's supply type and earthing system, and its proximity to its substation.

The causes of shunt faults may be considered as that these are basically due to failure of insulation .The breaking of insulation may be due to its weakening or ir may fail due to overvoltage .The weakening of insulation may be due to factors given below.

- Ageing ,Temperature, Rain , Hail ,Snow
- Chemical pollution,Foreign objects & Other causes

1.8 Probability of Different Faults

Faults may be classified as

1. Ground faults
2. Phase faults
3. All those faults which contain only one phase conductor are ground faults where all those faults which involve two phase conductors are phase faults.

Fault statistics is with reference to power system elements as follows.

Power system element	Probability of faults (%)
Overhead lines	50
Underground lines	9

Transformers	10
Generators	7
Switchgear	12
CT and PT relays	12

The severity of the fault can be expressed in term of magnitude of fault current and hence its potential for causing damage. In the power system the three phase fault is the most severe whereas the line to ground fault is the least severe.