STUDY OF TRANSFORMER FAULTS AND PROTECTION (BASED ON 132/33KV GRID- SUB-STASION, PGCB)

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DECLARATION

We hereby declare that this Thesis on **"Study of Transformer Faults and Protection"** is submitted to Daffodil International University for partial fulfillment of the requirement of the degree of B.Sc. in Electrical & Electronic Engineering. It has not been submitted to any other University or institution for the award of any degree previously. This project report does not breach any provision of copy right act.

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Authors

TABLE OF CONTENTS

Abstract

This thesis describes different types of transformer faults and its protection scheme for transformers. Mainly, distribution type transformer has been considered. The first part of the thesis provides the background for different types of transformers faults and the differential thesis provides the background for different types of transformer faults and the differential protection schemes currently applied. After that we have focused a special sector that is a method of modeling transformer with internal winding faults. An internal fault is simulated by dividing the transformer winding into several sub-coils. The simulation of the terminal voltages and currents is based on known leakage factors between the various coils of the distribution transformer. These leakage factors are calculated by using a simple method analyzed in this paper. Then we analyzed a method for protecting turn to turn fault of transformer. Problems for the differential protection caused by transformer inrush currents and harmonics are also discussed. We have also analyzed various vector group tests and a technique for determination of vector group of different types of transformer and make them suitable for parallel operation

CHAPTER 1

Introduction

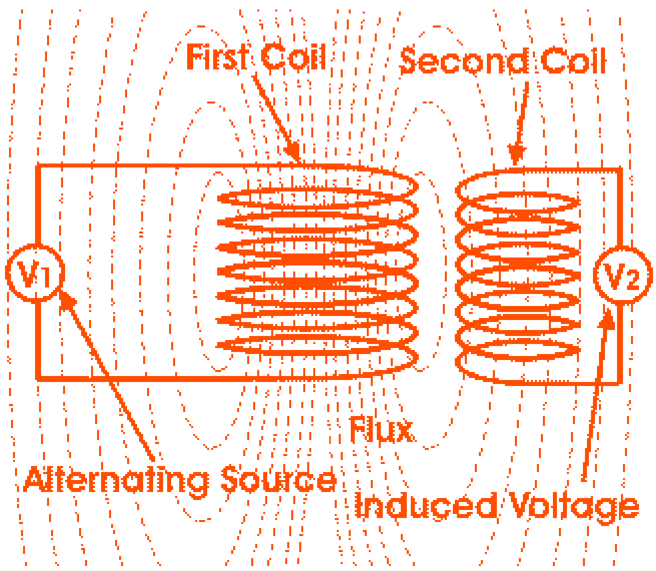
Definition of Transformer

A transformer is a static machine used for transforming power from one circuit to another without changing frequency. This is very basic definition of transformer.

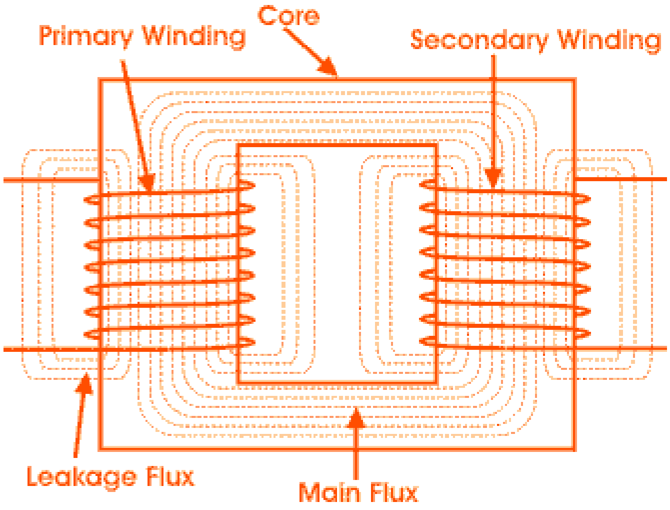
Basic Theory of Transformer

Say you have one winding which is supplied by an alternating electrical source. The alternating current through the winding produces a continually changing flux or alternating flux surrounds the winding. If any other winding is brought nearer to the previous one, obviously some portion of this flux will link with the second. As this flux is continually changing in its amplitude and direction, there must be a change in flux linkage in the second winding or coil. According to Faraday's law of electromagnetic induction, there must be an EMF induced in the second. If the circuit of the latter winding is closed, there must be an electric current flows through it. This is the simplest form of electrical power transformer and this is most basic of working principle of transformer.

For better understanding we are trying to repeat the above explanation in more brief here. Whenever we apply alternating current to an electric coil, there will be an alternating flux surrounding that coil. Now if we bring another coil near by this first one, there will be an alternating flux linkage with that second coil. As the flux is alternating, there will be obviously a rate of change of flux linkage with respect to time in the second coil. Naturally emf will be induced in it as per Faraday's law of electromagnetic induction. This is the most basic concept of theory of transformer.
The winding which takes electrical power from the source, is generally known as primary winding of transformer. Here in our above example it is first winding.



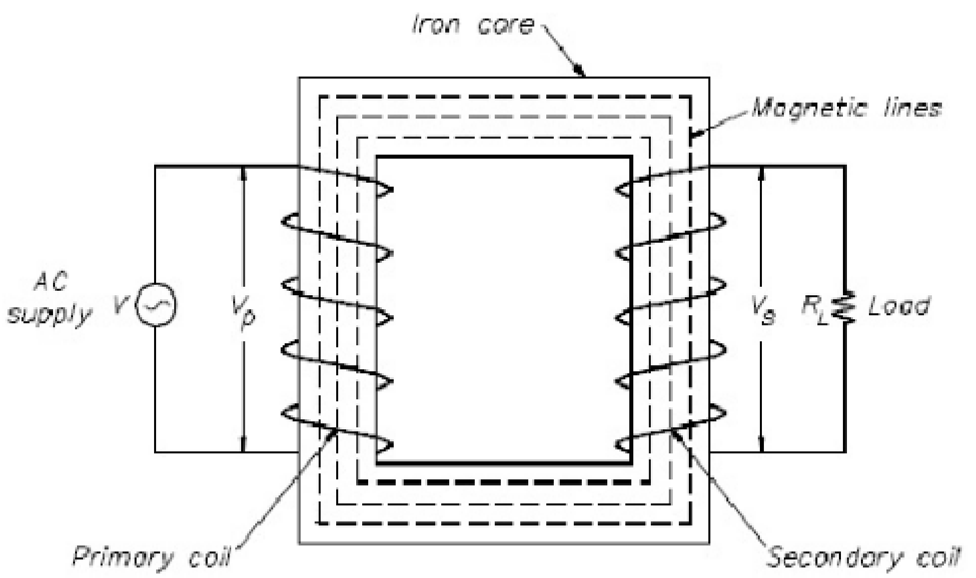
The winding which gives the desired output voltage due to mutual induction in the transformer, is commonly known as secondary winding of transformer. Here in our example it is second winding.



The above mentioned form of transformer is theoretically possible but not practically, because in open air very tiny portion of the flux of the first winding will link with second so the electric current flows through the closed circuit of latter, will be so small that it may be difficult to measure.

The rate of change of flux linkage depends upon the amount of linked flux, with the second winding. So it desired to be linked almost all flux of primary winding, to the secondary winding. This is effectively and efficiently done by placing one low reluctance path common to both the winding. This low reluctance path is core of transformer, through which maximum number of flux produced by the primary is passed through and linked with the secondary winding. This is most basic theory of transformer.

Main Constructional Parts of Transformer



So three main parts of a transformer are,

1. Primary Winding of transformer - which produces magnetic flux when it is connected to electrical source.
2. Magnetic Core of transformer - the magnetic flux produced by the primary winding, will pass through this low reluctance path linked with secondary winding and creates a closed magnetic circuit.
3. Secondary Winding of transformer - the flux, produced by primary winding, passes through the core, will link with the secondary winding. This winding is also wound on the same core and gives the desired output of the transformer.

CHAPTER 2

History of the Transformer

How is it used?

A transformer is used to bring voltage up or down in an AC electrical circuit. A transformer can be used to convert AC power to DC power. There are transformers all over every house, they are inside the black plastic case which you plug into the wall to recharge your cell phone or other devices. These types are often called "wall worts". They can be very large, as in national utility systems, or it can be very small embedded inside electronics. It is an essential part of all electronics today.

Who invented the transformer?

William Stanley's First Transformer built in 1885

William Stanley's First Transformer built in 1885

When was the transformer invented?

The property of induction was discovered in the 1830's but it wasn't until 1886 that **William Stanley**, working for **Westinghouse** built the first refined, commercially used transformer. His work was built upon some rudimentary designs by the Ganz Company in Hungary (ZBD Transformer 1878), and Lucien Gaulard and John Dixon Gibbs in England. Nikola Tesla did not invent the transformer as some dubious sources have claimed. The Europeans mentioned above did the first work in the field, George Westinghouse and Stanley made the transformer cheap to produce, and easy to adjust for final use.

Where were the first transformers used?

The first AC power system that used the *modern* transformer was in Great Barrington, Massachusetts in 1886. Earlier forms of the transformer were used in Austro-Hungary 1878-1880s and 1882 onward in England. Lucien Gaulard (Frenchman) used his AC system for the revolutionary Lanzo to Turin electrical exposition in 1884 (Northern Italy). In 1891 mastermind Mikhail Dobrovsky designed and demonstrated his 3 phase transformers in the Electro-Technical Exposition at Frankfurt, Germany.

Transformer development timeline:

1830s - Joseph Henry and Michael Faraday work with electromagnets and discover the property of induction independently on separate continents.

1836 - Rev. Nicholas Callan of Maynooth College, Ireland invents the induction coil

1876 - Pavel Yablochkov uses induction coils in his lighting system
1878 -1883 - The Ganz Company (Budapest, Hungary) uses induction coils in their lighting systems with AC incandescent systems. This is the first appearance and use of the toroidal shaped transformer.

1881 - Charles F. Brush of the Brush Electric Company in Cleveland, Ohio develops his own design of transformer (source: Brush Transformers Inc.)

1880-1882 - Sebastian Ziani de Ferranti (English born with an Italian parent) designs one of the earliest AC power systems with William Thomson (Lord Kelvin). He creates an early transformer. Gaulard and Gibbs later design a similar transformer and loose the patent suit in English court to Ferranti.

1882 - Lucien Gaulard and John Dixon Gibbs first built a "secondary generator" or in today's terminology a step down transformer which they designed with open iron core, the invention was not very efficient to produce. It had a linear shape which did not work efficiently. It was first used in a public exhibition in Italy in 1884 where the transformer brought down high voltage for use to light incandescent and arc lights. Later they designed a step up transformer. Gaulard (French) was the engineer and Gibbs (English) was the businessman behind the initiative. They sold the patents to Westinghouse. Later they lost rights to the patent when Ferranti (also from England) took them to court.

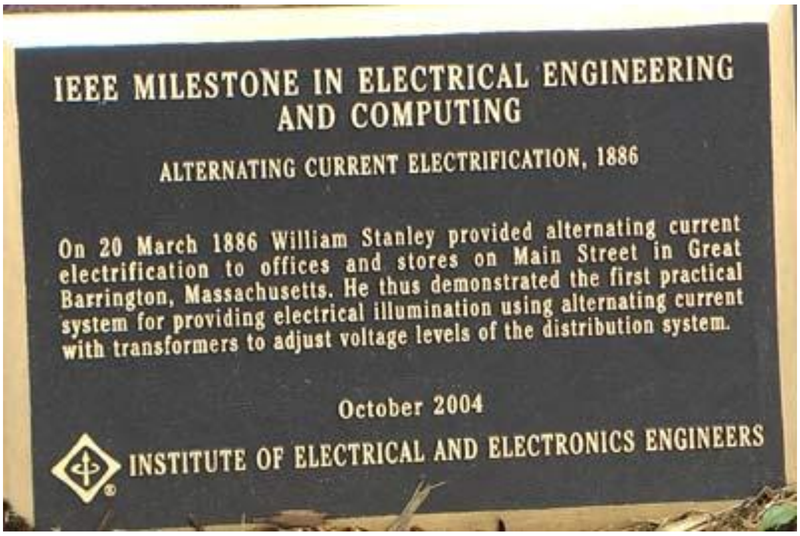
1884 - In Hungary Otto Blathy had suggested the use of closed-cores, Karoly Zipernowsky the use of shunt connections, and Miksa Deri had performed the experiments. They found the major flaw of the Gaulard-Gibbs system were successful in making a high voltage circuit work using transformers in parallel. There design was a toroidal shape which made it expensive to make. Wires could not be easily wrapped around it by machine during the manufacturing process.

1884 - Use of Lucien Gaulard's transformer system (a series system) in the first large exposition of AC power in Turin, Italy... This event caught the eye of George Westinghouse who bought Gaulard and Gibbs Transformer design. The 25 mile long transmission line illuminated arc lights, incandescent lights, and powered a railway. Gaulard won an award from the Italian government of 10,000 francs.

1885 - George Westinghouse orders a Siemens alternator (AC generator) and a Gaulard and Gibbs transformer. Stanley begin experimenting with this system.

1885 - William Stanley makes the transformer more practical due to some design changes: "Stanley's first patented design was for induction coils with single cores of soft iron and adjustable gaps to regulate the EMF present in the secondary winding. (See drawing at left.) This design was first used commercially in the USA in 1886". William Stanley explains to Franklin L. Pope (advisor to Westinghouse and patent lawyer.) that is design was salable and a great improvement. Pope disagrees but Westinghouse decides to trust Stanley anyway.

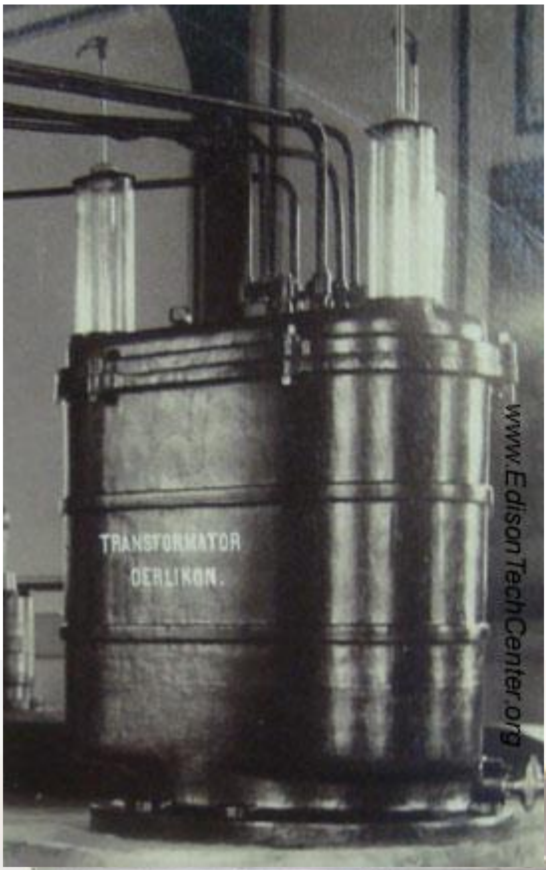
George Westinghouse and William Stanley create a transformer that is practical to produce (easy to machine and wind in a square shape, making a core of E shaped plates) and comes in both step up and step down variations. George Westinghouse understood that to make AC power systems successful the Gaulard design had to be changed. The toroidal transformer used by the Ganz Company in Hungary and Gibbs in England were very expensive to produce (there was no easy way to wind wire around an iron ring without hand labor).



1886 - William Stanley uses his transformers in the electrification of downtown Great Barrington, MA.This was the first demonstration of a full AC power distribution system using step and step down transformers.

Later 1880s **-** Later on Albert Schmid improved Stanley's design, extending the E shaped plates to meet a central projection.

1889 - Russian-born engineer Mikhail Dolivo-Dobrovolsky developed the first three-phase transformer in Germany at AEG. He had developed the first three phase generator one year before. Dobrovolsky used his transformer in the first powerful complete AC system (Alternator + Transformer + Transmission + Transformer + Electric Motors and Lamps) in 1891.



1891

Transformer used on the Lauffen to Frankfurt demonstration line.
3phase alternating current, 40 hz
Oerlikon Company
8 kV and 25 kV transmission

This transformer was created for the longest power transmission to date:109 miles from Lauffen am Neckar to Frankfurt, Germany. Mikhail Dobrovolsky (aka Mihail Dobrovolsky)
Photo courtesy of Historisches Museum Frankfurt.

1891

Early three phase transformer (circular core type)
Siemens and Halske company
5.7 kVA 1000/100 V

This transformer was created at the beginning of the modern electrical grid, the same year as the Frankfurt Electrical Exhibition which demonstrated long distance transmission of power.

1880s - today - Transformers are improved by increasing efficiency, reducing size, and increasing capacity.

The graphic to the left shows the progression and advancement of the transformer over the years.

William Stanley once wrote: " I have a very personal affection for a transformer." "It is such a complete and simple solution for a difficult problem. It so puts to shame all mechanical attempts at regulation. It handles with such ease, certainty, and economy vast loads of energy that are instantly given to or taken from it. It is so reliable, strong, and certain."

CHAPTER 3

Types Of Transformer

Power Transformer

These power transformers operate at 50 to 400Hz at a absolute nominal line voltage from 105 to 130 V. They are actually made with single and multiple secondary's with various step-up and step-down turns ratios.

•300 MVA 3 Winding Power Transformer (275 KV / 132 KV / 33 KV. (Y.Y.Δ).
•75 MVA & 45 MVA. 2 Winding Power Transformer (132 KV / 33 KV).
•30 MVA 2 Winding Power Transformer (132 KV / 11 KV).
•20 MVA & 15 MVA 2 Winding Power Transformer (33 KV / 11 KV).

Fig.2. General view of Power Transformer.

Secondary Transformer

Secondary's transformer could have a single tap, multiple taps and even sometimes no tap. Some units are prepared with a tapped primary. Output voltage could start ranging from three to several thousand volts with output currents from .01 to 1500 A.

The Cores Transformer

The cores transformers are made up of iron or steel laminations. They are packaged in a hermetically sealed case especially for military or space use or with an open frame or even plastic enclosure for commercial, consumer or any industrial use.

Isolation Transformer

These types of transformer operate with a one-to-
one turn's ratio between primary and secondary, as isolating the line

from the secondary load. Usually, an isolation transformer further comprises of Faraday shield, which is in fact a screen of nonmagnetic metal wound between the primary and secondary and then connected to the transformer core.

The Shield Transformer

The shield transformer acts particularly to prevent capacitive coupling of spurious signals and sound between windings, and it as well reduces transformer efficiency by improving leakage current.

Control Transformer

These are used as small power transformer for controlling components like relays and low voltage ac control devices. Common output voltages come in 12 and 24 V ac at current capabilities of 4 to16 A.

Audio Transformer

These audio transformers vary from the power transformer types in, which they are used to give matching electrical characteristics of an output amplifier to that of any normal load speaker. In high-fidelity audio systems, they further operate from 20 Hz to 20KHz. This audio transformer comprises of voice communications only and operates from 200 to 500 Hz.

Radio Frequency Transformer

These radio frequency transformers operate at a fixed high frequency with a capacitor across primary, secondary or sometimes even both to create a tuned or resounding circuit. Most types normally use an air core; however some are made up of ferrite slug to allow any sort of adjustment for inductance windings over a given range. They are generally assembled in aluminum-shielded container to reduce pickup or radiation of magnetic fields.

Pulse Transformer

These types are used for the generation and transmission of square wave pulses with emphasis on fast rise and fall times of the pulse and high-frequency response. These transformers are packaged in a miniature enclosure, 1/4 inch to 1/2 inch in diameter, and use an air core.

Instrument transformers

There are several transformer used as an instrument transformer.

- **Current transformers:**

A current transformer (CT) is a measurement device designed to provide a current in its secondary coil proportional to the current flowing in its primary. Current transformers are commonly used in metering and protective relays in the electrical power industry where they allow 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 presention the circuit being measured.

- **Voltage transformers:**

Voltage transformers (VT) or potential transformers (PT) are another type of instrument transformer, used for metering and protection in high-voltage circuits. They are designed to present negligible load to the supply being measured and to have a precise voltage ratio to accurately step down high voltage so that metering and protective relay equipment can be operated at a lower potential. Typically the secondary of a voltage transformer is rated for 69 V or 120V at rated primary voltage, to match the input ratings of protective relays.

RF transformers

There are several types of transformer used in radio frequency (RF) work. Steel laminations are not suitable for RF.

a. Air-core transformers

These are used for high frequency work. The lack of a core means very low inductance. Such transformers may be nothing more than a few turns of wire soldered onto a printed circuit board.

b. Ferrite-core transformers

Widely used in intermediate frequency (IF) stages in super heterodyneradioreceivers.are mostly tuned transformers, containing a threaded ferrite slug that is screwed in or out to adjust IF tuning. The transformers are usually canned for stability and to reduce interference.

c. Transmission-line transformers

For radio frequency use, transformers are sometimes made from configurations of transmission line, sometimes bifilar or coaxial cable, wound around ferrite or other types of core. This style of transformer gives an extremely wide bandwidth but only a limited number of ratios (such as 1:9, 1:4 or 1:2) can be achieved with this technique. The core material increases the inductance dramatically, thereby raising its Q factor. The cores of such transformers help improve performance at the lower frequency end of the band. RF transformers sometimes used a third coil (called a tickler winding) to inject feedback into an earlier (detector) stage in antique regenerative radio receivers.

d. Baluns

Baluns are transformers designed specifically to connect between balanced and unbalanced circuits. These are sometimes made from configurations of transmission line and sometimes bifilar or coaxial cable and are similar to transmission line transformers in construction and operation.

CHAPTER 4

Transformer Faults

In order to maximize the lifetime and efficiency of a transformer, it is important to be aware of possible faults that may occur and to know how to detect them quickly. Regular monitoring and maintenance can make it possible to detect new flaws before much damage has been done. Here we are going to focus on various types of transformer faults in brief.

Failures of transformer can be classified into following:

1. Winding failure due to short-circuits.

- Turn to turn faults
- Phase to phase faults
- Phase to ground faults
- Open winding or end to end faults
- Turn to earth faults

2. Earth faults:

- Star connected winding with neutral point earthed through an impedance
- Star connected winding with neutral point solidly earthed.

3. Terminal failures

- Open leads
- Loose connections
- Short-circuits

4. On-load tap change failures.

- Mechanical
- Electrical
- Short-circuit
- Over heating

5. Abnormal operating conditions.

- Over fluxing
- Overloading
- Overvoltage

6. Core faults.

7. Phase sequence and vector group compensation

8. External faults

Some definetion of Transformer Foults

Internal Earth Faults in Power Transformer

Internal Earth Faults in a Star Connected Winding with Neutral Point Earthed through an Impedance

In this case the fault current is dependent on the value of earthing impedance and is also proportional to the distance of the fault point from neutral point as the voltage at the point depends upon, the number of winding turns come under across neutral and fault point. If the distance between fault point and neutral point is more, the number of turns come under this distance is also more, hence voltage across the neutral point and fault point is high which causes higher fault current. So, in few words it can be said that, the value of fault current depends on the value of earthing impedance as well as the distance between the faulty point and neutral point. The fault current also depends up on leakage reactance of the portion of the winding across the fault point and neutral. But compared to the earthing impedance,it is very low and it is obviously ignored as it comes in series with comparatively much higher earthing impedance.

Internal Earth Faults in a Star Connected Winding with Neutral Point Solidly Earthed

In this case, earthing impedance is ideally zero. The fault current is dependent up on leakage reactance of the portion of winding comes across faulty point and neutral point of transformer. The fault current is also dependent on the distance between neutral point and fault point in the transformer. As said in previous case the voltage across these two points depends upon the number of winding turn comes across faulty point and neutral point. So in star connected winding with neutral point solidly earthed, the fault current depends upon two main factors, first the leakage reactance of the winding comes across faulty point and neutral point and secondly the distance between faulty point and neutral point. But the leakage reactance of the winding varies in complex manner with position of the fault in the winding. It is seen that the reactance decreases very rapidly for fault point approaching the neutral and hence the fault current is highest for the fault near the neutral end. So at this point, the voltage available for fault current is low and at the same time the reactance opposes the fault current is also low, hence the value of fault current is high enough. Again at fault point away from the neutral point, the voltage available for fault current is high but at the same time reactance offered by the winding portion between fault point and neutral point is high. It can be noticed that the fault current stays a very high level throughout the winding. In other word, the fault current maintain a very high magnitude irrelevant to the position of the fault on winding.

Internal Phase to Phase Faults in Power Transformer

Phase to phase fault in the transformer are rare. If such a fault does occur, it will give rise to substantial electric current to operate instantaneous over current relay on the primary side as well as the differential relay.

Inter Turns Fault in Power Transformer

Power Transformer connected with electrical extra high voltage transmission system, is very likely to be subjected to high magnitude, steep fronted and high frequency impulse voltage due to lightening surge on the transmission line. The voltage stresses between winding turns become so large, it can not sustain the stress and causing insulation failure between inter - turns in some points. Also LV winding is stressed because of the transferred surge voltage. Very large number of Power Transformer failure arise from fault between turns. Inter turn fault may also be occurred due to mechanical forces between turns originated by external short circuit.

Core Fault in Power Transformer

In any portion of the core lamination is damaged, or lamination of the core is bridged by any conducting material causes sufficient eddy current to flow, hence, this part of the core becomes over heated. Some times, insulation of bolts (Used for tightening the core lamination together) fails which also permits sufficient eddy current to flow through the bolt and causing over heating. These insulation failure in lamination and core bolts causes severe local heating. Although these local heating, causes additional core loss but can not create any noticeable change in input and output electric current in the transformer, hence these faults can not be detected by normal electrical protection scheme. This is desirable to detect the local over heating condition of the transformer core before any major fault occurs. Excessive over heating leads to breakdown of transformer insulating oil with evolution of gases. These gases are accumulated in Buchholz relay and actuating Buchholz Alarm.

CHAPTER 5

Protection Philosophy Of Transformer

Protection Philosophy:

The philosophy of transformer over current protection is to limit the fault current below the transformer through fault with stand capability. The fault withstand capability in turn is based on the possibility of mechanical of the windings due to the fault current, rather than on thermal characteristics of the transformer.

Reasons to provide transformer protection:

a. Detect and Isolate Faulty Equipment
b. Maintain System Stability
c. Limit Damage
d. Minimize Fire Risk
e. Minimize Risk to Personnel

Factors Affecting Transformer Protection:

a.Cost of Repair
b. Cost of Down Time
c. Affects on the Rest of the System
d. Potential to Damage Adjacent Equipment
e. Length of Time to Repair or Replace.

Basic Tenets of Protection:

a. Speed
b. Sensitivity
c. Reliability
d. Security

Protection Philosophy For Internal Faults:

Conditions	Protection Philosophy
Winding Phase-phase, phase-ground faults	Differential , over current Restricted ground fault protection
Winding inter-turn faults	Differential , Buchholz relay,
Core insulation failure, shorted laminations	Differential , Buchholz relay, sudden pressure relay
Tank faults	Differential , Buchholz relay and tank-ground protection
Over fluxing	Volts/Hz

Protection Philosophy For External Faults:

Conditions	Protecton Philosophy
Overload	Thermal
Overvoltage	Overvoltage
Oberfluxing	Volts/Hz
External system short circuit	Time over current, Instantaneous over current

CHAPTER 6

Transformer Protection

Transformer Protection:

The primary objective of the Transformer Protection is to detect internal faults in the transformer with a high degree of sensitivity and cause subsequent de-energisation and, at the same time be immune to faults external to the transformer i.e. through faults. Sensitive detection and de- energisation enables the faultdamage and hence necessary repairs to be limited. However, it should be able to provide backup protection in case of through faults on the system, as these could lead to deterioration and accelerated aging, and/or failure of the transformer winding insulation due to overheating and high impact forces caused in the windings due to high fault currents. In addition to the internal faults, abnormal system conditions such as over excitation, over voltage and loss of cooling can lead to deterioration and accelerated aging or internal failure of the transformer. Hence protection again these failures should be considered in as part of the comprehensive transformer protection scheme.

Transformer protection can be broadly categorized as electrical protection implemented by sensing mainly the current through it, but also voltage and frequency and, as mechanical protection implemented by sensing operational parameters like oil pressure/ level, gas evolved, oil & winding temperature.

Like in most things in Transformer Protection too, the extent of protective devices applied to a particular Transformer is dictated by the economics of the protection scheme. the probability of a particular type of failure and the cost of replacing and repairing the transformer as well the possibility of the failure leading to damage of adjacent equipment or infrastructure. Failure costs include all the direct and indirect costs associated with it. The protection scheme cost includes the cost of the protective device but is mainly the cost of the disconnecting device.

i.e. the Circuit Breaker and other auxiliaries like batteries and necessary infrastructure. Further the life cycle cost is taken into account.

There are no strict guidelines as to what protection devices should be used for a particular transformer. However, typically Transformers below 5000 KVA(Category I & II) are protected using Fuses. Transformers above 10,000KVA(Category III & IV) have more sensitive internal fault detection by using a combination of protective devices as shown in Figure 1. For ratings between the above a protection scheme is designed considering the service criticality, availability of standby transformers, potential of hazardous damage to adjacent equipment and people etc.

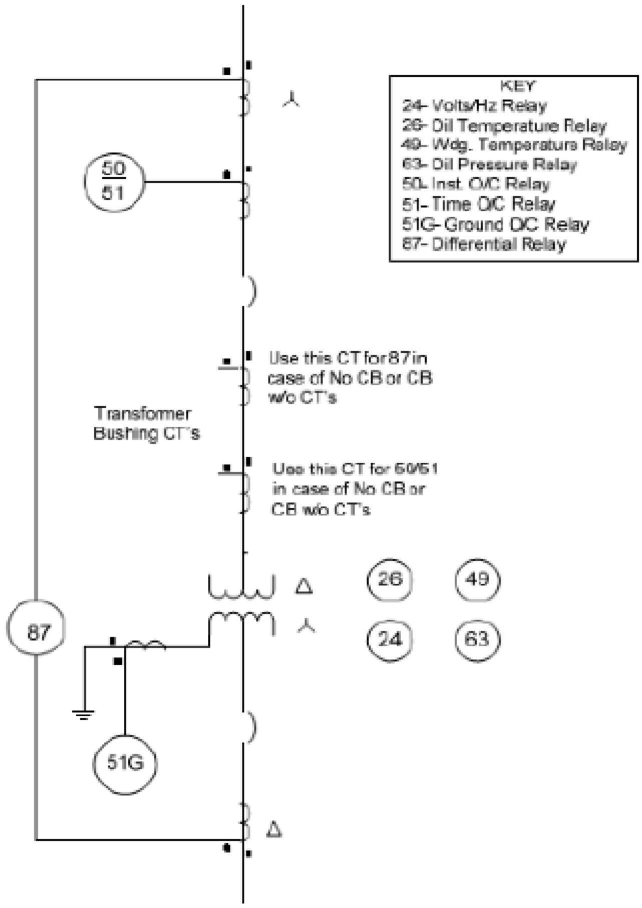


Fig 6.1. Typical Protection Scheme for Category III & IV Transformer

Transformer Overcurrent Protection:

Introduction:

Overcurrent protection is that protection in which the relay picks up when the magnitude of current exceeds the pickup value. The basic element in overcurrent protection is an overcurrent relay. The overcurrent relays are connected to the system, normally by means of CTs. Overcurrent relaying has following types:

(i)High Speed Overcurrent Protection
(ii)Definite Time Overcurrent Protection
(iii)Inverse Minimum Time Overcurrent Protection
(iv)Directional Overcurrent Protection

Overcurrent protection includes the protection from overloads. This is most widely used protection. Overloading of a machine or equipment means the machine is taking more current than its rated current. Hence, with overloading, there is an associated temperature rise. The permissible temperature rise has limit based on insulation class and material problems. Overcurrent protection of overloads is generally provided by thermal relays.

Overcurrent protection includes Short-Circuit Protection. Short-Circuits can be Phase Faults, Earth Faults or Winding Faults. Short-circuit currents are generally several times (5 to 20) full load current. Hence, fast fault clearance is always desirable on short-circuits.
When a machine is protected by differential protection, the overcurrent protection is provided in addition as a back up and in some cases, to protect a machine from sustained through fault.

Several protected devices are used for overcurrent protection. These include-

- Fuses
- Miniature Circuit-Breaker (MCB), Moulded Case Circuit-Breakers
- Circuit-Breakers Fitted With Overloaded Coils or Tripped by Overcurrent Relays
- Series Connected Trip Coils Operating Switching Devices
- Overcurrent Relays in conjunction with Current Transformer (CT)

The primary requirements of overcurrent protection are:

- Protection should not operate for starting currents, permissible overcurrents, current surges
- The protection should be coordinated with neighboring overcurrent protections so as to discriminate

Relays used in overcurrent protection:

The choice of relay for overcurrent protection depends upon the time/current characteristics and other features desired. The following relays are used-

(i)For instantaneous overcurrent protection:

1. attracted armature type
2. moving iron type
3. permanent magnet moving coil type, static.

(ii) For inverse time characteristics:

1. electromagnet induction type
2. permanent magnet moving coil type, static.

(iii)Directional Overcurrent protection:

Double actuating quantity induction relay with directional feature.

(iv)Static Overcurrent relays.

(v)HRC Fuses, Drop Out Fuses etc are used in low voltage media and high voltage distribution systems, generally up to 11 KV.

(vi)Thermal Relays are used widely for Overcurrent protection.

Relays Units For Overcurrent Protection:

There is a widely variety of relay units. These are classified according to their type and characteristics. The major characteristics include-

(1)Definite Characteristics
(2)Inverse Characteristics
(3)Extremely inverse
(4)Very inverse
(5)Inverse

Factors:

- Rated Current
- Inrush Current
- Short Circuit Currents
- Transformer Damage Curve

Transformer Categories:

Category	Single Phase (KVA)	3 Phase (KVA)
I	5 to 500	15 to 500
II	501 to 1667	501 to 5000
III	1668 to 10000	5001 to 30000
IV	Above 10000	Above 30000

Improvement in overcurrent protection:

Introduction:

The development of deregulation in power systems leads to a higher requirement on power quality. In the area of relay protection this means that a faster protection is needed, while undesirable operation of the protection system is almost unacceptable. A faster protection can guarantee that an abnormal operation mode somewhere in a system, such as voltage sag caused by faults, can be quarantined quickly, so as not to prop-agate to the rest of the system and cause instability. To do this, a relay protection should be sensitive. Unfortunately, high sensitivity sometimes causes undesirable operation of relay protection when there is no fault in the system. In a deregulated power market this directly leads to penalty compensation to the users that suffer from the blackout. Therefore, identification of those factors that produce this un-desirable operation of the relay and introducing procedures for their discrimination from the real fault cases are very important. In, such factors have been introduced from the viewpoint of overcurrent relays. Power system switching, such as motor starting and transformer energizing, is the most important source of undesirable operation of the relay protection. In, a method has been also recommended to study the effect of over currents due to the switching on the operation of overcurrent relays. However, [1] and [2] have not introduced a method that could discriminate these non-fault cases from the fault cases. There are different ways for reducing the starting current of induction motor, such as using autotransformers to step down the terminal voltage and star-delta connection for the stator windings, high sensitivity of relays can influence the operation of overcurrent relays, particularly when many switching are considered simultaneously. This may occur in the energizing a feeder after a long disconnection time which may lead to high starting currents that affect the operation of relays. Also in the case of controlled switching, the starting currents can be diminished theoretically, but in practice there are some factors that make it impossible to achieve the goal. Some factors are as follows:

- Deviations in circuit breaker mechanical closing time;
- Effects of circuit breaker prestrike;
- Errors in the measurement of residual flux;
- Transformer core or winding configurations that prevent an optimal solution.

Therefore, it is necessary to introduce a method that discriminates the common switching case from the fault case.

There are many algorithms for digital filtering in digital re-lays. The most popular algorithm that is commercially avail-able is discrete Fourier transform (DFT) with1-cycle sampling window. When the input signal has stable current waveform, but contains harmonics or dc components, DFT filter can re-move these unwanted components and yield accurate value of the input rms current. When the input signal is the inrush current of a normal switching, the DFT filter cannot have correct output during the transient period. In such a case, undesirable operation of the relay is possible. In order to overcome this problem the window width of the Fourier algorithm must be increased; however, the increase of the window width causes delay in the operation of the relay during the fault occurrence.

EFFECT OF SWITCHING ON RELAY RESPONSE

When a fault occurs in power system, there are harmonics, inter-harmonics and dc components in the current waveform. On the other hand, there are some non-fault events which distort the current waveform in the similar way. In the following sub-section, the effects of some non-fault switching cases on the current waveform are studied.

A.Transformer Energizing

When the primary winding of an unloaded transformer is switched on to normal voltage supply, it acts as a nonlinear inductor. In this situation there is a transient inrush current that is required to establish the magnetic field of the transformer. The magnitude of this current depends on the applied voltage magnitude at the instant of switching, supply impedance, transformer size and design. Residual flux in the core can aggravate the condition. The initial inrush current could reach values several times full load current and will decay with time until a normal exciting current value is reached. The decay of the inrush current may vary from as short as 20 cycles to as long as minutes for highly inductive circuits. The inrush current contains both odd and even order harmonics.

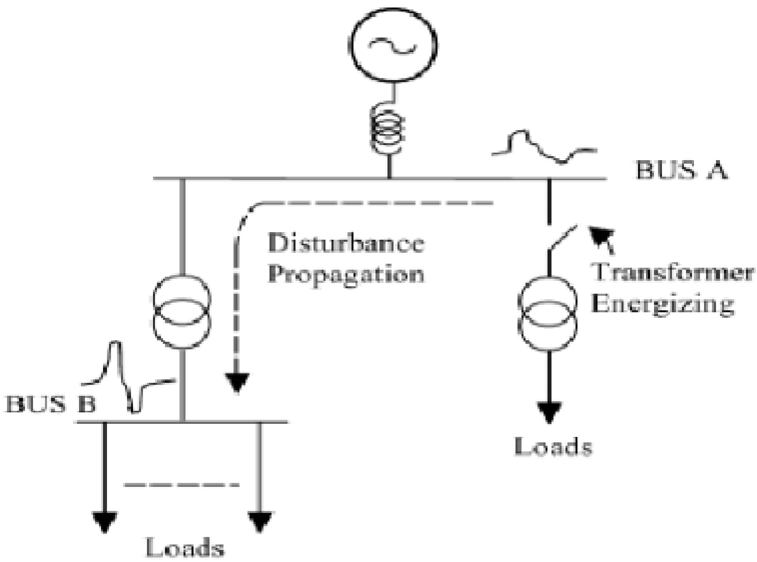


Fig.1. Disturbance propagation due to transformer energizing.

Although digital relay's filter is used to extract the fundamental component of the current, the magnitude of the signal may lead to undesirable operation of the relay. Another concern about transformer energizing is transient propagation. This causes considerable amount of even harmonics and dc component in the voltage. These disturbances may propagate through transformers to the rest of the system, and be magnified due to resonance effect. Because of this, the load currents at other bus bars can be severely distorted, which might have detrimental impact on the locally installed current relays. Fig. 1 shows this propagation trend. The current through the load feeder at bus bar B can be affected by the disturbance propagated from trans-former energizing at bus bar A.

B. Motor Starting

Starting the medium voltage (MV) and low voltage (LV) induction motors is another subject to be considered. The starting current of a large induction motor is typically five to six times the rated current. In fact, the starting current has a very high initial peak. That value is damped out after a few cycles, normally no more than two cycles depending on the circuit time-constant. Then, it drops rapidly to a multiple value of its nominal level, and is maintained during most of the acceleration process. The current is then smoothly reduced to the nominal value that depends on the mechanical load of the motor. This trend has been shown in Fig. 2 that corresponds to the direct starting of a three-phase motor connected to the supply at the worst switching angle. The motor has the following data: 380 V, 7.5 KW, 50 Hz, 1500 rpm, Istarting/Irated= 6 and X/R=5, where Rand X area stator resistance and reactance, respectively.

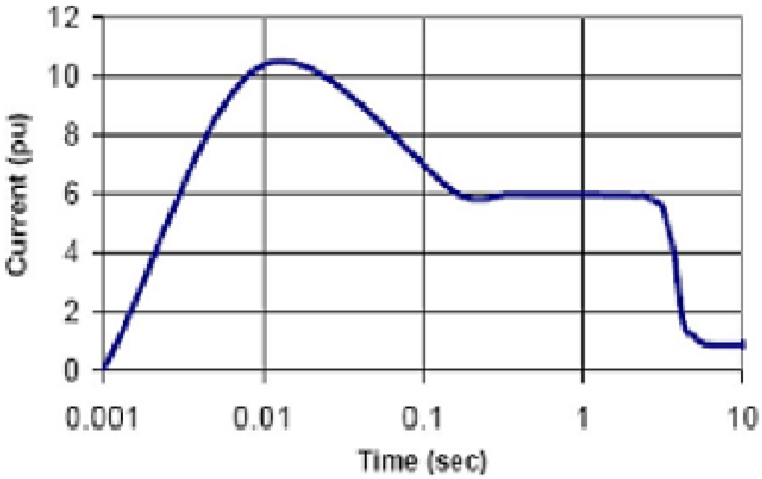


Fig.2. Induction motor direct starting (V=1pu).

Fig.2. Induction motor direct starting (V=1pu).

Table 1

Relay Characteristics Type	Standard Inverse (SI)	Very Inverse (VI)	Extreme Inverse (EI)	Long Inverse (LI)
A	0.02	1	2	1
C	0.14	13.5	80	120

Generally starting time of an induction motor is shorter than 5 or 6 s. However, it can be as long as 20 to 30 s for motors having high inertia loads. This puts a severe strain on overcurrent protection. In addition, the under voltage protection is potentially affected.

Transformer Monitoring:

Standard Gauges and Indicators

- Liquid Level
- Tank Pressure
- Oil Temperature
- Hot Spot Temperature
- Gauges have contacts which can be brought back to SCADA

LTC Controls

- LTC Position
- LTC Malfunction
- LTC Malfunction

Fan/Pump Controls

- Fan/Pump Operating Stages
- Fan/Pump Malfunction

  On-Line Water in Oil Monitoring
  On-Line Dissolved Gas Monitoring
  On-Line Acoustical and Partial Discharge Monitoring

Application of Overcurrent Protection:

Overcurrent protection has a wide range of applications. It can be applied when there is an abrupt difference between fault currents within the protected sections and than outside the protection section and this magnitudes are almost constant.The overcurrent protection is provided for the following-

(i)Motor Protection:

Overcurrent protection is the basic type of protection used against overloads and short-circuits in stator windings of motors. Inverse time and instantaneous phase and ground overcurrent relays can be employed for motors above 100 KW. For small/medium size motors where cost of CTs and protective relays is not economically justified, thermal relays and HRC fuses are employed, thermal relays used for overload protection and HRC fuses for short-circuit protection.

(ii)Transformer Protection:

Transformers are provided with overcurrent protection against faults, only, when the cost of differential relaying cannot be justified. However, overcurrent 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 500 KVA installed in distribution system are generally protected by drop-out fuses, as the cost of relays plus circuit-breakers is not generally justified.

(iii)Line Protection:

The lines (feeders) can be protected by:

- Instantaneous overcurrent relays
- Inverse time overcurrent relays
- Directional overcurrent relays

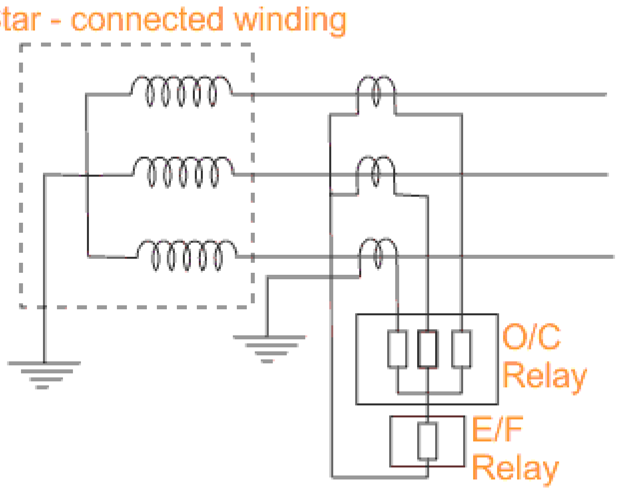
(iv)Protection of Utility Equipments:

The furnaces, industrial installations, commercial, industrial and domestic equipments are all provided with overcurrent protection.

Over Current and Earth Fault Protection of Transformer

Backup protection of electrical transformer is simple Over Current and Earth Fault protection applied against external short circuit and excessive over loads. These over current and earth Fault relays may be of Inverse Definite Minimum Time (IDMT) or Definite Time type relays. Generally IDMT relays are connected to the in-feed side of the transformer.

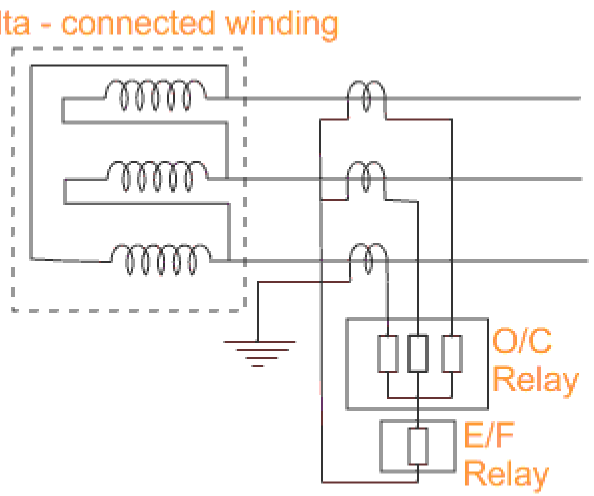
The over current relays can not distinguish between external short circuit, over load and internal faults of the transformer. For any of the above fault, backup protection i.e. over current and earth fault protection connected to in-feed side of the transformer will operate. Backup protection is although generally installed at in feed side of the transformer, but it should trip both the primary and secondary circuit breakers of the transformer.



Backup O/C & E/F Protection Scheme

Over Current and Earth Fault protection relays may be also provided in load side of the transformer too, but it should not inter trip the primary side Circuit Breaker like the case of backup protection at in-feed side. The operation is governed primarily by current and time settings and the characteristic curve of the relay. To permit use of over load capacity of the transformer and co- ordination with other similar relays at about 125 to 150% of full load current of the transformer but below the minimum short circuit current.

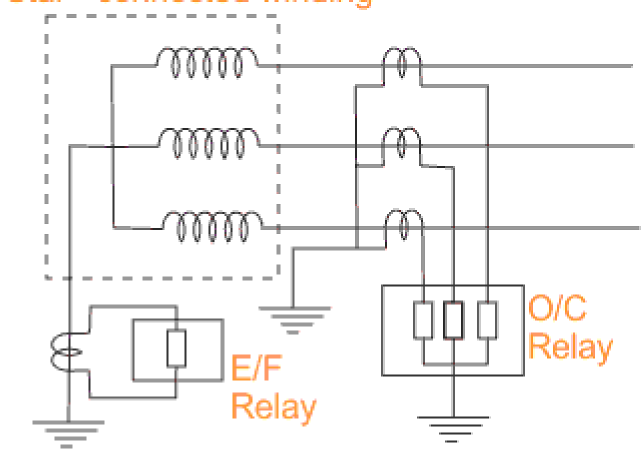
Backup protection of transformer has four elements, three over current relays connected each in each phase and one earth fault relay connected to the common point of three over current relays as shown in the figure. The normal range of current settings available on IDMT over current relays is 50% to 200% and on earth fault relay 20 to 80%.



Backup O/C & E/F Protection Scheme

Another range of setting on earth fault relay is also available and may be selected where the earth fault current is restricted due to insertion of impedance in the neutral grounding. In the case of transformer winding with neutral earthed, unrestricted earth fault protection is obtained by connecting an ordinary earth fault relay across a neutral current transformer.

The unrestricted over current and earth fault relays should have proper time lag to co - ordinate with the protective relays of other circuit to avoid indiscriminate tripping.



O/C & Unrestricted E/F Protection Scheme

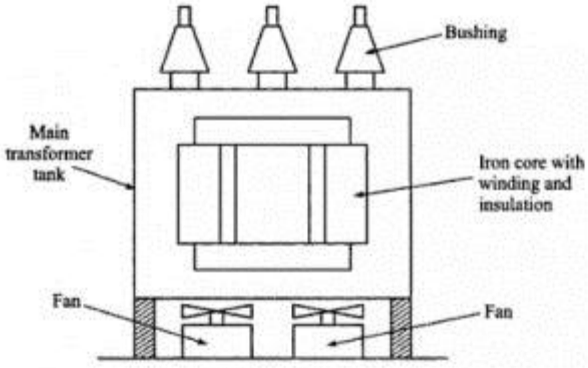
Transformer cooling methods

1) Dry type transforms:

a) Self-air cooled Transformer(up to 3 MVA):

The transformed is allowed to cool natural conventional air flow surrounding it through heat radiation.

b) Forced Air Cooled Transformer (Up to 15 MVA):



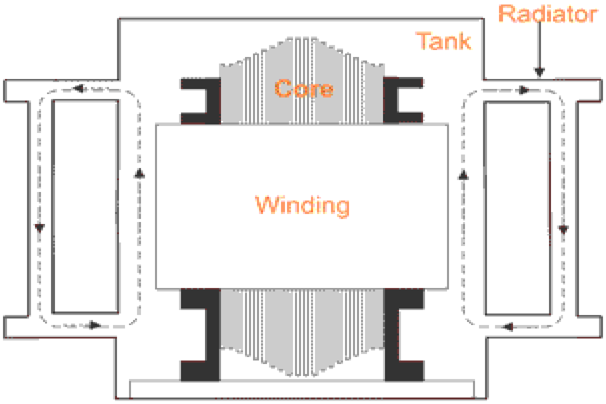
Forced air cooled Transformer

The air is circulated through the winding of transformer by means of blower. This arrangement is housed in metal box with proper insulation between windings. The blowers will blow the air through the windings and hence hot air is gained cooled by the outside natural conventional air.

2) Oil immersed type Transformer:

in this type the transformer winding and core are immersed in the mineral oil which has good electrical insulating property to block the current flow through the oil and high thermal conductivity prosperity for efficient heat removal from the windings and core.

a) Oil-Immersed Self cooled Transformer:

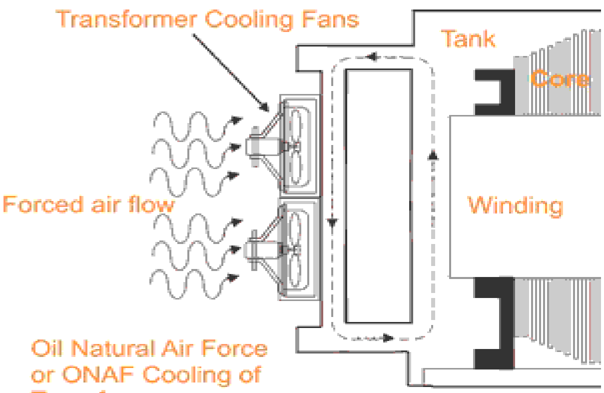


Direction of convectional flow of oil in Transformer

Oil-Immersed Self cooled

In this type the transformer windings and core are cooled by the mineral oil. The heated oil circulated through radiator by national convention and hence cooled by the surrounding air. This type is normally used for distribution type transformer with low ratings.

b) Oil-Immersed forced air cooled Transformer

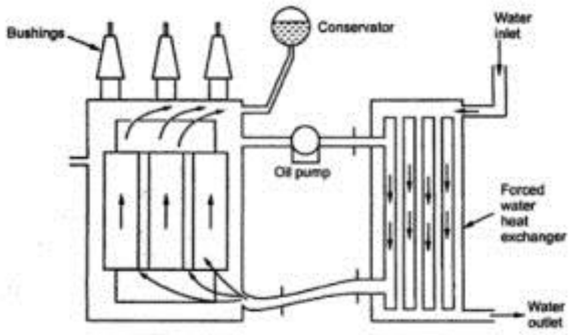


Oil Natural Air Force or ONAF Cooling of Transformer

Oil immersed forced air cooling transformer

In this type the transformer is cooled by the oil which in turn cooled by the forced air in radiator. A bank of coolers or blowers is situated in the transformer radiator which forces the air through the cooling fins. The hot oil enters in these cooling fins by the natural convention and cooled oil again flows through the windings. This cooling method is used normally large transmission transformers situated outdoors, in power plants and in power stations.

c) Oil-Immersed water cooled Transformer



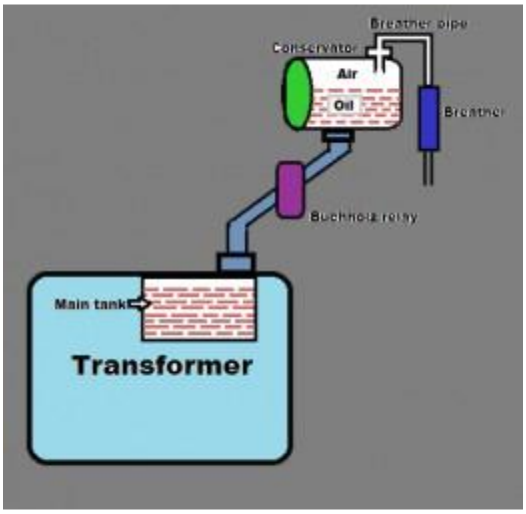
Forced Water Cooled Transformer

This type of cooling is used for very large transformers with very high power rating above 500 MVA. In this the Transformer is cooled by oil which then passes through the oil-water heat exchangers. Two 100 % oil pumps are placed to circulate the hot oil through the two heat exchangers. The heat oil dissipates the heat to the water and again flows through the windings and core. The service water is used for cooling. We can operate the transformer with one cooler but if two fails then we have to trip the transformer.

Buchholz relay

Buchholz relay is a type of oil and gas actuated protection relay universally used on all oil immersed transformers having rating more than 500 kVA. Buchholz relay is not provided in relays having rating below 500 kVA from the point of view of economic considerations.

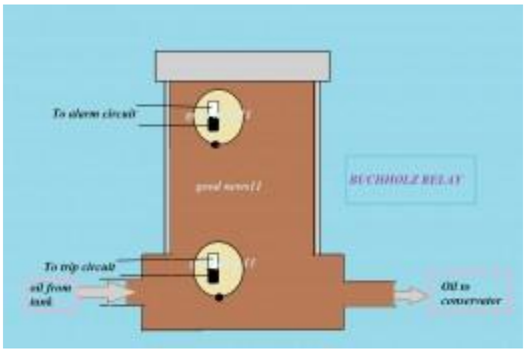
Buchholz relay is used for the protection of transformers from the faults occurring inside the transformer. Short circuit faults such as inter turn faults, incipient winding faults, and core faults may occur due to the impulse breakdown of the insulating oil or simply the transformer oil. Buchholz relay will sense such faults and closes the alarm circuit.



Working principle

Buchholz relay relies on the fact that an electrical fault inside the transformer tank is accompanied by the generation of gas and if the fault is high enough it will be accompanied by a surge of oil from the tank to the conservator

Whenever a fault occurs inside the transformer, the oil in the transformer tank gets overheated and gases are generated. The generation of the gases depends mainly on the intensity of fault produced. The heat generated during the fault will be high enough to decompose the transformer oil and the gases produced can be used to detect the winding faults. This is the basic principle behind the working of the Buchholz relay.



Construction

Buchholz relay can be used in the transformers having the conservators only. It is placed in the pipe connecting the conservator and the transformer tank. It consists of an oil filled chamber. Two hinged floats, one at the top of the chamber and the other at the bottom of the chamber which accompanies a mercury switch each is present in the oil filled chamber. The mercury switch on the upper float is connected to an external alarm circuit and the mercury switch on the lower is connected to an external trip circuit.

Operation

Operation of the Buchholz relay is very simple. Whenever any minor fault occurs inside the transformer heat is produced by the fault currents. The transformer oil gets decomposed and gas bubbles are produced. These gas bubbles moves towards the conservator through the pipe line. These gas bubbles get collected in the relay chamber and displaces oil equivalent to the volume of gas collected. The displacements of oil tilts the hinged float at the top of the chamber thereby the mercury switch closes the contacts of the alarm circuit.

The amount of gas collected can be viewed through the window provided on the walls of the chamber. The samples of gas are taken and analyzed. The amount of gas indicates the severity of and its color indicates the nature of fault occurred. In case of minor faults the float at the bottom of the chamber remains unaffected because the gases produced will not be sufficient to operate it.

During the occurrence of severe faults such as phase to earth faults and faults in tap changing gear, the amount of volume of gas evolves will be large and the float at the bottom of the chamber is tilted and the trip circuit is closed. This trip circuit will operate the circuit breaker and isolates the transformer.

Advantages of Buchholz relay

- Buchholz relay indicates inter turn faults and faults due to heating of core and helps in the avoidance of severe faults.
- Nature and severity of fault can be determined without dismantling the transformer by testing the air samples.

Limitation of Buchholz relay

It can sense the faults occurring below the oil level only. The relay is slow and has a minimum operating range of 0.1second and an average operating range of 0.2 seconds.


Conservator
EXPLOSION VENT
BREATHER
Buchholz Relay
COOLING
TUBES

CHAPTER 7

Maintenance schedule tables

BATTERY CELL INSPECTION

Division: Dhaka	Substation: 132/33KV Grid	Identification No:
Date: 01-03-2014	Set No: 1 (110V)	Reference File:
Schedule : ☐√	Emergency : ☐	Special : ☐

Cell No	Voltage	Level	Sp. Gravity	Temp(ºC)
1	1.2	Normal	1.27	Normal
2	1.2	Normal	1. 27	"
3	1.2	Normal	1. 27	"
4	1.2	Normal	1. 27	"
5	1.2	Normal	1. 27	"
6	1.2	Normal	1. 27	"
7	1.2	Upper	1. 27	"
8	1.2	Upper	1. 27	"
9	1.2	Normal	1. 27	"
10	1.2	Norma	1. 27	"
11	1.2	Norma	1. 27	"
12	1.2	Norma	1. 27	"
13	1.2	Norma	1. 27	"
14	1.2	Lower	1. 27	"
15	1.2	Lower	1. 27	"
16	1.2	Norma	1. 27	"
17	1.2	Lower	1. 27	"
18	1.2	Norma	1. 27	"
19	1.2	Norma	1. 27	"
20	1.2	Norma	1. 27	"
21	1.2	Norma	1. 27	"
22	1.2	Norma	1. 27	"
23	1.2	Norma	1. 27	"
24	1.2	Norma	1. 27	"
25	1.2	Norma	1. 27	"
26	1.2	Norma	1. 27	"
27	1.2	Norma	1. 27	"
28	1.2	Norma	1. 27	"
29	1.2	Lower	1. 27	"
30	1.2	Lower	1. 27	"
31	1.2	Upper	1. 27	"
32	1.2	Upper	1. 27	"
33	1.2	Norma	1. 27	"
34	1.2	Norma	1. 27	"
35	1.2	Norma	1. 27	"
36	1.2	Norma	1. 27	"
37	1.2	Norma	1. 27	"
38	1.2	Norma	1. 27	"
39	1.2	Norma	1. 27	"
40	1.2	Norma	1. 27	"
41	1.2	Norma	1. 27	"
42	1.2	Norma	1. 27	"
43	1.2	Norma	1. 27	"
44	1.2	Norma	1. 27	"
45	1.2	Norma	1. 27	"
46	1.2	Norma	1.27	"

Cell No	Voltage	Level	Sp. Gravity	Temp(ºC)
47	1.2	Normal	1. 27	Normal
48	1.2	Normal	1. 27	"
49	1.2	Normal	1. 27	"
50	1.2	Normal	1. 27	"
51	1.2	Normal	1. 27	"
52	1.2	Normal	1. 27	"
53	1.2	Normal	1. 27	"
54	1.2	Normal	1. 27	"
55	1.2	Upper	1. 27	"
56	1.2	Normal	1. 27	"
57	1.2	Normal	1. 27	"
58	1.2	Normal	1. 27	"
59	1.2	Normal	1. 27	"
60	1.2	Normal	1. 27	"
61	1.2	Normal	1. 27	"
62	1.2	Normal	1. 27	"
63	1.2	Lower	1. 27	"
64	1.2	Normal	1. 27	"
65	1.2	Normal	1. 27	"
66	1.2	Lower	1. 27	"
67	1.2	Normal	1. 27	"
68	1.2	Lower	1. 27	"
69	1.2	Lower	1. 27	"
70	1.2	Lower	1. 27	"
71	1.2	Lower	1. 27	"
72	1.2	Normal	1. 27	"
73	1.2	Normal	1. 27	"
74	1.2	Normal	1. 27	"
75	1.2	Normal	1. 27	"
76	1.2	Normal	1. 27	"
77	1.2	Normal	1. 27	"
78	1.2	Normal	1. 27	"
79	1.2	Normal	1. 27	"
80	1.2	Normal	1. 27	"
81	1.2	Normal	1. 27	"
82	1.2	Normal	1. 27	"
83	1.2	Normal	1. 27	"
84	1.2	Normal	1. 27	"
85	1.2	Normal	1. 27	"
86	1.2	Normal	1. 27	"
87	1.2	Normal	1. 27	"
88	1.2	Normal	1. 27	"
89	1.2	Normal	1. 27	"
90	1.2	Normal	1. 27	"
91	1.2	Normal	1. 27	"
92	1.2	Normal	1.27	"
Total Set Voltage -110v				

BUS-BAR & STRUCTURE INSPECTION AND MAINTENANCE

Division :Dhaka	**Substation: 132/33KV Grid**	**Identification No:...............**
Date: 01-03-2014	**Bus bar Name / No : ....**	**Reference File: ....**
Schedule : ☐√	**Emergency :** ☐	**Special :** ☐

Bas Bar Number:

Sl. No	Item	Condition	Action Taken	Reference
1	Cleanliness	☐√ Cleaned ☐ Dirty		
2	Bus-bar joints	☐√ O.K ☐ Loose/Burnt (state in detail below)		
3	Bus-bar support insulator	☐√ Good ☐ Cracked		
4	Bus-bar VT Fuse	☐ Good ☐√ Defective	Changed fuse	
5	Bus-bar VT Terminal Block	☐ Good ☐ Defective		
6	Cable Termination (If any)	☐√ Good ☐ Defective		
7	Bird's Nest (Gantry Structure)	☐√ Yes ☐ No	Cleaned nest	
8	Rusting	☐√ Present ☐ Not Present	Cleaned rust	
9	Structure Grounding	.1 Ω		

Observation & Action Taken:

1. We founded the Bus-bar VT Fuse defective. So we changed the fuse.
2. There were some bird`s nest on the gantry Structure. We cleaned the nest.
3. We cleaned the rust

DISCONNECTOR SWITCH / EARTH SWITH INSPECTION AND MAINTENANCE

Division: GMD, Dhaka	**Substation: 132/33KV Grid**	**Identification No:**
Date: 01-03-2014	**Feeder Name:**	**Reference File:**
Schedule : ☐√	**Emergency :** ☐	**Special :** ☐

DISCONNECTOR SWITCH / EARTH SWITH NUMBER:

Item	Condition		Action Taken	Reference
Overall Cleanliness	Good ☐√	Bad ☐		
Operating Handle / Lever	Good ☐	Defective ☐√	Maintenance operating handle	
Motor Operating Mechanism	Good ☐√	Defective ☐		
Operating Handle / Pipe Grounding	O.K ☐√	Loose ☐		
Earth Switch Ground Connection	Good ☐√	Bad ☐		
Earth Switch Lock	O.K ☐√	Not O.K ☐		
Interlocking Mechanism (If any)	Functional ☐√	Defective ☐		
Insulator	Working ☐√	Defective ☐		
Silver Contact	Good ☐√	Defective ☐		
Operating Rods/ Lever	O.K ☐√	Loose ☐		
Gear Box/ Lubrication	Good ☐	Bad ☐√	Maintenance gear box	
Switch Blade Alignment	O.K ☐√	Not O.K ☐		
Rusting	Exists ☐	Not Exists ☐√	Existed rust	
Contact resistance	**R** - Phase	40 µ Ω		
	Y - Phase	41µ Ω		
	B - Phase	40µ Ω		

Note (If any):

1. Operating handle maintenance
2. We maintenance gear box and cleaned rust.
3. Others parameter is ok.

INSPECTION & MAINTENANCE OF POWER TRANSFORMER

Division: Dhaka		**Substation: 132/33KV Grid**		**Identification No:**		
Date: 01-03-2014		**Bay Location:**		**Reference File:**		
Make:	**Type:**	**Sl. No.**	**R:**	**Y:**	**B:**	**Year:**
Schedule : ☐√		**Emergency :** ☐		**Special :** ☐		

TRANSFORMER NUMBER:

Sl. No	Item	Condition	Action Taken	Reference
1.	Overall Cleanliness	☐ Clean ☐√ Not Cleaned	Cleaned the overall cleanliness	
2.	Oil Level :	Low | High | Normal | Defective Indicator		
	(i) Main Tank	☐ ☐ ☐√ ☐		
	(ii) OLTC	☐ ☐ ☐√ ☐		
	(iii) Bushing	☐ ☐ ☐√ ☐		
3.	Oil Leak:	Yes No		
	Main Tank	☐ ☐√		
	OLTC	☐ ☐√		
	Bushing	☐ ☐√		
	Conservator	☐√ ☐	Maintenance conservator	
	Radiator	☐ ☐√		
4.	Oil Condition(Visual)	Good Not Good		
	Main Tank	Colour: ☐ ☐√ (Record colour)	Changed main tank oil	
		Odour: ☐√ ☐		
	OLTC	Colour: ☐ ☐√ (Record colour)	Changed OLTC oil	
		Odour: ☐√ ☐		
5.	Temperature Meter:	Good Defective		

	(i) Oil	☐ ☐√	Changed temperature meter	
	(ii) Winding	☐√ ☐		
6.	Pressure Relief Diaphragm for cracks	☐√ ☐ OK Cracked		
7.	Color of Silica Gel	☐ ☐√ OK Colour Changed	New silica gel putted	
8.	Cooler Fans /Pumps	☐√ ☐ In operation Out of operation		
9.	<u>Local Control Cubicle:</u>	Clean Not Cleaned		
	(i) Transformer	☐ ☐√	Cleaned Transformer control cubicle	
	(ii) OLTC	☐ ☐√	Cleaned OLTC control cubicle	
10.	<u>OLTC Operation:</u>	Good Defective		
	Manual	☐√ ☐		
	Electrical – Local	☐√ ☐		
	Electrical – Remote	☐ ☐√	Changed battery	
	Electrical – SCADA	☐√ ☐		
11.	Space Heater	☐√ ☐ O.K Defective		
12.	Un-usual Internal Noise	☐√ ☐ Yes No	Some maintenance for reduce noise	
13.	<u>Bushing :</u>	Good Cracked Punctured		
	(i) HT	☐√ ☐ ☐		
	(ii) LT	☐ √ ☐ ☐		
	(iii) Tertiary	☐√ ☐ ☐		
14.	Wheel Lock	☐√ ☐ Secured Unsecured		

<table>
<tr><th>Sl. No</th><th>Item</th><th colspan="4">Condition</th><th>Action Taken</th><th>Reference</th></tr>
<tr><td rowspan="3">15.</td><td><u>Buchholz Relay:</u></td><td colspan="2">Good</td><td colspan="2">Defective</td><td></td><td></td></tr>
<tr><td>Main Tank</td><td colspan="2">☐√</td><td colspan="2">☐</td><td></td><td></td></tr>
<tr><td>OLTC</td><td colspan="2">☐√</td><td colspan="2">☐</td><td></td><td></td></tr>
<tr><td rowspan="8">16.</td><td colspan="5"><u>Test of Oil (Dielectric Strength):</u></td><td></td><td></td></tr>
<tr><td>Tank Type
(As applicable)</td><td>Main Tank</td><td colspan="3">OLTC Tank</td><td></td><td></td></tr>
<tr><td>Single Tank</td><td>6.36 kV</td><td colspan="3">6.36 kV</td><td></td><td></td></tr>
<tr><td colspan="5">Banking Tank</td><td></td><td></td></tr>
<tr><td>Phase R</td><td>6.36 kV</td><td colspan="3">6.36 kV</td><td></td><td></td></tr>
<tr><td>Phase Y</td><td>6.36 kV</td><td colspan="3">6.36 kV</td><td></td><td></td></tr>
<tr><td>Phase B</td><td>6.36 kV</td><td colspan="3">6.36 kV</td><td></td><td></td></tr>
<tr><td colspan="7">Test report for Tan Delta, Chemical, Dissolved Gas etc. (If any) shall be attached in separate sheets.</td></tr>
<tr><td rowspan="5">17.</td><td rowspan="5"><u>Insulation test:</u>
Temperature:
at .... ^{0}C
Humidity:
.........................%
Weather:
...........................</td><td rowspan="2">Position</td><td colspan="2">Time</td><td rowspan="2">Absorption Co-efficient
(R60/R15)</td><td></td><td></td></tr>
<tr><td>R15
(For 15 sec)</td><td>R60
(For 60 sec)</td><td></td><td></td></tr>
<tr><td>HT-LTE</td><td>2MΩ</td><td>2.27MΩ</td><td>1.135</td><td></td><td></td></tr>
<tr><td>LT-THE</td><td>1.5MΩ</td><td>2.5MΩ</td><td>1.66</td><td></td><td></td></tr>
<tr><td>LT-HT</td><td>4MΩ</td><td>6MΩ</td><td>1.5</td><td></td><td></td></tr>
<tr><td rowspan="2">18.</td><td rowspan="2">Earth Resistance:</td><td colspan="2">Connected with mesh</td><td colspan="2">without mesh</td><td></td><td></td></tr>
<tr><td colspan="2">.18Ω</td><td colspan="2">.17Ω</td><td></td><td></td></tr>
</table>

Observation and Action taken:

We was observation that there was some maintenance required. Following maintenance we done.

1. Cleaned the overall cleanliness
2. Maintenance conservator
3. Changed main tank oil
4. Changed OLTC oil
5. Changed temperature meter
6. New silica gel putted
7. Cleaned Transformer control cubicle
8. Cleaned OLTC control cubicle
9. Changed battery
10. Some maintenance for reduce noise

MONTHLY TREE TRIMMING REPORT

Division: Dhaka	**Transmission Line:**	**Identification No:**
Month 01-03-2014	**Section:**	**Reference File:**
Schedule : ☐√	**Emergency :** ☐	**Special :** ☐

Date	**No. of tower**		**Name of area**	**Description of cut trees**	**Comment**
	From	**To**			
05	2	7	Fulbaria	Mahgony, koray, banyan. Etc.	Some branches of trees have been cut
06	7	12	Fulbaria	Mahgony, koray, banyan. Etc.	Some branches of trees have been cut

Extra information/comments (if any)

DAILY DATA TABLE

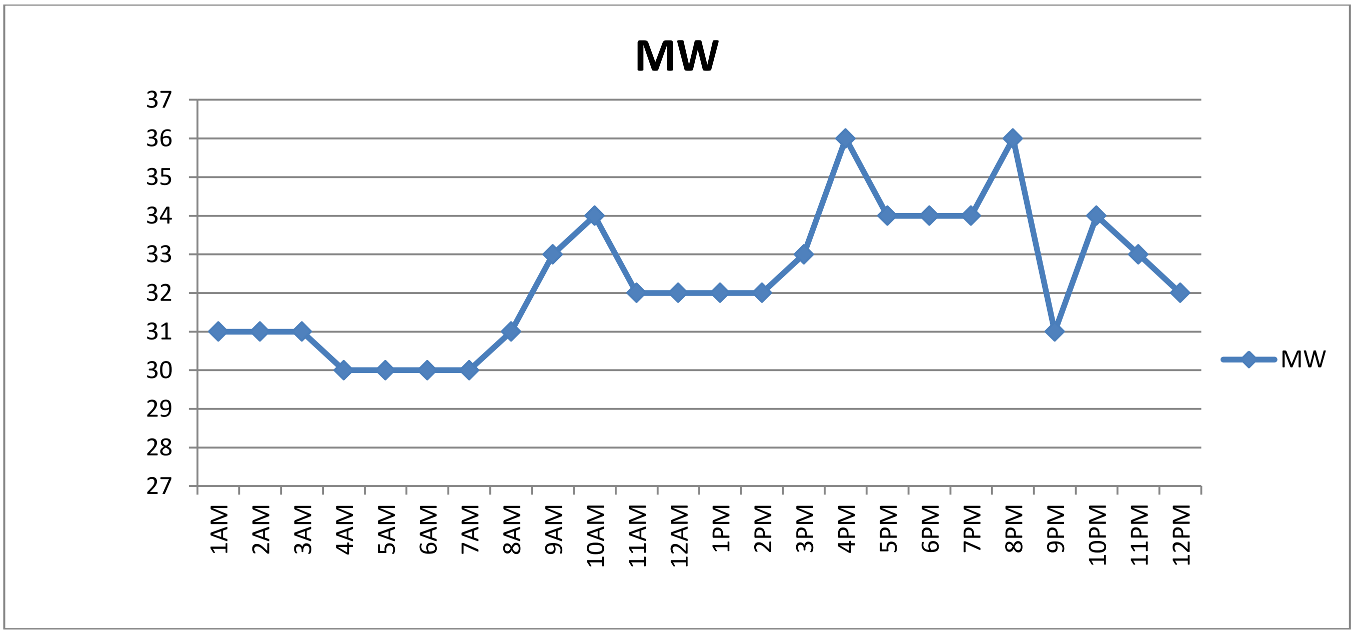
TIME	132 KV Bus Volt	Transformer 1														
		132KV Side						TAP	WIND TEMP	OIL TEMP	33KV Side					
		PF	MWH	MVAR	Ampere						PF	MW	MVAR	Ampere		
					R	Y	B							R	Y	B
7:00	126	0.99	30	3	150	151	150	9	53	45	0.99	30	3	601	604	601
8:00	128	1	31	0	106	106	105	9	53	45	1	31	0	421	424	421
9:00	123	0.99	33	5	166	165	165	9	54	45	0.98	33	5	660	664	669
10:00	122	0.98	34	5	170	171	170	9	55	56	0.98	34	5	681	684	681
11:00	122	0.98	32	5	160	161	160	9	56	47	0.98	32	5	640	644	640
12:00	121	0.98	32	5	160	161	160	9	56	48	0.98	32	5	641	644	641
13:00	122	0.99	32	4	159	160	159	9	57	48	0.99	32	4	640	644	640
14:00	121	0.98	32	5	160	161	160	9	58	49	0.98	32	5	640	644	640
15:00	124	0.99	33	5	165	164	165	9	58	51	0.98	32	5	641	645	641
16:00	125	1	36	6	166	159	159	9	55	51	1	33	5	640	644	640
17:00	128	0.98	34	0	165	164	165	9	56	50	1	32	5	641	645	641
18:00	128	0.99	34	0	180	176	180	9	58	50	0.99	33	5	660	665	660
19:00	131	0.99	34	0	175	174	174	9	57	48	0.98	36	6	721	726	721
20:00	131	0.98	36	1	170	169	169	9	56	53	0.99	39	0	780	785	781
21:00	132	0.99	31	1	155	154	154	9	53	49	0.98	38	0	760	766	761
22:00	131	1	34	1.5	170	169	169	9	54	49	0.98	38	2	760	765	761
23:00	132	0.98	33	2	170	169	169	9	53	49	1	31	1	620	624	620
0:00	132	0.99	32	2	160	160	161	9	54	48	1	34	5	680	685	679
1:00	132	1	31	2	155	154	155	9	54	48	1	34	2	681	685	681
2:00	132	0.99	31	1	155	154	154	9	53	47	1	33	2	660	664	660
3:00	132	0.98	31	0	156	153	156	9	46	42	1	31	2	622	624	622
4:00	131	1	30	0	150	148	150	9	46	42	1	31	1	621	624	623
5:00	131	0.99	30	0	150	148	150	9	46	42	1	31	0	620	624	620
6:00	131	0.98	30	1	150	148	148	9	46	42	1	30	0	600	604	600

DAILY DATA TABLE

Transformer 2															Transformer Breaker					
132KV Side						TAP	WIND TEMP	OIL TEMP	33KV Side						132KV		33KV		33KV Bus Volt	Total MW
PF	MWH	MVAR	Ampere						PF	MW	MVAR	Ampere			403 B	413 B	T-1	T-2		
			R	Y	B							R	Y	B	SF6 (mpa)	SF6 (mpa)	SF6 (mpa)	SF6 (mpa)		
0.99	30	3	150	151	150	9	53	45	0.99	30	3	601	604	601					31.2	60
1	31	0	106	106	105	9	53	45	1	31	0	420	424	420					31.6	42
0.98	33	5	166	165	165	9	54	45	0.98	33	5	660	664	660					30.27	66
0.98	34	5	170	171	170	9	55	56	0.98	34	5	681	684	681					30	68
0.98	32	5	160	161	160	9	56	47	0.98	32	5	640	644	640					29.84	64
0.98	32	5	160	161	160	9	56	48	0.98	32	5	641	644	641					30.89	64
0.99	32	4	159	160	159	9	57	48	0.99	32	4	640	644	640					30.89	64
0.98	32	5	160	161	160	9	58	49	0.98	32	5	640	644	640					29.89	64
0.99	33	5	165	164	165	9	58	51	0.98	32	5	641	645	641					30	62
1	36	6	160	159	159	9	55	51	1	33	5	640	644	643					29.89	64
0.98	34	0	165	164	165	9	56	50	1	32	5	641	645	641	0.64	0.65	0.46	0.46	28.89	63
0.99	34	0	180	178	180	9	58	50	0.99	33	5	660	665	660					29.8	64
0.99	34	0	175	174	174	9	57	48	0.99	36	6	721	726	721					28.09	63
0.98	36	1	170	169	169	9	56	50	0.99	39	0	780	784	781					30	68
0.99	31	1	155	154	154	9	53	49	0.98	38	0	760	766	781					29.84	64
1	34	1	170	169	169	9	51	49	0.98	38	2	760	765	761					29.87	64
0.98	33	2	170	169	169	9	53	49	1	31	1	620	624	620					30	68
0.99	32	2	160	160	161	9	54	48	1	34	5	680	685	679					31.04	42
1	31	2	155	154	155	9	54	48	1	34	2	681	685	681					30.04	68
0.99	31	1	155	154	154	9	53	47	1	33	2	660	664	660					29.37	64
0.98	31	0	156	153	156	9	46	42	1	31	2	622	626	622					30.46	64
1	30	0	150	148	156	9	46	42	1	31	1	621	624	624					31.48	42
0.99	30	0	150	148	150	9	46	42	1	31	0	620	624	624					30.89	64
0.98	30	1	150	148	148	9	46	42	1	30	0	600	604	604					30.84	64

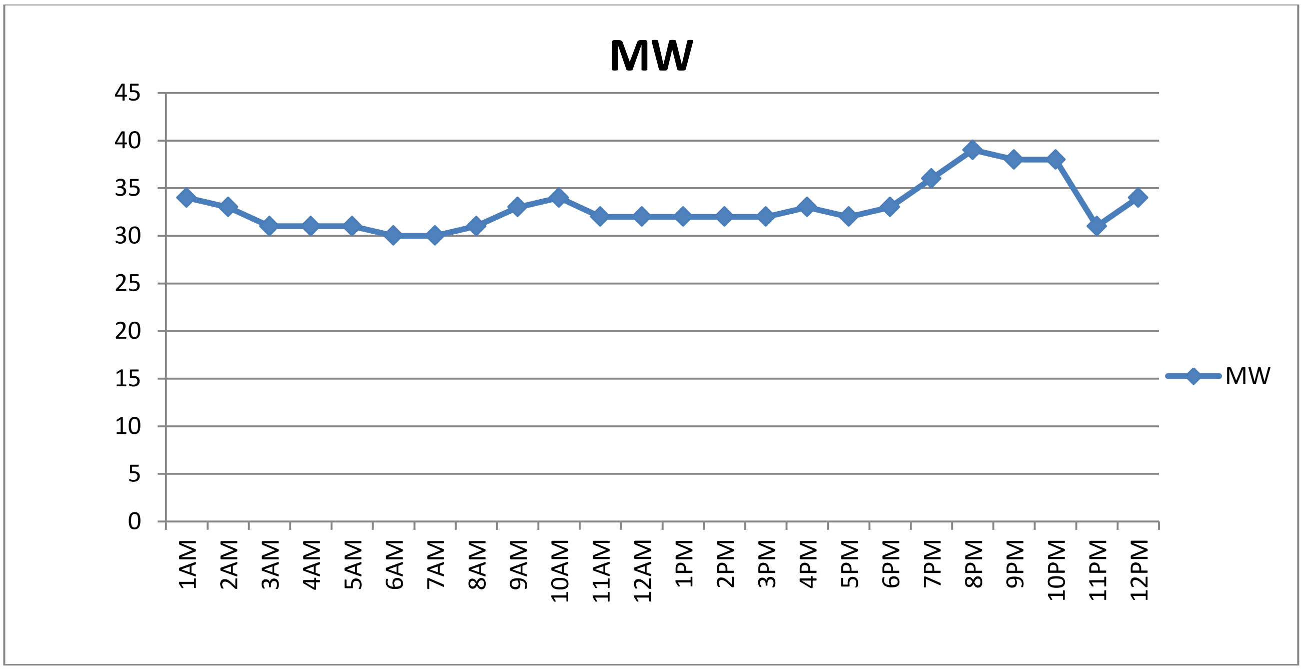
132KV side daily load curve

Hours	MW
1AM	31
2AM	31
3AM	31
4AM	30
5AM	30
6AM	30
7AM	30
8AM	31
9AM	33
10AM	34
11AM	32
12AM	32
1PM	32
2PM	32
3PM	33
4PM	36
5PM	34
6PM	34
7PM	34
8PM	36
9PM	31
10PM	34
11PM	33
12PM	32



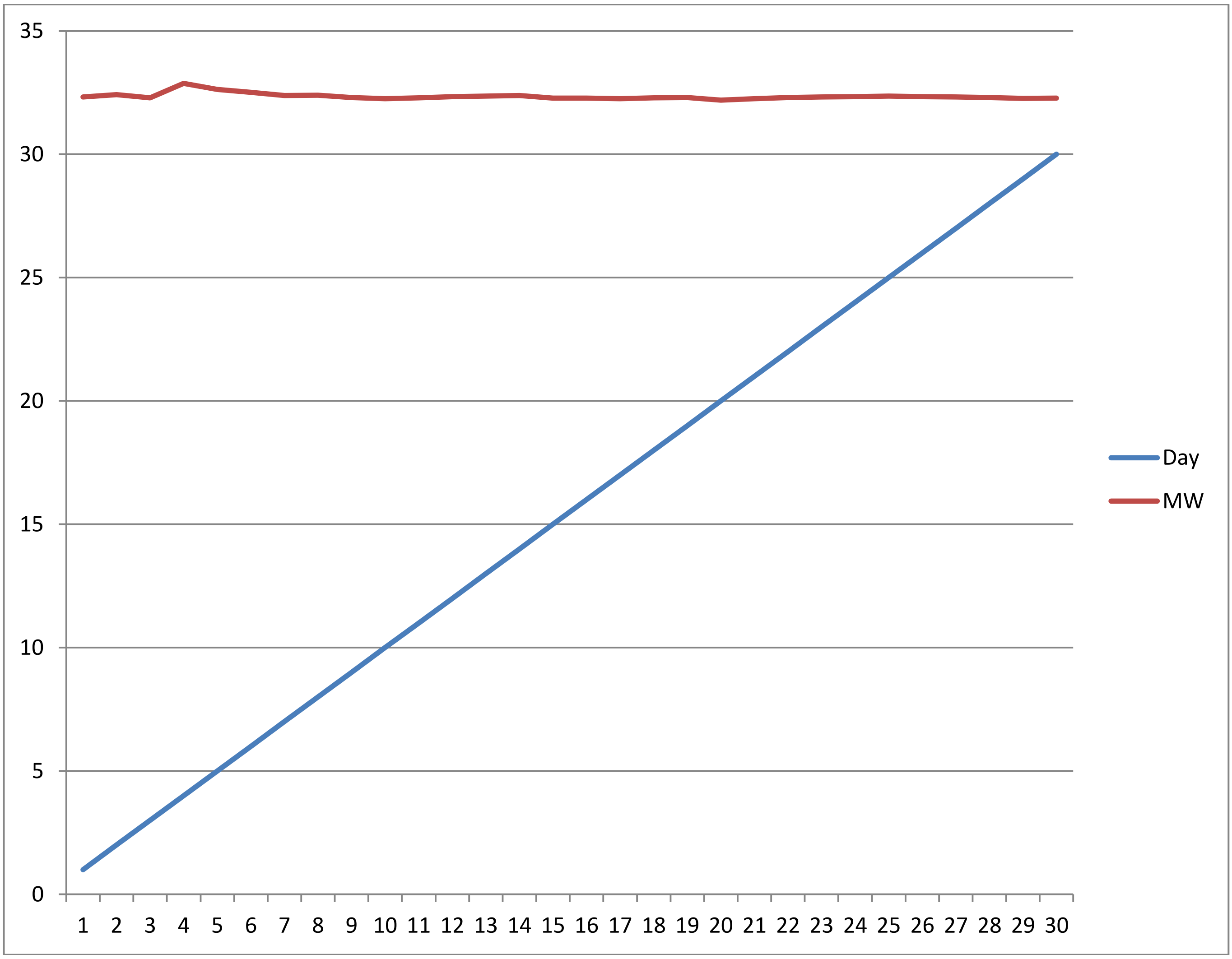
33KV side daily load curve

Hours	MW
1AM	34
2AM	33
3AM	31
4AM	31
5AM	31
6AM	30
7AM	30
8AM	31
9AM	33
10AM	34
11AM	32
12AM	32
1PM	32
2PM	32
3PM	32
4PM	33
5PM	32
6PM	33
7PM	36
8PM	39
9PM	38
10PM	38
11PM	31
12PM	34



132KV side monthly load curve

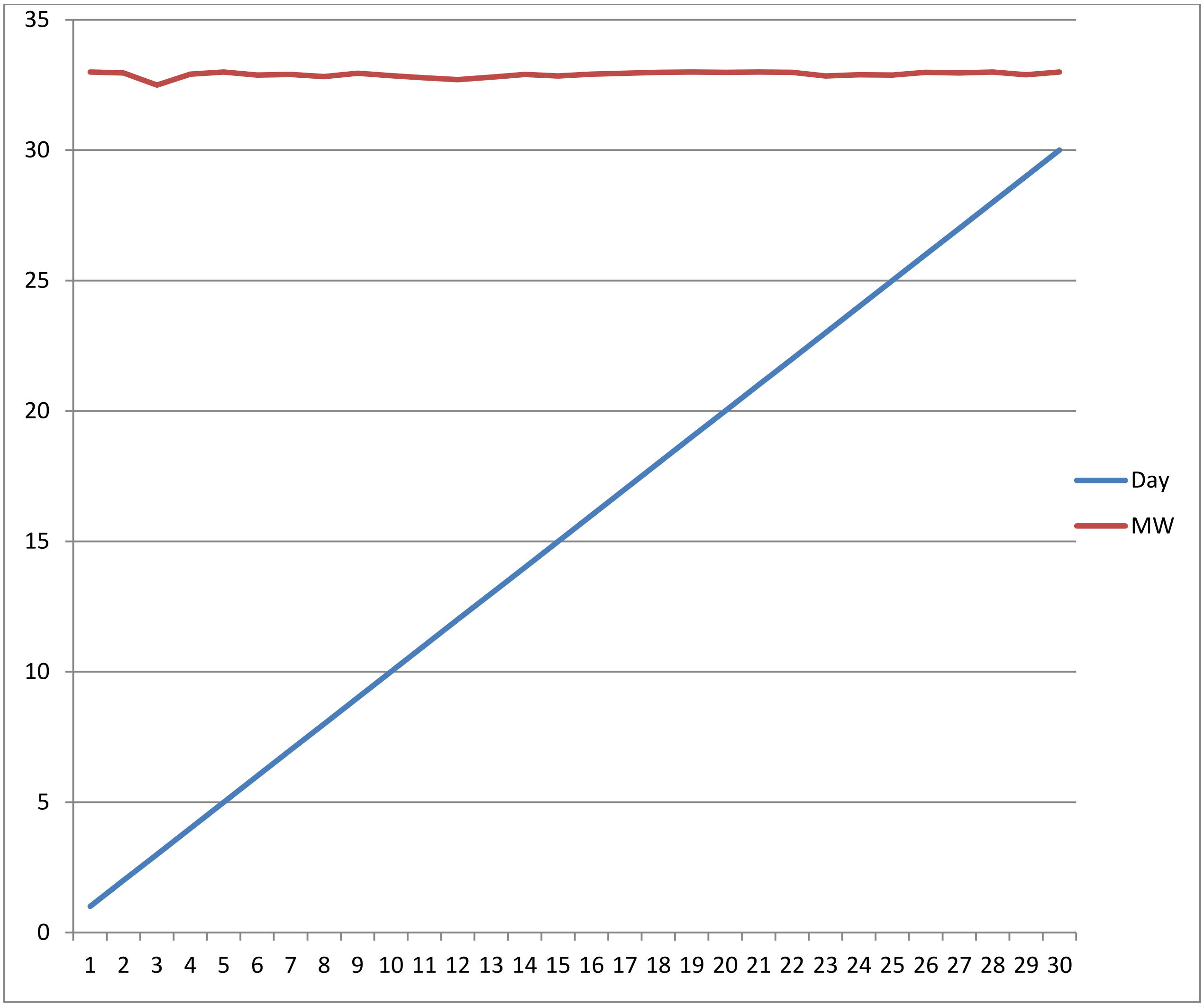
Day	MW
1	32.33
2	32.42
3	32.29
4	32.88
5	32.63
6	32.51
7	32.38
8	32.4
9	32.3
10	32.25
11	32.29
12	32.34
13	32.36
14	32.38
15	32.28
16	32.28
17	32.25
18	32.29
19	32.3
20	32.2
21	32.25
22	32.3
23	32.33
24	32.34
25	32.36
26	32.34
27	32.33
28	32.3
29	32.27
30	32.28



35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Day
MW

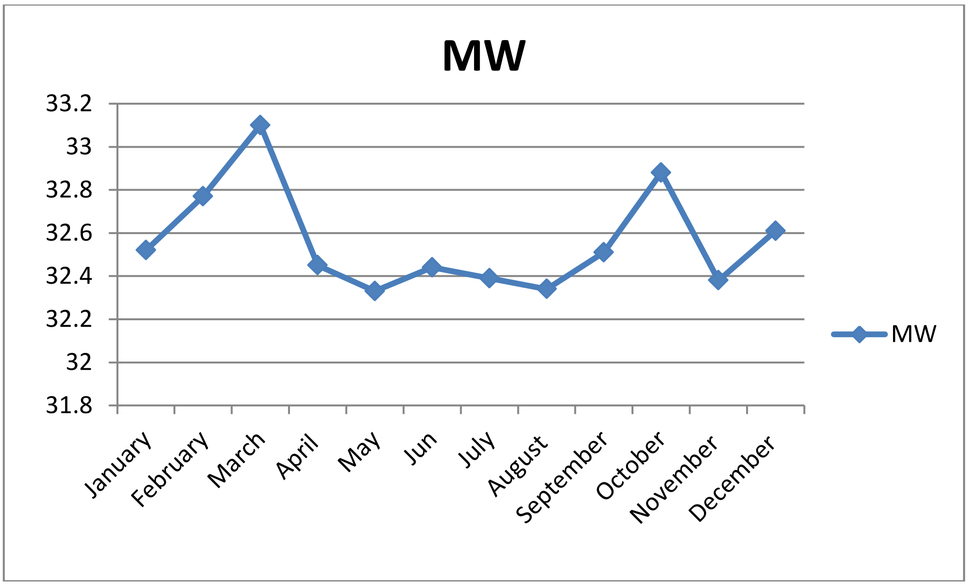
33KV side monthly load curve

Day	MW
1	33
2	32.96
3	32.5
4	32.92
5	33
6	32.88
7	32.9
8	32.82
9	32.95
10	32.86
11	32.78
12	32.7
13	32.8
14	32.9
15	32.84
16	32.91
17	32.95
18	32.98
19	33
20	32.99
21	33
22	32.98
23	32.85
24	32.89
25	32.88
26	32.98
27	32.96
28	33
29	32.89
30	33


35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Day
MW

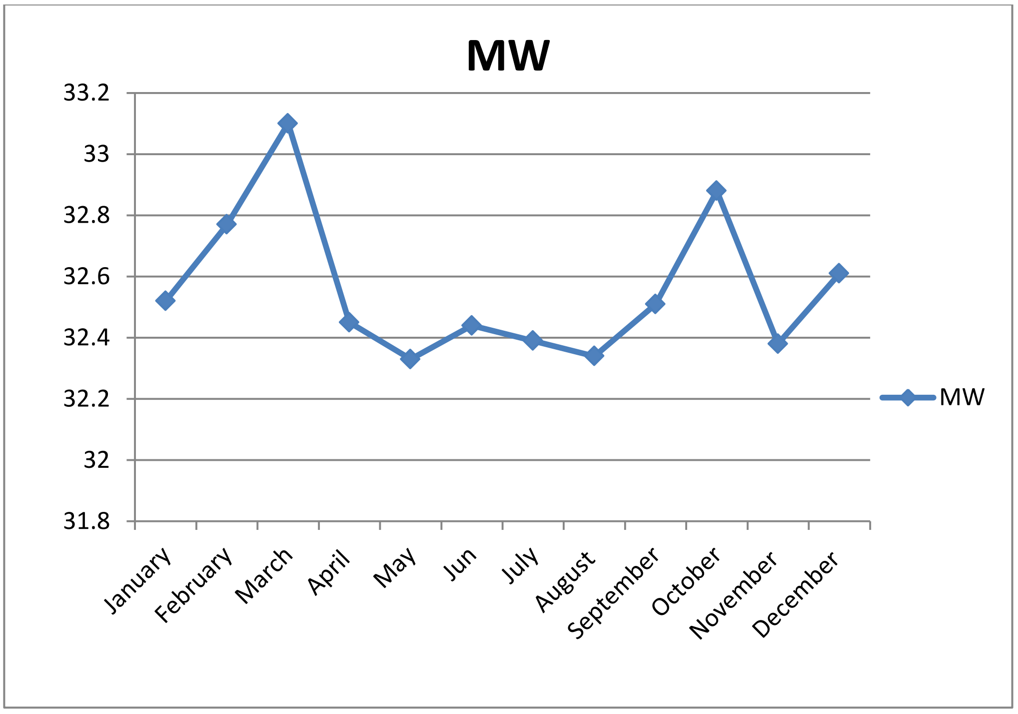
132KV side yearly load curve

Month	MW
January	32.34
February	32.10
March	32.67
April	32.45
May	32.33
Jun	32.41
July	32.39
August	32.30
September	32.51
October	32.55
November	32.38
December	32.31



33KV side yearly load curve

month	MW
January	32.52
February	32.77
March	33.1
April	32.45
May	32.33
Jun	32.44
July	32.39
August	32.34
September	32.51
October	32.88
November	32.38
December	32.61



Discussion of load curve:

The curve showing the variation of load on the power station with respect to time is known as a load curve.

We can know that how much power requires of the day by the load curve. We also can know that how much power need in the year easily find out by the load curve. We calculate maximum demand, average load and how much power is being generate by the load curve. Load curve is important system. If we know this system we can solve these problems easily.

The load on a power station is never constant; it varies from time to time. These load variations during the whole day are recorded hourly and are plotted against time on the graph. The curve thus obtained is known as daily load curve as it shows the variations of load time during the day. It is clear that load on the power station is varying being maximum at 8 P.M. in this case.

The monthly load curve can be obtained from the daily load curves of the month.
The monthly load curve is generally used to fix the rates of energy.
The yearly load curve can be obtained from the monthly load curve.

Conclusion

Power transformer is one of the important equipment in power. Although equipped with surge arresters, differential, multiple grounding protection, but because of complex internal structure, electric and thermal field uneven and due to many other factors, the accident rate remains high**.**

In this thesis paper, we discussed briefly about various types of faults and protection scheme of transformer. We are optimistic about analyzing the transformer faults in details and find the required protection schemes

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