"A STUDY ON OPERATION SYSTEM AND EQUIPMENT OF NARAYANGANJ PALLI BIDYUT SAMITY-1 33/11 KV SUB-STATION"

This report presented in partial fulfillment of the requirements for the Degree of Bachelor of Science in Electrical and Electronic Engineering

Submitted by

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DECEMBER 2018

Certification

This is to certify that this project and thesis entitled **"A STUDY ON OPERATION SYSTEM AND EQUIPMENT OF NARAYANGANJ PALLI BIDYUT SAMITY-1 33/11 KV SUB-STATION"** is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 16 December 2018.

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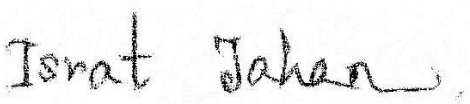

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Prof. Dr. M. Shamsul Alam

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The project and thesis entitled **"A STUDY ON OPERATION SYSTEM AND EQUIPMENT OF NARAYANGANJ PALLI BIDYUT SAMITY-1 33/11 KV SUB-STATION"** submitted by: **K. M. Najmul Haque**, ID No: 143-33-2185 and **Kazi Sabbirul Islam**, ID No: 143-33-2242 Session: Fall 2014 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering**.

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TO WHOM IT MAY CONCERN

NARAYANGANJ PALLI BIDYUT SAMITY-1

CHANGAIN, SONARGAON, NARAYANGANJ.

স্থাপিত-২০০৫ ইং

Certificate of Accomplishment

This is to certify that ***K. M. Najmul Haque*** *Son of* ***Md. Mizanur Rahman*** *Student of* ***Daffodil International University (DIU)*** *bearing ID no:* ***143-33-2185****, Completed 11(eleven) Week* ***Industrial Attachment*** *Successfully from* ***September 20th, 2018*** *to* ***December 05th, 2018****.*

After Successful Completion Of the course, he has been released on the afternoon of December 05th, 2018.

We wish him all Success.

Date: 05.12.2018

05/12/18

(Md. Shahriar Hasan)
Assistant General Manager (HR)

5/12/18

(A. K. M Shadat Hossain)
Deputy General Manager (Tec.)

(Eng. Md. Sairul Islam)
General Manager

NARAYANGANJ PALLI BIDYUT SAMITY-1

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Training Schedule

" শেখ হাসিনার উন্নয়ন- ঘরে ঘরে বিদ্যুৎ "

বাংলাদেশ পল্লী বিদ্যুতায়ন বোর্ড
BANGLADESH RURAL ELECTRIFICATION BOARD

ISO 9001, ISO 14001 &
OHSAS 18001 Certified

বাংলাদেশ পল্লী বিদ্যুতায়ন বোর্ড
(প্রতিনিয়ত উন্নয়নের জন্য প্রশিক্ষণ)
প্রশিক্ষণ পরিদপ্তর (৮তলা)
প্রশিক্ষণ একাডেমী ভবন
জোয়ার সাহারা, খিলক্ষেত
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ক্রমিক নং	প্রশিক্ষণ স্থান	মেয়াদ	মন্তব্য
০১	**নারায়নগঞ্জ পল্লী বিদ্যুৎ সমিতি-১**	২০/০৯/২০১৮খ্রিঃ হতে ১৯/১০/২০১৮খ্রিঃ **এবং** ০৫/১১/২০১৮খ্রিঃ হতে ০৫/১২/২০১৮খ্রিঃ তারিখ পর্যন্ত	Switchgear and Protective relays এবং ফিল্ড প্রশিক্ষণ সম্পর্কিত সিডিউল প্রস্তুত করে Internship Program (attachment) আয়োজনের জন্য অনুরোধ জানানো যাচ্ছে।
০২	কেন্দ্রীয় ওয়ার্কসপ, গনকবাড়ি, নবীনগর, সাভার, ঢাকা	২০/১০/২০১৮ খ্রিঃ হতে ০৪/১১/২০১৮খ্রিঃ তারিখ পর্যন্ত	

১৪/১১/১৮
আল রুহকাইয়া নিপা
উপ-সহকারী প্রকৌশলী
প্রশিক্ষণ পরিদপ্তর

Dedicated to

Our Parents

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LIST OF ABBREVIATIONS

AAC	All Aluminum Conductor
ABCB	Air Break Circuit Breaker
ACB	Air-Blast Circuit Breaker
ACR	Automatic Circuit Re-closer
AVR	Automatic Voltage Regulator
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
CSR	Aluminum conductor steel-reinforced
CT	Current Transformer
DESCO	Dhaka Electric Supply Company
LA	Lightning Arrester
OCR	Oil Circuit Re-closer
PFI	Power Factor Improvement
PGCB	Power Grid Company of Bangladesh
PT	Potential Transformer
VCB	Vacuum Circuit Breaker

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First-of-all Thanks to Allah. Then we would like to take this opportunity to express my appreciation and gratitude to my supervisor **Professor. Dr. M. Shamsul Alam, Professor and Dean** of the **Faculty of Engineering** for being dedicated in supporting, motivating and guiding us through this project. This project can't be done without his useful advice and helps. Also thank you very much for giving us opportunity to choose this project.

We wish to convey our heartfelt gratitude to Almighty Allah for His help to complete the Internship successfully. We also thank the management of Narayanganj Palli Bidyut Samity-1 (NPBS-1) for providing us such opportunity to accomplish our Internship. We would specially thank **Md. Shahriar Hasan, AGM (HR)** and **Engr. A. K. M. Shadat Hossain, DGM (Tec.)** who gave us the permission to do internship work.

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To our beloved family, we want to give them our deepest love and gratitude for being very supportive and for their inspiration and encouragement during our studies in this University.

ABSTRACT

As technology is advancing the consumptions of power is gradually rising. There are three steps for proper electrification these are Electric Power Generation, Electric Power Transmission and Electric Power Distribution. These three steps are equally important for proper electrification, without any one of this three the electricity system will be incomplete. Power Grid Company Ltd is the only authorized company for the Electric Power Transmission sector in Bangladesh by BPDB (Bangladesh Power Development Board) company. Bangladesh Rural Electrification Board (BREB) has many sub-stations all over the country and which are connected through the distribution line, these stations are called sub-station. This report paper provides the synopsis assessment of all the systems existing 33/11KV Narayanganj Palli Bidyut Samity-1. Bangladesh Rural Electrification Board (BREB) has the vast electricity distribution network all over the country and the electric power plants are connected to the transmission line to assure the continuity of electric power. The electric power plants produce the power and feed in to the transmission line. All power plants are connected in parallel with the transmission and distribution line.

CHAPTER-1

INTRODUCTION

1.1 Introduction

In the fall semester of 2018 we got an opportunity to complete the field study in Narayanganj Palli Bidyut Samity-1. It covers Sonargaon, Bondor, Rupganj (Half). They introduce electricity among the illiterate or village people and encourage them for using electricity appropriate way (without any miss use).

1.2 History of Electricity Generation and Distribution in Bangladesh

Dhaka, the capital city of Bangladesh is an ancient city. There is a public saying that Nawab of Dhaka installed a small generator in his residence "Ahsan Monjil" and started generating power at 5pm on 7th of December 1901, which is considered as the introduction of electricity in the Department of Electrical and Electronic Engineering Dhaka city. Later, in and around 1930, M/S. DEVCO, a subsidiary of M/S. Octavian's Steel Company, developed electricity distribution system at 400V level under complete private ownership and brought that for public use. Most probably in the year 1933 a power generating station named "Dhanmondi Power House" was established with two 1500 KW generators each and from there the electricity distribution system was started to sale to the public on commercial basis. At first BPDB (Bangladesh Power Development Board) used to generate transmit and distribute power. Then Bangladesh government formulated National Energy Policy in 1996 and segregated power generation, transmission, and distribution functions in to separate services.
BPDB started generating power; transmission responsibility was given to PGCB (Power Grid Company Bangladesh). BPDB used to distribute power to mainly the urban areas except the metropolitan city of Dhaka. The responsibility of distributing power in Dhaka was given to Dhaka Electric Supply Authority (DESA). Later, DESA went through lots of controversies and corruption, so government created a new subsidiary named Dhaka Electric Supply

Company Ltd. (DESCO) and provided the responsibility of electricity distribution in Mirpur, Gulshan, Baridhara and Uttara area of Dhaka.

1.3 Bangladesh Rural Electrification Board (BREB)

It constituted under a government ordinance of 1977 and started functioning in 1978. It implements the program of distribution of power in rural areas and constructs power distribution line and power Sub-Stations through rural electric societies which is Palli Bidyut Samity (PBS) on the principal of co-operative.

1.4 Palli Bidyut Samity (PBS)

Company profile: Narayanganj Palli Bidyut Samity-1 (NPBS-1)

Fig. 1.1: Main gate of NPBS-1

Based on the universal Principal of cooperative, Palli Bidyut Samity (PBS) of BREB are formed as domestic, decentralized and autonomous organizations where the number consumer enjoy equal opportunities and are entitled to exercise equal rights. Continuous support from the government and donor agencies and the people associated with the programmer and comparative transport and accountable system of the PBS has helped to set a high standard of performance of the organization. The owners of PBSs are its consumer's members and PBS management is accountable to a locally elected Board of Directors and the

overall performances of the PBS are controlled by BREB. BREB is basically running on founding from the government and development partners. Some of the PBSs are still not financially self-reliant as most of their consumers are residential connection holders. A 'PBS Revolving fund' was established with the help of financially sound Samitys for the PBSs which are yet to be self-reliant to reduce their dependence on government and development partners.

1.4.1 Strategy

Its main ethics is "No Profit No Loss".

1.5 Territory of BREB

BREB already covered almost all of part of our country. Mainly they provide electricity in rural people but they also distributes in industrial areas. They covered all most 4,09,985 Km line and constructed 4,09,106 Km. The territorial map is given below in consists of fig. 1.2

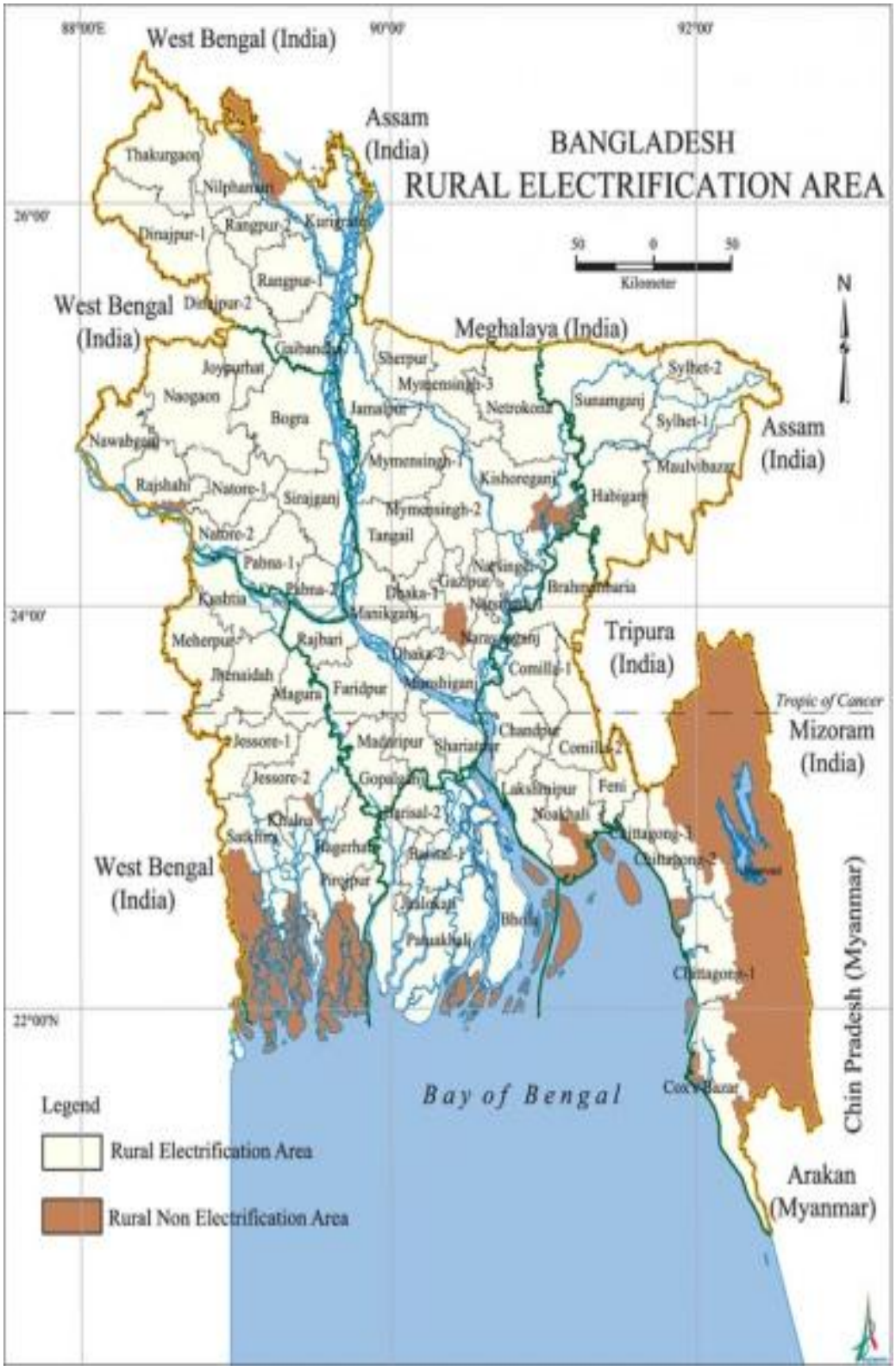


Fig. 1.2: Territory Map of BREB

1.6 Object of Internship

- To compare our theoretical knowledge with the practical work.
- To see the practical equipment's those are being used in power generation, transmission and distribution system.
- To gather idea about the company.
- To gather the idea about the distribution of NPBS – 1.
- Risks related during the distribution process.

1.7 Scope and Methodology

This report is based on the internship program where we reviewed about Switchgear and Protective Relays and the basic making process of a transformer and establishment of switchgear, current transformer and potential transformer, voltage regulator. We also reviewed the operation of Transformer and testing process of these components. The report contains relevant information about a sub-station as was observed during the internship program.

CHAPTER-2

TRANSFORMER

2.1 Transformer

A transformer is a static (or stationary) piece of apparatus by means of which a.c electric power in one circuit is transferred into electric power of the same frequency in another circuit by electromagnetic induction.

1. It is a static device and do not have rotor.
2. It transfers electric power from one circuit to another.
3. It does so without change frequency.
4. It accomplishes this by electromagnetic induction.
5. Voltage and current of one circuit can be changed in another circuit.
6. They operate only with alternating current.

2.2 Basic Principle of Transformer

Transformer refers to the static electromagnetic setting which can transfer power from one circuit to another one. In AC circuits, AC voltage, current and waveform can be transformed with the help of transformers. Each transformation is usually to transfer from one circuit to another one by the way of electromagnetism, but it has no direct relation with this circuit. It also can be transformed through electromagnetism (electrical manner). This electromagnetism is known as auto-transformer. Transformer plays an important role in electronic equipment. AC and DC voltage in power supply equipment are almost achieved by transformer's transformation and commutation. At the same time the electrical parameters transformed by transformer are not one but a few ones. Most of the isolation, matching and impedance in the circuit carry out by transformer. Most of isolation, matching and impedance in the circuit carry out by transformer. Simple schematic diagram of the transformer is shown in fig. It is connected by closed-magnet (iron cores), two windings and AC power supply. The winding is called the primary winding; another winding is connected with load and it is called secondary windings. Things that are important for transformer: Structure, Core

diameter, Insulation label, Cooling system, Tapping system, Coil thickness, Tank and Conservator. There are three types of transformers:

1. Power transformer
2. Distribution transformer
3. Instrument transformer

2.3 Main Parts of Transformer

1. Core
2. Low tension (LT) coil
3. High tension (HT) coil
4. Transformer oil
5. Transformer tank
6. Bushing
7. Tapping
8. Radiator
9. Breather box with silica gel
10. Conservator tank etc.

2.4 List of Raw Materials of Transformer

Transformer's raw materials are shown below

1. Winding machine
2. Tools
3. Raw materials
    a. Copper wire 5.5 kg for HT side
    b. Copper wire 5 kg for LT side
    c. Insulation paper
    d. Cotton tape
    e. Scotch tape

f. Gum
g. Thinner
h. Insulating burnish
i. Strapping sill
j. Gas cap
k. Ampere tube
l. Pressure release valve
m. Super glue
n. Scrap paper
o. HT bushing
p. LT bushing
q. Socket

2.5 Transformer Coil

There are three types of coil. They are:

1. Low voltage coil or LT coil
2. High voltage coil or HT coil
3. Tap changing coil

2.6 Power Transformer

Power transformer is an essential element for power system. They allow relatively low voltages from generators to be raised to a high level for efficient power transmission. There are two types of power transformer. They are step up and step down.

Fig. 2.1: Power Transformer

There are two types of instrument transformer:

1. Current transformer (CT)
2. Potential transformer (PT)

2.6.1 Current Transformer (CT)

Current transformer is used to measure the amount of current in a line by a predefine CT ratio. CT protects the transformer by reducing the current of the main line according to the CT ratio. It is not possible to measure the current of high voltage system directly because of insulation problem of measuring instruments. It is also not possible to use current flowing through the system directly for protection purpose due to its high value and high insulation problem. So we must need a transformer which takes high input but the output is low. This type of transformer is called CT.

Fig. 2.2: Current Transformer

2.6.1.1 Categories of Current transformer

Normally current transformer is provided with multi-core. Cores are divided into two categories.

1. Protective
2. Measuring

- **Protective CT**

Protective core of current transformer is used for over current protection, earth fault protection and differential protection etc.

- **Measuring CT**

Measuring core of current transformer is used to supply current to measuring instruments like ammeters, watt-meters, kVA meters and kWh meters etc.

2.6.1.2 Purpose of Current Transformer is following

- To reduce the line current to a value which is suitable for standard measuring instruments, relays etc.
- To isolate the measuring instruments namely meters, relays etc. from high voltage side of an installation.
- To protect measuring instruments against short circuit currents.

2.6.2 Potential Transformer (PT)

Potential transformer is used to measure the amount of voltage in a line. It protects the transformer by dropping the voltage of the line according to the PT ratio. It is also used to measure the amount of power transmitted through the line. Because of insulation problem of measuring instruments, direct measurement of voltage in high voltage system is not possible and also not possible to use of voltage in high voltage system protection purpose due to its high value and high insulation problem of protective relays. So we must need a transformer which takes high input voltage but the output voltage is low. This type of transformer is called PT.

Fig. 2.3: Potential Transformer

2.6.2.1 Precaution for using PT

- Make sure that no secondary winding of PT are left short circuited.
- Neutral terminal of the secondary windings are connected to earth.
- Neutral terminal of the primary windings is connected to earth.
- Earthling points are connected to earth. I.e. tank, support structure etc.
- There is no entry/hole for entering lizards/insects in the secondary terminal box.

2.6.2.2 The purpose of Potential Transformer is following

i. To reduce the line voltage to a value, this is suitable for standard measuring, instruments and relays etc.
ii. To isolate the measuring instruments, meters, relays etc. from high voltage side of an installation.
iii. To sense abnormalities in voltage and give voltage signals to protective relays to isolate the defective system.

Generally the transformers are either Δ to Y or Y to Δ connected. If high voltage side Delta connected then Low Voltage side Y connected and vice versa.

Significance of Δ to Y connection

The closed circuit on the delta side provides some benefits. Voltages on the secondary's have improved balance. Also it cancels third harmonic since these are not supported on the three-wire system. A delta connection on the secondary side provides the possibility of large circulating currents if the characteristics of the 3 windings are not perfectly balance. Y connection avoids this.

Significance of Y to Δ connection

The Y-Δ transformer can be used to eliminate one node at a time and produce a network that can be further simplified.

2.7 Coil Winding

- **High Voltage Coils**

Generally round insulated wire of either copper (Cu) or aluminum (Al) is used as basic raw material for high voltage coil. The coils are made in number of layers. The starting and finishing leads of each coil are terminated on either side of the coil. These leads are properly sleeved and locked at number of points.

- **Low Voltage coils**

The shape of the basic raw-material (Al or Cu) is rectangular.

- **HT Side**

In HT side, the voltage is high and current is low. For this reason the insulation must be higher than LT side insulation. HT insulation paper is used in HT side.

- **LT Side**

In LT side, the voltage is low and current is high. For LT side coil insulation, LT insulation paper or DPC paper is used.

2.8 Tap Changing

Tap changing means the changing of voltage by a switch. It is provided in HT coil for changing purpose. Sometimes taps are getting from HT coil; also sometimes an extra coil is used for taps. Taps are also depending on the winding.

i. On load tap changing
ii. Off load tap changing

Fig. 2.4: Testing Tap

On load tap changing means that the taps are changed during the loading condition but in that condition off load tap changing cannot network properly. It is dangerous to change the taps off load tap changer during loading condition. Because when it moves from one tap to another tap it can be sparked and fire.

2.9 Protection

Every transformer must have a protection system otherwise it will damage.

i. Cooling system
ii. Thermal protection
iii. Oil level indicator
iv. Silica gel
v. Insulation

2.9.1 Cooling System

In transformers, the cooling has a special importance to ensure safe operation and to increase the life time of the transformer. The heat occurred in the transformers is dissipated at the cooling unit by the help of coil.

Fig. 2.5: Transformer with cooling system

2.9.2 Oil level Indicator

Oil level indicator indicates the oil level in the conservator and gives too low or too high indications by the contacts on it.

2.9.3 Insulation

There are three types of insulation. They are

i. Insulating paper
ii. Oil
iii. Varnish

2.9.3.1 Insulating paper

High quality crepe insulating paper is used to build up main insulation of the CT and PT. The craft paper is used to avoid short circuit between core and coil.

Fig. 2.6: Insulation paper

2.10 Core Assembles

Silicon steel sheet is cut by designed shape. This sheet is sliced for decreasing eddy current loss. By adding this sliced sheet the core is created. After that the limbs of the core are tightly wrapped with cotton tape. Then an insulating press board is wrapped on all the three limbs.

Fig. 2.7: Core assemble

We saw two types of transformer in NPBS-1, one is power transformers and another is distribution transformers. In NPBS-1 they use cooling system, insulation paper, oil level indicator and silica gel to protect their transformers.

2.11 Testing For Transformer

In practical it is very important to determine the transformer reaction for different loads. The performance depending on parameters can be obtained by solving the equivalent circuit for any load conditions. Although when a transformer is rewind with different primary and secondary windings the equivalent circuit also changes. In order to get the equivalent circuit parameters test methods are fast choice. From the analysis of the equivalent circuit one can determine the electrical parameters. On the other hand, if the temperature rise of the

transformer is required then test method is the most dependable way. There are several tests that are done on the transformer in NPBS-1 which is under NPBS-1 areas. Our country's transformer test is doing in BREB workshop.

2.11.1 Transformer Oil Test

An oil sample will identify many things on a transformer. The following tests can be performed with the oil sample.

2.11.2 Acid Neutralization Test

The acid neutralization test is a test of the fluid that declares of how much it has oxidized. Oxidization decreases its dielectric property. Acidity shows chemical reaction with organic insulation. Oxidized fluid will allow interior components to rust.

2.11.3 Dielectric Breakdown Test

Dielectric strength of insulating oil is measured in this test. In NPBS-1, they have dielectric strength measuring machine manufactured by Megger to test the oil. A diagram of the machine is shown in fig. In the figure within the transparent glass part. There are two electrodes placed at a distance. The test is done by applying an AC voltage between the electrodes. The gap between the electrodes is specified and the gap is 2.5 mm. There is a digital keypad with a display on the right side of the machine. This keypad is used to apply the voltage right before the insulation breaks down. So that a conducting path is formed. Then the dielectric strength is calibrated from the specified distance and the applied voltage. If the dielectric strength is decreased then the arc extinguishing capacity will be decreased. Here it is important to mention that the module shown in fig. is strictly monitored and controlled by engineers due to its delicacy.

- Old oil rating is less than 26 kV, that is satisfied.
- New oil rating is less than 30 kV, that is satisfied.

Fig. 2.8: Dielectric Oil Test Module of BREB-workshop

2.11.4 Moisture Content Test

Water decreases the power of insulation of oil. Moist can be formed from two sources. One of them is by the breathing process or from oil degradation. Now to absorb the moisture in the air sucked in by the transformer during the breathing process, silica gel breather is used. Now a question may rise that what is transformer breathing. Well when load on transformer increases the insulating oil of transformer gets heated up, expend and gets expel out in to the conservator tank present at the top of the power transformer and subsequently pushes the dry air out of the conservator tank through the silica gel breather. This process is called breathing out of the transformer. Oil degradation also produces moisture.

2.11.5 Pre-commissioning Test

The following tests are to be carried out on current transformer during commissioning and suspected performance and major faults:

- Insulation test
- Polarity test
- Turn ratio test
- Test for checking magnetization curve

a) Insulation Test

The insulation test resistance should be measured by 1KV or 500 volts megger. The insulation resistance should be measured to earth and between circuits. While measuring the insulation resistance between primary and secondary or primary to earth or body higher voltage meggers may be used.

b) Polarity Test

Each current transformer should be individually tested to verify that the primary and secondary polarity marking are correct. The mille-ammeter connected to the secondary of the current transformer should be robust moving coil, permanent magnet, current zero type. A low voltage battery is used via a single pole d.c ammeter should indicate a positive flick and on opening a negative flick.

c) Turn Ratio Test

The ratio of the current transformer is checked by means of a primary injection set as per the circuit diagram.

The turn 'R' of a transformer is determined by the equation:

$$\mathbf{R}=\mathbf{I}\ p/\mathbf{I}s$$

Where **I** p is the primary current **I**sis the secondary current as measured during the test. The ratio **I** p/**I**s should approximate to the ratio marked on the current transformer name plate.

2.12 Transformer Cooling System

Transformer is heated up while running. Too much heat built in transformer is not allowed. Excessive heat reduces the performance and its lifetime. In NPBS-1 there is cooling system installed with generator. In the following section, generator cooling system will be discussed.

2.12.1 Air Cooling

In NPBS-1, air cooling method is used to cool the generator. Air is passed through the generator to dissipate the heat. The air around the generator is hot. So passing cool air replaces the hot air around generator and eventually the temperature falls down.

2.12.2 Water cooling

Water fins are surrounded by the generator to absorb heat and then carrying the heat away. Water is being flown continuously by a motor and the heat is being dissipated away. At the NPBS-1 they use water cooling system to cool down the generator.

CHAPTER-3
SUBSTATION

3.1 Substation

Substation is an indispensable part of power. Substation is used for different purposes. Mainly substation is used for transmission of power, distribution of power. Usually at NPBS-1, transformer produces 11kV output voltage which is then decreased to 400V by step-down transformer for distributing and reducing I^2R loss purpose. Substation is also used for the maintenance of auxiliary equipment of the power. In this chapter, we will discuss the main parts of a substation used in NPBS-1.

Figure 3.1: The substation of NPBS-1

Fig 3.1 shows the partial part of the substation at NPBS-1 where the Current Transformers (CT), Power Transformers (PT), Isolators, Insulators are connected and arranged. Below, different equipment of the substation is described from the collective perspective. At NPBS-1 we visited the substation. We also visit Sonargaon 132/33kV power plant and DPBS-1 main work shop. There we saw different types of equipment to obtain our desired voltage levels. Mainly substation is used for transmission of power. The equipment that are used in the substation of NPBS-1 is as follows:

- Power Transformer
- Instrument Transformer
  - Current Transformer (CT)
  - Potential Transformer (PT)
- Bus bar
- Transmission and Distribution
- Insulators
- Isolators
- Auxiliary System
- Underground Cables

3.1.1 Power Transformer

In NPBS-1 we closely observed power transformers and they are generally installed for step down the voltage. For long line transmission high voltage in needed. In NPBS-1 there are total six power transformers in each unit.

Transformer-1 of the substation which is used for stepping down the rated voltage from 11kV to 240V. This is a Δ connected transformer.

Fig. 3.2: Power transformer of Narayanganaj PBS-1

Generally two type of losses occur in a transformer –

1. Copper loss
2. Core loss or iron loss

3.1.1.1 Copper loss

Copper loss is power lost in the primary and secondary windings of a transformer due to the ohmic resistance of the windings. Copper loss is I^2Rloss.

Total copper losses = $I_1^2 .R_1 + I_2^2 .R_2$

3.1.1.2 Core loss or iron loss

Hysteresis loss and eddy current loss both depend upon magnetic properties of the materials used to construct the core of transformer and its design.

Hysteresis loss: (W_h) is expressed by: $W_h = \eta B^{1.6}_{max} f.v$ watt

The induced emf in the core sets up eddy current in the core, and hence **eddy current loss** (W_e) occurs, which is given by:

$W_e = PB^2_{max}.f^2t^2$ Watt

3.1.2 Instrument Transformer

During our internship we saw instrument transformers. There were two kinds of instrument transformers. They are Current Transformer and Potential Transformer. Instrument transformers are used for measuring and protection purposes.

3.1.3 Bus bars

During our internship in NPBS-1 we observed bus bars. Bus bar is a bar or line where different types of lines such as transmission line, distribution line etc operates at the same voltage level. Bus bar is used as the common electrical bar. The incoming and outgoing lines in a substation are connected to the bus bar. In NPBS-1 they used single bus bar.

Fig. 3.3: Bus Bar

- **Single Bus Configuration**

As the name suggests, it consist of a single bus bar and all the incoming and outgoing lines are connected to it. At NPBS-1, the reason why they have used single bus configuration is due to the fact that it has low initial cost, less maintenance needed and simple operation. However, the disadvantage of single bus bar system is that if repair is to be done on the bus bar or a fault occurs on the bus, there is a complete interruption of the power supply as we were told.

3.1.4 Transmission and Distribution

During our internship we saw the transmission and distribution system of NPBS-1. A substation receives electrical power from generating station via incoming transmission lines and delivers electrical power via the outgoing transmission lines. Overhead lines are used for transmission and distribution.

3.1.5 Insulators

We saw different types of insulators in the substation of NPBS-1 which are used in power lines. There are three types of insulators. Fig 3.4 shows these insulators which are pointed for identification purpose. And they are-

- Suspension type insulator.
- Pin type insulator.
- Strain insulator.

Fig. 3.4: Insulators used in NPBS-1 substation

3.1.6 Isolators

In substation we also saw the isolators. It is the extra protection part of the system. It is often desired to disconnect a part of the system for general maintenance and repairs. It is accomplished by an isolator. Isolator does not have the arc extinction capacity. It operates under no load condition. It does not have any specified current breaking capacity or current making capacity. Isolator not even used for breaking load currents. While opening a circuit we have to open the circuit breaker first and then we can open the isolator. While closing circuit, the isolator is closed first than circuit breakers.

3.1.7 Auxiliary System

During our intern period we saw different types of auxiliary system used in NPBS-1. The systems are Lube Oil Pumps, Outdoor lighting and receptacles, Control house, Heating and ventilation, Chiller air conditioning, Battery charger input and Motor-operated switches etc. For these auxiliary purposes NPBS-1 take power from Grid.

3.1.8 Underground Cable

An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover. In NPBS-1 substation, we saw these cables for the grounding, metering and internal connection purpose.

Fig. 3.5: Underground cable of NPBS-1 substation.

The cable shown in fig 3.5 is actually an XLPE cable ranges from 6.6kV to 33kV in voltage rating. XLPE cables use cross linked polyethylene as insulator and this equalizes the electrical stress of the cables.

3.2 Single Line Diagram of Narayanganj PBS-1, 33/11kV Substation

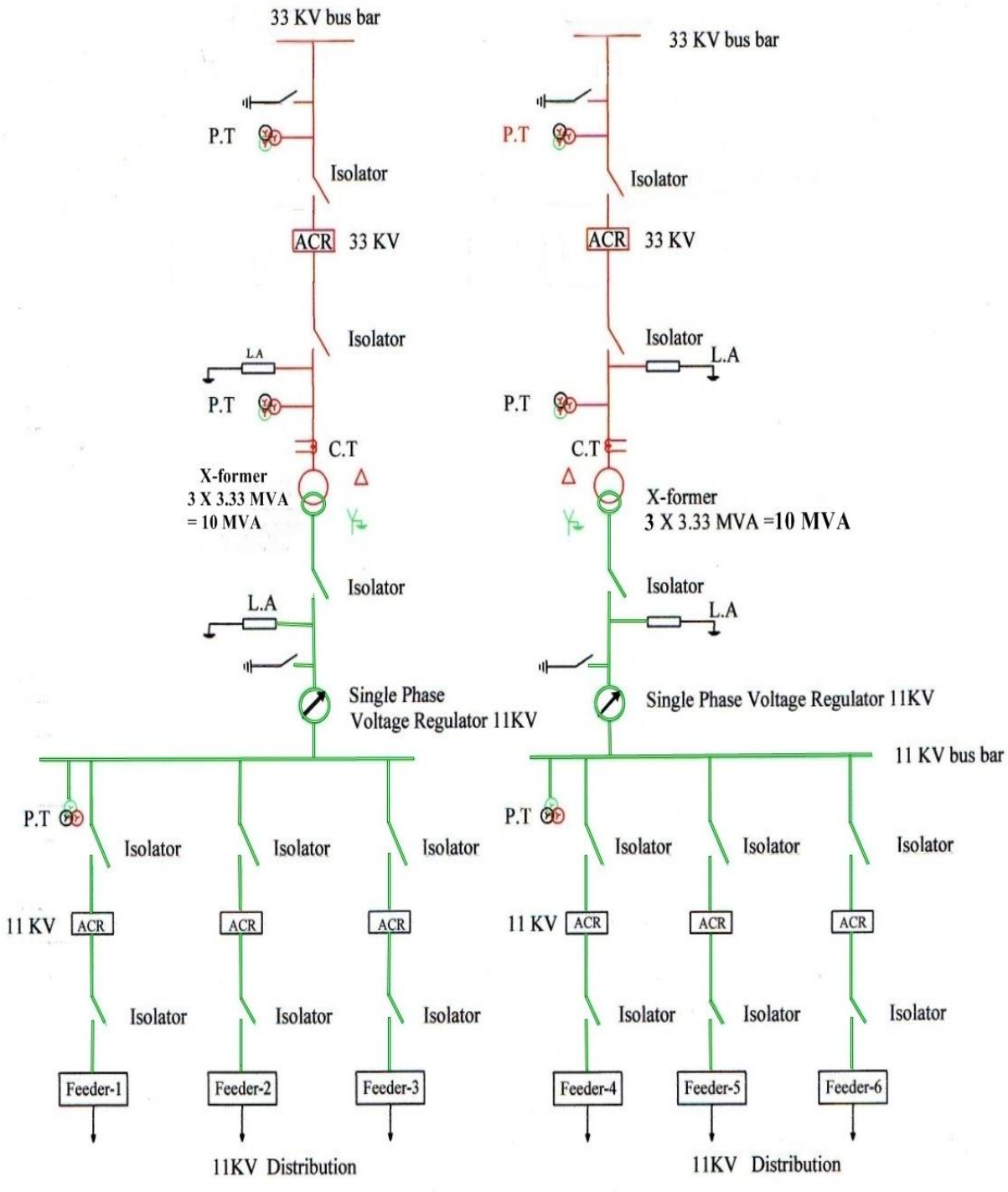


Fig. 3.6: Single line diagram of Narayanganj PBS-1, 33/11kV substation

CHAPTER-4
VOLTAGE REGULATOR

4.1 Introduction to Voltage Regulator and its necessity

General Information:

- It increase or decrease system voltage by some mechanism;
- It plays auto transformer rule to increase or decrease voltage;
- Maximum increase or decrease voltage is ±10%;
- From neutral position it changes maximum 16 steps both rise and lower direction;
- Each step changes 5/8% volt.

Necessity of voltage regulator:

- Improve system voltage up to allowable range.
- Control load voltage.

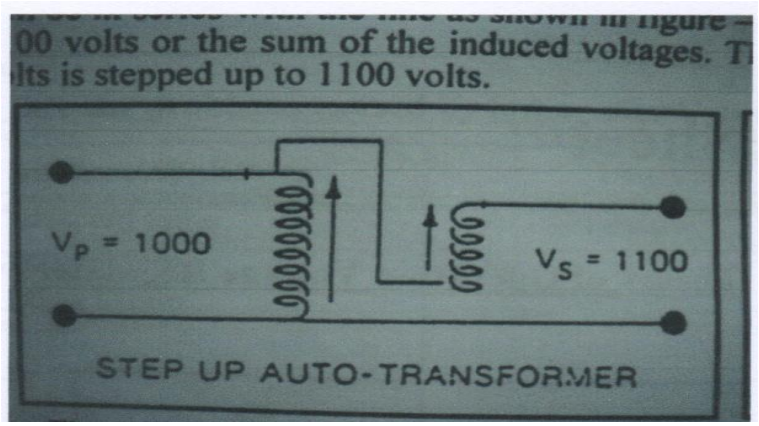


Fig. 4.1: Step up autotransformer

4.2 Allowable Voltage Drop

Name / Types of Line	Maximum Voltage Drop (volt)	% Voltage Drop
Primary Line	6.9	3
Distribution X-former	3.5	1.5
Secondary Main	4.6	2
Secondary Branch / Service	4.6	2
Total Voltage Drop at Customer's Service Entrance	19.6	8.5

Table 4.1: Allowable Voltage Drop

Base Voltage 230 volts.

4.3 Voltage Levels at BREB/PBS System

Allowable Variation	Phase to Neutral Voltage (volts)	Phase to Phase Voltage (volts)
Maximum (105%)	241.5	418.3
Nominal (100%)	230	400
Minimum (96.5%)	221.9	386

Table 4.2: Voltage levels at BREB/PBS system

Maximum Voltage Drop is 19.6 volts (241.5-221.9) on 230 volts Base.

4.4 Classification of Voltage Regulator

a) Induction type voltage regulator.
b) Step type voltage regulator.

Step type voltage regulators are used in BREB/PBS system.

4.4.1 Kinds of Step Type Voltage Regulator

1. According to Brands used in BREB/PBS system:
    i. General Electric Company at USA.
    ii. Cooper Power System, USA.
    iii. Siemens Power Transmission and Distribution LLC.
    iv. Toshiba Do Brazil S.A.
2. According to Capacity used in REB/PBS system:
    i. 700/624/656 Amps – for installing in 10 MVA S/S;
    ii. 328 Amps – for installing in 5 MVA S/S;
    iii. 100 Amps – for installing in distribution line.
3. According to connection of series winding:
    i. Straight Type (ANSI Type A) used in PBS System.

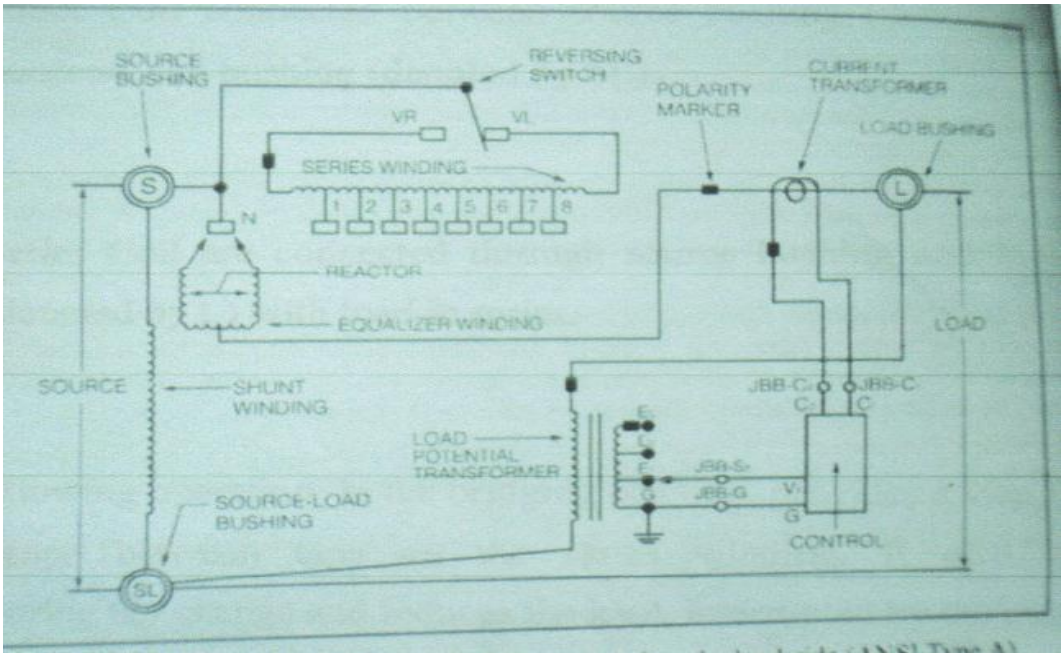


Fig. 4.2: Series winding located on the load side

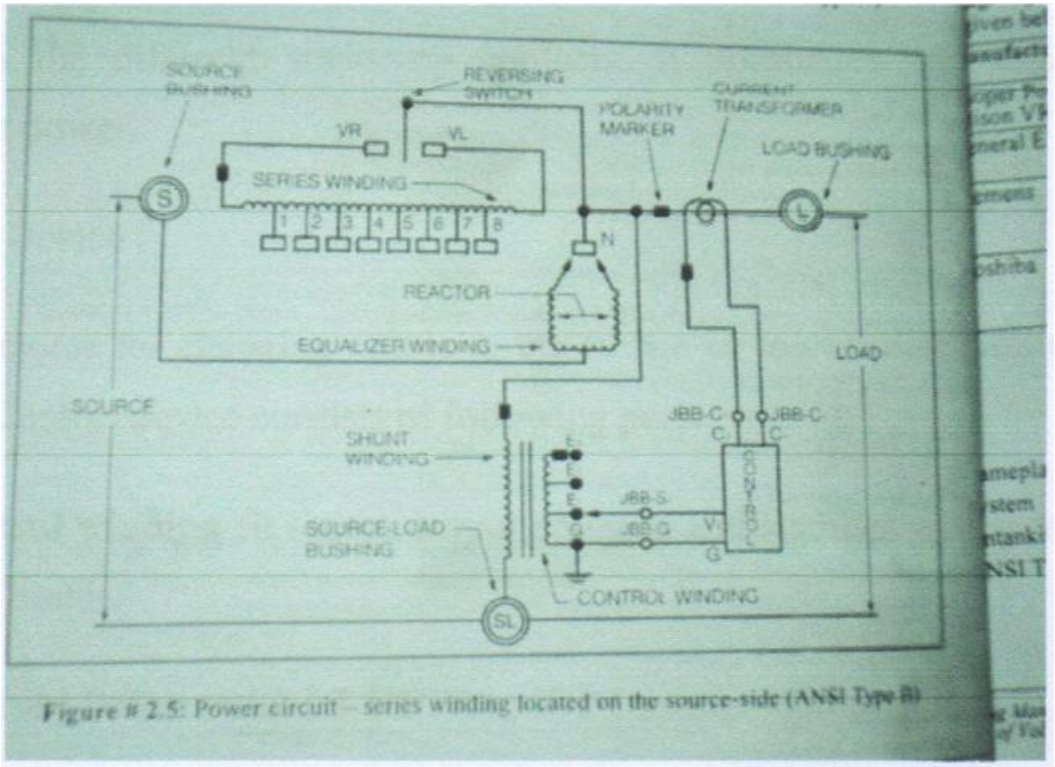


Fig. 4.3: Series winding located on the source side

4.5 Main Internal Feature

4.5.1 Series coil and Shunt Coil

- Shunt coil and series coil are couple both electrically and magnetically as like as an Auto transformer. The ratio of shunt coil and series coil is 10:1.
- Shunt coil connected between source bushing (denoted by S) and source-load bushing (denoted by SL).
- Series coil are connected through source bushing and load bushing (denoted by L) with load in series.

4.5.2 Reactor

This winding allowing operation in the bridging position, provides a step half as the potential difference between taps on the series winding. It also eliminates discontinuities during tap change and reduces the KVA interrupted by the mechanism.

4.5.3 Equalization Coil

Equalization coil minimizes the circulating current in the reactors when moving contacts are on the different stationary contacts. It eliminates arc voltage and consequently arc power.

4.5.4 Control Device

It controls the motor for changing regulator tap to raise or lower direction to adjust output voltage. Control device consists of following parts:

a) **Control winding:**
   It sense output voltages and supplies power to control and TC motor.
b) **Internal Differential PT (IDPT):** IDPT senses source voltage.
c) **Ratio Correcting Transformer (RCT):** RCT adjust voltage as close as possible to 120V.

4.5.5 Tap Changer

To maintain proper voltage, tap changer is required. Tap changer is of two types –

i. Spring Drive Tap Changer.
ii. Direct Drive Tap Changer.

Tap changer consists of –

a) Reversing Switch.
b) Moving Contacts.
c) Fixed Contacts.
d) Holding Switch.
e) Motor and Capacitor.
f) Position Indicator.
g) Neutral Light Switch.

4.6 Extended Range of Ratings

1. In case of step type regulator it is the fact that regulator losses decrease as the regulator moves from the extreme tap positions (boost or buck) closer to the neutral point.
2. Where less than the full 10% regulation is satisfy. The load carrying capabilities of the regulator can be extended.

This is shown in the tabulation below for single-phase step regulators rated 19.9kV and below:

Range of Voltage Regulation (%)	Amperes as Percent of Rated Current
±10.00	100
±8.75	110
±7.5	120

Table 4.3: Extended range of ratings

The capability can be increased a maximum of 160 percent.

4.6.1 Range of Regulation

The range of regulation is the only component of the regulator control system not adjusted in the control cabinet. It is adjusted at the regulator position indicator which is generally mounted on the regulator tank.

CHAPTER-5

SWITCHGEAR

5.1 Definition of Switchgear

A switchgear or electrical switchgear is a generic term which includes all the switching devices associated with mainly power system protection. It also includes all devices associated with control, metering and regulating of electrical power system. Assembly of such devices in a logical manner forms switchgear. This is very basic definition of switchgear.

Fig. 5.1: Switchgear of NPBS-1 (Sonargaon)

Switchgear is an arrangement of some apparatus which are used to control & protect the electrical circuits & equipment.

5.2 Circuit Breaker (CB)

Electrical circuit breaker is a switching device which can be operated manually as well as automatically for controlling and protection of electrical power system respectively. A circuit breaker is equipment which can be

1. Make or break a circuit either manually or automatically under normal conditions
2. Break a circuit under abnormal conditions

A circuit breaker has two contacts Fixed & Moving contact –

During the separation of contacts, due to large fault current and high current density at the contact region the surrounding medium ionizes and thus a conducting medium is formed. This is called the ARC.

5.2.1 Types of Circuit Breaker (CB)

According to arc quenching media the circuit breaker can be divided as –

01. Oil circuit breaker.
02. Air circuit breaker.
03. SF6 circuit breaker.
04. Vacuum circuit breaker.

5.2.2 Oil circuit breaker

Mineral oil has better insulating property than air. In oil circuit breaker the fixed contact and moving contact are immerged inside the insulating oil. Whenever there is a separation of current carrying contacts in the oil, the arc in circuit breaker is initialized at the moment of separation of contacts, and due to this arc the oil is vaporized and decomposed in mostly hydrogen gas and ultimately creates a hydrogen bubble around the arc. This highly compressed gas bubble around the arc prevents re-striking of the arc after current reaches zero crossing of the cycle. The oil circuit breaker is the one of the oldest type of circuit breakers.

Fig. 5.2: Oil Circuit Breaker

5.2.3 Air Circuit Breaker (ACB)

The air circuit breaker is a medium voltage circuit breaker. The rated current is up to 10,000A. The rated voltage is up to 72 KV. In NPBS - 1 air circuit breaker are used in AC motor feeders and ac bus-bar. It is usually electrically controlled but some are microprocessor controlled. The air circuit breakers are easy to maintain.

The advantages of ACB are as follows.

- Relatively inexpensive,
- Simple construction,
- Simple maintenance requirements.

The disadvantages of ACB are as follows.

- Limited interrupting capacity,
- Chance of loss of air pressure due to leakage from air pipe junctions.

5.2.4 SF6 Circuit Breakers for 33/11KV

Sulfur Hexafluoride circuit breakers are used in Central workshop in high voltage. The SF6 gas is an electro negative gas and has a strong tendency to absorb free electrons. In the power plant SF6 circuit breakers are used in 33 KV/11 KV transformer and generator. The three phases are maintained by one control board. The generator circuit breaker is 10000A where generator output is 7125 A.

The advantages of SF6 are as follows.

- Relatively smaller size,
- High interrupting capacity.

The disadvantages of SF6 are as follows.

- SF6 breakers are costly due to the high cost of SF6.

5.2.5 Vacuum circuit breaker

A vacuum circuit breaker is such kind of circuit breaker where the arc quenching takes place in vacuum. The technology is suitable for mainly medium voltage application. For higher voltage vacuum technology has been developed but not commercially viable. The operation of opening and closing of current carrying contacts and associated arc interruption take place in a vacuum chamber in the breaker which is called vacuum interrupter. The vacuum interrupter consists of a steel arc chamber in the centre symmetrically arranged ceramic insulators. The vacuum pressure inside a vacuum interrupter is normally maintained at 10^{-6} bar.

5.3 High Voltage (HV) Switchgear

High voltage switchgear is used for power control and distribution systems. **It** has rated working voltage up to 132 kV. Components which are essential for HV switchgear are as follows.

- Insulator,

- Isolator,
- Bus bar,
- Current transformer,
- Potential transformer.

5.4 Low Voltage (LV) Switchgear

The low voltage switchgear is used for all the auxiliary power needs such as motors (pumps), fans, heaters etc. In Savar 132 MW grid, low voltage switchgear distributes power from station transformers to auxiliary units and grid internal network.

5.5 Protection

One of the basic functions of switchgear is protection, which is interruption of short-circuit and overload fault currents while maintaining service to unaffected circuits. Switchgear also provides isolation of circuits from power supplies. Switchgear is also used to enhance system availability by allowing more than one source to feed a load.

5.5.1 Over Current Protection

In substation, transformer is designed to operate continuously at rated kVA, frequency and power factor over a range of 95% to 105% of rated value. Now, operating of the transformer beyond rated kVA may result in harmful over current. This leads to overheating and failure of insulation. This is very a risky condition for people working in the unit. Hence, such a protection is taken in controller unit.

5.5.2 Restricted Earth Fault Protection

The working function of it is similar to transformer differential protection. It protects the high voltage winding of power transformer against internal faults. One set current transformer on

neutral and phase side of the power transformer are exclusively used for this protection. The protection cannot detect turn-to-turn fault within one winding. Upon the detection of a phase to phase or phase to ground fault in the winding, the unit is tripped automatically from control unit in substation.

5.5.3 Under Voltage Trip

In substation, there is also protection relay for under voltage occurrence. This method is used to prevent closing of the breaker by mistake. In this system tripping is generally delayed. This is done so that the voltage drop is caused by fault and time is allowed for the appropriate fuse or breaker to operate and the voltage to be recovered without the loss of power supply.

5.5.4 Protection of Transformer

It is just like any other plant, it has got different types of transformers like Power transformer, Current transformer, many Step-up and Step-down transformers for transmission of current to grid and others. And therefore, lots of protection has been taken care of for the safety purpose here in NPBS-1 and substations. Actually, the NPBS-3 authority installed a protection scheme as a whole for the transformer protection ever since the plant was built for easy monitoring and protection purpose. And that protection scheme is described down here briefly based on the collective perspective.

5.5.5 Transmission Line Protection

Transmission Line protection systems are designed to identify the location of faults on the transmission line and to isolate only the faulted section. The key challenge to the transmission line protection lies in reliably detecting and isolating faults compromising the security of the system. As we were only showed the Distance relay, it is discussed below.

5.5.6 Distance Relay

From the collective perspective, distance relay work on the basis that the impedance of a transmission line is proportional to its length. For distance measurement it is appropriate to use a relay capable of measuring the impedance of a line up to a predetermined point. Such a relay is described as a distance relay and is designed to operate only for faults occurring between the relay location and the selected reach point, thus giving protection for faults that may occur in different line sections.

5.6 Bus-bar

Bus-bar is a thick copper bar that conducts electricity. Bus-bar is used to carry large current and to distribute current. In a bus-bar voltage and phase sequence remain same. The size of bus bar determines the amount of current that it can carry.

There are several types of bus bars. These are as follows.

- Single bus-bar,
- Double bus-bar,
- Ring bus-bar.

Double bus-bar has several advantages. These are as follows.

- Cost of installation is less,
- Cost of equipment is less,
- Requires less space.

5.7 Lightning Arrester

We have seen many lightning arresters to be used near power transformer section in substations and grid where they are used to bypass current to the ground when high voltage or thunder strike occurs. In this chapter, the protection system in NPBS-1 has been discussed which includes protection against abnormalities in Transformer, Transmission line. These are the major parts that need to be protected all the time. All of these protections are automatically programmed to trigger as per situation and they are controlled and monitored from control room.

5.7.1 Types of Lightning Arrestor (in use)

Low-voltage surge arrester: Apply in Low-voltage distribution system, exchange of electrical appliances protector, low-voltage distribution transformer windings distribution arrester: Apply in 3kV, 6kV, l0kV AC power distribution system to protect distribution transformers, cables and power station equipment. The station type of common value arrester: Used to protect the 3 ~ 220 kV transformer station equipment and communication system. Magnetic blow value station arrester: Use to 35 ~ 500 kV protect communications systems, transformers and other equipment.

5.7.2 Types of Lightning Arresters (in construction)

There are several types of lightning arresters in general use. They differ only in constructional details but operate on the same principle, providing low resistance path for the surges to the ground.

- Rod arrester
- Horn gap arrester
- Multi gap arrester
- Expulsion type lightning arrester
- Valve type lightning arrester
- Silicon Carbide Arrestor
- Metal Oxide Arrestor

5.8 ACR

Automatic circuit re-closer is essentially a self-contained device, which sense over currents to time and interrupt fault currents and to re-energize the line by rec1osing. In electric power distribution, a rec1oser, or auto rec1oser, is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault. Recloser are used on overhead distribution systems to detect and interrupt momentary faults. Since many short-circuits on overhead lines clear themselves, a re-closer improves service continuity by automatically restoring power to the line after a momentary fault.

5.8.1 Temporary faults

Tree branches touching energized lines Lightning surges flashing over an insulator Birds, reptiles bridging between an energized line and grounded surface. Wind blow conductors touching one another.

5.8.2 Recloser Classifying Features

- Single phase or three phase.
- Interrupters: Oil or Vacuum.

•Insulation: Oil, Air or Epoxy.

5.8.3 The Controller Allows Protection Against the Following Types Of Faults

- Phase-to-phase and three-phase short circuits
- Bolted fault (the bolted fault element works independently from the short-Circuit protection elements and thus provides more settings flexibility)
- Single-phase and double-phase earth-faults
- Resistive earth fault (sensitive earth fault)
- Upstream and downstream broken wire
- Low system voltage
- Low system frequency

5.8.4 Controlling part of the re-closer

Monitoring and control of the re-closer is performed by PTCC, which is located lower down the pole. **It** houses the operator control panel and microelectronics that provide the protection functions. It is connected to re-closer by a detachable control cable. Internal equipment panel is used to mount all the equipment's.

CHAPTER-6
PROTECTIVE RELAYS

6.1 Introduction to Protective Relay

In our internship period, our co-supervisor sir discussed about protective relays. He also practically showed us about protective relays in this chapter we will discuss about the protective relays, how a relay opens a circuit, the types of relays, etc.

When a fault occurs on any part of the system, it must be quickly detected and disconnected from the system. There are two principal reasons for it.

- Firstly, if the fault is not cleared quickly, it may cause unnecessary interruption of service to the customers.
- Secondly, rapid disconnection of faulted apparatus limits the amount of damage to it and prevents the effects of fault from spreading into the system. The detection of a fault can be achieved by using fuses or relays in conjunction with circuit breakers.
- A fuse performs both detection and interruption functions automatically in low voltage circuits only.
- For high voltage circuits (above 3·3 kV), relays and circuit breakers are employed to serve the desired function of automatic protective gear.
- Therefore, the function of a protective relay is to detect fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system.

6.2 How a relay open Circuit Breaker

When a fault (say line to ground) occurs on the transmission line, the current flowing in the line increases to an enormous value. This results in a heavy current flow through the relay coil, causing the relay to .operate by closing its contacts

- This in turn closes the trip circuit of the breaker, making the circuit breaker open and isolating the faulty section from the rest of the system.

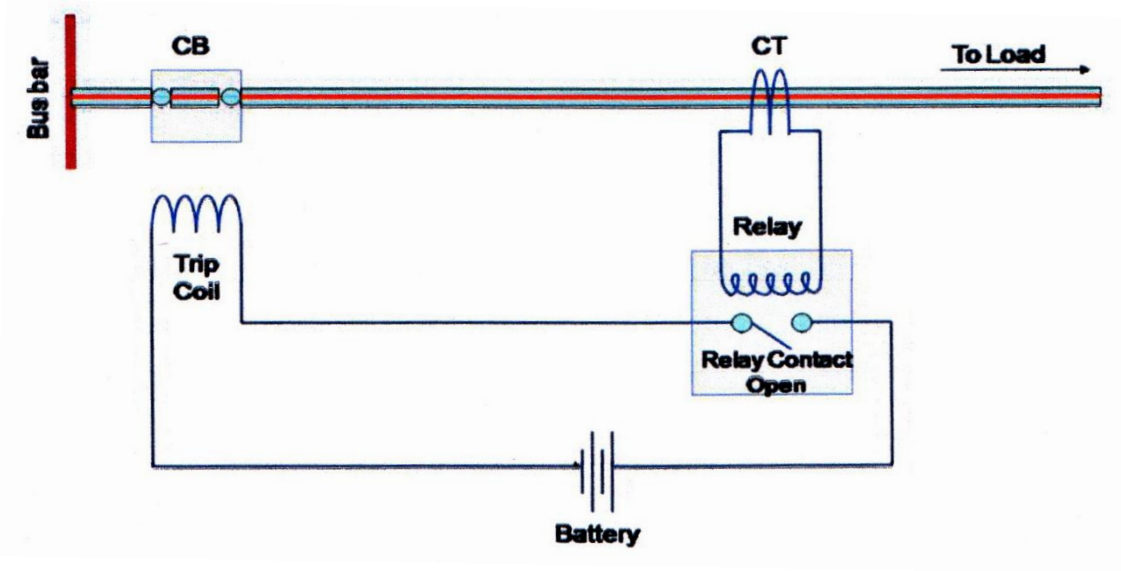


Fig. 6.1: How to a relay open a Circuit Breaker

6.3 Fundamental Requirements of Relaying

- **Selectivity:** It is the ability of the protective system to select correctly that part of the system in trouble and disconnect the faulty part without disturbing the rest of the system.
- **Speed:** The relay system should disconnect the faulty section as fast as possible.
- **Sensitivity: It** is the ability of the relay system to operate with low value of actuating quantity.

- **Reliability:** It is the ability of the relay system to operate under the predetermined conditions.
- **Simplicity:** The relaying system should be simple so that it can be easily maintained.
- **Economy:** The most important factor in the choice of a particular protection scheme is the economic aspect. As a rule, the protective gear should not cost more than 5% total cost. However, when the apparatus to be protected is of utmost importance (e.g. generator, main transmission line etc.), economic considerations are often subordinated to reliability.

6.4 Relay Contact

- Each relay has two mechanical parts inside. The first one is the contacts of the relay and second is the two terminals.

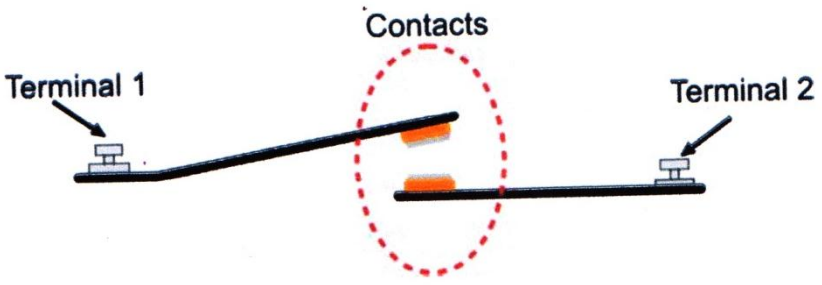


Fig. 6.2: Relay Contact

- When the contacts are 'in contact' then the current flows from Terminal 1 to Terminal 2.

6.4.1 NO and NC Contacts

- There are two types of contacts: the NO and the NC. NO stands for Normal Open contact, while NC stands for Normal Closed contact.

Fig. 6.3: NO and NC Contacts

6.4.2 Changing States NO and NC Contacts

- Both contacts (NO and NC) will change state if a force is applied to the left metal heading from UP to DOWN.
- A relay may have a combination of the above contacts.

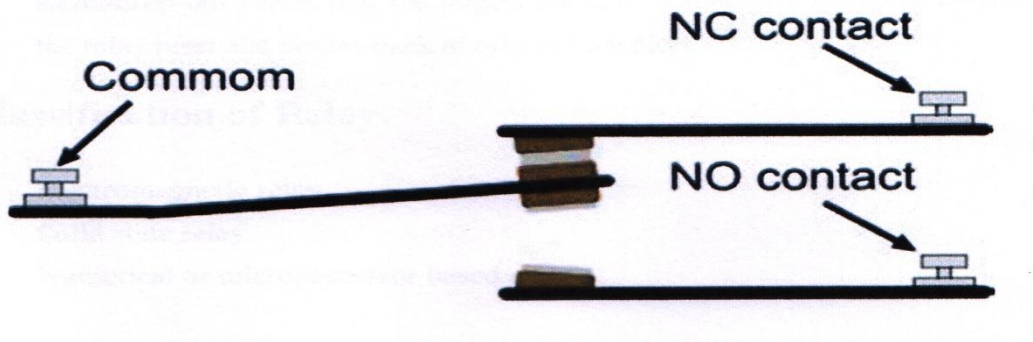


Fig. 6.4: Changing States NO and NC Contacts

6.4.3 Combinational Operation of NO and NC Contacts

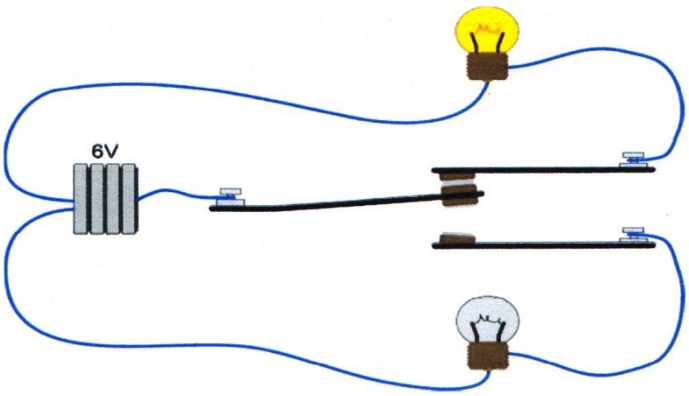


Fig. 6.5: Combinational Operation of NO and NC Contacts

6.5 Pick-up Value and Reset Value of a Relay

•Pick up value: It is the smallest value of actuating quantity that causes the normally closed contacts to just open or the normally opened contacts to Just close.

- Reset/drop-out value: It is the largest value of actuating quantity at which the relay reset and comes back to original position.

6.6 Classification of Relay

- Electromagnetic relay
- Solid state relay
- Numerical or microprocessor based relay

6.6.1 Electromagnetic Relay

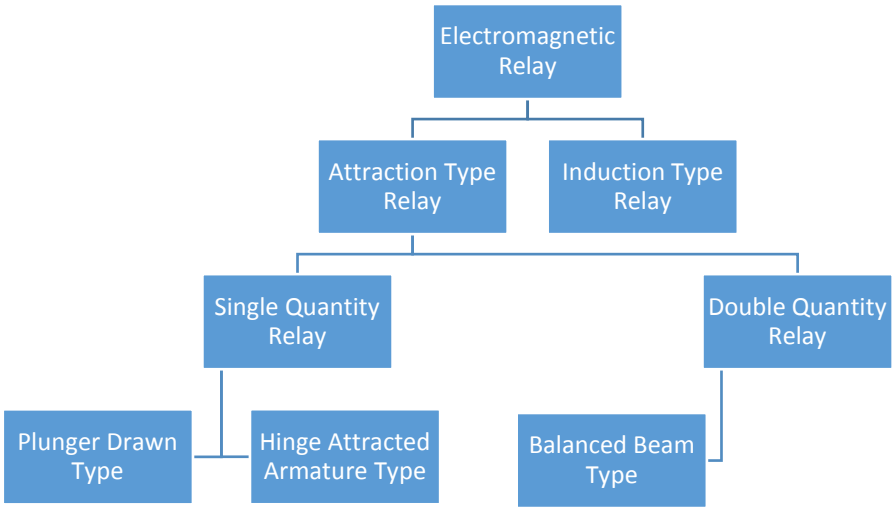
When this electromagnetism principle is used for relay operation then the relay is called electromagnetic relay.

They work on the following two main operating principles:

- Electromagnetic attraction type relays operate by virtue of an armature being attracted to the poles of an electromagnet or a plunger being drawn into a solenoid. Such relays may be actuated by d.c. or ac. quantities.

- Electromagnetic induction type relays operate on the principle of induction motor and are widely used for protective relaying purposes involving a.c. quantities.

6.6.1.1 Classification of Electromagnetic Relay



6.6.1.2 Principle of Single Quantity Relay

The coil is energized by operating quantity which may be proportional to voltage or current.

- The electromagnetic force exerted on the moving element of relay is proportional to the square of flux in air gap.

- If saturation is neglected the exerted force is proportional to square of operating current. Therefore, net force on relay at any instant, $F = K_1I^2 - K_2$

  Where, K_1 = Force conversation constant,

  I = Magnitude (r.m.s) of actuating current,

K_2 = Restarting force including friction

- When the relay is on the verge of picking up, the attractive force becomes equal to the restarting force. So the net force becomes zero.
- Therefore, **'I'** indicates the pickup value for this relay.

6.6.1.3 Single Quantity Attraction Type Relay

Armature attracted type relay:

- The current flowing through the coil electro-magnetizes the armature core.
- The normal current is not enough to electro-magnetize the core to attract the armature which is pivoted properly.

•When the current exceeds the normal rating, the iron core attracts enough strongly the armature which closes the contacts of relay.

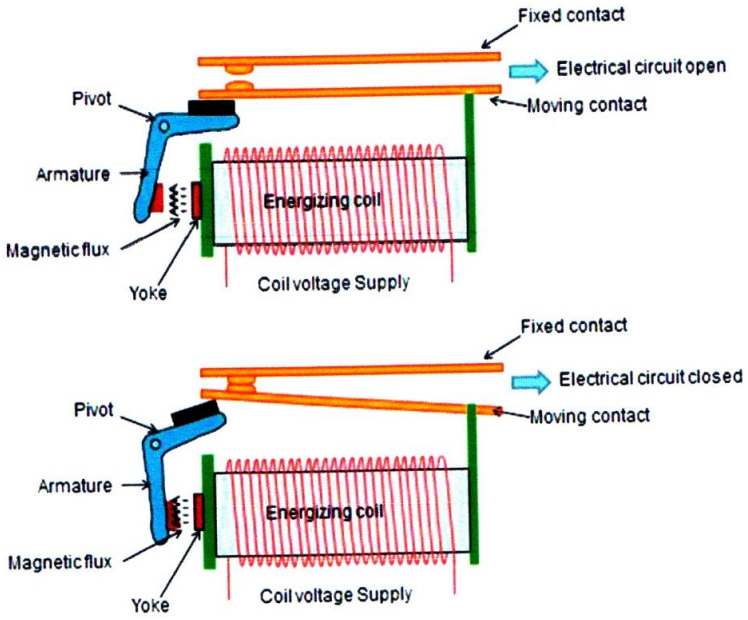


Fig. 6.6: Single Quantity Attraction Type Relay

6.6.1.4 Limitation of Attraction Type Relay

- Unless the pole pieces of armature attraction or plunger drawn type relay have "shading ring" to split the air gap flux into two out of phase components, such relays are not suitable for operation on ac current in the picked up position.
- This is because there could be excessive vibration that will produce objectionable noise and excessive wear.
- This tendency to vibrate is related to the fact that an ac relay without shading ring has a tendency to reset every half cycle when the flux passes through to the zero.

6.6.1.5 Principle of Double Quantity Relay

The operation of such relay includes two actuating quantity obtained from CT and PT fed to relay in order to produce a net torque. Therefore, net force on relay at any instant, $F = K_1I_1^2 – K_2I_2^2$

Where, K_1 and K_2 = Force conversation constant,

I_1 = Magnitude (rms) of operating current,

I_2 = Magnitude (rms) of restraining current.

- When the relay is on the verge of picking up, the attractive force becomes equal to the restarting force. So the net force becomes zero.

Therefore,

$$K_1I_1^2 – K_2I_2^2 = 0$$

Or, $I_1/ I_2 = \sqrt{(K_2/K_1)}$

Which follows the characteristics below,

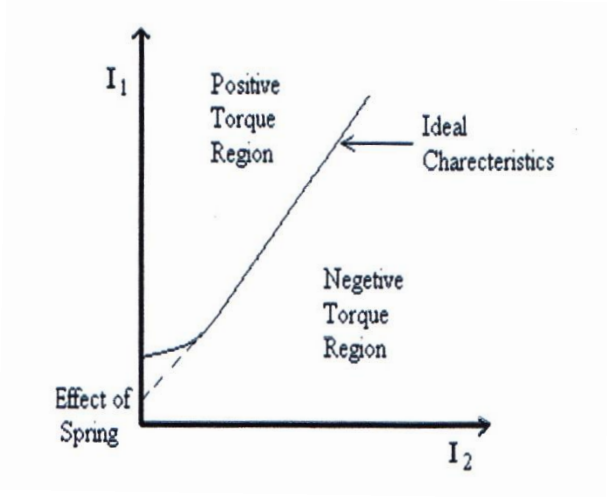


Fig. 6.7: Curve of double quantity relay

6.6.1.6 Balanced beam type relay

- This type of relay consists of horizontal beam pivoted centrally, with one armature attracted to other side. So long as the operating force is equal to the restraining force, the beam remains in horizontal position.
- The current in one coil gives operating force, and the current in other coil produces restraining forces.
- The beam is given slight mechanical bias by means of spring or weight adjustment such that under normal operating condition the contacts are open.
- When the operating torque becomes more than the restraining torque, the contact closes.

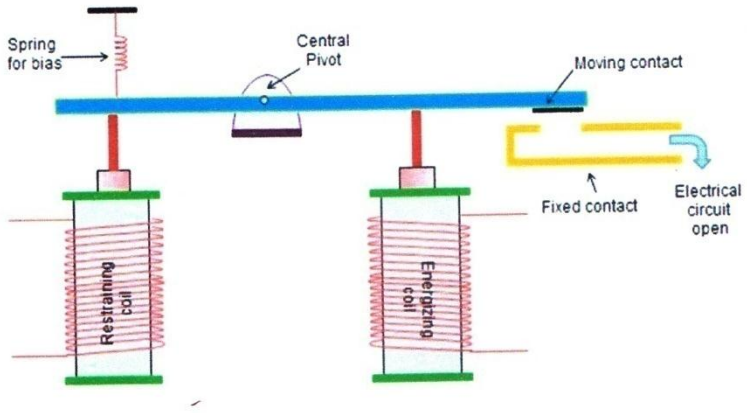


Fig. 6.8: Balanced Beam Type Relay

6.6.1.7 Principle of Induction Type Relay

- It is most widely used for protective relaying purposes involving only AC quantity. Basically it is like a split phase induction motor. Actuating force is developed in a movable element by the interaction of electromagnetic fluxes with eddy currents that are induced in the rotor by these fluxes.
- The two alternating fluxes Φ and Φ are dispatched in space and time which induce voltage on the rotor and in tum generates eddy currents, i Φ and i Φ respectively.
- The current i Φ produced by flux Φ interacts with other flux Φ and vice versa to produce forces that act on the rotor.

Let, $\Phi 1 = \Phi \sin \omega t$

$\Phi 2 = \Phi \sin(\omega t + \theta)$

Where, θ is the angle by Φ2 leads by Φ1.

- We assume the rotor material has negligible self-inductance, and then the rotor current is in phase with the induced voltage in the rotor. Therefore,

i Φ1 ∝ Φ 1 cos ωt and i Φ2 ∝ Φ2cos(ωt +θ)

Two opposite forces F and F are acting on the rotor which are given by,

$$F_1 \propto \Phi_1 \, i \, \Phi_2$$

$$F_2 \propto \Phi_2 \, i \, \Phi_1$$

Therefore, net force $F \propto (F_2 - F_1) \propto (\Phi_2 \, i \, \Phi_1 - \Phi_1 \, i \, \Phi_2)$

Or, $F \propto [\Phi_1 \ \Phi_2 \{\sin(\omega t+\theta) \cos \omega t - \sin\omega t \cos(\omega t +\theta)\}]$

Or, $F \propto \Phi_1 \ \Phi_2 \sin(\omega t+\theta- \omega t)$

$\therefore F \propto \Phi_1 \ \Phi_2 \sin\theta$

The significant point is that, the net force on the rotor at every instant is constant regardless of time.

6.6.2 Shaded Pole Structure Type Relay

In simple structure, it consists of pivoted aluminum disc free to rotate in the air-gap of an electromagnet. One half of each pole of the magnet is surrounded by a copper band known as shading ring that causes two out of phase flux components. By the interaction of these flux torque is produced to close the electrical circuit.

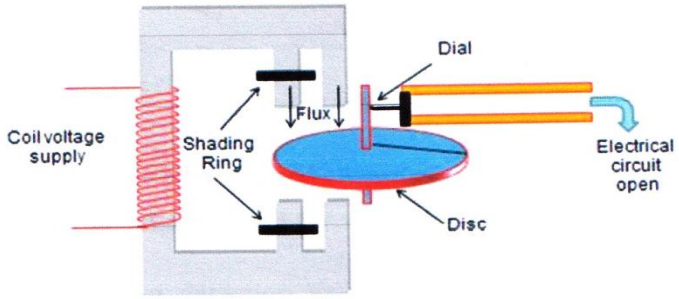


Fig. 6.9: Shaded Pole Relay

6.6.3 Principle of Solid State Relay

The AC type Solid State Relay (SSR) turns "ON" at the zero crossing point of the AC sinusoidal waveform, prevents high inrush currents when switching inductive or capacitive loads while the inherent turn "OFF" feature of thyristors and TRIACs provides an improvement over the arcing contacts of the electromechanical relays.

- A Resistor-Capacitor (RC) snubber network is generally required across the output terminals of the SSR to protect the semiconductor output switching device from noise and voltage transient spikes when used to switch highly inductive or capacitive loads.

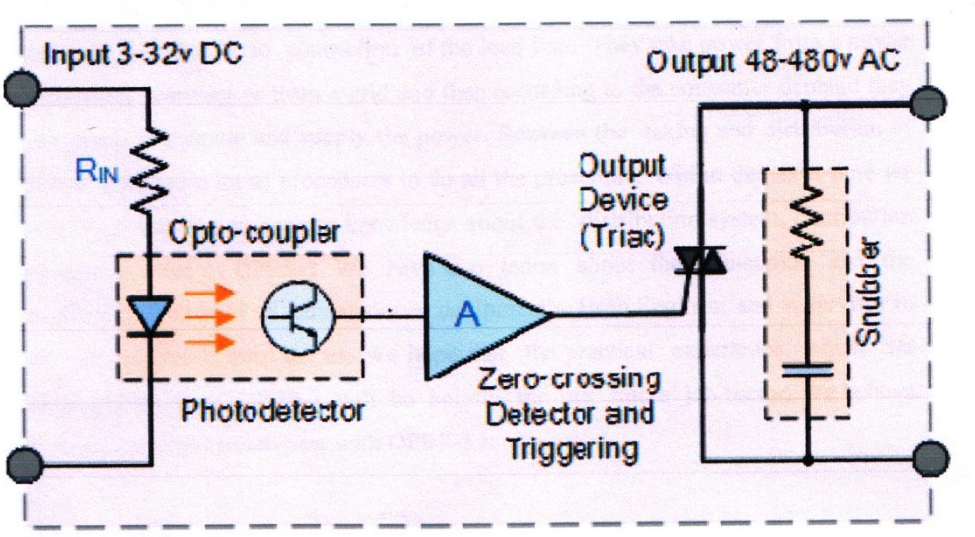


Fig. 6.10: Solid State Relay

- In most modem SSR's this RC snubber network is built as standard into the relay itself reducing the need for additional external components.

- Non-zero crossing detection switching (instant "ON") type SSR's are also available for phase controlled applications such as the dimming or fading of lights at concerts, shows, disco lighting etc. or for motor speed control type applications.

CHAPTER-7

CONCLUSION

7.1 Conclusion

We are very happy to do the industrial attachment with the NPBS - 1. NPBS - 1 is an established company and has a good reputation. Here Engineers play great role. This attachment makes our theoretical knowledge strong. We learn practically how a sub-station step downs power for distribution that power to the consumer. A distribution company has to design and calculate many relative things after distribution load. According to the whole process and consumer demand they decide to connection of the load line. They take power from a power generation company or from a grid and then according to the consumer demand they step down the power and supply the power. Between the taking and distribution of power there are a lot of procedures to do all the procedure. Within the short time we have

tried our best to acquire knowledge about the distribution system, distribution planning system of NPBS - 1. We have also learnt about the sub-station and the working principle of all sub-stationed equipment's. Both Engineer and supervisor in all sectors were helpful to us. We hope that the practical experience which we have gained from NPBS - 1 will be helpful for our future job sector. We believe that our industrial attachment with NPBS - 1 is successful.

Reference

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