A
Project Report
On

"AUTOMATIC POWER FACTOR CONTROLLER"

Submitted in partial fulfillment of the requirements

Of the degree of

Bachelor of Engineering in Electrical Engineering

Submitted by

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included; I have adequately cited and referenced the original sources. I also declared that I have adhered to all principles of academic honesty and integrity and have not represented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission have not been taken when needed.

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Abstract

A low power factor is always problems for the industrial because due to this motor not able to work on the full efficiency. There is also burden increases on the utility side due to this they force to generate a more reactive power, because of this a transmission efficiency decreases. A new technology for power factor improvement of 3 phase induction motor as well as for single phase induction motor, as improvement of power factor is necessary for industrial as well as domestic areas; to make power factor as close as unity without facing penalty from electrical distributers. As we know in industries most of motor which is usually used is induction motor and induction motor having low power factor also. Home appliances which are generally used are generally having low power factor. Hence there is need of power factor improvement in case of household appliances as well as in industrial purpose. Induction motor is most widely used motors in industries. As name of this motor specifies this motor having low power factor. Hence there is need of power factor improvement. Effect of this induction motor starts to works near the unity and also his full efficiency.

Key Words :- Automatic Power Factor Controller (APFC), Power factor (PF), Current Transformer (CT), Miniature circuit breaker(M.C.B).

Contents

ANNEXURE-1

List of Projects:-

1. Automatic power factor controller panel.

List of Paper Presentation:-

1. International conference on automatic power factor controller at VIDYALANKAR INSTITUTE OF TECHNOLOGY (RACEM-2019)
2. International conference on automatic power factor controller at DATTA MEGHE COLLEGE OF ENGINEERING.
3. Paper Presentation in INTERNATIONAL ORGANIZATION OF SCIENTIFIC RESERCH (IOSR).

Chapter 1

Introduction

1.1 Overview

Power factor is the ratio between the KW and the KVA drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system .In industry most of the load is inductive in nature which results in lagging power factor that is why there is loss and wastage of energy which results in high power bills and heavy penalties from electricity boards. If the load is uneven it is very difficult to maintain unity power factor. To overcome this difficulty APFC panel is used which maintains unity power factor. So industries require automatic power factor correction system. APFC or Automatic Power Factor Control Panels are mainly used for the improvement of Power Factor. Power Factor can be explained as ratio of active power to apparent power and it is a key factor in measuring electrical consumption. Everyone knows that how costly electricity has become in present time. Therefore it becomes utmost important to cut down on electrical consumption for reducing expenditure. APFC Panels come real handy in the achievement of this purpose Use of these control panels becomes indispensable in those industries where electrical installations are meant to supply to large electrical load. A dip in Power Factor can attract operational losses and a penalty from electricity board, responsible for electricity supply. APFC Panels can effectively and automatically manage quickly changing and scattered loads along with the retention of high Power Factor. We are renowned manufacturers of APFC Panels symbolized with quality and reliability. These are available in different current ratings to cater to distinct applications.

1.2 What is Power factor?

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit. A power factor of less than one means that the voltage and current waveforms are not in phase, reducing the instantaneous product of the two waveforms (V × I). Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. A negative power factor occurs when the device (which is normally the load) generates power, which then flows back towards the source, which is normally considered the generator. In the circuit, and is a dimensionless number in the closed interval of −1 to 1. A power factor of less than one means that the voltage and current waveforms are not in phase, reducing the instantaneous product of the two waveforms (V × I). Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. A negative power factor occurs when the device (which is normally the load) generates power, which then flows back towards the source, which is normally considered the generator.

1.3 Needs of power factor correction

Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a powerfactor that is less than one.Power factor correction may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the costscharged to them by their electricity supplier.An electrical load that operates on alternating current requires apparent power, which consists of real power plus reactive power. Real power is the power actually consumed by the load. Reactive power is repeatedly demanded by the load and returned to the power source, and it is the cyclical effect that occurs when alternating current passes through a load that contains a reactive component. Power factor correction attempts to adjust the power factor of an AC load or an AC power transmission system to unity through various methods. Simple methods include switching in or out banks of capacitors or inductors which act to cancel the inductive or capacitive effects of the load, respectively. For example, the inductive effect of motor loads may beoffset by locally connected capacitors.

1.4 Power Triangle

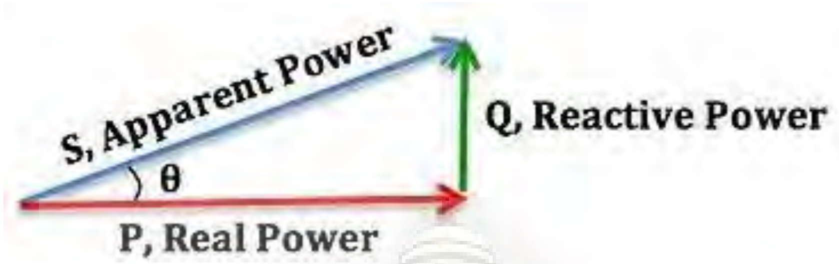

Figure 1.1 Power Triangle

1.4.1 Active Power :-

The power which is actually consumed or utilized in an AC Circuit is called True power or Active Power or real power. It is measured in kilo watt (kW) or MW. It is the actual outcomes of the electrical system which runs the electric circuits or load.

1.4.2 Reactive Power :-

The power which flows back and froth that mean it moves in both the direction in the circuit or react upon itself, is called Reactive Power. The reactive power is measured in kilo volt ampere reactive (kVAR) or MVAR.

1.4.3 Apparent Power :-

The product of root mean square (RMS) value of voltage and current is known as Apparent Power. This power is measured in kVA or MVA

1.5 Lagging and leading power factor:-

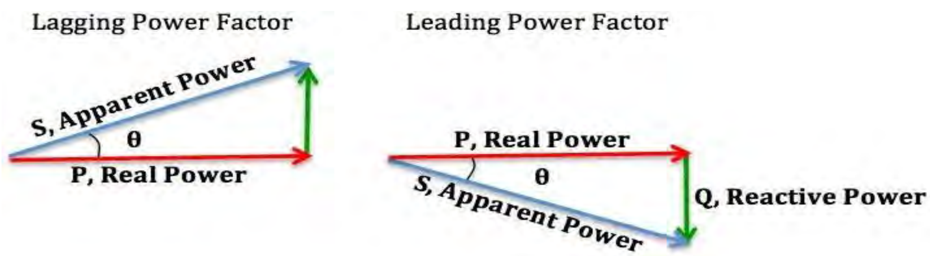

Figure 1.5 Lagging and Leading Power Factor

There is also a difference between a lagging and leading power factor. The terms refer to whether the phase of the current is leading or lagging the phase of the voltage.

1.5.1 Lagging Power factor :-

A lagging power factor signifies that the load is inductive, as the load will "consume" reactive power, and therefore the reactive component is positive as reactive power travels through the circuit and is "consumed" by the inductive load.

1.5.2 Leading Power Factor :-

A leading power factor signifies that the load is capacitive, as the load "supplies" reactive power, and therefore the reactive component is negative as reactive power is being supplied to the circuit.

1.6 Power factor correction of linear loads:-

A high power factor is generally desirable in a power delivery system to reduce losses and improve voltage regulation at the load. Compensating elements near an electrical load will reduce the apparent power demand on the supply system. Power factor correction may be applied by an electric power transmission utility to improve the stability and efficiency of the network. Individual electrical customers who are charged by their utility for low power factor may install correction equipment to increase their power factor so as to reduce costs. Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying or absorbing reactive power, adding capacitors or inductors that act to cancel the inductive or capacitive effects of the load, respectively.

In the case of offsetting the inductive effect of motor loads, capacitors can be locally connected. These capacitors help to generate reactive power to meet the demand of the inductive loads. This will keep that reactive power from having to flow all the way from the utility generator to the load. In the electricity industry, inductors are said to consume reactive power and capacitors are said to supply it, even though reactive power is just energy moving back and forth on each AC cycle.

1.7 Non-linear Loads :-

Examples of non-linear loads on a power system are rectifiers (such as used in a power supply), and arc discharge devices such as fluorescent lamps, electric welding machines, or arc furnaces. Because current in these systems is interrupted by a switching action, the current contains frequency components that are multiples of the power system frequency. Distortion power factor is a measure of how much the harmonic distortion of a load current decreases the average power transferred to the load.

1.8 Distortion in three-phase networks :-

In practice, the local effects of distortion current on devices in a three-phase distribution network relay on the magnitude of certain order harmonics rather than the total harmonic distortion. For example, the triple, or zero-sequence, harmonics (3rd, 9th, 15th, etc.) have the property of being in-phase when compared line-to-line. In a delta-wye transformer, these harmonics can result in circulating currents in the delta windings and result in greater resistive heating. In a wye-configuration of a transformer, triple harmonics will not create these currents, but they will result in a non-zero current in the neutral wire. This could overload the neutral wire in some cases and create error in kilowatt-hour metering systems and billing revenue. The presence of current harmonics in a transformer also result in larger eddy currents in the magnetic core of the transformer. Eddy current losses generally increase as the square of the frequency, lowering the transformer's efficiency, dissipating additional heat, and reducing its service life.

1.9 Automatic Power factor correction (APFC) in non-linear loads

1.9.1 Passive APFC :-

The simplest way to control the harmonic current is to use a filter that passes current only at line frequency (50 or 60 Hz). The filter consists of capacitors or inductors, and makes a non-linear device look more like a linear load. An example of passive APFC is a valley-fill circuit. A disadvantage of passive APFC is that it requires larger inductors or capacitors than an equivalent power active APFC circuit. Also, in practice, passive APFC is often less effective at improving the power factor.

1.9.2 Active APFC :-

Active power factor correction can be single-stage or multi-stage In the case of a switched-mode power supply, a boost converter is inserted between the bridge rectifier and the main input capacitors. The boost converter attempts to maintain a constant DC bus voltage on its output while drawing a current that is always in phase with and at the same frequency as the line voltage. Another switched-mode converter inside the power supply produces the desired output voltage from the DC bus. This approach requires additional semiconductor switches and control electronics, but permits cheaper and smaller passive components. It is frequently used in practice.

1.9.3 Dynamic PFC :-

Dynamic power factor correction (DPFC), sometimes referred to as "real-time power factor correction," is used for electrical stabilization in cases of rapid load changes (e.g. at large manufacturing sites). DPFC is useful when standard power factor correction would cause over or under correction. DPFC uses semiconductor switches, typically contactor to quickly connect and disconnect capacitors or inductors to improve power factor

Chapter 2

Aim of the Project

2.1 Aim of the Project:-

1. The Aim of this project is to design and build a panel system that is called to control the power factor of the system.

2. Automatic Power factor controller Panel basically maintains the power factor unity of the system. It will automatically switch on the capacitance and feed the reactive power to the system as per the required value.

2.2 Objectives and Scope:-

The main objective of our project is to design and construct contactor based system that will help us in finding power factor automatically. A dip in Power Factor can attract operational losses and a penalty from electricity board, responsible for electricity supply. APFC Panels can effectively and automatically manage quickly changing and scattered loads along with the retention of high Power Factor. Our goal is to design and develop an APFC Panel that will handle the task described.

2.3 Problem Statement:-

In power distribution, power-factor correction (PFC) has traditionally been understood in terms of adding (in general) capacitive reactance at points in the power distribution system to offset the effect of an inductive load. One could say "reactive" load, but historically, power engineers have been most concerned with motors as loads when dealing with power factor. Correction could take the form of a bank of capacitors or a "synchronous condenser" (an unloaded synchronous motor). More broadly, PFC can also be needed in any line-powered apparatus that uses ac-dc power conversion. These applications can range in scale from battery chargers for portable devices to big-screen TVs. Cumulatively, their input rectifiers are the largest contributor to mains-current harmonic distortion. Once the voltage crosses that point, the current is only limited by the source impedance of the utility line as well as by the resistance of the diode that is forward-biased and the reactance of the capacitor that smooth out the dc. As the power lines exhibit non-zero source impedance, the high current peaks cause some clipping distortion on the peaks of the voltage sinusoidal .The Problem with Power Factor. Whatever the cause, what"s actually so wrong with power factors less than unity? Part of the problem is economic. Another part has to do with safety. Whatever their phase relationships, all those superposed harmonic currents create measurable I2R losses as they are drawn from the generator, through miles of transmission and distribution lines, to the home or workplace.

2.4 Approaches To Unity Power Factor:-

Since the discontinuous input-filter charging current creates the low power factor in switch-mode power supplies, the cure is to increase the rectifier"s conduction angle. Solutions include passive and active PFC and passive or active filtering. Passive PFC involves an inductor on the power-supply input. Passive PFC looks simple, but isn"t really practical for reasons that include the necessary inductance, conduction losses, and possibility of resonance with the output filter capacitor.

Chapter 3

Literature Survey

The following data was surveyed for obtaining basic idea and knowledge of the project titled **'AUTOMATIC POWER FACROR CONTROLLER PANEL (APFC PANEL)'**.

1. Gopal Reddy K :-

This paper present the Controller based to correct the power factor automatically without any human presence. It automatically to the increase and decrease in power factor. It also helps the industries to continue even during peak hours.The ripple current is divided into the different parts. Mainly the low frequency and high frequency components. The root mean square value of the capacitor currentwas derived for the both components.

2. Prof. D. D. Ahire :-

This paper involves simulation of basic power electronics conventional rectifier circuits and the analysis of the current and voltage waveforms.A Apfc integrated breaker switch capacitor bank into a compact design with low cost sensing element an intelligent control unit.The device provided more accurate voltage control and power factor correction than traditional shunt capacitor bank installation.

3. Prof. krunal shah :-

This paper present a Contactor based APFC system that can sustain up to the rating of 20-25 Kva of the industrial load. The model will serve the purpose of detecting the variation in power factor and automatically uses the matching KVAr. Shufling presents an intelligent power fac tor compensator controlled that can perform the power factor correction without existing harmonic resonance under varying demand condition. In addition the controller relay on the common low cost sensing devices and does and require additional measurements.

4. Aparna Sarkar and Umesh Hiwase:-

This paper deals with advance method of power factor correction by using microcontroller. As Switching of capacitors are done automatically hence we get more accurate result, Power factor correction techniques make system stable and due to improvement in power factor its efficiency also increases.in a phase and quadrature components of the supply current are vector controlled implementation of the compensator in a power electronic system of operating with a very poor power factor. third harmonics distortion (THD) show that a system draw a leading current this method offers only 0.7% THD which also implies that power factor improved.

5. Sujata Nazarkar:-

The additional degree of control freedom introduced by a freewheeling interval has been exploited through the decoupling controller. It shows fast transient response and increases current stress by reducing inductor-current ripple and increases the current-handling capability at heavy loads. Boost PFC converter is much simpler and has better dynamic performance of the PCCM boost PFC converter against load disturbance while maintaining low input-current distortion.

6. Yash Shinge:-

Utility companies get rid of from the power losses whereas the consumers are free from low power factor penalty charges. The automotive power factor correction by the use of capacitive load banks is extremely economical because it reduces the cost by decreasing the power drawn from th9e supply. Other advantage is that it is automated process, hence no man power is required.

Chapter 4

Design Methodology

The following design methodology is used for developing the panel/model of Automatic Power factor Controller Panel (APFC Panel).

4.1 Construction

4.1.1 Basic block of APFC Panel :-

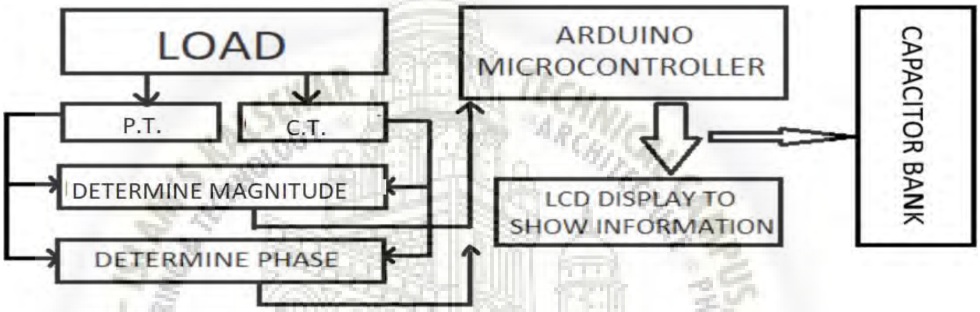

Figure 4.1.1 Block Diagram of APFC Panel

The above figure is the basic block diagram of automatic power factor panel. A load is connected with the voltmeter and ammeter. Voltmeter is used to measure the voltage and ammeter is used to measure the current. If there is no change in the magnitude of the voltage and current so the controller not operate. If there is change in the change of the voltage of current above the limit then this data fed to the controller. Controller Measure this and gives the command to the contactor and contactor release the capacitor power in the load. So by this way power factor improved.

4.2 Circuit Diagram :-

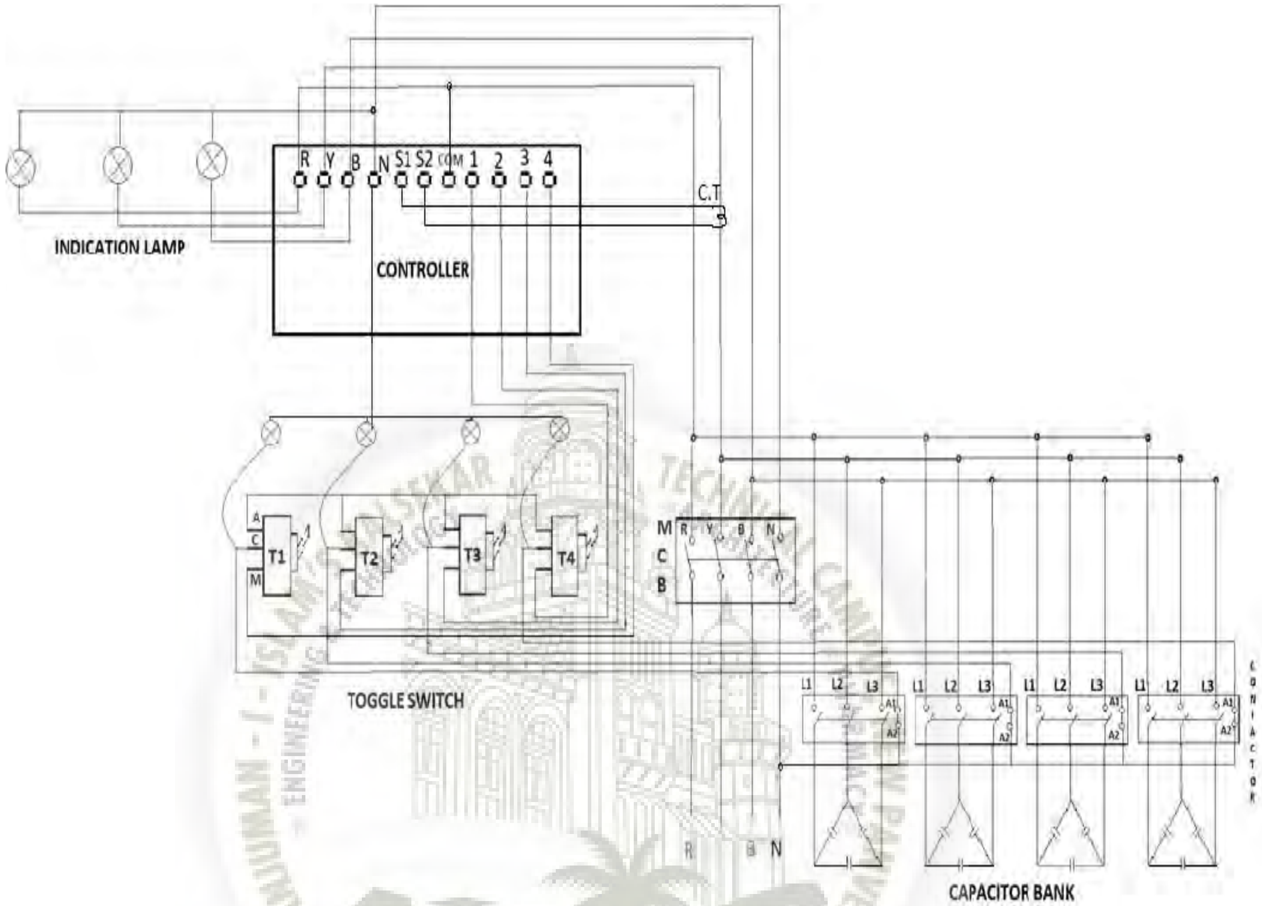

Figure 4.2 Circuit Diagram of APFC Panel

A 3 pole M.C.B is connected in series in line with controller. A M.C.B is used to protection for the overcurrent and short circuit. A continue voltage and current measure with meter and this data fed to the controller. The output controller is fed to input of the contactor. A controller is a brain of the panel. Controller performs all the mathematical operation which is required in the panel. It compares the data and gives the initial command to the contactor and contactor release the power in the load. So by this method power factor gets improved.

4.3 Methodology:-

1) Two signals (voltage & current) are introduced in Controller from line by using Current transformer. When the load is inductive at that time power factor is quite low.
2) Due to the low power factor current lags the voltage by the large angle.
3) Controller calculates phase angle between this two signals by measuring time interval using timer. Controller calculates the power factor by formula (Cos X phase angle).Then it calculates the required compensation.
4) Controller acts as the brain of the circuit it do all the mathematical operation.
5) When the difference is detected then the controller close the contactors and contactors acts as switch between the capacitor and supply.
6) Required capacitors are added in system to improve the power factor of the load.
7) As capacitors are added, power factor gets increased up to the desired value.
8) The improved Power factor is displayed on display of the controller panel.
9) When the power factor is improved then the capacitor is disconnected from the load side and also remaining charged of the capacitor is discharged into the resistor.
10) If the capacitor is not discharged then may be capacitor gets damaged and might be possible to person gets shocked.

4.4 Calculations:-

In the designing of **APFC panel for 4 KVA load, Active power & Maximum Rated current** are calculated to determine rating of contactor to be used as well as cable size.**(Assume PF=0.7)**

Consider a system have output power (Kw)=3.725Kw at 0.85 power factor.
Power factor=Active power/Apprant power.
KVA=3.725/0.7=5.32 KVA .
From the power form
KVA^2=KW^2+KVAr^2 .
(5.32)^2=(3.725)^2+(KVAr)^2
KVAr=3.79 KVAr
Now power factor corrected from 0.7 to 0.99
KVA=3.725/0.99
3.762 kVA

KVA^2=KW^2+KVAr^2

(3.762)^2=(3.725)^2+ (KVAr)^2

KVAr=0.52 KVAr

Difference between the power = 3.79-0.52

= 3.27 KVAr

Alternate Method

KVAr = KW(tan(ø1)-tan(ø2))

=3.75*[tan(cos1(0.7))-tan(cos1(0.99))]

$C = KVAr/ 2\pi fv^2$

$= 3.27 / 2*3.14*50*415^2$

$= 6.04843*10^{-8}$ μF.

Chapter 5

Components specification and application

5.1 Components and description:-

Reactive Power compensation system is designed to work automatically on LT power supply to measure, display & connect, disconnect the required capacitor banks through Capacitor Duty contactor with protection of MCB / HRC Fuses & series reactors to each bank to achieve the set Target power factor. Contactor Switched Automatic power factor system is the highly accurate, properly designed system with required creep age distance as per required standards. APFC System equipped with advanced, Digital Microprocessor based relay to measure, calculate and display all electrical network parameters. It accurately measures cycle to cycle reactive power requirement for required capacitors are connected to switching element, device installed in the system, so as required capacitors are connected / disconnected to the network. APFC Controllers close loop fast response multi method switching algorithm helps system to have close & precise control on power factor.

5.2 Component Rating and quantity:-

SR NO	COMPONENT	RATING
1	CONTROLLER	Type 1003
2	CAPACITORS	0.5,1,2(total 4.5KVAr)
3	POWER CONTACTORS	32A
4	M.C.B	2-63A
5	TOGGLE SWITCH	20A

Table 5.2 Components Required and Description

5.3 Component Description:-

5.3.1 Automatic power factor controller Type 1003

5.3.1.1 General :-

The controller as received by the user will either be mounted in a panel or supplied for mounting in a panel. In any case a panel is required for connecting the controller in the electrical system. The controller forms the so to say "brain" of the power factor control system and is an inherent part of it. various points in the system need attention for correct operation and proper operation cannot be expected unless these are attended to.

5.3.1.2 System consideration:-

The controller needs three phase four wire voltage connections.it sense the total resultant power factor of the system and switches the capacitors through the appropriate control gear in the panel so as to correct the power factor to the required level.

To enable the controller to measure the power factor correctly:

The R,Y,B,N voltage connection must be correct. Ensure this point positively. It is not enough to have the correct phase sequence alone, the actual phase connection must be correct and the voltage must be within plus/minus 10% of the nominal value specified for the controller.

The current transformer must be on the:

1) Main incomer

2) Y Phase

3) CT rating must be of the order of the actual load current and not only the rating of the bus bar. The main incomer is that the point on the bus through which will pass the current of all the loads and the current of all the capacitors under the control of the controller. The control circuits of the panel on which the controller is mounted are equally important. If you wish to use external manual control, pay careful attention to signal flow. Push button must be used for the contactors to enable automatic cut off in case of power failure. Do provide isolating contacts for each contactor otherwise the control lock out in auto, by feedback over the manual bus.

5.3.1.3 Operational check:-

The controller can be checked out before it is mounted in panel by applying simulated current input at lagging or leading power factor. (it is not possible to check the controller with single phase supply unless you have ordered the controller to work in single phase) Apply only voltages to the R,Y,B,N terminals the controller will show a display of A-Low, and the OFF LED will be on. This display indicates that the current input to too low. It is not possible to make any other tests without load.

5.3.1.4 Operation in system :-

(a) When a load current is absent, or the CT is not connected to the controller, or when or load current is less than 1%of the rated current. The situation is not different from a above condition.

(b) When the load current is above 1% of rating of CT (this level should at least be 5% to 10% for meaningful operation.) At switch on the display should show the power factor of the system. The display reads the connection if your voltage and CT connection to the controller are wrong, and no further operation is possible. The controller will keep all stages off. It will necessary to change the voltage connection through all possible combinations. The controller will continue to show conn till ur connections are correct. The are some combinations of wrong voltage connection and CT polarity that are accepted by the Controller as correct.. The controller will switch the stages on one by one if the power factor read by the controllers less than 0.98lag.The power factor will keep increasing at each switching. The switching will stop when it is above 0.98lag and 0.99 lead.

5.3.1.5 Controller Wiring Diagram Of APFC:-

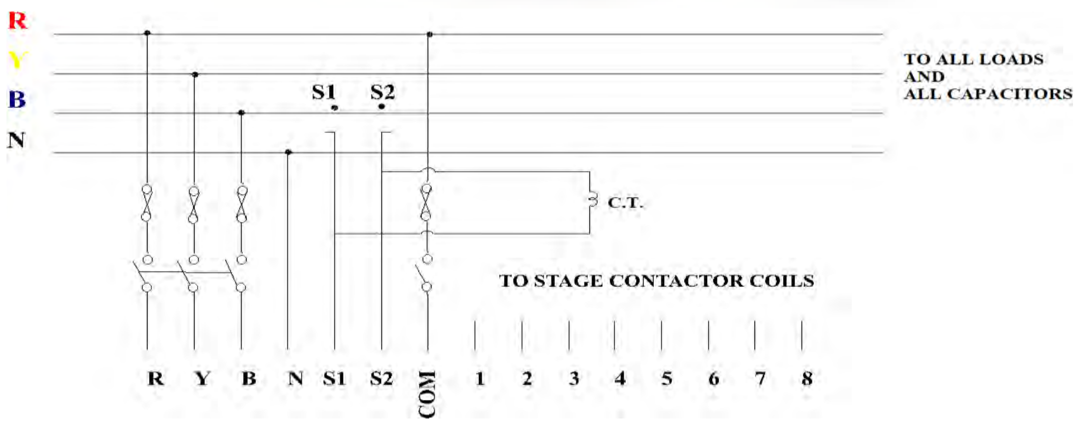

Fig.5.3.1.5 Controller circuit diagram

5.3.1.6 Controller :-

Figure 5.3.1.6 Controller

Sr no.	Specification	Ratings
1	Model number	Type 1003
2	Type of Project	Digital power factor meter
3	Accuracy	±0.5% ±1 digit
4	Input current Range	5 Amp
5	Display	7 segment display LED
6	Power Supply	230 V
7	Mounting Type	Panel Type
8	Panel Cut-out	96*96 mm

Table 5.3.1.6 Specification of controller

5.4 Capacitor bank:-

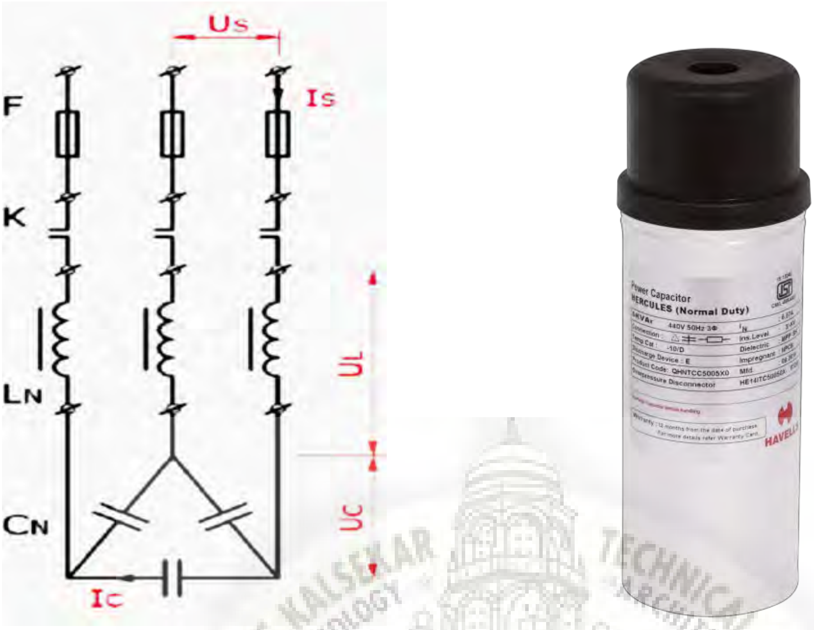

Fig 5.4 capacitor bank

5.4.1 Introduction:-

A Capacitor Bank is a group of several capacitors of the same rating that are connected in series or parallel with each other to store electrical energy . The resulting bank is then used to counteract or correct a power factor lag or phase shift in an alternating current (AC) power supply. They can also be used in a direct current (DC) power supply to increase the ripple current capacity of the power supply or to increase the overall amount of stored energy.

Frequency	50 Hz
Connection Type	3 Phase
Temperature cat	51 C
Insulation level	3 Kv
KVAr	2
Voltage/ Current	440 V AC / 2.62 Amp
Weight	0.6 kg

Table 5.4.1. Capacitor Bank Specification

5.4.2 What Does a Capacitor Bank Work?

Capacitor banks work on the same theory that a single capacitor does; they are designed to store electrical energy, just at a greater capacity than a single device. An individual capacitor consists of two conductors which are separated by a dielectric or insulating material. When current is sent through the conductors, an electric field that is static in nature then develops in the dielectric which acts as stored energy. The dielectric is designed to permit a predetermined amount of leakage which will gradually dissipate the energy stored in the device which is one of the larger differences between capacitors and batteries.

5.4.3 How is Capacitance Measured?

Capacitors are rated by the storing characteristic referred to as capacitance which is measured by the scientific unit, farad. Each capacitor will have a fixed value that they are rated at storing which can be used in combination with other capacitors in a capacitor bank when there is a significant demand to absorb or correct AC power faults or to output DC power.

5.4.4 What are the Applications of a Capacitor Bank?

The most common use of a capacitor bank for AC power supply error correction is in industrial environments which use a large number of transformers and electric motors. Since this equipment uses an inductive load, they are susceptible to phase shifts and power factor lags in the power supply which can result in a loss of system efficiency if left uncorrected. By incorporating a capacitor bank in the system, the power lag can be corrected at the cheapest cost for the company when compared to making significant changes to the company power grid or system that is supplying the equipment. Other uses for capacitor banks include Marx generators, pulsed lasers, radars, fusion research, nuclear weapons detonators, and electromagnetic rail guns and coil guns.

5.4.5 Applications:-

- Power Factor Correction (PFC)
- Automatic capacitor banks
- Fixed PFC applications, e.g. motor compensation
- Detuned PFC systems
- Dynamic PFC systems
- Filter Application

5.4.6 Features:-

- Compact design in cylindrical aluminium can with stud.
- Stacked winding
- MPP technology
- Voltage range 400 … 525 V
- Output range 1.0 … 30.0 KVAr

5.4.7 Electrical:-

- Long life expectancy of up to 100000 hours
- Max. transient inrush current handling capability is 200 x I R

5.4.8 Mechanical and maintenance:-

- Reduced mounting costs
- Easy installation and connection
- Low weight and compact volume
- Maintenance-free

5.4.9 Safety:-

- Self-healing
- Overpressure disconnector
- Shock hazard protected optimized capacitor safety terminals above 6KVAr

5.4.10 Rated Voltage 415 V AC

Sr no.	KVAr	Current (A)	Capacitance (3XμF)
1	1	1.4	6.2
2	2	2.8	12.3
3	2.5	3.5	15.4
4	3	4.2	18.5
5	4	5.6	24.6
6	5	7	30.8

Table 5.4.10 Three Phase Power Capacity (normal Duty)

5.5 Contactor:-

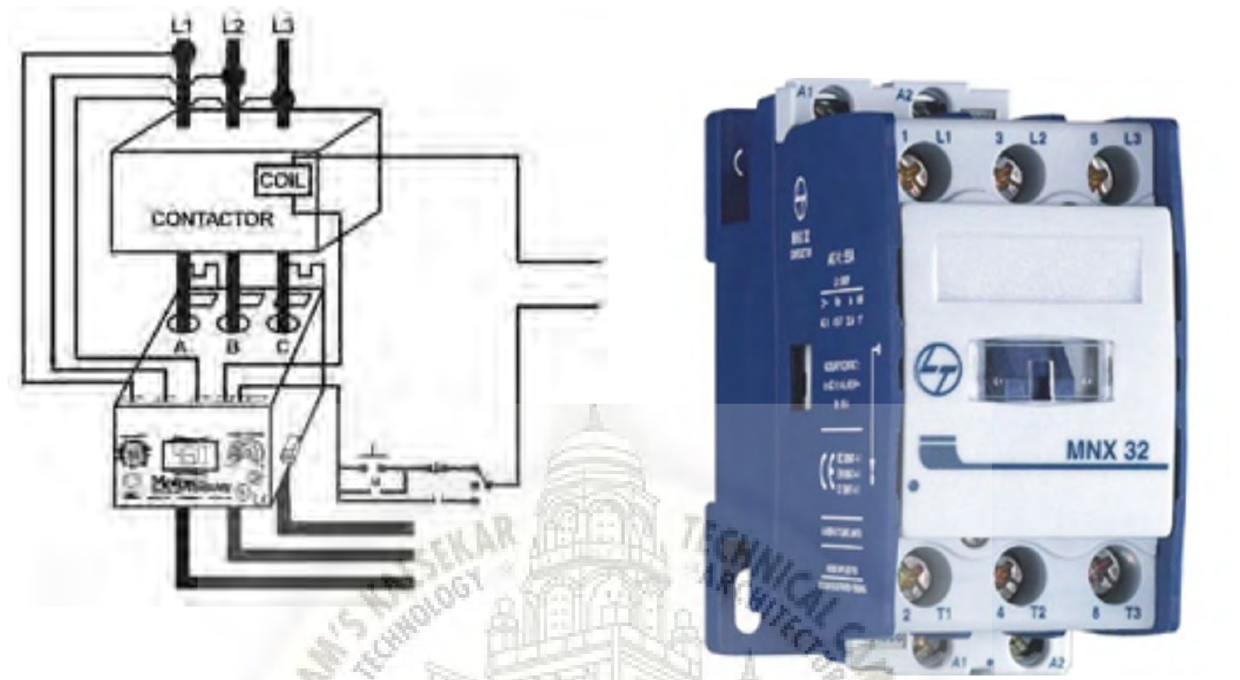

Fig.5.5 4-Pole Contactor

A contactor is an electrically controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch.

Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contactor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, to large devices approximately a meter (yard) on a side.

A contactor also has

1. Contact
2. Spring
3. Electromagnet

A contactor has three components. The contacts are the current carrying part of the contactor. This includes power contacts, auxiliary contacts, and contact springs. The electromagnet (or "coil") provides the driving force to close the contacts. The enclosure is a frame housing the contacts and the electromagnet. Enclosures are made of insulating materials such as Bakelite, Nylon 6, and thermosetting plastics to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts. Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather. Magnetic blowouts use blowout coils to lengthen and move the electric arc. A basic contactor will have a coil input (which may be driven by either an AC or DC supply depending on the contactor design). The coil may be energized at the same voltage as a motor the contactor is

controlling, or may be separately controlled with a lower coil voltage better suited to control by programmable controllers and lower-voltage pilot devices.

5.6 Miniature Circuit Breaker

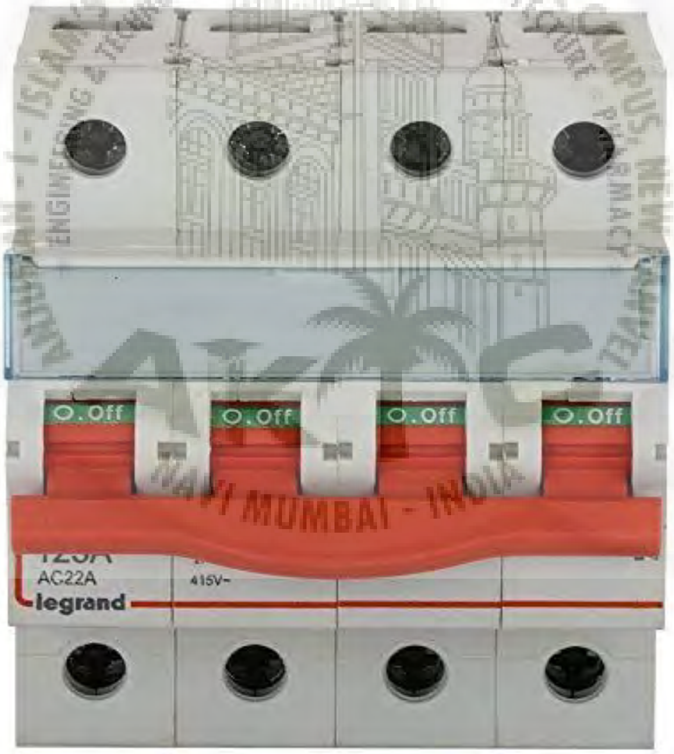

Fig.5.6(a) Miniature Circuit Breaker

An MCB or miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a moulded insulating material. The main function of an MCB is to switch the circuit, i.e., to open the circuit (which has been connected to it) automatically when the current passing through it (MCB) exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary. MCBs are of time delay tripping devices, to which the magnitude of over-current controls the operating time. This means, these get operated whenever overload exist long enough to create a danger to the circuit being protected. Therefore, MCBs doesn"t respond to transient loads such as switches surges and motor starting currents. Generally, these are designed to operate at less than 2.5 milliseconds during short circuit faults and 2 seconds to 2 minutes in case of overloads (depending on the level of current).

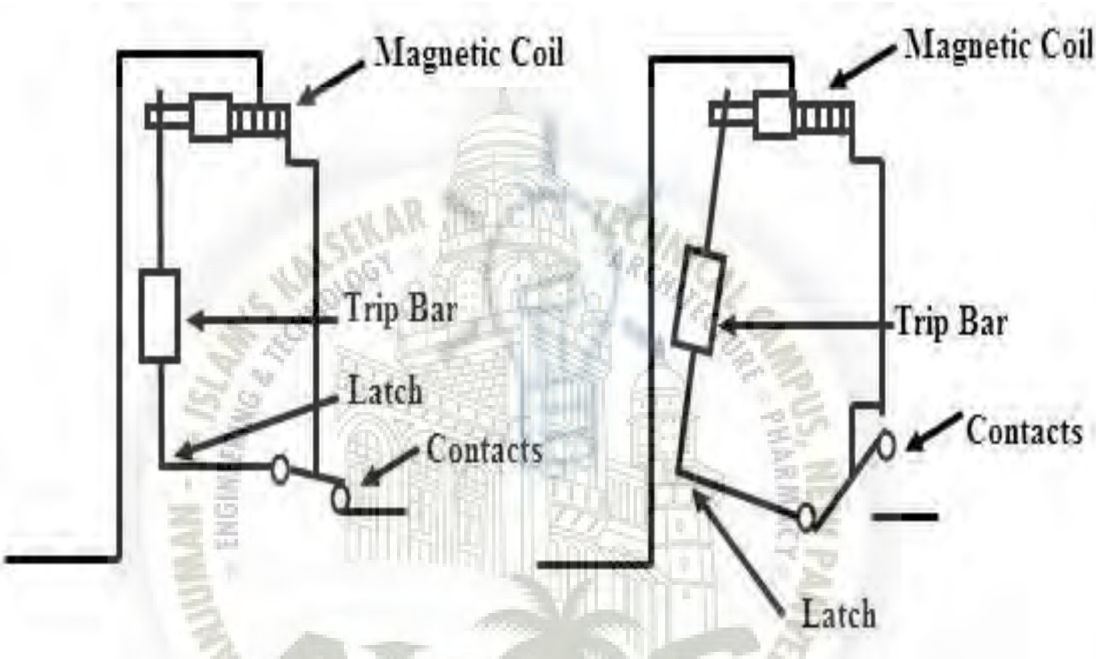

Fig.5.6(b) Working of MCB

A typical external appearance of an MCB is shown in figure. MCBs are manufactured in different pole versions such as single, double, triple and four pole structures with different fault current levels. Mostly, MCBs are linked to give two and three-pole versions such that a fault in one line will break the complete circuit and hence complete circuit isolation are provided. This feature will be helpful in case of single phasing in three phase motor protection.

These are rated at 220V for DC supply and 240/415 for AC supply (single and three-phase) with different short circuit current capacity. Typically, single phase devices have load current range of up to 100 A. Some MCBs have facility to adjust its tripping current capacity while some devices are fixed for some load current and short circuit rating. MCBs are used to perform many functions such as local control switches, isolating switches against faults and overload protection devices for installations or specific equipments or appliances.

- **Types of MCBs**

MCBs are classified into three major types according to their instantaneous tripping currents. They are

Type B MCB

Type C MCB

Type D MCB

The minimum and maximum trip currents of these MCBs are given in a tablular form below, where Ir is the rated current of the MCB. MCBs can also be classified based on number of poles such as single pole, double pole, triple pole and four pole MCBs.

MCB Type	Minimum Trip Current	Maximum Trip Current
Type B	3 Ir	5 Ir
Type C	5 Ir	10Ir
Type D	10 Ir	20 Ir

Table 5.6 Rated Current (Ir) of MCB

5.7 Wire:-

5.7.1 LT XLPE Cables:-

The XLPE Cables insulated heavy duty cables are introduced world-wide in mid sixties. These cables have overcome the limitations of PVC Cables such as Thermal degradation, poor moisture resistance and thermoplastic in nature.

5.7.2 Technical Advantages:-

- Higher Current ratings
- Higher short circuit ratings
- Thermosetting in nature
- Higher Insulation Resistance, 100 times more then PVC
- Higher resistance to moisture.
- Longer Service Life
- Low Dielectric Loss

5.8 Toggle Switch:-

Fig 5.8 toggle switch

5.8.1 Configuration:-

Maintained-contact toggle switches and momentary-contact toggle switches differ in terms of switch configuration. ON/OFF toggle switches have separate ON and OFF functions and work like light switches. Three-position toggle switches have a centre position that may or may not perform an OFF function.

Switch functions for momentary-contact toggle switches include the following.

(1) Momentary ON describes contacts which interrupt the circuit when the toggle switch is in the normal, open (NO) position.

(2) Momentary OFF describes contacts which establish a circuit when the toggle switch is in the normal, closed (NC) position. Alternate ON/OFF describes a switch where the first actuation turns the toggle switch ON and the second actuation turns the toggle switch OFF.

(3) Three-position momentary centre-neutral toggle switches have a centre position that can perform an OFF or neutral function.

There are several configurations for pole and throw toggle switches.

1.) Single pole single throw (SPST) toggle switches make or break the connection of a single conductor in a single branch circuit. This switch type typically has two terminals and is referred to as a single-pole switch.

2.) Single pole double throw (SPDT) toggle switches make or break the connection of a single conductor with either of two other single conductors. These switches usually have three terminals and are commonly used in pairs. SPDT switches are sometimes called three-way switches.

3.) Double pole single throw (DPST) toggle switches make or break the connection of two circuit conductors in a single branch circuit. They usually have four terminals.

4.) Double pole double throw (DPDT) toggle switches make or break the connection of two conductors to two separate circuits. They usually have six terminals are available in both momentary and maintained contact versions.

A normally open (NO) toggle switch has contacts that are open or disconnected in their unactuated (normal) position. A normally closed (NC) toggle switch has contacts that are closed or connected in their unactuated (normal) position.

5.9 Current transformer (C.T):-

A current transformer (CT) is a type of transformer that is used to measure alternating current (AC). It produces a current in its secondary which is proportional to the current in its primary. Current transformers, along with voltage or potential transformers, are instrument transformers. Instrument transformers scale the large values of voltage or current to small, standardized values that are easy to handle for measuring instruments and protective relays. The instrument transformers isolate measurement or protection circuits from the high voltage of the primary system. A current transformer provides a secondary current that is accurately proportional to the current flowing in its primary. The current transformer presents a negligible load to the primary circuit. Current transformers are the current-sensing units of the power system and are used at generating stations, electrical substations, and in industrial and commercial electric power distribution. Like any transformer, a current transformer has a primary winding, a core and a secondary winding, although some transformers, including current transformers, use an air core. In principle, the only difference between a current transformer and a voltage transformer (normal type) is that the former is fed with a 'constant' current while the latter is fed with a 'constant' voltage, where 'constant' has the strict circuit theory meaning.

The alternating current in the primary produces an alternating magnetic field in the core, which then induces an alternating current in the secondary. The primary circuit is largely unaffected by the insertion of the CT. Accurate current transformers need close coupling between the primary and secondary to ensure that the secondary current is proportional to the primary current over a wide current range. The current in the secondary is the current in the primary (assuming a single turn primary) divided by the number of turns of the secondary. In the illustration on the right, 'I' is the current in the primary, 'B' is the magnetic field, 'N' is the number of turns on the secondary, and 'A' is an AC ammeter. Current transformers typically consist of a silicon steel ring core wound with many turns of copper wire as shown in the illustration to the right. The conductor carrying the primary current is passed through the ring. The CT's primary, therefore, consists of a single 'turn'. The primary 'winding' may be a permanent part of the current transformer, i.e. a heavy copper bar to carry current through the core. Window-type current transformers are also common, which can have circuit cables run through the middle of an opening in the core to provide a single-turn primary winding. To assist accuracy, the primary conductor should be centred in the aperture.

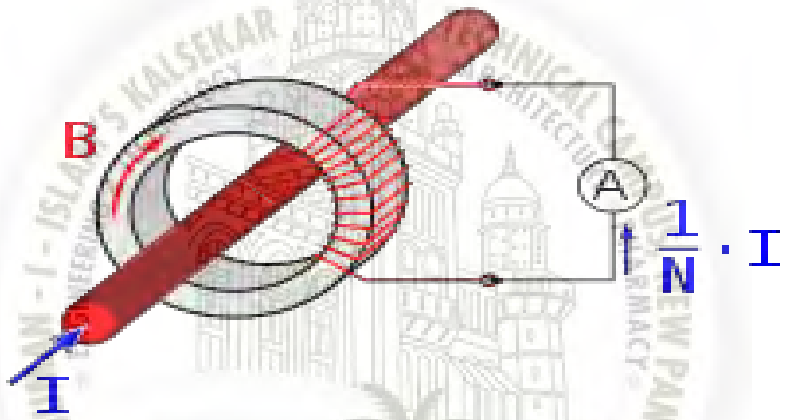

Fig 5.9 Current Transformer

5.9.1 Safety:-

Current transformers are often used to monitor high currents or currents at high voltages. Technical standards and design practices are used to ensure the safety of installations using current transformers.

The secondary of a current transformer should not be disconnected from its burden while current is in the primary, as the secondary will attempt to continue driving current into an effective infinite impedance up to its insulation break-down voltage and thus compromise operator safety. For certain current transformers, this voltage may reach several kilovolts and may cause arcing. Exceeding the secondary voltage may also degrade the accuracy of the transformer or destroy it. Energizing a current transformer with an open circuit secondary is equivalent to energizing a voltage transformer (normal type) with a short circuit secondary. In the first case the secondary tries to produce an infinite voltage and in the second case the secondary tries to produce an infinite current. Both scenarios can be dangerous and damage the transformer.

5.9.2 Construction

Bar-type current transformers have terminals for source and load connections of the primary circuit, and the body of the current transformer provides insulation between the primary circuit and ground. By use of oil insulation and porcelain bushings, such transformers can be applied at the highest transmission voltages.

Ring-type current transformers are installed over a bus bar or an insulated cable and have only a low level of insulation on the secondary coil. To obtain non-standard ratios or for other special purposes, more than one turn of the primary cable may be passed through the ring. Where a metal shield is present in the cable jacket, it must be terminated so no net sheath current passes through the ring, to ensure accuracy. Current transformers used to sense ground fault (zero sequence) currents, such as in a three-phase installation, may have three primary conductors passed through the ring. Only the net unbalanced current produces a secondary current - this can be used to detect a fault from an energized conductor to ground. Ring-type transformers usually use dry insulation systems, with a hard rubber or plastic case over the secondary windings.

Frequency	50 Hz
Line Voltage	415 V
Ratio	50:5 Amp
Class	5.0
VA	85

Table. 5.9.2 Current Transformer Ratings

Current transformers, especially those intended for high voltage substation service, may have multiple taps on their secondary windings, providing several ratios in the same device. This can be done to allow for reduced inventory of spare units, or to allow for load growth in an installation. A high-voltage current transformer may have several secondary windings with the same primary, to allow for separate metering and protection circuits, or for connection to different types of protective devices. For example, one secondary may be used for branch overcurrent protection, while a second winding may be used in a bus differential protective scheme, and a third winding used for power and current measurement.

5.10 Indication lamp:-

lastic Monoblock Indicators ECX1050/2050 series 22mm plastic-base indicator lights are reliable, low-cost devices offered in a variety of colors; both LED and incandescent illuminated units are available in 24 or 120 VAC/DC versions (for all colors). Bulbs in ECX1050 series can be replaced; bulbs in ECX2050 series are not replaceable.

Fig.5.10(A) 22mm Plastic Monoblock Indicator Lights

Fig.5.10(B) 12mm Plastic Monoblock Indicator Lights

5.10.1 LED:-

- Available in a choice of colors
- 24 and 120-volt models
- Frosted diffuser for even lighting
- Incandescent or LED indicator lights

Chapter 6

Industrial visit at JITE Sub-Station

An power substation is a subsidiary station of an electricity generation, transmission and distribution system where voltage is transformed from high or medium to low or the reverse using transformers. Electric power flows through several substations between generating plant and consumer changing the voltage level in several stages.
A substation that has a step-up transformer increases the voltage with decreasing current, while a step-down transformer decreases the voltage with increasing the current for domestic and commercial distribution. The word substation comes from the days before the distribution system became a grid. At first substations were connected to only one power station where the generator was housed and were subsidiaries of that power station.

ELEMENT OF SUB-STATION

Substations generally contain one or more transformers and have switching, protection and control equipment. In a large substation, circuit breakers are used to interrupt any short-circuit or overload currents that may occur on the network. Smaller distribution stations may use re-closer circuit breakers or fuses for protection of branch circuits. A typical substation will contain line termination structures, high-voltage switchgear, one or more power transformers, low voltage switchgear, surge protection, controls, grounding (earthing) system, and metering. Other devices such as power factor correction capacitors and voltage regulators may also be located at a substation.
Substations may be on the surface in fenced enclosures, underground, or located in special-purpose buildings. High-rise buildings may have indoor substations. Indoor substations are usually found in urban areas to reduce the noise from the transformers, to protect switchgear from extreme climate or pollution conditions.

KVAR Calculation

$S = 25\ MVA$

$S = 25 \times 10^6\ VA$

$S = 25000000\ VA$

$\cos\phi_1 = 0.8$

$$P = S \times \cos\phi_1$$
$$= 25000000 \times 0.8$$
$$= 20000000\ W$$
$$= 20\ MW$$

Actual power Factor = $\cos\phi_1 = 0.8$

Required power Factor = $\cos\phi_2 = 0.95$

$$\phi_1 = 36.86$$
$$\phi_2 = 18.19$$

KVAR Required :- $kW(\tan\phi_1 - \tan\phi_2)$

$$= 20000000(\tan(36.86) - \tan(18.19))$$
$$= 8422804.721\ VAR$$
$$= 8422.804\ KVAR$$

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DEPARTMENT OF ELECTRICAL ENGINEERING

13/03/2019

To,

Executive Engineer (Training)

100KV MSEB Substation Jite,

Dist Raigad.

Subject:- Permission for visit to Substation (One Day).

Through: HOD Electrical Engineering AIKTC, Panvel.

Respected Sir,

We the Student of Kalsekar Technical Campus, Panvel in the department of Electrical Engineering.

We are doing project work on the topic Automatic Power Factor Controller as a case study and a review. Now we are facing some difficulties in this work so we want visit to JITE Substation on date 16/3/19 or 23/3/19. Kindly grant us the permission we are ready to pay the fees towards visit.

Thank You.

SHAIKH AFSAR ALI.

SALMANI RAAMZAN ALI.

SHAH RAHUL.

SAYED FAHIZ.

Prof. YAKUB H.KHAN

Anjuman-I-Islam's Kalsekar Technical Campus New Panvel

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100/22KV SUB-STN JITE

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Office of The Deputy Ex.Engineer
100/22KV Sub-stn, Jite

Ref.No: DYEE/100KV/JITE/Training/No. 965 Date: 18.03.2019

CERTIFICATE

This is to certify that Mr.Ramzan Ali Salmani, Mr.Fahiz Sayad, Mr. Rahul Shah, Mr.Afsar Ali Shaikh the student of Final year B.E. Electrical Engineering from Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, have carried out their final year project on "Automatic Power Factor Controller" (a case study and review) at 100KV Jite sub-station, Raigad.

In this case study, they have studied the single line diagram, active and reactive power, improvement of power factor, rating of CT, PT, Circuit breaker and KVAr required.

Dy. Ex Engineer
100/22KV Jite Substation,
M. S. E. Transmission Co. Ltd.
Deputy Executive Engineer
100/22KV Substation, Jite

CHAPTER 7

Conclusion & Future Scope

7.1 Conclusion:-

From our project we observed that this APFC Panel will help us in finding

- Raising power factor is a proven way of increasing the efficient way of use of electricity by utilities and end users.
- It reduces the consumer"s electricity bills.
- It also helps to reduce the rating of the transformer, cable size, circuit breaker size.
- It can be concluded that power factor correction technique can be applied to the industries, power systems and also house hold to make them stable and due to that the system becomes stable and efficiency of the systems as well as the apparatus increases. When the detected power absorbed by the load is greater than the compensator rating, the power factor will not be corrected to unity but certainly, will be improved and the apparent power supplied by the AC supply will be reduced. They achieve better power quality by reducing the apparent power drawn from the AC supply and minimizing the power transmission losses. Hence the efficiency of the systems as well as the apparatus increases.

7.2 Future Scope:-

1. As industries Better utilization of electrical machine.
2. Decreased monthly energy cost.
3. Reduction of losses.
4. Overloading is avoided.

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