Industrial Training Report (Aug-Dec 2022)

Place of training: Panel designing, Udaipur, Rajasthan

Period of training: 04 July – 15 August 2022

Submitted to

Department of Electrical Engineering

Summer Training In-charge at TINJRIT:

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By

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(Batch 2020-2024)

Branch: Electrical Engineering

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This is to certify that **PUNIT JAIN** completed an internship with **ENERGY POWER INSTRUMENT**as an Intern in the **ELECTRICAL DEPARTMENT**from July04, 2022, to August 15, 2022.

During the internship, he worked on Power Panel Designing, Automatic Power Factor Controller, and Panel Fabrication. Throughout the internship period, he demonstrated a high level of comprehension, effectively managed assignments, and consistently exhibited exceptional efficiency. Moreover, he maintained a professional demeanour and displayed excellent moral character. Based on my knowledge,

I hereby certify his overall work as excellent. I wish him the best of luck in his future endeavours.

Date: 20/05/2022

GST No :-08CNVPB3010R1ZL

For EPI

Authorised Signatory

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This is to certify that **PRAVEEN MEGHWAL** completed an internship with **ENERGY POWER INSTRUMENT**as an Intern in the **ELECTRICAL DEPARTMENT**from July04, 2022, to August 15, 2022.

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Date: 20/05/2022

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This is to certify that **JAYESH MENARIA** completed an internship with **ENERGY POWER INSTRUMENT**as an Intern in the **ELECTRICAL DEPARTMENT**from July04, 2022, to August 15, 2022.

During the internship, he worked on Power Panel Designing, Automatic Power Factor Controller, and Panel Fabrication. Throughout the internship period, he demonstrated a high level of comprehension, effectively managed assignments, and consistently exhibited exceptional efficiency. Moreover, he maintained a professional demeanour and displayed excellent moral character. Based on my knowledge,

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This is to certify that **Akshay Solanki** completed an internship with **ENERGY POWER INSTRUMENT**as an Intern in the **ELECTRICAL DEPARTMENT**from July04, 2022, to August 15, 2022.

During the internship, he worked on Power Panel Designing, Automatic Power Factor Controller, and Panel Fabrication. Throughout the internship period, he demonstrated a high level of comprehension, effectively managed assignments, and consistently exhibited exceptional efficiency. Moreover, he maintained a professional demeanour and displayed excellent moral character. Based on my knowledge,

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Date: 20/05/2022

GST No :-08CNVPB3010R1ZL

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Certificate II

This is to certify that Akshay Solanki, Jayesh Menariya, Kapil Kalal, Praveen Meghwal and Puneet Jain, Bachelor of Electrical Engineering has successfully completed Industrial Training on the Panel Designing from ENERGY POWER INSTUMENTS as partial fulfillment of Bachelor of Engineering EE. The Industrial Training Report, Presentation and Project are genuine work done by them and the same is being submitted for evaluation.

Signature

Rajkumar Soni

HOD [EE]

ACKNOWLEDGMENT's

We take this opportunity to express my profound gratitude and deep regards to my guide **Mr. Rajkumar Soni** (Head of EE) for his exemplary guidance, monitoring and constant encouragement throughout the course of the training. The blessing, help and guidance given by him time to time shall carry me a long way in the journey of life on which we are about to embark.

We specially take the opportunity to thank our coordinator Mr. Rajkumar Soni, Dr. Abrar Ahmed, for their valuable information and guidance which helped me in completing this task through various stages. We also take this opportunity to express a deep sense of gratitude to all my teachers of Electrical Engineering Department for their coordinal support.

We are obliged to the staff members of the (**ENERGY POWER INSTUMENTS** and **Mr. Rohit Patel**), for the valuable information provided by them in their respective fields. We are grateful for their corporation provided by them during my training period.

We are thankful to the almighty and our parents for their moral support and my friends with whom we shared our day-to-day experience and received lots of suggestions that improved my quality of work.

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Training modules:

1. **Control panel design basics.**
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5. **Automatic power factor correction panel.**

Control panel design basics are simple. Cost is always important, but so is an attractive appearance, simple operator controls and reliable operation. Simple panel designs are less expensive to produce and easier to operate and maintain.

It helps when you understand design is a process. Often you think you know exactly what you want when you get started and find you want something different when you're done.

When you first put your design requirements on paper, they seem unorganized. That's normal. No one gets everything right in one pass. Design is a process and **it takes time to get it right**.

Rewrite your requirements until they're properly organized and clear. Understand what you want, write it down using clear language, then proceed with the actual hardware design.

1 • Start physical

Good control **panel design includes physical and electrical** requirements. Don't shortcut the design process and produce schematic drawings without producing physical layout drawings. Alternate between the physical and electrical until all potential problems have been solved.

Good control panel design includes accurate physical layout drawings and schematic drawings. This **minimizes problems** and delivery delays due to unresolved physical layout problems discovered during production or testing.
Include National Electric Code (NEC) required clearance for power wiring and Underwriters Laboratories (UL) required clearance around heat producing devices.

- NEC requires bending radius clearance for incoming and outgoing power connections to insure the installing electrician has adequate room to make their power connections,
- UL requires manufacturer recommended clearance for heat producing devices (Programmable Logic Controllers, Variable Frequency Drives, etc.) to insure for adequate room for ventilation.

2 • Analyze the power circuits

Identify each power circuit and determine the required wire size and circuit protection. The right wire size ensures the circuit can deliver the required load current. The right circuit protection ensures the wiring doesn't overheat and start a fire.

- Select power wire size based on load current
- Select power circuit protection based on wire size.

Then determine the best power component type to use based on function and select the right size based on voltage and load current. The right type insures it'll function as desired and the right size insures it'll reliably handle the load

.

3 • Use the best control type

Always **start with simple control components** (Relays, Timers, etc.) When simple doesn't get the job done, use something with more functionality like a programmable Smart Relay or a Programmable Logic Controller (PLC). These provide significantly more functionality, but they also require a computer and programming software and someone who knows how to program the desired functionality.
Some control panel designers start with a Programmable Logic Controller (PLC). Sometimes a PLC is the way to go, but you should always **use the simplest control type appropriate to the application**.

4 • Use the best operator device type

Always **start with simple operator devices** (Pushbuttons, Pilot Lights, Digital Panel Meters, etc.). For a stylish appearance add a Color Graphic door laminate. When simple doesn't get the job done, use a color touch screen display as the Human Machine Interface (HMI). This provides significantly more functionality, but it also requires a computer and programming software and someone who knows how to program the desired functionality.
Some control panel designers start with a Human Machine Interface (HMI). Sometimes an HMI is the way to go, but you should always **use the simplest operator device type appropriate to the application**.

5 • Use the best-in-class products by category

Experienced control panel designers use the **best-in-class products by product category**. This is subjective based on product awareness. Experienced control panel designers are aware of the array of products available in a product category. This allows them to compare and use products that provide the **best balance of price, form and function**.
Some control panel designers try to use one manufacturer for all components in a panel. European companies tend to do this and some US companies do too. Sometimes there's a reason why this makes sense, but generally it limits your ability to **use best in class products by product category**.

Key words –Power Factor, APFC Panel, Power factor

correction, Inductive, Capacitor, penalty

1.INTRODUCTION

The power factor is the ratio between KW and KVA generated by the electric load, where KW is the active power and KVA is the apparent power. This is a measure of how current is effectively converted to work output and is a good indicator of the impact of load current, especially on operating system supply. Most art burdens are a stimulus to the environment that results. Disconnection of electrical components results in power outages and waste resulting in high power bills and heavy fines from the power board. When the weight of the inequality is very high, it is very difficult to maintain the unity element. To overcome this problem, APFC panels were used, retaining elements of unity. As such, industries require automatic electronic correction systems. APFC or automatic factor control panel panels are widely used for power factor optimization. Power factor can be defined as the ratio of apparent energy to active energy, and an important factor in measuring power consumption is the fact that everyone knows how much electricity is available today. Thus, in order to reduce costs, it is important to reduce the cost of electricity. To achieve this end, APFC panels are actually easily accessible. The use of these control panels is important in industries where power installations are used to supply a wide range of electronics. Decreased power factor may attract those responsible for power supply, operating loss and fines from power supply. APFC panels can effectively and automatically control rapid change and load loads while maintaining a high-power factor. It will use existing ratings to respond to various requests.

ii. DETAILS OF APFC

2.1 Power factor without using APFC Panel

Most industrial loads have a character, ie inductive loads, so the power factor is low or very poor depending on the power of the reactive power. These reactive loads include electric motors, induction heaters, furnaces, lamp ballasts, and the like. These loads cause the currents to hang at certain angles, leading to a poor power factor. This low power factor attracts high internal current, which in turn creates excess heat in the equipment, a huge voltage drops and poor voltage regulation. A low power factor requires a high KVA for the equipment, so the cost of the equipment increases. Therefore, energy waste will increase. There for the electricity board put extra penalty on those industries. Keeping the above things in mind, one can say that the power factor must be corrected for a better utilization of the power, and to overcome all the drawbacks discussed above there for the APFC panel will comes in to play to improve the power factor and reduces the penalty from the electricity board.

2.2 METHODS OF IMPROVING POWER FACTOR

1. Phase advancer

2.Synchronous condenser

3. Using capacitor bank

2.2.1 Phase advancer

This method helps improve the power factor is also known as a phase advisor using an AC exciter. However, it can only be used for induction motors because the stator of the motor draws the winding current that is 90 ° behind the voltage and results in a lower power factor. The only way to get rid of this problem would be to use an external source that would provide exciting ampere-winding. The phase advisor helps solve this problem when it is connected to the motor's rotor circuit. The exciting ampere-turns provided by the consultant are at slip frequency. A leading International Journal of Engineering Research & Technology (IJERT) Power factor can also be obtained by providing a greater ampere-turn. The main advantages of using a phase advisor include the low amount of reactive power drawn by the motor. It can also be used in places where a synchronous condenser is unacceptable. However, phase motors cannot be used for motors below 200 hp. Which is informal.

2.2.2 SYNCHRONOUS CONDENSER: Another way to improve the power factor is to use a 3-phase synchronous motor, which is over-excited and operates without load. This setup is known as a synchronous condenser. The interesting part is that synchronous motors can operate under pioneer, lagging, or unity power factor. If an inductive load is present, the condenser will be connected to the edge of the load and act as a capacitor to correct the power factor. The synchronous condenser has many advantages as it requires less maintenance, can last up to 25 years and is not affected by harmonics. However, its disadvantages include high maintenance, cost and noise. Additional equipment is also required to start the motor as it does not have self-starting torque.

2.2.3. USING CAPACITOR BANK -

A well-known factor that decreases the power factor is the current due to the inductive load. To improve the power factor, static capacitors are installed parallel to devices operating at low power factor. The major current drawn by such capacitors neutralizes or corrects the lagging reactive component of the load current. Static capacitors have many advantages because they are lighter, easier to install, have less damage and require less maintenance. However, the losses are quite notable where if the voltage is exceeded the capacitors will be damaged quickly and their repair will become expensive. He also has a short service life (8–10 years). iv. BASIC THEORY OF APFC PANEL

2.3 Needs for automatic power correction

Power factor correction (PFC) is a technique counteracting the undesirable effects of electric loads that create a power factor 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 costs charged 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 be offset by locally connected capacitors.

2.4 DESIGN METHODOLOGY

Panel design comprising following steps

1. GA drawing

2. Meter wiring

3. Control wiring diagram.

4. Single line diagram

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2.5 WORKING

Meter and controlled wiring diagram Figure no. (2) shows the meter wiring and figure (3) shows the controlled wiring. Three c.t. connected with three phase and measure current through and as per reactive power requirement relay gives the output signal to no duty contactor as per requirement the duty contactor on or off simultaneously. In relay auxiliary power supply is phase to phase.one phase is going to auto manual switch and second phase going to cooling fan. In the auto manual switch to contactor is connected with 2 switch point. First point ka1 and second point KM 1when auto manual switch terminal is auto side then KA1 contactor is energize figure (3) shows the ka1 is off when contactor energize ka1 is converted in NC (normally closed) in all four bank and as per reactive power requirement APFC relay pass the output signal to any kc contactor and kc contactor energize than capacitor duty contactor is convert NO (normally open) to NC contactor and delta connected capacitor is fed the reactive power in supply line. AS in figure -4 shows that three 5 KVA capacitors and one 10 KVAR capacitor 4 bank APFC panel designed in the system require 15 KVAR supply when APFC relay give signal to duty contactor there after kc1 contactor will energize as per figure (3) in kc1 contactor connect with 5 KVAR delta connected capacitor so 5 KVAR fed in the supply line but require 15 KVAR the kc2 contactor is energize and another capacitor is connected means 15kvar demand is not connect with supply till then APFC relay gives the signal to duty contactor.

• Manual connection

When auto manual switch manual terminal side km1 is energize and convert in no to nc then as per figure (3) km1 works as nc when we press the start button PB (push button) then kc contactor is energized and KC contactor work NO to NC and capacitor connect with the supply this process is totally is manually and to disconnect the capacitor press the stop P.B then KC contactor de-energize then capacitor will disconnect. This manual system is use for continuous flow of reactive power.

2.6 CONCULSION

By installing suitable capacitor bank into circuit the power factor is improved the value become nearer to 0.9 to 0.95 consequently, it minimizes loss of power system and improve efficiency of system. by using the APFC panel system become more stable and reliable also, efficiency of power system is highly increased. capacitor banks have generated reactive power and requirement of reactive power drawl from system therefore consumers can better utilize the power supply by using APFC panel and optimize use of power in power system.

ELECTRICAL CONTROL PANEL ELECTRICAL COMPONENTS

Eight types of electrical components exist within an electrical panel enclosure which define and organize the several different functions carried out by the panel. These components include:

- **Main circuit breaker.** This is like the disconnect of the main electrical panel leading into a home or office. Main circuit breakers handle between 120V–480V in most industrial applications.
- 

-

- **Surge arresters.** This component prevents lightning strikes or utility power surges from damaging the electrical components inside the panel due to overvoltage.
- 

- **Transformers.** Depending on the incoming voltage, transformers may reduce voltage to 120V for various components or step down voltage to 24V in instances where incoming power is 120V.
- 
-
- **Terminal blocks.** These blocks help to organize and distribute the array of wires coming from various sources to different electrical devices.

- **Programmable Logic Controller (PLC).** This is essentially a CPU contained inside the control panel. This unit is the brains of the control panel, providing monitoring and control of the various mechanical processes. In will include various inputs and outputs to and from mechanized functions of the production equipment.

- **Relays and contactors.** These on/off switches control mechanized functions based on commands from the PLC. Smaller relays control functions like lights and fans. Larger relays, called contacts, control more advanced functions like motors.

- **Network switches.** The communication hub of the control panel, network switches facilitate communication between the PLC and the various network compatible devices on the production line.

- **Human Machine Interface (HMI).** These components allow an operator to monitor or control certain functions of the machinery. Common HMIs include video monitors, joysticks, buttons, switches, and keyboards.

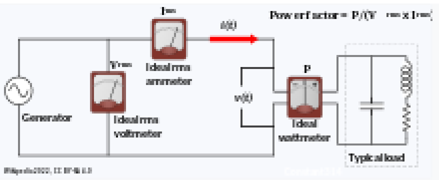
POWER FACTOR

In electrical engineering, the **power factor** of an AC power system is defined as the ratio of the *real power* absorbed by the load to the *apparent power* flowing in the circuit. Real power is the average of the instantaneous product of voltage and current and represents the capacity of the electricity for performing work. Apparent power is the product of RMS current and voltage. 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 may be greater than the real power, so more current flows in the circuit than would be required to transfer real power alone. A power factor magnitude of less than one indicates the voltage and current are not in phase, reducing the average product of the two. A negative power factor occurs when the device (which is normally the load) generates real power, which then flows back towards the source.

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

Power-factor correction increases the power factor of a load, improving efficiency for the distribution system to which it is attached. Linear loads with a low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.

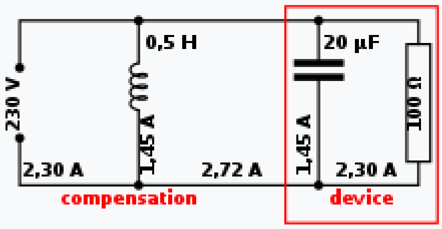
General case[edit]



Schematic showing how power factor is calculated

The general expression for power factor is given by where is the real power measured by an ideal wattmeter, is the RMS current measured by an ideal ammeter, and is the RMS voltage measured by an ideal voltmeter. Apparent power, , is the product of the RMS current and the RMS voltage. If the load is sourcing power back toward the generator, then and will be negative.

Power factor correction of linear loads[edit]



Power factor correction of linear load

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.

The reactive elements in power factor correction devices can create voltage fluctuations and harmonic noise when switched on or off. They will supply or sink reactive power regardless of whether there is a corresponding load operating nearby, increasing the system's no-load losses. In the worst case, reactive elements can interact with the system and with each other to create resonant conditions, resulting in system instability and severe overvoltage fluctuations. As such, reactive elements cannot simply be applied without engineering analysis.

1. Reactive power control relay; 2. Network connection points; 3. Slow-blow fuses; 4. Inrush-limiting contactors; 5. Capacitors (single-phase or three-phase units, delta-connection); 6. Transformer (for controls and ventilation fans)

An **automatic power factor correction unit** consists of a number of capacitors that are switched by means of contactors. These contactors are controlled by a regulator that measures power factor in an electrical network. Depending on the load and power factor of the network, the power factor controller will switch the necessary blocks of capacitors in steps to make sure the power factor stays above a selected value.

In place of a set of switched capacitors, an unloaded synchronous motor can supply reactive power. The reactive power drawn by the synchronous motor is a function of its field excitation. It is referred to as a **synchronous condenser**. It is started and connected to the electrical network. It operates at a leading power factor and puts vars onto the network as required to support a system's voltage or to maintain the system power factor at a specified level.

The synchronous condenser's installation and operation are identical to those of large electric motors. Its principal advantage is the ease with which the amount of correction can be adjusted; it behaves like a variable capacitor. Unlike with capacitors, the amount of reactive power supplied is proportional to voltage, not the square of voltage; this improves voltage stability on large networks.

Synchronous condensers are often used in connection with high-voltage direct-current transmission projects or in large industrial plants such as steel mills.

For power factor correction of high-voltage power systems or large, fluctuating industrial loads, power electronic devices such as the static VAR compensator or STATCOM are increasingly used. These systems are able to compensate sudden changes of power factor much more rapidly than contactor-switched capacitor banks and, being solid-state, require less maintenance than synchronous condensers.

Non-linear loads[edit]

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.

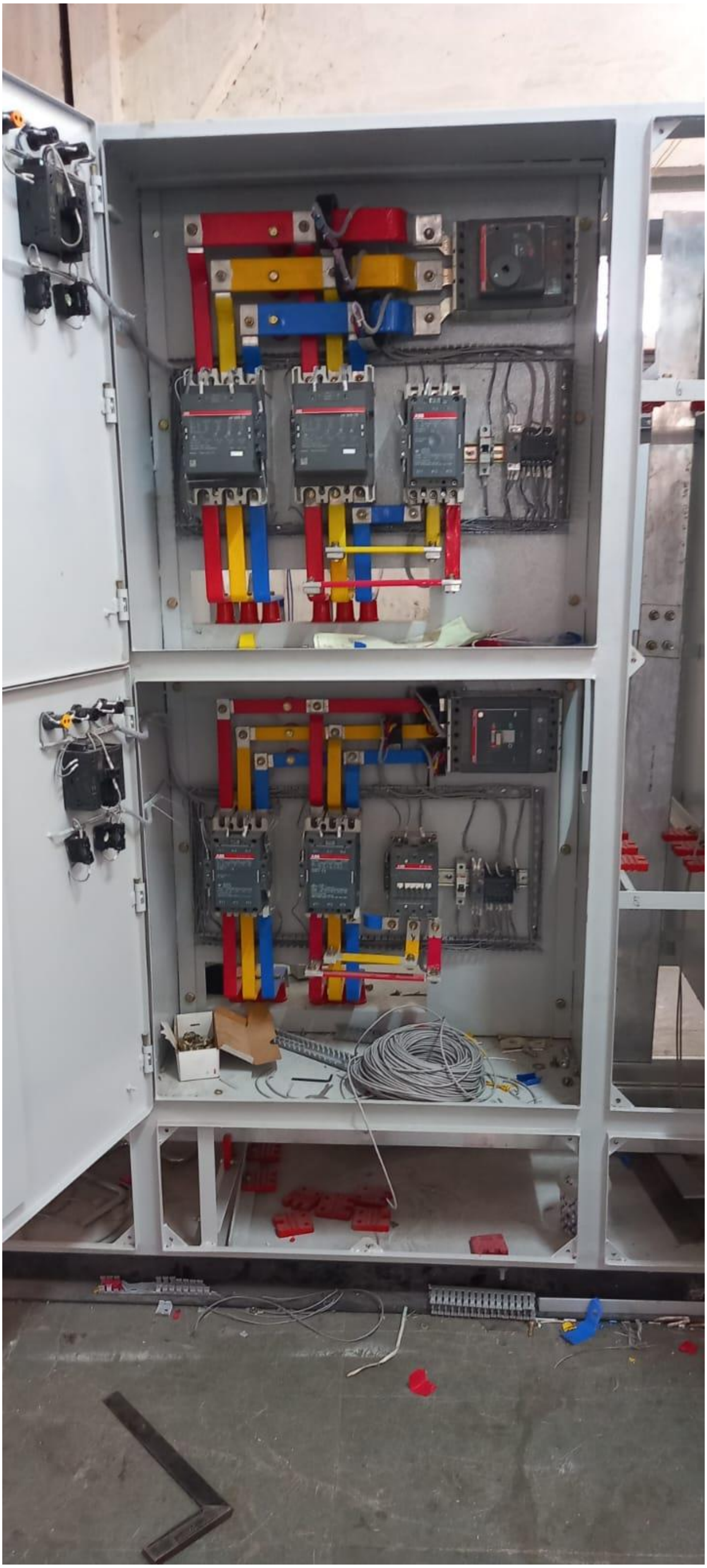
Automatic Power Factor Controllers

Electrical loads such as motors can cause electrical systems to be very inductive, which results in very 'lagging power factor' i.e. wastage of energy. The simple solution to maintain the power factor in required range is to connect or disconnect the power factor correction capacitors. Manual switching is just impossible for rapidly fluctuating loads and hence an automatic control system is required which continuously monitors the power factor and make appropriate corrections to maintain it within the required range.

System Design

Baron Automatic Power Factor Correction System is unique with its Custom Based Design, based on the Load Study Conducted on site with High Speed Power Quality Analyzer with recording interval selected as appropriate to the study,

depending on the Loading pattern.
The System is basically designed as a series RLC Circuit to suppress the transient inrush current, while injecting reactive current. Its Components Selection is critical due to the inherent operating parameters of the Capacitors which draws high inrush current during switching and while opening out. The Electrical charges remains in the capacitor thereby building up the Re-striking Voltage. This characteristics of the Capacitors needs careful study and selection of the correct components to ensure long life for the total system.
The choice of capacitor duty contactors with damping resistors provide protection from inrush current during switching. The coil wound inductors provide additional protection from short time high current peaks. The sequential cyclic switching of capacitors with preset time delay for safe discharge of capacitors, increases the life of capacitors and avoids problems rooting from voltage peaks while energizing the charged capacitors at sinusoidal peak instants of supply voltage.
The selection of capacitor stages with appropriate stage ratios matching the load profile provides power factor correction with high-resolution.



Salient Features

Microprocessor based Power Factor Controller with special features

- Four Quadrant Measurement
- Accuracy of +0.8% for Reactive Power, + 0.5% for Current 6 or 12 steps to operate Capacitor Circuits.
- Precise and quick relay controls
- Continuous monitoring of defective capacitor stages.
- Counting, Storing and Display of number of switching operation
- Alarm for excess operation than programmed limits.
- Dual control curve characteristics: to avoid over compensation under light loads and to avoid inductive reactive power under regenerative conditions.
- Monitoring of harmonic levels continuously with alarm and safety trip facility.
- Zero voltage & Zero current tripping with alarm signals.
- Manual/Automatic operation with ability to switch each individual Capacitor

System Protection by incoming molded case circuit breaker selected with tripping characteristics for the individual capacitor circuit as well as multi bank parallel switching characteristics
Feeder Protection by MCB having tuned tripping characteristics to ensure avoidance of any inadvertent tripping by the inrush current of the capacitors. Capacitor duty contactors with two sets of contacts, one for restricting inrush current and other for continuous loading of the capacitors, specially designed with the damping resistance to restrict the inrush current into capacitor stages energized

Direct Benefits

- Reduction in MD kVA
- Reduction in KWH Consumption
- Reduction in KVAH Charges
- Avoidance of PF Penalty
- Availing PF Incentive

Indirect Benefits

- Reduction/Avoidance of End Termination Darkening or Burn Outs
- Reduction/Avoidance of Motor winding failures

- Improved System Performance due to Healthy Voltage
- Low Electric Break Downs/ Reduced Plant Down Time