



Economic Improvement of Power Factor Using Automatic Compensators for Domestic Use

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Abstract – This paper explains the model of the project to correct the power factor using Automatic Compensators. Energy is very important in our contemporary world. Finding the reasons for power losses and increasing the stability of the power system is very important. The electricity market is growing rapidly due to increased load. The Electricity network feeds to a large array of electrical loads, power electronic devices, and agriculture load which provides a changing demand on the generating units. These leads to decrease in power factor of the load. Lower $\cos \phi$ (Power Factor) leads to increased current flow and causes voltage drops. Due to this system becomes inefficient and monthly bill increases. Suitable capacitors depending upon the fluctuations of the load should automate and run without any human intervention. This can be engineered by using Automatic compensators which can improve power factor approximately equal to one (unity). In our load, there is Inductive load in maximum. This consumes apparent power which affects the Generating unit which in turn increases losses and decreases efficiency of the power system.

Index Terms – Real power, total power, Inductive load, $\cos \phi$ Compensation

I. INTRODUCTION

The $\cos \phi$ (Power Factor) is defined as the ratio between real to reactive powers. It's a statistic for how well the Current (Amperes) was effectively turned to productive work performance and, more importantly, acts as a predictor for load current's loss on supply system's efficiency. In the Distribution system, the majority of the load is inductive, resulting in lagging power. This is one of the reasons for energy loss and waste. As a result, you'll be paying a lot of money for electricity and you'll be getting a lot of penalties. It is extremely difficult to preserve the unity power factor when the load is uneven. So, industries require automated compensators.

These boards were especially seen in applications maintaining unity $\cos \phi$. It is a very important entity in power system studies. Electrical energy became a compulsory need for all human beings. So efficient usage of this energy is very much important for us to save it for future. These panels are extremely useful for achieving the above goal. In industries where electrical facilities are supposed to supply enormous electrical loads, these control panels become essential. A drop in $\cos \phi$ results in

an increase of reactive power and hence losses will be increased and efficiency will be decreased. Discoms coat higher rates for our usage if $\cos \phi$ becomes less than usual.

These boards are efficiently and digitally handle rapidly oscillating, dispersed demands while maintaining a larger $\cos \phi$. India is well-known producer of these that are synonymous for more standard and dependability.

These boards are important technologies to increase the $\cos \phi$ and ensuring adequate real power delivery. If the consumer connects an inductive load, the power factor is trailing, and $\cos \phi$ becomes less than 0.96 if the end users uses more load which is inductive. It is also called as lagging PF, the utility companies will charge more bill from the consumer As a result, it's critical to keep the $\cos \phi$ under control. Be that as it may, DC energy is expected to run the circuit. The 230v circuit is shut down to 12v utilizing a potential transformer

II. EXISTING METHODS

Techniques for increasing $\cos \phi$:

- i. Capacitors Bank
- ii. Synchronous Condensers

Calculation of the Power Factor

A voltmeter and an ammeter measures source voltages and currents drawn in the $\cos \phi$ calculation. Active power is measured with a wattmeter.

We now know that $P = VI \cos \theta$ watts.

As a result, we can calculate the electrical power factor.

We can now calculate $Q = VI \sin \theta$ VAR, which is the reactive power.

The capacitor deployed in parallel with the load in local can now provide this reactive power.

III. PROPOSED SYSTEM

The suggested model makes use of a 230v 50Hz mains deliver as a power supply and uses a PT to reduce the voltage to 12v. The energy supply tool sends the 12-volt AC to two separate DC voltages of +nine volts and +five v. Model potential transformer is received through the 12volts AC line and

projected for microcontroller enter by potential transformer model. A CT extracts a I(amperes) signal pattern from the mains-supply, that's then done via a modern I sensor circuit for any other plc input. This PLC calculates $\cos \phi$ and takes condensor away from the capacitor bank. The detected voltage signal is captured from the 12VAC signal and processed by the voltage detection circuit for input to the microcontroller. The current converter extracts a current signal sample from the mains. This sample is processed by a current sensor circuit for another microcontroller input. The microprocessor calculates the power factor and removes the capacitor from the bank. The results are displayed on the 20x4 LCD panel. Below is a functional block diagram of the entire project.

On a 20x4 LCD panel, the results are displayed. The following is a functional block diagram for the entire project.

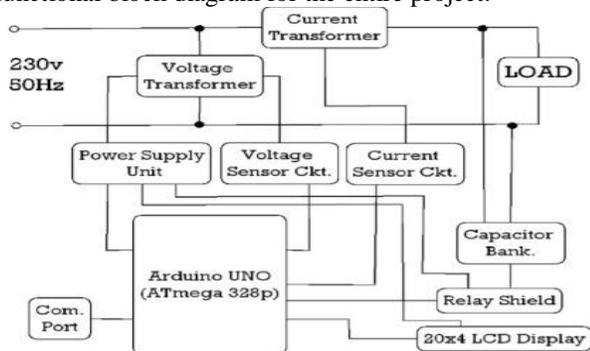


Fig.1 Block diagram of automatic compensator

IV. PLANNING

Entire APFC-unit is made up with 8 parts. These collaborate to achieve a power factor correction as a group.

The following are the modules:

- a. RPS.
- b. Potential Transformer.
- c. Current Transformer.
- d. PLC.
- e. L-load circuit.
- f. Circuit breaker.
- g. LCD.
- h. Condensor Bank.

Energy Supply may provide 230v power of Ac at frequency of 50Hz. Yet, for running the circuit, dc energy was needed. The 230v supply is stepped down to 12v by means of voltage transformer. Then, the sinusoidal signal is converted to square using ac to dc converters and filters.

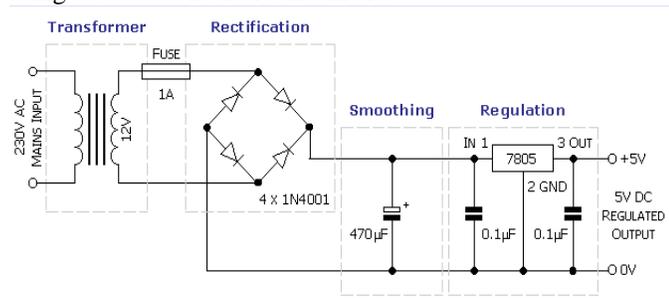


Fig.2 Energy unit block diagram

A potential divider model divides by 12 v from 1:10, giving sinusoid signal of 1.2 v components. Sine-shaped signals are provided with a continuous line deviation of 2.5 V. As a result, sinusoid signal assembly can be seen in positive edges (05V) and microcontrollers can read it through input Its similar. Circuit circuit diagram The voltage sensor is shown below.

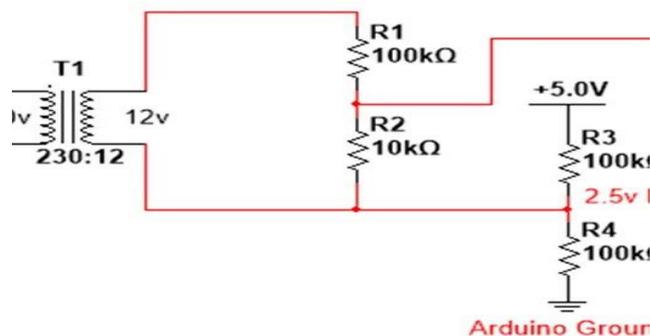


Fig.3 Voltage Sensor Circuit Diagram

A current transformer retrieves the current signal passing via the mains. The current signal is transformed into a voltage form by a burden resistor, which represents the properties of the current signal. A DC offset voltage of 2.5 volts to lift up the reference point and read the entire sinusoid in analogue mode within its operating range (0-5v). The current sensor circuit's circuit diagram is depicted in the diagram below.

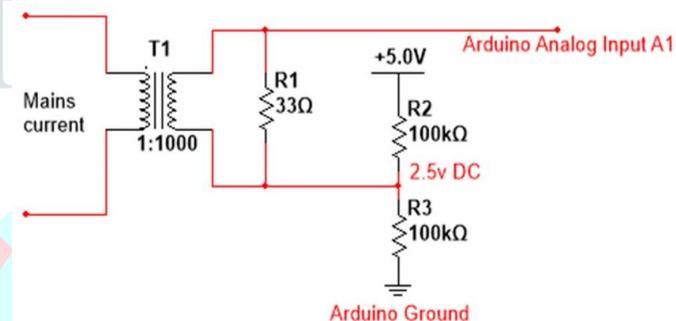


Fig.4 Current Sensor

In this project, Arduino is used. The Arduino IDE was used to create a program for the project's calculation and automatic operations, which was then burned onto the microcontroller.

The developed program calculates the network's V, I, P, S, Q, and $\cos \phi$.

The inductive load circuit is a collection of inductive loads that consume a lot of electricity due to the trailing $\cos \phi$. The circuit as a whole replicates a high-inductive load that operates at low frequency.

A high voltage circuit connects the loads and capacitors and is electrically separated from the high-voltage circuit. A relay is utilized to make capacitors on in a high voltage circuit utilizes a control signal from the microcontroller, in order to protect the microcontroller and electrically protected from the high-voltage circuit.

A condenser bank is an array of capacitors of different sizes. Various types of capacitance are provided by combining multiple capacitors in series and parallel to compensate for the insufficient $\cos \phi$.

Implemented design of the project is shown below

VI. SYSTEM OUTLINE



Fig.5 Project model

V. TECHNICAL SKETCH

Technological structure being categorised to three key steps:

- a. Calibration process
- b. Reactive power calculation process
- c. Capacitor switching.

a. Calibration Process:

Calibration is done by using voltage and current sensors used in the model. Determination of real, reactive and apparent power are done in Matlab software. Sensors used in our model are potential transformers and current transformers which are used to sense V and I respectively.

The V and I constants used in our model are 180 volts and 1.5 amps respectively as our reference. Exact phase calibration is done by using a pure resistor, $\cos \phi$ as 1, modifying the phase angle between voltage and current.

b. Reactive power calculation process:

The calibrated power variables are now used to measure the necessary reactive power. Let the existing $\cos \phi$ is $\cos \phi^1$, the desired $\cos \phi$ is $\cos \phi^2$, then

$$\begin{aligned} \text{Necessary Volt Ampere Reactive} &= P (\tan \phi^1 - \tan \phi^2) \\ \text{Required Farads, } C &= (\text{Volt Ampere Reactive} / 2\pi f V^2) \end{aligned}$$

P is the Active power in KiloWatts,
f refers to frequency (Hertz),
V refers to power system voltage.

c. Capacitor switching:

Banks of switch capacitors are connected to the core system. The capacitors in a distribution power system are normally connected in parallel rather than in series. Shunt power capacitors are used to provide leading KVAR to a power system whenever it is required.

The system's functional schema is depicted in the following diagram.

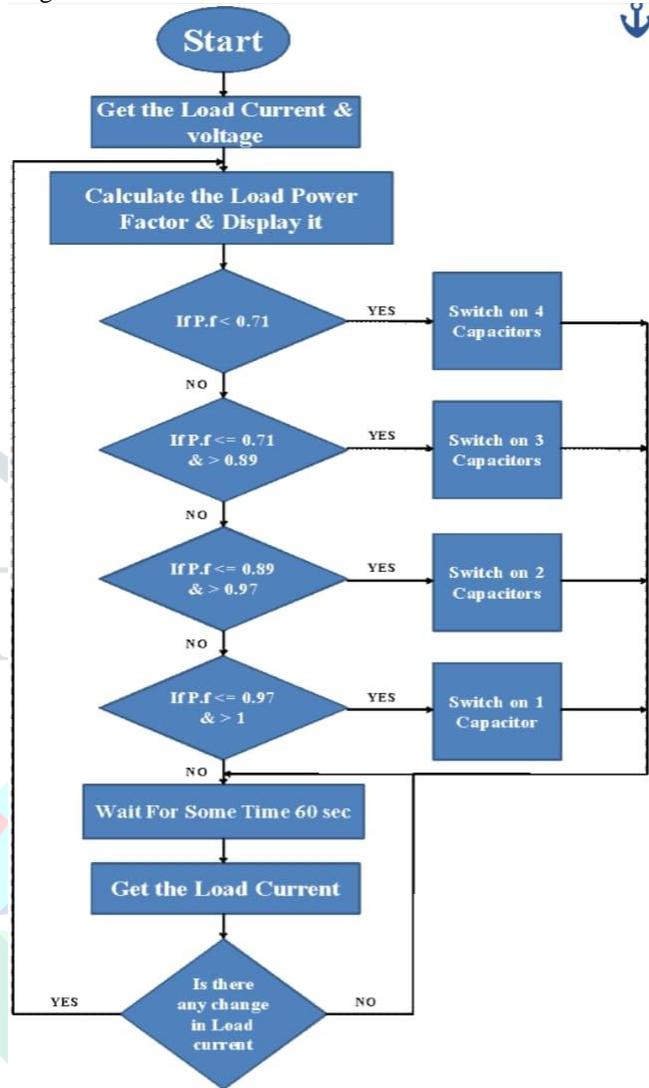


Fig.6 Flow Chart shows working of Model

VII. OUTCOMES

Some highly inductive loads were added to build a load network to show the operating process of the APFC and Energy Monitoring system. Various $\cos \phi$'s have been added with system connecting the combined loads. Demand network consists of a combination of passive elements and chain of inductors with high inductance values connected in series. When the resistance is lowered while keeping the inductance constant, the proportion of the inductance to the resistance film increases and the power factor decreases. As a result, the power factor of the system has decreased.

S No	Before Correction PF	Required Capacitance (Farads)	After Correction PF
1	0.86	1.3645	0.88
2	0.86	2.865	0.9
3	0.86	4.212	0.93
4	0.86	6.765	0.96
5	0.86	7.653	0.98

Table: Calculation of capacitance required

The above table shows the capacitance required to get the required power factor. Initially, the power factor is 0.86. After a capacitance of 1.3645 Farads, the power factor increased to 0.88. If we replace capacitance with 2.865 Farads, the power factor becomes 0.9. This process continued until we get desired power factor (>0.98).

The microcontroller detects the delay between the voltage and current produced by the load and connects the required capacitor value to optimize the system's power factor.

VIII. ADVANTAGES

The following are some of the advantages that may be obtained by using the right power factor correction:

- i.Reduced power usage due to greater energy efficiency.
- ii.As a result of lower electricity use, power plants emit less greenhouse gases and utilize less fossil fuels.
- iii.Electricity bills are reduced.
- iv.Extra kVA is only available from the existing supply.
- v.I²R losses in transmission and distribution equipment are reduced.
- vi.Voltage drop reductions on long wires.
- vii.Reduced electrical load on cables and electrical components, resulting in longer equipment life.

IX. CONCLUSION AND IMPLICATIONS FOR THE FUTURE

To improve the system's stability and efficiency this type of protection should be addressed. Capacitors should not be subjected to fast on off-on circumstances or overcorrection; otherwise, the capacitor bank's lifespan will be drastically reduced. The APFC system assists in drawing low current from the system and lowering utility costs. Reducing energy consumption is good for the environment by reducing greenhouse gas emissions and fossil fuel depletion at power plants.

The use of capacitive load banks for automated power factor adjustment is particularly efficient since it lowers price by reducing amount of energy required from utility services. Manpower is not required because it functions automatically, and thus this type of technology employing condenser-banks can be employed to industrial purposes in the future.

REFERENCES

- [1] Anish Kumar, L. Lohith Akshay, G. Yashwanth Reddy, B. Chandar, K. Vishnu "Automated Power Factor Correction and Surge Protection", IJERT, 23 June 2021.
- [2] Arin Juan Sari, M. Ary Murty and Ig Prasetya Dwi W "Power Factor Correction Control Based on Internet of Things Using Lumped Compensation Capacitor Bank" IEEE, Dec.2021
- [3] Wahab K., Rahal M. and Achkar R." Economic Improvement of Power Factor Correction ", 2021.

[4] "Hybrid Three-Phase Rectifiers with Active Power Factor Correction ", Department of Energy Technology, 23 June 2021.

[5] Rajan Sehgal, Ramakant Gupta, Sagar Sahariya and Sparsh Agarwal, "Power Factor Improvement in Distribution Network Using Shunt Capacitor ", 2021.

[6] Pooja Sabale and S.B Mohod, "Implementation of seven-level inverter with power factor correction ", Sep. 2021.

[7] "Power Factor Correction: A Guide for the Plant Engineer." www.eaton.com/. Eaton Corporation, Aug. 2014. Web. 14 July 2016

[8] W. Mack Grady and Robert J. Gillespie, "Harmonics and how they relate to power factor", Prof. of the EPRI power quality issues & opportunities conference (PQA'93), San Diego, CA, November 1993.

[9]. International Standard IEC 60831-1

[10]. International Standard IEC 60831-2

[11]. Impact of APFC Panel at LT Side of Transformer Bhogadi. Havya, K. Ravi Kumar (Associate Professor) Department of Electrical and Electronic Engineering, Vasavi College of Engineering, Hyderabad, Andhra Pradesh, India.

[12] P. N. Enjeti and R Martinez "A high-performance single-phase rectifier with input power factor correction", IEEE Trans. Power Electron...vol.11, No.2, Mar.2003.pp 311-317

[13] Alexander, C. K., & Sadiku, M. N. (2007). Fundamentals of electric circuits. Boston: McGraw-Hill Higher Education

[14] Stephen, J. C. (1999). "Electric Machinery and Power System Fundamentals." 3rd.ed. United State of America: McGraw-Hill Companies, Inc.

[15] MD Singh, K B Khanchandani. (2007), "Power Electronics" 2nd.ed. McGraw-Hill Companies, Inc.