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"Minimizing Penalty in Industrial Power Consumption By Engaging APFC Unit": A Review

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Abstract- *In the industrial sector the various motoring loads are continuously running and increasing the inductive load. So the power factor in this system get reduces due to the inductive reactive power. But the electricity board has a standard limit regarding the power factor values and if the power factor goes below the specified limit the electricity company charges the penalty to the industrial consumers. APFC device reads power factor from line voltage and line current by determining the delay in the arrival of the current signal with respect to voltage signal from the function generator with high accuracy by using an internal timer. This time values are the calibrated as phase angle and corresponding power factor. Then the values are displayed in Liquid crystal display modules. Then the motherboard calculates the compensation requirement and accordingly switches on different capacitor banks. This is developed by using AVR microcontroller.*

KEYWORDS: *Power factor, Penalty, AVR microcontroller, capacitor bank, contactors and current transformer, potential transformer*

1. INTRODUCTION

The low power factor leads to the increase in the load current, increase in power loss, and decrease in efficiency of the overall system. In previous various method use for power factor correction in all this method, the switching of the capacitor is manual. In this paper we are using a method of the reactive power compensation by capacitor switching with automatic control using AVR microcontroller [1].

1.2 POWER FACTOR

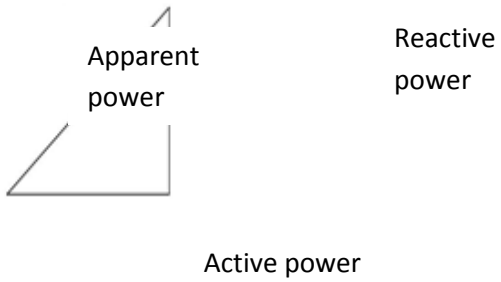

Fig -1: Power Triangle

The power factor is the ratio of the active power to the apparent power .The active power is the real power delivered to the loads such as motors, lamps etc. The reactive power is used just for the purpose of producing magnetic field for the flow of active power. The apparent power is the combination of the active and reactive power. The load current of any motor consist of the resistive component and inductive component. The inductive component consists of leakage current and magnetizing current. The leakage current is totally dependent on the load current but the magnetizing component is nearby 20 to 60% of the full load current. The capacitors are employed to reduce inductive reactance in the induction motor thereby reducing losses in the supply [2].

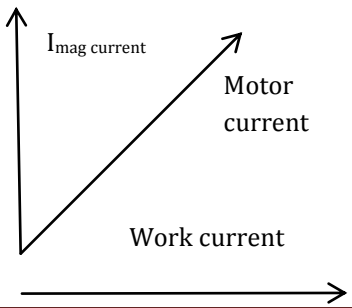

Fig -2: Inductor Current Vector Diagram

1.3 SOURCES OF REACTIVE POWER (INDUCTIVE LOADS) DECREASE THE POWER FACTOR [3]

-Transformers
-Induction Motors
-Induction generators (wind mill generators)
-High Intensity (HID) lighting

1.4 BENEFITS OF POWER FACTOR CORRECTION

The advantages that can be achieved by applying the power factor correction are [4]:

- Environmental benefit-reduction of power consumption due to improved energy efficiency. Reduced power consumption means less greenhouse gas emissions and fossil fuel depletion by power stations.
- Reduction of electricity bills.
- Extra kVA available from the existing supply.
- In transformers and distribution equipment I2R losses decrease.
- In long cables reduction of voltage drop.
- Extended equipment life- reduced electrical burden on cables and electrical Component.

2. PROPOSED SYSTEM

An AVR microcontroller is used in this project as a central processing unit to calculate the power factor and to switch the capacitors. The working of this project is explained with the help of the below block diagram.

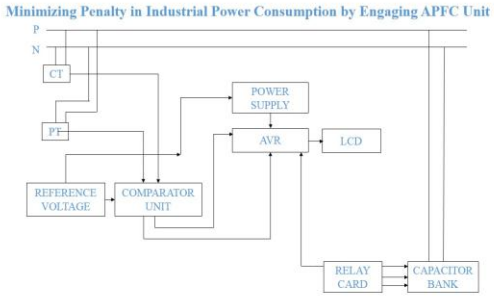

Fig -3: Block diagram of PFC using AVR microcontroller

It uses a potential transformer to supply the voltage to the Resistor divider network (like zero voltage crossing circuit), which detects the zero crossing of the voltage wave form. These voltage pulses from the operational amplifier are applied to the AVR microcontroller as interrupt signals. Similarly, a current transformer is used here to give the current wave to the Resistor divider network wherein the operational amplifier output is enabled for every 10 ms by comparing the zero position of the current with the predefined setting. This signal is also applied to the AVR microcontroller as an interrupt signal. The microcontroller finds time elapse between these two interrupts and substitutes it in a certain equation for calculating the power factor. If this power factor value is above 0.96 then the AVR doesn't send any command signals to the relay driver to switch the capacitors on. But, if it is less than 0.96, then the AVR sends command signals to the relay driver so that the capacitor bank on. Therefore, these capacitors reduce the lagging nature of the load by giving leading currents to it. The number of capacitors' switching depends on the value of the power factor – very low power factor needs all the capacitor, whereas high power factor needs none of those.

2.1 HARDWARE

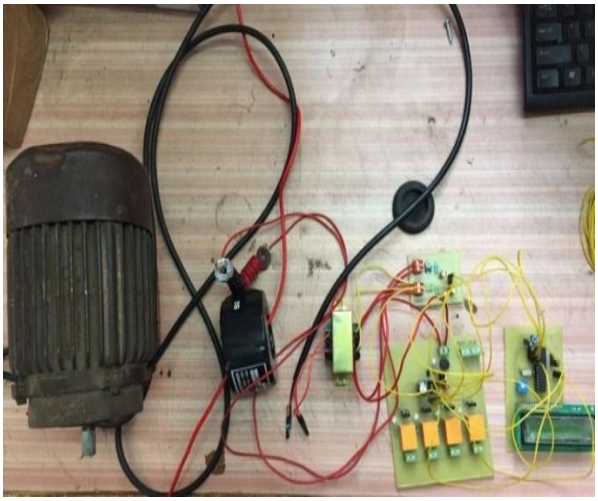

Fig -4: Hardware setup

The proposed work can be explained in the form of block diagram as shown in figure 3. It comprises of following 9 blocks [1],

- CT & PT
- Comparator unit

- Resistor divider network
- AVR
- LCD
- Relay
- Capacitor bank

2.1.1 Voltage & current measurement unit

Current transformer (CT) is connected series with line, and Potential transformer (PT) is connected parallel with supply line. CT & PT are used to step down the voltage and current for resistor divider network.

2.1.2 Comparator unit

It compares the value of voltage and current from CT and PT and gives this value to microcontroller.

2.1.3 Resistor divider network

Resistor voltage dividers are commonly used to create reference voltages, or to reduce the magnitude of a voltage so it can be measured. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them.

2.1.4 AVR

The ATmega328 is a single-chip microcontroller created by Atmel in the mega AVR family. The ATmega328 is commonly used in many projects and autonomous systems where a simple, low-powered, low-cost micro-controller is needed.

2.1.5 LCD

A microcontroller program must interact with the outside world using input and output devices that Communicate directly with a human being. One of the most common devices attached to a microcontroller is a Liquid crystal display. Some of the most common LCDs connected to the microcontroller are 16x2 and 20x2 displays.

2.1.6 Relay

Relay outputs are provided which operate to connect or disconnect the capacitor banks depending upon of the power factor conditions.

2.1.7 Capacitor bank

Capacitor bank is an assembly of number of capacitors which are used to contribute KVAr in the electrical system and finally improve the power factor. Shunt capacitors bank are arrangements of series/paralleled connected units.

2.1.8 SOFTWARE REQUIREMENT

Arduino sketch software

2.3 RESULT

Use of induction motor as load various readings are arrive .at time of no load value of current I_{rms} is 0.02mA and for induction motor it is 0.18mA.Below figure show the various reading taken at time of load(induction motor).

Apparent power	Real power	voltage	current	Power factor
019	020	237	0.09	0.95
019	020	236	0.09	0.97
019	020	238	0.09	0.96
019	020	237	0.09	0.96
019	021	237	0.08	0.96
019	020	237	0.08	0.97
019	020	237	0.09	0.97

Power factor						
Before	0.67	0.75	0.77	0.77	0.77	0.77
After	0.95	0.96	0.7	0.97	0.94	0.97

Fig -5: Testing result

3. CONCLUSION

In our project "Minimizing Penalty in Industrial Power Consumption by Engaging APFC Unit" in which the advanced method of the power factor correction by using the AVR and Automatic power factor correction unit which has the many advantages over the various methods of the power factor correction. The switching of capacitors is done automatically by using the contactors and thus the power factor correction is more accurate. Thus in this paper presented the possible advanced method for the correction of the power factor.

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