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Microcontroller Based Automatic Power Factor Improvement

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***Abstract*: Electric energy being the only form of energy which can be easily converted to any other form plays a vital role for the growth of any industry. The Power Factor gives an idea about the efficiency of the system to do useful work out of the supplied electric power. Thus, the aim is to inject capacitances of required values when the power factor falls below the specified level. Primarily, a signal of pulse width proportional to the phase difference is generated. From the ON time period of each pulse the power factor can be determined. A low value of power factor leads to increase is electric losses and also draws penalty by the utility. Significant savings in utility power costs can be realized by keeping up an average monthly power factor close to unity. To improve the power factor to desired level, reactive power compensators are used in the substations. The exact value of the capacitance to be injected is then found out using some mathematics. Micro-controller will switch all the capacitors, which taken together is very close to the exact value of the capacitance.**

***Keywords*: Capacitance, Micro-controller, Power factor.**

1. Introduction

Automatic power factor correction techniques can be applied to industrial units, power systems and also households to make them stable. As a result, the system becomes stable and efficiency of the system as well as of the apparatus increases. Therefore, the use of microcontroller based power factor corrector results in reduced overall costs for both the consumers and the suppliers of electrical energy. Power factor correction using capacitor banks reduces reactive power consumption which will lead to minimization of losses and at the same time increases the electrical system's efficiency. Power saving issues and reactive power management has led to the development of single phase capacitor banks for domestic and industrial applications. The development of this seminar is to enhance and upgrade the operation of single phase capacitor banks by developing a microprocessor based control system. The control unit will be able to control capacitor bank operating steps based on the varying load current. Current transformer is used to measure the load current for sampling purposes. Intelligent control using this micro-processor control unit ensures even utilization of capacitor steps, minimizes number of switching operations and optimizes power factor correction.

In the present scenario there is huge number of loads are Inductive in nature. This Inductive loads drawn inductive current and this inductive current result into large phase angle between voltage and current of source and this deflection between them cause lagging power factor. This lagging power factor result in flowing of reactive current which causes power loss, unstability of power supply, increase in cost, etc. Due to these losses, power factor should be unity or near about unity which reduce electricity bills, improve stability etc.

Power factor can be improved by using the three methods-

1. By using the synchronous motor as synchronous condenser.
2. By using the phase advancers.
3. By using the capacitors bank.

2. Related Work

A. Power Factor

The power factor (PF) 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" 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. It is schematically shown in Fig. 1.

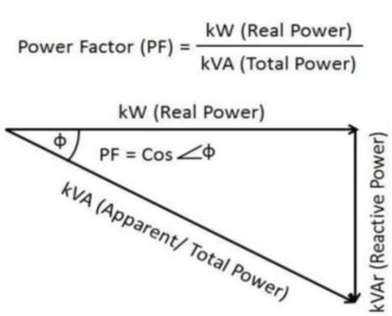

Fig. 1. Schematic diagram for power factor

A load with a power factor of 1.0 result in the most efficient loading of the supply and a load with a power factor of 0.5 will result in much higher losses in the supply system. A poor power factor can be the result of either a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or distorted/ discontinuous current waveform. Poor load current phase angle is generally the result of an inductive load such as an induction motor, power transformer, lighting ballasts, welder or induction furnace.

A poor power factor due to an inductive load can be improved by the addition of power factor correction, but, a poor power factor due to a distorted current waveform requires a change in equipment design or expensive harmonic filters to gain an appreciable improvement. To have an efficient system the power factor should be maintained near to 1. Utilities typically charge additional costs to commercial customers who have a power factor below some limit, which is typically 0.9 to 0.95.

B. Power Factor Correction

Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor (PF) that is less than 1. 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. Capacitive Power Factor correction is applied to circuits which include induction motors as a means of reducing the inductive component of the current and thereby reduce the losses in the supply. Capacitors connected at each starter and controlled by each starter are known as "Static Power Factor Correction".

Resistive constituent of motor current are:

i. Load current
ii. Loss current

Inductive constituent of motor current are:

i. Leakage reactance
ii. Magnetizing current

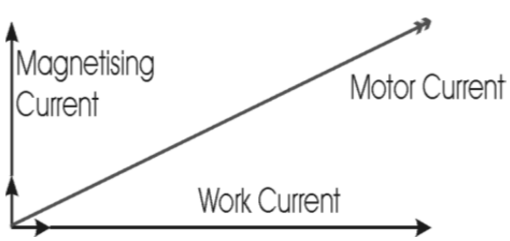

Fig. 2. Power factor correction

3. Circuit Diagram

The line current and the line voltage are first stepped down using C.T and P.T. The objective is to produce a signal having pulse width proportional to the phase difference between voltage and current. Thus, to realize this, the stepped down voltage and the line current are applied to the zero-crossing detectors (ZCD1 and ZCD2 respectively). The output voltage waveforms from ZCD1 and ZCD2. The outputs from ZCD1 and ZCD2 are fed to the 2 input XOR gate. The XOR gate results high only when one input is low and the other input is high. Hence, the output of the XOR gate is a series of pulses whose width is proportional to the phase difference between the two signals.

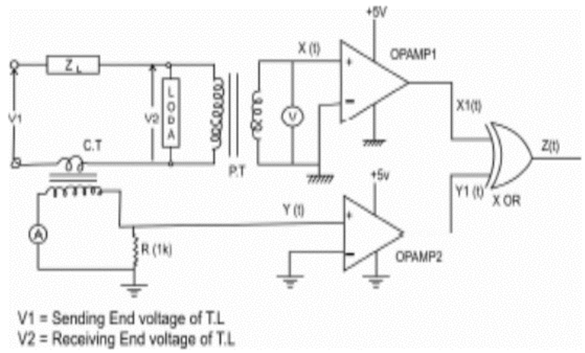

Fig. 3. Circuit diagram of detection of power factor

The line current and the line voltage are first stepped down using C.T and P.T. The objective is to produce a signal having pulse width proportional to the phase difference between voltage and current. Thus, to realize this, the stepped down voltage and the line current are applied to the zero-crossing detectors (ZCD1 and ZCD2 respectively). The output voltage waveforms from ZCD1 and ZCD2. The outputs from ZCD1 and ZCD2 are fed to the 2 input XOR gate. The XOR gate results high only when one input is low and the other input is high. Hence, the output of the XOR gate is a series of pulses whose width is proportional to the phase difference between the two signals.

In the above block diagram there is the supply signal Voltage and current is given by CT and PT to the rectifier unit which converts these ac signals to dc signal. Then this dc supply is given to regulator. There is regulator 7805 is used. +ve 12V supply is given to ZCD(V) and ZCD(C) for their operation and also give to the LCD display unit. +ve 5V supply is given to microcontroller. Operational amplifier act as comparator and generate dual pulses. These pulses are given to two interrupt pin that is INT0 and INT1 of microcontroller PIC 16F887.

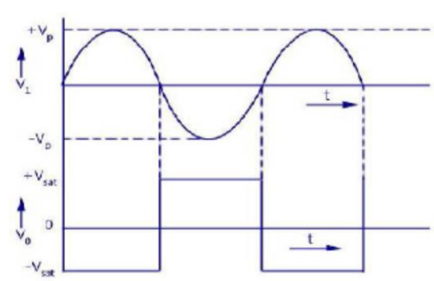

Fig. 4. Waveforms

Microcontroller have internal timer circuit which calculate time in millisecond which then convert into phase angle and power factor will display on LCD. If Power factor will be low then microcontroller give signal to relay driver ICULN2003A which actuates relay which help in connection of capacitor with the power supply. Thus Power factor will be improved and show on LCD.

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