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A Novel Approach for Power Factor Correction Using Microcontroller in Domestic Loads

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Abstract: The need for power factor correction is for compensating the lagging reactive power due to the highly varying inductive loads and is done by either switching on the capacitor banks or by synchronous condenser. Presently, capacitors switching is done manually. The disadvantages are definite time lag, reduction in operating efficiency and lower reliability of the entire system. In the present modern trends of computerization, the use of computers and microcontrollers can also be applied to solve this problem. In this paper, we have utilized the most common microcontroller for the purpose of switching on or off the capacitor banks. In today's trend there is ever growing demand for power and more stress is being laid on optimum utilization of available power. This is where power factor plays a vital role. For efficient utilization of electrical power, power factor of the system should be high.

Key words: Power factor · Microcontroller · Capacitors · Power utilization · Reactive power

INTRODUCTION

In the today's trend there is ever growing demand for power and more stress is being laid on optimum utilisation of available power. This is where power factor plays a vital role. For efficient utilisation of electrical power, power factor of the system should be high. To obtain the best possible economic advantage from electric power, both generating and consumer plants should be operated at high efficiency, to achieve this it is essential to have a high power factor throughout the system.

Most of the machines operated in industries have a inherent low power factor which means that supply authorities have to generate much more current than theoretical requirements. In addition, transformers and cables have to carry this extra current, when the overall power factor of generating system is insufficient and the loss of power goes high, to avoid this power factor improvement is a must.

The methods employed to activate the improvements involves injecting KVAR into the system in phase opposition to wattless current and effectively cancel its effect in the system [1]. The power factor can be improved by connecting devices like static capacitors or synchronous condensers which takes a leading power in parallel with load. They are compact, reliable, highly efficient and they can be used easily for automatic power factor control [2].

Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying reactive power of opposite sign, adding 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. If a load had a capacitive value, inductors (also known as *reactors* in this context) are connected to correct the power factor. In the electricity industry, inductors are said to consume reactive power and capacitors are said to supply it, even though the reactive power is actually just moving back and forth on each AC cycle [3, 4].

The low power factor is mainly due to the fact that most of the power loads are inductive and therefore take lagging current. In order to improve the power factor, some devices taking leading power should be connected parallel with the load. One such device can be a capacitor. The capacitor draws a leading current and partly or completely neutralizes the lagging reactive component of load current. This raises the power factor of the load [5, 6]. Rather going for a intelligence technique or power factor correction can be done by power electronics switches for better output results, here Microcontroller is used in combination of synchronous condensers in order check the economic constraints and output error values compared with some other intelligence technique since it is proposed for using in the domestic loads [7-9].

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AUTOMATIC POWER FACTOR CORRECTION

Basically in a large power system, an automatic power factor correction unit is used to improve power factor. A power factor correction unit usually 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. To be able to measure 'power factor', the regulator uses a CT (Current transformer) to measure the current in one phase [10].

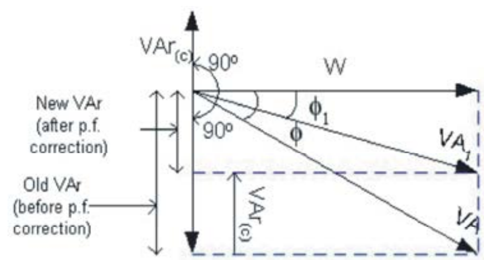

Fig. 1: Phasor Diagram for power factor correction

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 0.9 or other selected values (usually demanded by the energy supplier) [11].

Instead of using 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. This is referred to as a synchronous condenser. It is started and connected to the electrical network. It operates at full 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 condenser's installation and operation are identical to large electric motors. Its principal advantage is the ease with which the amount of correction can be adjusted; it behaves like an electrically variable capacitor [12]. Unlike capacitors, the amount of reactive power supplied is proportional to voltage, not the square of voltage; this improves voltage stability on large networks [13]. Synchronous condensers are often used in connection with high voltage direct current transmission projects or in large industrial plants such as steel mills. So instead of synchronous condensers normal capacitors can be used for domestic loads [14, 15].

Proposed Methodology: In this methodology, we propose the hardware for the automatic power correction for domestic loads, which in turn can be connected with input supply of the secondary consumers. So that the power factor can be maintained at a rate of 0.8 to 0.9 which in turn reduce the power loss due to minimized power factor. A standard 5V dc supply is given from the supply unit. First of all a 230V supply is stepped down to 9V. The voltage at the secondary is then passed to the bridge rectifier. The 9V ac is converted to dc. From there it is passed to the voltage regulator circuit. The output of the voltage regulator is a standard 5V dc supply. This 5V supply is given to the zero crossing detectors, microcontroller, LCD display, inverter circuit etc.

The line voltage is given to the potential transformer. Similarly current is passed to the current transformer from the line. The voltage and current are stepped down in the potential and current transformer respectively. Then the voltage and current from the instrumentation transformer are passed to the zero crossing detectors. Here the sine wave inputs are converted to square wave outputs of either two states, high or low.

Then the output voltage and current waveform are given to microcontroller to port 1.0 and 1.1 respectively. In the microcontroller difference in the instant of crossing zero is calculated by using timer in the program. After skipping a high and low pulse of voltage waveform timer starts counting (T1). This is continued for a full cycle of the voltage waveform. The above process is repeated for the current waveform with reference to the reference point of the voltage waveform (T2).

Φ is calculated by using the conversion,

$\Phi = (T2 * 360)/T1$

From the look up table corresponding cos Φ is calculated. This calculated power factor is then compared with the reference power factor. If the calculated power factor is less than the reference power factor then a low pulse is given to 7404IC which sends a high pulse to the relay circuit which in turn close the capacitor bank. If the calculated power factor is more than the reference power factor then a high pulse is given to 7404IC, which will send a low pulse to the relay circuit. Thus the closed capacitor bank gets disconnected from the circuit. All the above mentioned processes are repeated for infinite loop.

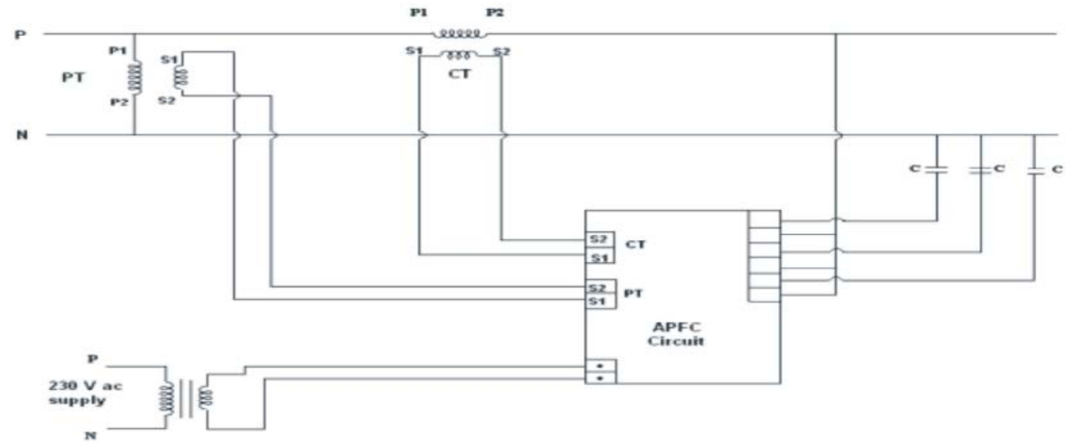

Fig. 2: Power circuit for proposed system

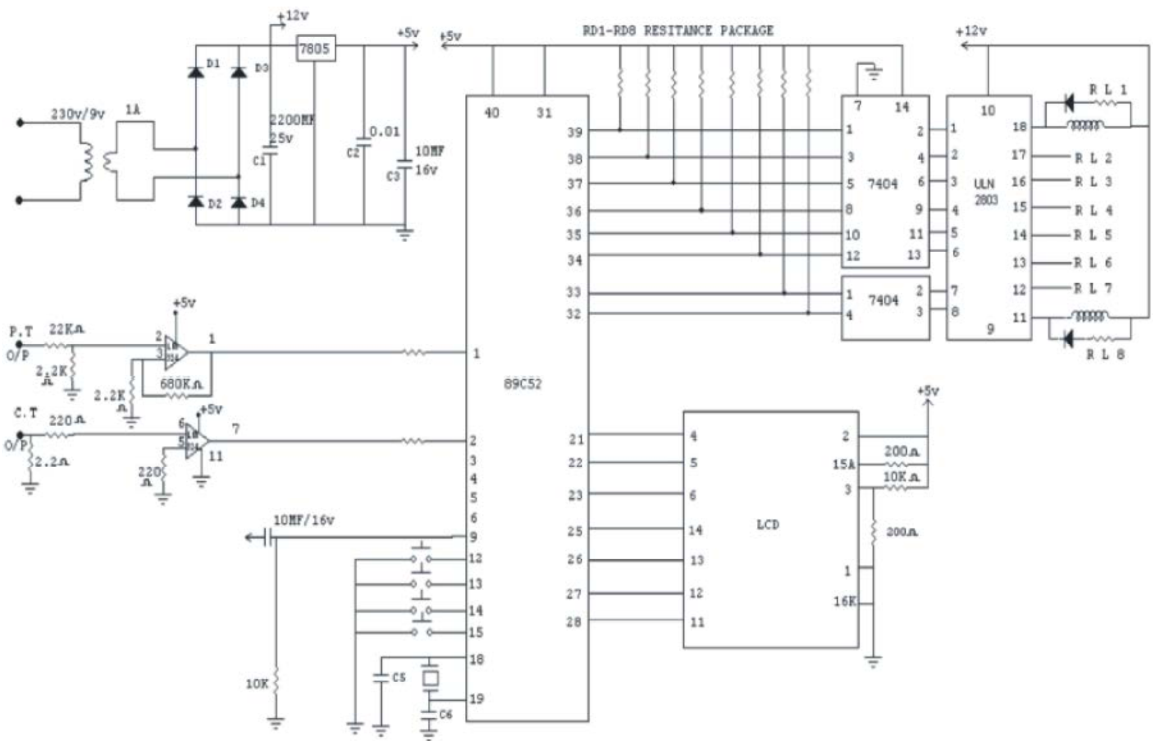

Fig. 3: APFC Circuit Diagram for proposed system

The actual value, preset value and corrected value is displayed through the LCD display. When the supply is turned on, the first screen of the LCD display is “power factor controller”. To see the preset value and the actual value, the menu key is pressed. In other words, to view the next screen, the menu key is pressed. The preset value can be incremented or decremented by using the increment key or the decrement key. This updated value is made reference by pressing the enter key At the beginning high signal is given to alarm circuit to avoid the working of relays under normal conditions. For this purpose alarm the program initializes circuit. As per the program low signal will be given as an alarm to the switching circuit, which in turn activates the relay. If measured power factor is less than the reference power factor, then the alarm is given to relays.

To calculate the time period of voltage waveform for a complete 360 degree a reference point is fixed by skipping a high and low pulse. Then the timer starts counting as per the software (T1). From the same reference point, time period for current waveform is calculated (T2).

$$\Phi = (T2 * 360)/T1$$

The controller using timers measures power factor. This is explained through waveforms as follows,

Actual cosφ is calculated from the look-up table. Using DPTR register does this. At the beginning of the program, a reference power factor is set and stored in the internal data memory. This reference power factor is compared with the calculated or actual power factor. If the carry flag is set, then controller will send a low signal to relay circuit. Carry flag is set means reference power factor is higher than the calculated power factor.

LCD display displays the calculated and reference power factor and has the provision to increment or to decrement the reference power factor. Using the inc/dec keys does this.

DISCUSSIONS

So, the proposed hardware for the automatic power correction for domestic loads, which in turn can be connected with input supply of the secondary consumers. So that the power factor can be maintained at a rate of 0.8 to 0.9 which in turn reduce the power loss due to minimized power factor. A novel approach has been proposed here for implementing this in the state of Tamilnadu for all the secondary consumers. Which would help us to save a loads in our consumption and losses due to power factor. The various salient features of the system developed by us are mentioned below

- Fully automated control will be available to control power factor.
- This system consumes less power and hence there is not much of effect in regulation as a result of this power.
- Easy control and switching is possible in our system. This is because we use static capacitors banks for power factor improvement and also, they are added or removed in steps.
- The proposed system is highly accurate, precise and also has a quick response. Hence it is very efficient and economic.

So, the system proposed will work to a great extend in the power factor correction in domestic loads which would move the power consumption to further level of energy saving.

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