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Implementation of Thyristor Switched Capacitors for Power Factor Improvement

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Abstract

This paper provides Thyristor Switched Capacitor controlled by help of programmed microcontroller where it is depicted that the power factor can be improved to unity with light loading and can be maintained to around 0.98 with increase in system loading. This paper provides implementation done on 8051 microcontroller using Keil software to program the microcontroller, PSpice to determine time lag between current and voltage and Proteus to display power factor according to the load. Whenever an inductive load is connected to the transmission line, power factor lags because of lagging load current. To compensate for this, a shunt capacitor is connected which draws current leading the source voltage. The net result is improvement in power factor. The time lag between the zero voltage pulse and zero current pulse duly generated by suitable operational amplifier circuits in comparator mode are fed to two interrupt pins of the 8 bit microcontroller of 8051 family. Thereafter program takes over to actuate appropriate number of opto-isolators duly interfaced to back to back SCRs. This results in bringing shunt capacitors into the load circuit to get the power factor till it reaches unity. Keywords-Thyristor Switched Capacitor (TSC), Keil, PSpice, Proteus, Power factor improvement

1. Introduction

Unlike Director Current Circuits, where only resistance restricts the current flow, in Alternating Current Circuits, there are other circuits aspects which determines the current flow; though these are akin to resistance, they do not consume power, but loads

the system with reactive currents; like D.C. circuits where the current multiplied by voltage gives watts, here the same gives only Volt Amperes (VA). Reactance is caused by either inductance or by capacitance. The current drawn by inductance lags the voltage while the one by capacitance leads the voltage. Almost all industrial loads are inductive in nature and hence draw lagging wattles current, whichunnecessarily load the system, performing no work. Since the capacitive currents is leading in nature, loading the system with capacitors wipes out them. The lower the power factor, the worse the situation becomes from the supply authorities' viewpoint. Accordingly, consumers are encouraged to improve their load power factor and in many cases are penalized if they do not. Improving the power factor means reducing the angle of lag between supply voltage and supply current.

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.The reactive elements 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 a 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.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 current transformer to measure the current in one phase.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 (usually demanded by the energy supplier), say 0.9.

2. System Modelling

This circuit consists of DC power supply unit, zero voltage crossing detectors, Micro-controller, LCD display, opto-isolator, SCR and Capacitor. The required DC power supply for Micro-controller and other peripherals is supplied by the DC power supply.

For the calculation of the power factor by the Micro-controller we need digitized voltage and current signals. The voltage signal from the mains is taken and it is converted into pulsating DC by bridge rectifier and is given to a comparator which generates the digital voltage signal. Similarly the current signal is converted into the voltage signal by taking the voltage drop of the load current across a resistor of 10 ohms.

This A.C signal is again converted into the digital signal as done for the voltage signal. Then these digitized voltage and current signals are sent to the micro-controller. The micro-controller calculates the time difference between the zero crossing points of current and voltage, which is directly proportional to the power factor and it determines the range in which the power factor is. Micro-controller sends information

regarding time difference between current and voltage and power factor to the LCD display to display them. Depending on the range it sends the signals to the opto-isolators that in turn switch ON back to back connected SCRs (power switches) to bring the capacitors in shunt across the load. Thus, the required numbers of capacitors are connected in parallel to the load as required. By this the power factor will be improved.

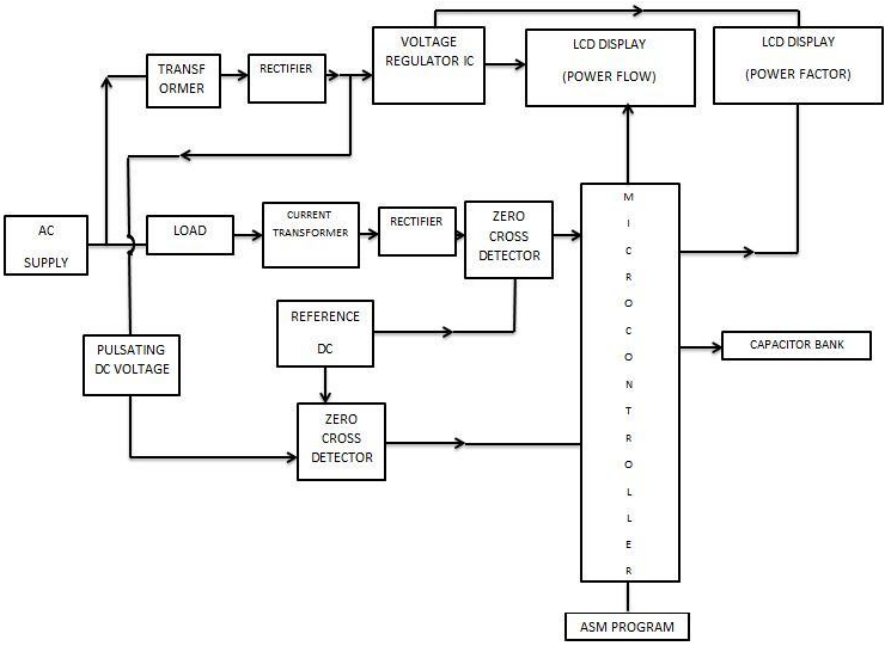

Fig. 1: Block diagram for power factor improvement using Thyristor Switched Capacitor.

3. Software Used and Implementation

Keil is aGerman based Software development company which has been used to program the 8051 microcontroller.It provides several development tools likeIDE (Integrated Development environment), Project Manager,Simulator, Debugger, C Cross Compiler, Cross Assembler, Locator/Linker.

OrCadPSpice is a SPICE analog circuit and digital logic simulation program for Microsoft Windows. The name is an acronym for Personal SPICE - SPICE itself being an acronym for Simulation Program with Integrated Circuit Emphasis. SPICE (Simulated Program with Integrated Circuit Emphasis) is a general purpose software that simulates different circuits and can perform various analysis of electrical and electronic circuits.It has been used to determine time lag between current and voltage.

Proteusis software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is developed by Labcenter Electronics.It has been used to display power factor according to the load.

4. Simulation and Results

4.1 Description of Zero Voltage Sensing

In order to generate Zero crossing Voltage Pulses first we need to step down the supply voltage to 12 V and then it is converted into pulsating D.C. Then with the help of potential divider the voltage of 3 V is taken, which is given to a comparator. The comparator generates the zero crossing pulses by comparing this pulsating D.C with a constant D.C voltage of 0.6 V which is taken across a diode.

Similarly for Zero Crossing Current Pulses the voltage drop proportional to the load current across a resistor is taken and is stepped up to generate Zero Crossing Current Pulses same as above. The zero crossing pulses from a pulsating D.C are shown in the figure.

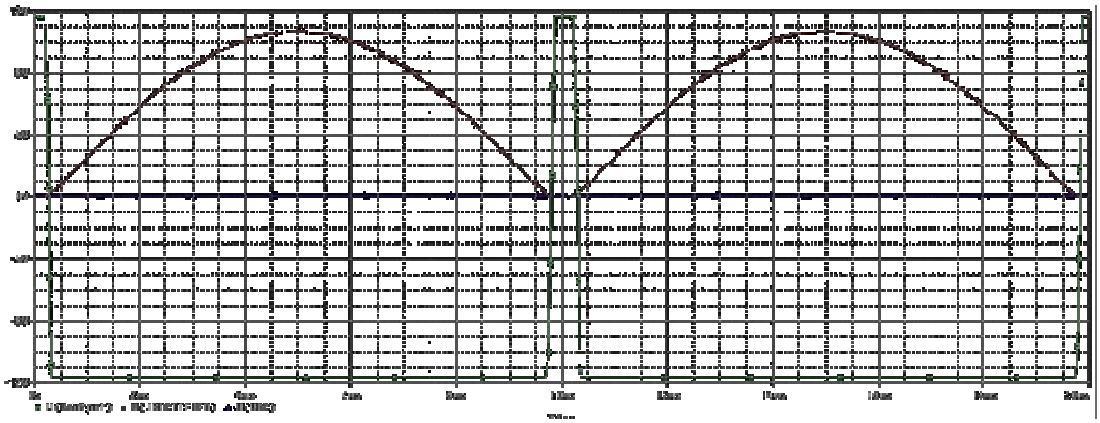

Fig. 2: Zero crossing pulses using OrcadPSpice.

Table 1: Power Factor according to the time lag.

Delay between voltage and current (in micro seconds)	Power Factor
Greater than 9000 and between 0 to 450	1
450 to 550	0.987
550 to 650	0.982
650 to 750	0.968
850 to 950	0.960
950 to 1150	0.940
1150 to 1250	0.929
1250 to 1350	0.917

5. Conclusions

This paper presents simulation of automatic switching of capacitor bank for power factor improvement. Power factor improvement is very useful in any installation as low power factor when corrected, leads to consequent saving in charges, by way of reduced demand charges, and lesser low power factor penalties. Apart from penalties

like maximum demand charges, penalty for low power factor, the factory cabling and supply equipment can be relieved of a considerable wattless or reactive load, which will enable additional machinery to be connected to the supply without enlarging these services. Additionally, the voltage drop in the system is reduced.

The method employed to achieve the improvements outlined involves introducing reactive power into the system in phase opposition to the wattless or reactive current mentioned above which effectively cancels its ill impact in the system. It is evident from the simulation results that the microcontroller based Thyristor Switched Capacitor is providing a better power factor to nearly unity with light loading and can be maintained to around 0.98 with increase in system loading.

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