

## Thyristor Controlled Reactor for Power Factor Improvement

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### ABSTRACT

Power factor improvement is the essence of any power sector for reliable operation. This paper provides Thyristor Controlled Reactor regulated by programmed microcontroller which aids in improving power factor and retaining it close to unity under various loading conditions. The implementation is done on 8051 microcontroller which is programmed using Keil software. To determine time lag between current and voltage PSpice software is used and to display power factor according to the variation in load Proteus software is used. Whenever a capacitive load is connected to the transmission line a shunt reactor is connected which injects lagging reactive VARs to the power system. As a result the power factor is improved. The results given in this paper provides suitable microcontroller based reactive power compensation and power factor improvement technique using a Thyristor Controlled Reactor module.

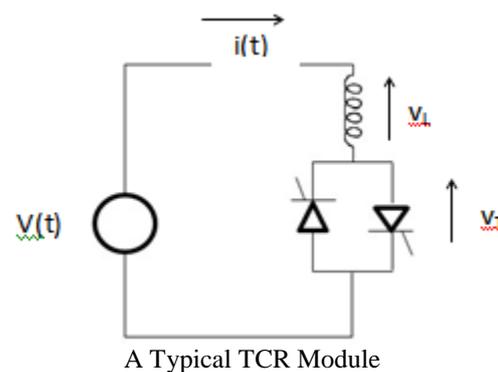
**Keywords**-Thyristor Controlled Reactor (TCR), Keil, PSpice, Proteus, Power factor improvement

### I. INTRODUCTION

In AC system; reactive power is utilized for developing magnetic field in a coil. The transformer, reactors, motors are the major consumer of reactive power. Reactive power is either generated or consumed in almost every component of the system, generation, transmission, and distribution and eventually by the loads. The impedance of a branch of a circuit in an AC system consists of two components, resistance and reactance. TCR and Thyristor Switched Reactor (TSR) both are composed of a shunt-connected reactor controlled by two parallel, reverse-connected thyristors. TCR is controlled with proper firing angle input to operate in a continuous manner, while TSR is controlled without firing angle control which results in a step change in reactance.

Reactance can be either inductive or capacitive, which contribute to reactive power in the circuit. Most of the loads are inductive, and must be supplied with lagging reactive power. It is economical to supply this reactive power closer to the load in the distribution system. Reactive power compensation in power systems can be either shunt or series.

TSC shares similar composition and same operational mode as TSR, but the reactor is replaced by a capacitor. The reactance can only be either fully connected or fully disconnected zero due to the characteristic of capacitor. With different combinations of TCR/TSR, TSC and fixed capacitors, meet various requirements to absorb/supply reactive power from/to the transmission line.



A thyristor-controlled reactor (TCR) is a reactance connected in series with a bidirectional thyristor valve. The thyristor valve is phase-controlled, which allows the value of delivered reactive power to be adjusted to meet varying system conditions. Thyristor-controlled reactors can be used for limiting voltage rises on lightly loaded transmission lines. The current in the TCR is varied from maximum (determined by the connection voltage and the inductance of the reactor) to almost zero by varying the firing delay angle.

Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying reactive power of opposite sign, adding inductors which act to cancel the capacitive effect of the load. When switched on or off the reactive elements can create voltage fluctuations and harmonic noise. A power factor correction unit consists of a number of inductors 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 inductors in steps to make sure the power factor stays above a selected value.

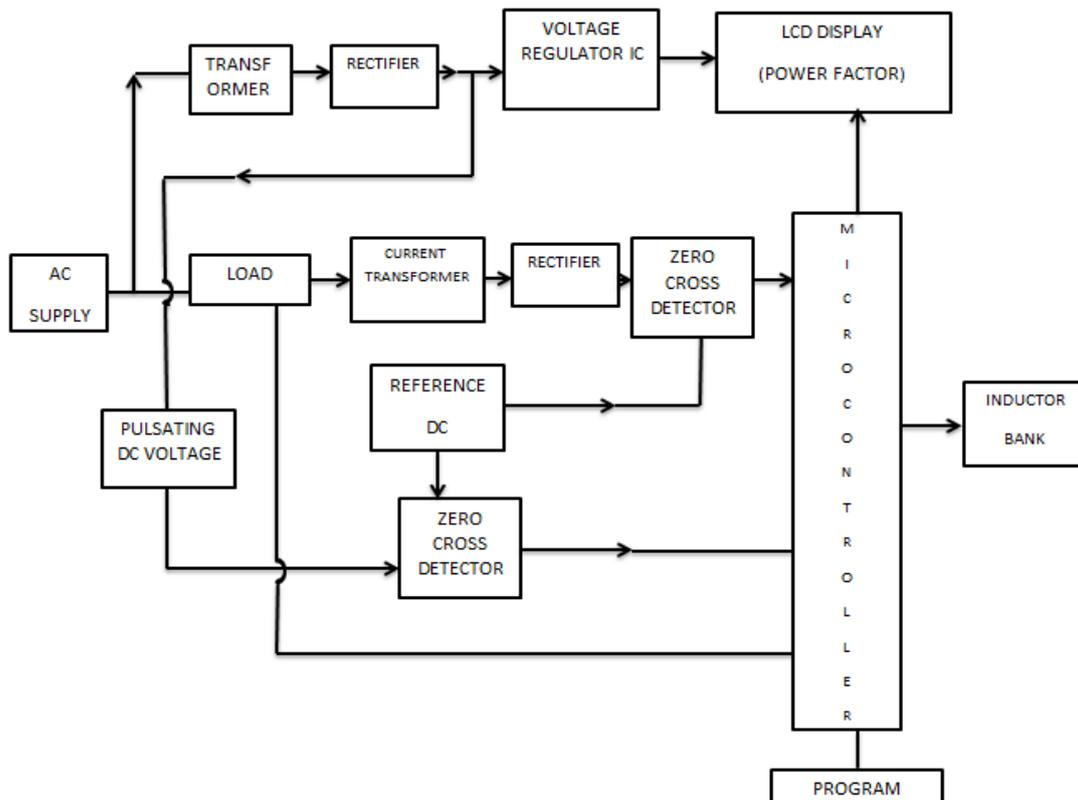
## II. SYSTEM MODELLING

This system modelling provides implementation of a similar Thyristor controlled Reactor model using a microcontroller based switching of inductor bank. It consists of DC power supply unit, zero voltage crossing detectors, Micro-controller, LCD display, opto-isolator, SCR and inductor. The required DC power supply for Micro-controller and other peripherals is supplied by the DC power supply.

We need digitized voltage and current signals for the calculation of the power factor by the

Micro-controller. The AC voltage signal 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. 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.



Block diagram for power factor improvement using Thyristor Controlled Reactor

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 inductors in shunt across the load. Optical isolator, is a component that transfers electrical signals between two isolated circuits by using light. opto-isolators are suitable for providing electrical isolation, solid-state relaying, logic level converting, transmitting digital

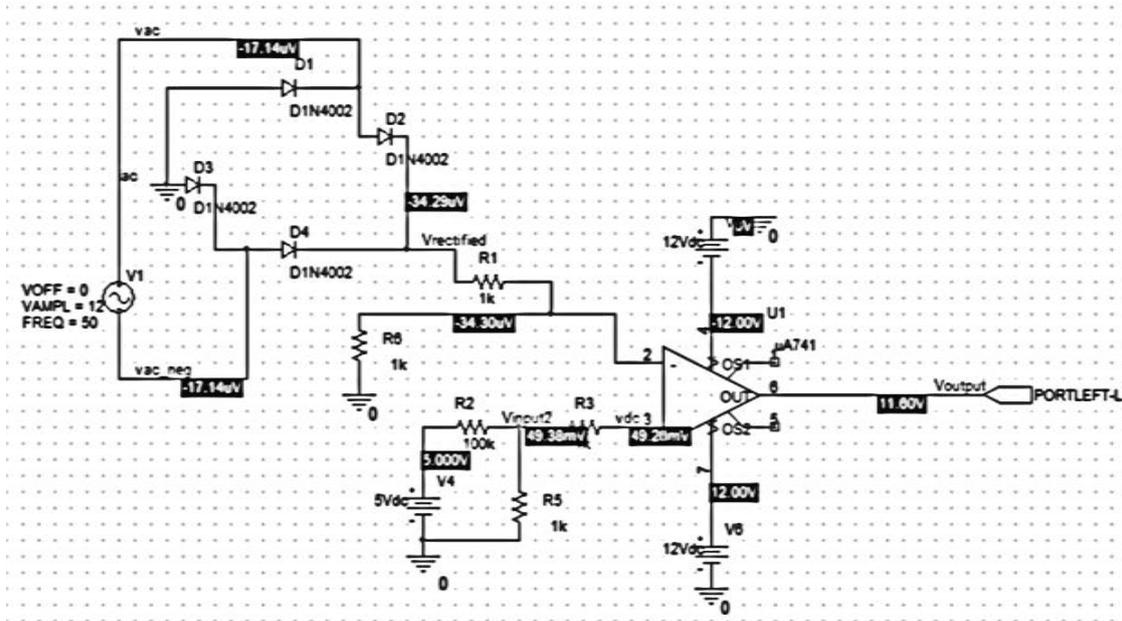
(on/off) signals (but some techniques allow use with analog (proportional) signals). Usually, opto-isolators are enclosed in a dark container wherein the source and sensor - collectively referred to as a closed pair in such cases- are facing each other. Thus, the required numbers of inductors are connected in parallel to the load as required. By this the power factor will be improved.

### III. SOFTWARE USED AND IMPLEMENTATION

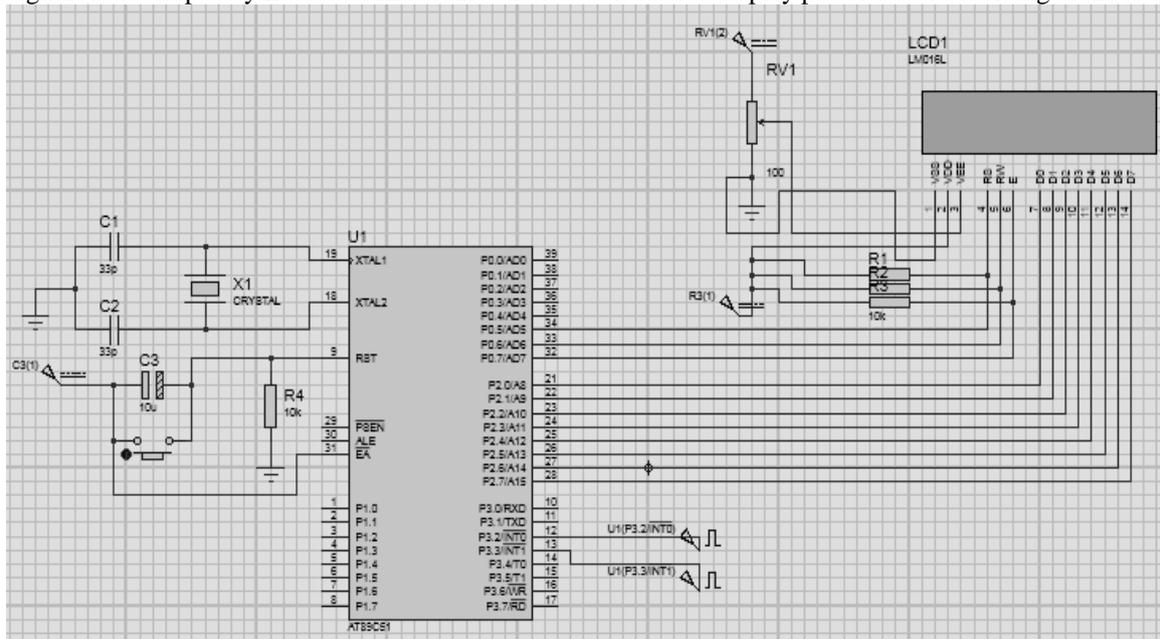
Keil is a German based Software development company which has been used to program the 8051 microcontroller. It provides several development tools like IDE (Integrated Development environment), Project Manager, Simulator, Debugger, C Cross Compiler, Cross Assembler, Locator/ Linker.

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. In the system modelling the time lag between voltage and current reflects the operating power factor of the system.



Proteus is 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.

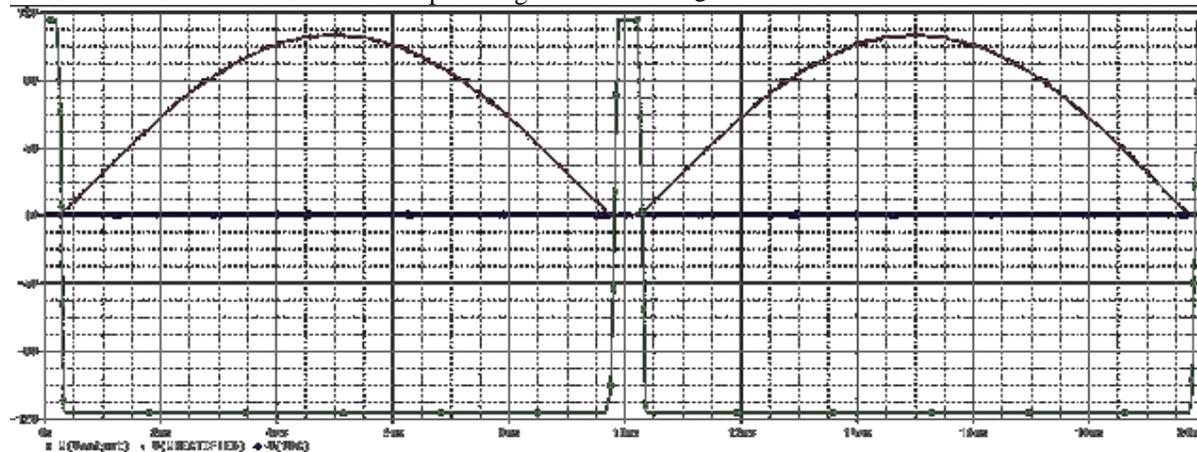


## IV. SIMULATION AND RESULTS

### 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.



Zero crossing pulses using OrcadPSpice

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.

Power Factor according to the time lag

Delay between voltage and current (in micro seconds)	Power Factor	Improved Power Factor
Greater than 9000 and between 0 to 450	1	1
450 to 550	0.987	0.989
550 to 650	0.982	0.989
650 to 750	0.968	0.989
850 to 950	0.960	0.987
950 to 1150	0.940	0.985
1150 to 1250	0.929	0.985
1250 to 1350	0.917	0.985

## V. CONCLUSION

This paper presents simulation of automatic switching of inductor bank for power factor improvement in a microcontroller based TCR module. 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. 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 which leads to a more reliable and secure operation.

The method employed to achieve the improvements outlined above involves introducing reactive power into the system in phase opposition to the wattless or reactive current which effectively cancels its ill impact in the system. It is evident from

the simulation results that the microcontroller based Thyristor Controlled Reactor 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.

## REFERENCES

- [1] P. N. Enjeti and R Martinez, A high performance single phase rectifier with input power factor correction (2003), IEEE Trans. Power Electron., Vol.11, No.2, pp. 311-317.
- [2] Md M. Biswas, Kamol K. Das (2011), Voltage level improving using VAR compensator, Global Journals Inc., Vol.11, Issue 5.
- [3] M.Prasad, R.S. Moni, P.Hatvarsson, "Systems Aspects on Enhanced Stability using Static VAR Compensation (SVC) and Thyristor controlled series capacitor

- (TCSC)", Transmission & Distribution in 2000 Technical conference February 1996, pp. 15-19.
- [4] VenuYarlagadda, B. V. Sankar Ram and K. R. M. Rao (2012), Testing and Control of TSC-TCR type Static Var compensator using microcontroller, International Journal of Control and Automation, Vol.5, No. 3.
- [5] J.G. Cho, J.W. Won and H.S. Lee (2000), Reduced conduction loss zero-voltage-transition power factor correction converter with low cost, IEEE Trans. Industrial Electronics, Vol.45, no. 3, pp. 395-400.
- [6] IEEE Power Engg. Society/CIGRE, "FACTS Overview", Publication 95 TP 108, IEEE Press, New York, 1995.
- [7] IEEE Power Engineering Society, "FACTS Applications", Publication 96 TP 116-0, IEEE Press, New York, 1996
- [8] W.A.Lyon, Transient Analysis of Alternating Current Machinery, Chapter 2, John Wiley, New York, 1954.
- [9] R.J. Koessler, "Dynamic simulation of SVC in distribution systems," IEEE Trans. Power System, vol.7, no.3, pp. 1285-1291, Aug. 1992.
- [10] V. Yarlagadda, K. R. M. Rao and B. V. S. Ram, "Voltage Stability Improvement Using Thyristor Controlled Series Capacitor (TCSC) Using Lmn And VCPI Stability Indices", Ijser, vol. 3, Issue 4, (2012) April.