International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

# Implementation of Static VAR Compensator (SVC) For Power Factor Improvement

Amol P.Patil[1], Prof.P.V.Baviskar[2]
[1] *Electronics Department, SSVPS, B.S.D.C.O.E. Dhule, patilamol407@yahoo.com*
[2] *Electronics Department, SSVPS, B.S.D.C.O.E. Dhule, baviskarpv@rediffmail.com*

**Abstract**— Electrical distribution systems are having large losses as the loads are wide spread, reactive power compensation facilities and their improper control. A comprehensive static VAR compensator consisting of capacitor bank in four binary sequential steps with a thyristor (SCR) controlled reactor of smallest step size is employed in the investigative work. This work deals with the performance evaluation through analytical studies and practical implementation on an existing system consisting of a distribution transformer of 1phase, 50Hz, 1KV/230V capacity. The PIC controller determines firing pulse of SCR to compensate excessive reactive power component for PF improvement. The switching operations achieved are transient free & practically no need to provide inrush current limiting reactors, TCR size minimum providing small percentages of harmonics, facilitates step less variation of reactive power depending on load requirement so as to maintain power factor near unity always.

**Keywords**- reactive power, static VAR compensator, capacitor bank, power factor

## I. INTRODUCTION

It is well known through public discussions at various levels that a substantial power loss is taking place in our low voltage distribution systems on account of poor power factor, due to limited reactive power compensation facilities and their improper control. The expansion of rural power distribution systems with new connections in wide spread remote areas, giving rise to more inductive loads resulting in very low power factors. There is great necessity to closely match reactive power with the load so as to improve power factor, boost the voltage and reduce the losses. In this paper, a more reliable, fast acting and low cost scheme is presented by arranging the thyristor switched capacitor units in four binary sequential steps. Due to this reactive power variation with the least possible resolution is possible. Therefore, power companies force their customers, especially those which are with the large loads, to maintain power factors of the supply above a specified amount( 0.90 or higher) or be subject to pay additional charges called low power factor penalty. Some consumers install power factor correction schemes at their industry to avoid these higher costs or penalty. Besides the enhancement transformer loading capability the shunt capacitor also improves the performance of feeder, reduces voltage drop in the feeder & transformer, better voltage at load end, improves power factor, improves system security with enhanced utilization of transformer capacity, increases over all efficiency, saves energy due to reduced system losses, avoids low power factor penalty, and reduces maximum demand charges. SVC is an automated impedance matching device, designed to bring the system closer to unity power factor. SVCs are used in two main situations :a) Connected to the power system, to regulate the transmission voltage ("Transmission SVC"). b) Connected near large industrial loads, to improve power quality ("Industrial SVC").

### 1.1 Objectives of Proposed Work

The following expected outcomes are achieved by using microcontroller control signals to Static VAR Compensator (SVC) which fulfill the requirement of reactive power for a 1 PH, 50 Hz.

- To maintaining the power factor at unity.
- To maintain minimum feeder current
- To improve the distribution feeder efficiency.
- To improve the voltage at load end.
- To relief in maximum demand and effective utilization of transformer capacity.
- To save the monthly bill on account of poor power factor, and results in maximum demand charges.
- To conserve the energy.

### 1.2 Components of Proposed System

Following are the main components required for the project;

A. Thyristor/ Contactor Switched Capacitor (TSC/CSC)
B. ZCD V and ZCD I For Phase Shift Measurement.
C. Current Transformer (Ct) and Potential Transformer (Pt).
D. Signal Conditioning Unit.
E. PIC Controller Interface.
F. Isolation and Firing Circuit of SCR.

## II. STATIC VOLTAGE COMPENSATOR USING PIC

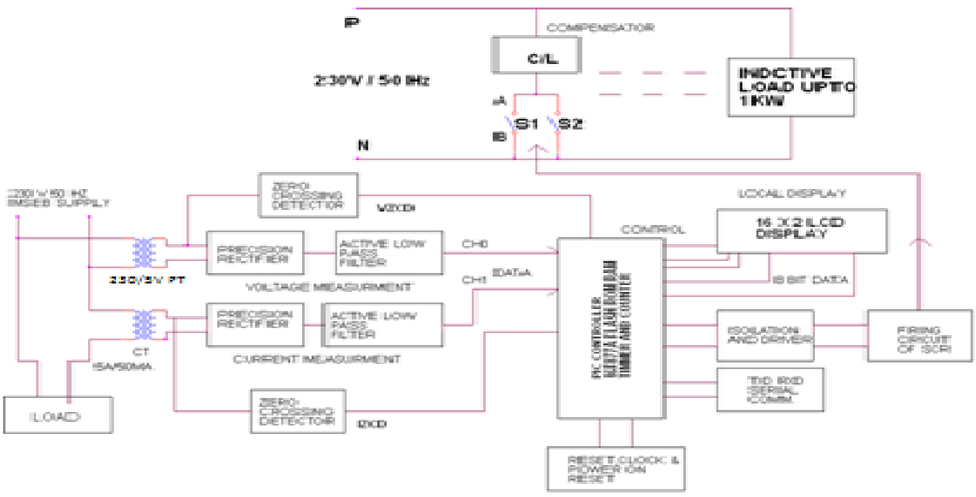



*Figure 1. Arrangement for SVC using PIC*

Our work consists of following sections for measurement of current and voltage.

1. Current Transformer (CT) and potential Transformer (PT) .
2. Signal Conditioning Unit.

### 1. Current Transformer (CT) & Potential Transformer (PT):-

This is the input stage of the MDC system it actually senses the consumed power by load. Since the magnitude of voltage and current which can process these high level signals is difficult. So these signals are transformed into equivalent small level signals 0-230 V range is dropped to 0-6v by potential transformer and 0-15 a current is dropped to 0-50 mA current.

**2.1 Signal Conditioning Circuit :-**

This is the second block comprising precision rectifier. The line provided by electricity board carries ac signals of 50 Hz. After dropping these signals to low levels the actual processing can be accomplished by transforming this ac signal to an equivalent dc signals. General Purpose IC OP07 is used as filters along with the diodes, resistors and capacitors. In ordinary bridge rectifier, there is a voltage drop in diodes. Diode will act as a rectifier within linear range only, before the knee point (.3v or .7v) output is zero. Thus the output of the rectifier is not exactly proportional to the input signal. A precision rectifier using op- amps is very accurate in this respect.

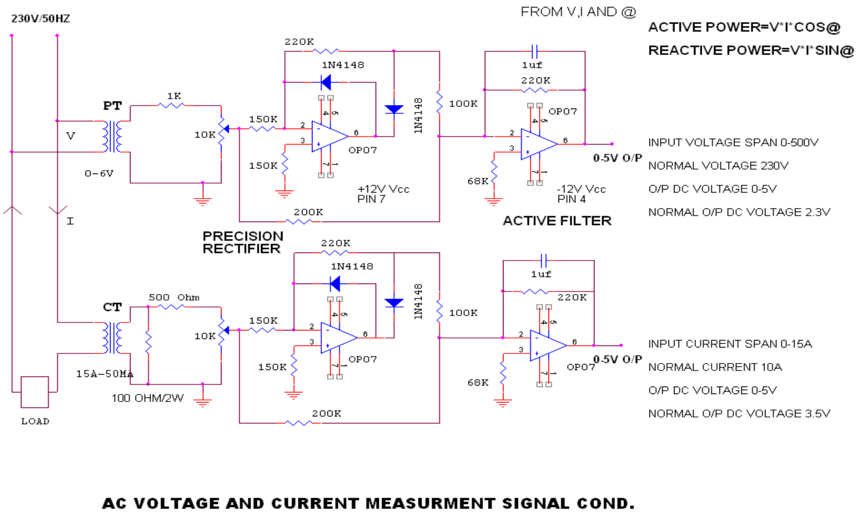



*Figure 2. Signal Conditioning Block*

The dc signal is then applied to the ADC. Out of 8 channels, chan0 is used for PT and chan1 is used for CT. As shown in circuit diagram the load lines are connected through CT & PT. The specification of CT and PT are as given.

**a) <u>Current Sensing Transformer ( CT)</u>**

Primary current up to 15 amp, Primary number of turns = 14
Primary wire gauge = 8 swg, Second number of turns = 250
Secondary wire gauge = 22 swg
Secondary voltage up to 5 volts with v burdon of 100 ohm.

**b) <u>Voltage Sensation Transformer (P.T) :-</u>**

Input Voltage = 230 v , Output voltage = 12v/500mA.

The output of CT is directly proportional to the line current. Secondary is connected to a dummy load of 100 ohm/2w. And after that potential divider arrangement is done using 1kΩ and 10kΩ trim pot is varied to achieved the linearity and scaling. This signal is applied to the precision rectifier. The working of the precision rectifier is as given. In the circuit, diodes D1 and D2 are included within the feedback loop of the amplifier. If the diodes are non conducting the amplifier is effectively acting open loop and an input signal of magnitude VF /A0l is all that is required to the cause diode conduction ( Vf is the diode forward voltage drop ) Negative input signals cause diode D1 to conduct and the output signal which appears at the cathode of D1 is

$$Eo = \left(\frac{R2}{R1}\right) Ein$$

The nonlinear diode resistance, since it is included within the feedback loop gain in the circuit and has negligible effect on the output signal. Positive input signals cut off diode D1 and cause D2 to conduct. This maintains the virtual earth at the inverting input terminal of the amplifier, and the output signal is zero since it is connected directly to this point via resistor R2.Finally rectified DC voltage is passed through a active filter. For filter and precision rectifier general purpose op- amp 741 is used. CT signal is applied to channel 1 of ADC and PT signal is applied to channel 2 of ADC.

**2.2 Triggering Circuit of SCR**

While developing firing circuit it is assumed that, firing circuit may handle higher current rating (up to 25 A) whose gate drive requirement may be up to 0.1 A to 1 A. Just we have to replace SCR of higher rating only to handle a load of higher wattages. Isolation is provided between power circuit and controller circuit using optocoupler MCT2E to limit the current of LED of optocoupler 330Ω Resistance is connected in series with anode of LED which is driven by a PWM pulse from the part of micro controller through a driver buffer 74245 o/p of the optocoupler is taken from emitter and is applied to reset pin of the 555 timer. 470K Ω will provide positive feedback. 1K Ω and 0.01Micro farad capacitor will provide stability.

$T_c = 0.693\,(R_A + R_B)\,C$ $\qquad$ $T_d = 0.693(R_B)\,C$

$T = T_c + T_d$ $\qquad$ $F = 1/T$

Output of IC 555 timers is applied to push pull pair of transistor that is BC 547 /BC 557 or SL 100 / Sk 100 for current amplification which provides sufficient current to gate of SCR. To limit the gate current 390 Ω resistor and RC series combination is inserted between gate and push pull pair. Separate isolated +12V supply is provided to firing circuit. Power circuit consist of SCR 25ria12 having current rating up to 25 Amp and PIV rating 1200V to improve the dv/dt rating of SCR snubber circuit is connected in parallel with anode & cathode . Load (compensator) is in series with scr. The following wave form describes the working of power circuit.

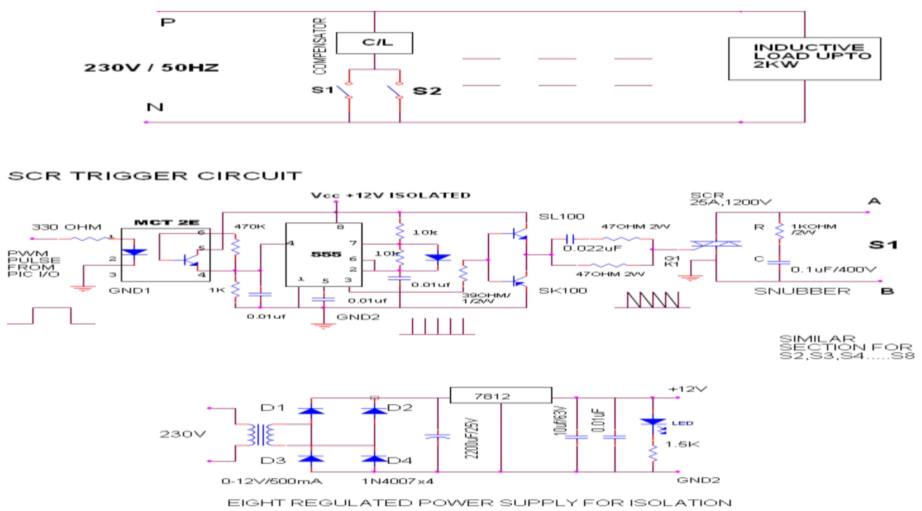



***Figure 3. Triggering Circuit for SCR***

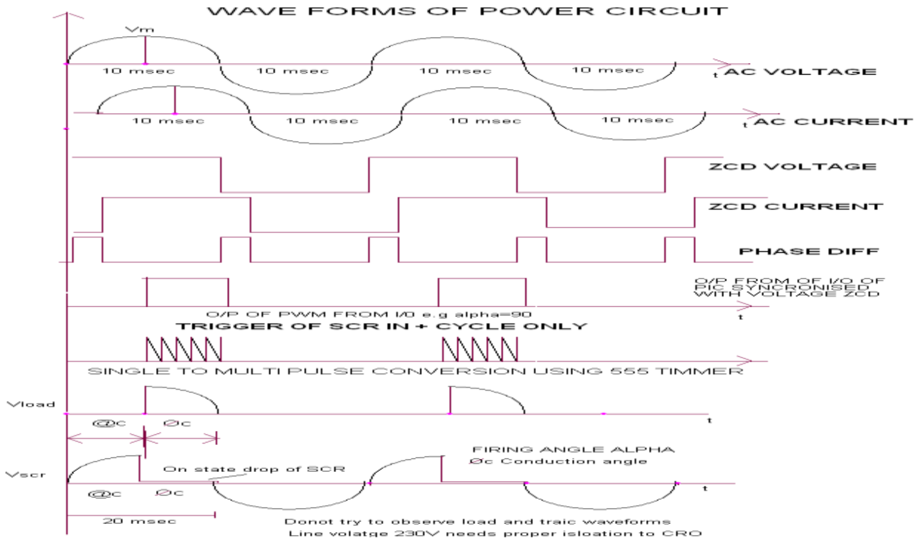



*Figure 4. Waveform across triggering and power circuit*

## 2.3 ARRANGMENT FOR PHASE SHIFT MEASUREMENT

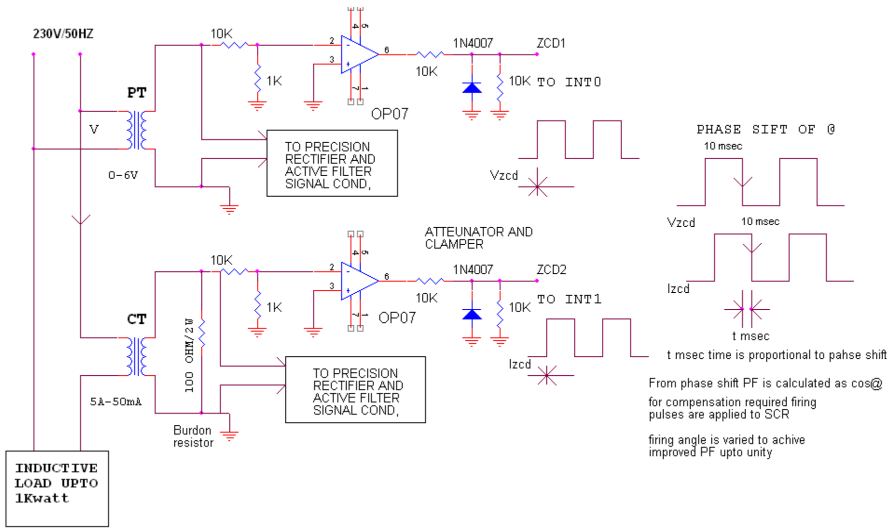



*Figure 4. ZCD Block diagram for phase shift measurement*

Diode will act as clamper which convert bipolar signal to unipolar. Both the square wave signals for voltage & current will be given to INT0 & INT1 of PIC controller. When INT0 interrupt will occur then internal timer will start and it will stop at INT1interrupt. Time measurement by timer will give the respective phase shift in terms of Θ.

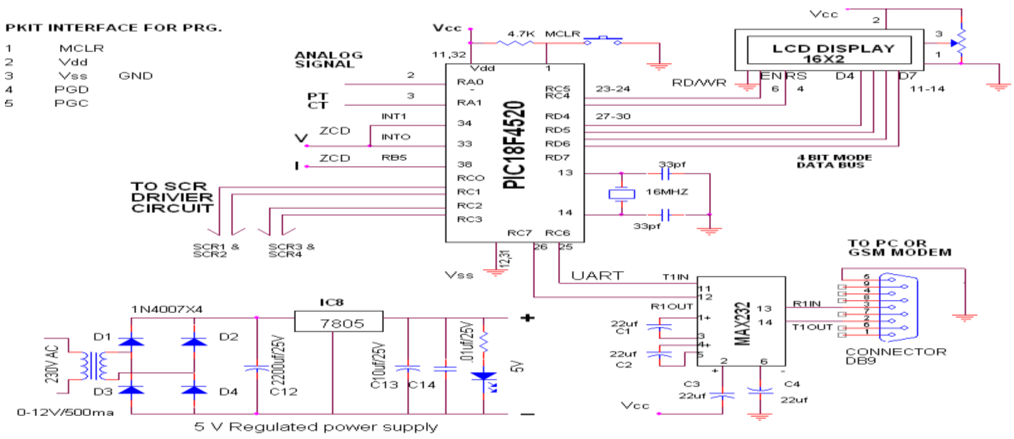
**Display Unit**

LCD pin description

LCD displays are available typically as 16 x 12 or 20 x 2 along with LCD controller. 16 x 2 means 16 characters per line with 2 such lines. A standard LCD controller chip HD 44780U can receive data from a microcontroller and communicate with the LCD. In LCD module there are three control lines and 8 Data lines. The three control signals are enable (EN), register select (RS) and read/write RW.

## III. PIC CONTROLLER INTERFACING DIAGRAM




PIC INTERFACE FOR SVC

***Figure 5. PIC interfacing for static VAR compensator***

PIC18F877A is PIC controller used for the system. The basic feature of PIC controller is it has inbuilt ADC (10-bit, 8channel) which can be used for current& voltage signals which reduces the hardware requirement of system. PIC has three external interrupt which can be used for ZCD output for measurement of phase shift. It has Capture/Compare/PWM (CCP) modules which can be used to generate trigger pulses for SCR. The output of V and I measurement signal conditioning circuit *i.e.* V and I and also the output of ZCD circuit for V and I *i.e.* ZCD V and ZCD I are given to PIC18F458 microcontroller card. Fig.3 shows block diagram of PIC18F458 operation; in which inputs to controller are V analog, I analog, ZCDV, ZCD I while outputs from controller are PWM pulses to thyristors and signals consists of each parameters values to LCD display card for showing on display

## IV. CONCLUSIONS

From this paper our conclusion is that power factor of inductive load without compensation is not near to unity .With the help of static VAR compensator power factor improve near to unity of inductive load.

This method is used to

- To improve the voltage at load end.
- To relief in maximum demand and effective utilization of transformer capacity.
- To save the monthly bill on account of poor power factor, and to maintain the power factor at unity.
- To maintain minimum feeder current
- To improve the distribution feeder efficiency.
- To conserve the energy.

## REFERENCES

[1] Sameer U. Bagwan1, Anwar M. Mulla2, U. Gudaru3 "Hardware Circuit Implementation of Static VAR Compensator(SVC)with Thyristor Binary Compensator. International Electrical Engineering Journal (IEEJ) Vol. 5 No. 1, pp. 1240-1246, (2014)

[2] Abhinav Sharma1, Vishal Nayyar2, S. Chatterji3, Ritula Thakur3, P.K. Lehana*. "PIC Microcontroller Based SVC for Reactive Power Compensation and Power Factor Correction"-.International Journal of Advanced Research in Computer Science and Software Engineering, sept.2013.

[3] Miss.S.D.Arote, Dr.N.P.Futane "Power Factor Improvement Technique Using Static VARCompensator (SVC)"-, E&TC Dept, Govt. College of Engineering and Research Avasari Khurd, Tal:- Ambegaon, Dist:- Pune,2013.

[4] Dadgonda R. Patil and Uppala Gudaru, "The Experimental Studies of Transient Free Digital SVC Controller with Thyristor Binary Compensator at 125 KVA Distribution Transformer", IEEE Proceedings of the World Congress on Engineering 2012 Vol II, WCE 2012, , London, U.K. July 4 - 6, 2012

[5] Mohamed Mamdouh Abdel Aziz, Essam El-Din Abou El-Zahab, Ahmed Mohamed Ibrahim. "LC Compensators for Power Factor Correction of Nonlinear Loads" IEEE transactions on power delivery, vol. 19, no. 1, january 2004

[6] R. Cimbals, O. Krievs, L. Ribick "A Static Synchronous Compensator for Displacement Power Factor Correction under Distorted Mains Voltage Conditions"- Faculty of Power and Electrical Engineering, Riga Technical University,Kronvalda bulv. l- 2011

[7] Taufik* and Bryan Paet** Johor Baharu, "A Small Scale Static VAR Compensator for Laborat ory Experiment" - Malaysia. 2nd IEEE International Conference on Power and Energy (PECon 08), December 1-3, 2008.

[8] VenuYarlagadda[1],K.R.M.Rao[2],B.V.Sankarram[3] "Hardware Circuit Implementation of Automatic Control of Static VAR Compensator (SVC) using Micro Controller", International Journal of Instrumentation, Control and Automation (IJICA) ISSN : 2231-1890 Volume-1, Issue-2,2011.

[9] PIC microcontroller & embedded system, Mazidi, 3rd Edition ,Pearson.

[10] "Power Electronics circuits devices and applications" M. H. Rashid PHI 3rd edition, New Delhi, 2004,