Implementation of SVC (Static Var Compensator) For Power Factor Improvement Using Microcontroller

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Abstract— Electrical distribution systems bearing large losses as the loads are wide spread, reactive power compensation facilities and improper control of the same. The comprehensive static VAR compensator consisting of capacitor bank in four binary sequential steps in conjunction with a thyristor (SCR) or Traic controlled reactor of smallest step size is employed in the investigative work. Same work deals with the performance evaluation through analytical studies and practical implementation on an existing system consisting of a distribution transformer of 1 PH phase 50 Hz, 230V capacity. This paper describes development of single phase SCR based Static VAR Compensate SVC for reactive power compensation and power factor correction using microcontroller. The microcontroller determines the firing pulse for the SCR or Traic to compensate excessive reactive components, thus withdraw PF near to unity. Power factor improvement circuits were added in power systems to sinusoidal shape the AC line current and to put it in phase with the ac line voltage.

Key words: Microcontroller, Reactive Power, Static VAR Compensator (SVC), Capacitor bank, LCD Display

I. Introduction

Power factor improvement circuits were added in power systems to sinusoidal shape the AC line current and to put it in phase with the ac line voltage. It is necessary to deals with the generation and transmission of electrical power and consumption of electrical power has an interest in the power factor of loads because of the dynamic behavior of industrial loads. It is well documented in literature and 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. Power factors affect cost and efficiencies for both the electrical power industry and the consumers in addition to the increased operating costs

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(usually 0.90 or higher) or be subject to pay additional charges called low power factor penalty. Electricity utilities thus measure reactive power used by large industrial customers and charge higher rates as per utilized power factor. Some consumers install power factor correction schemes at their industry to avoid these higher costs or penalty. Power factor correction used to adjust the power factor of an AC load or an AC power transmission system to unity (1.00) through various methods.

There are various methods invented for power factor correction. Simplest methods include switching in or out banks of capacitors. This method for improvement of power factor using switching in or out capacitor banks is also called as dynamic VAR compensator or dynamic power factor control. In this method reactive power generation is carried out through switching in or out the capacitors to obtain a desired power factor at various load conditions hence called as Dynamic VAR Compensator. In this system switching action is performed by relays, which are unreliable, sluggish, require frequent maintenance and also introduce switching transients. Another method power factor correction can be implemented using unloaded synchronous motor connected across the supply. In this method power factor of the motor is varied by adjusting the field winding excitation and can be made to behave like a capacitor when over excited. When we compare between these two method, we can conclude that capacitor bank provides power factor control in discrete steps whereas synchronous motor provides a smooth control of power factor but they are not fast enough to compensate VAR for rapid load changes due to large time constant of their field circuit and they have much higher losses. The above mentioned techniques for power factor correction are very simple but these techniques having some disadvantages like dynamic VAR compensation, use of mechanical switches and relays, not fast enough for rapid load changes and higher losses, so more so more reliable technique must be used to correct for non-linear loads. In this project an active power factor corrector is used for reactive power compensation. One of the new technique for active power factor correction is SCR based active power factor corrector to regulate the reactive power. Same method of active power factor correction can be addressed by continuous and static VAR control, low losses, and flexibility and provides the smooth control of flow of reactive power.

The target of this project is to improve power factor of the supply by using static VAR compensator. This project introduces the design, development and implementation is more efficient and the cost effective Active Power Factor Corrector comprising microcontroller based hardware and compatible software which will be able to control the power factor of both linear and nonlinear load. In this project, Power factor correction scheme is implemented by arranging the thyristor switched capacitor units in four binary sequential steps. This helps to introduce the reactive power variation with the least possible resolution.

II. Components of Proposed System

Basics Components of system consists of following blocks

1) Thyristor Switched Capacitor (TSC)
2) Current Transformer (CT) and Potential Transformer (PT)
3) Analog to Digital converter
4) Microcontroller
5) Isolation and firing circuit of SCR.

A. Design of Static Var Compensator

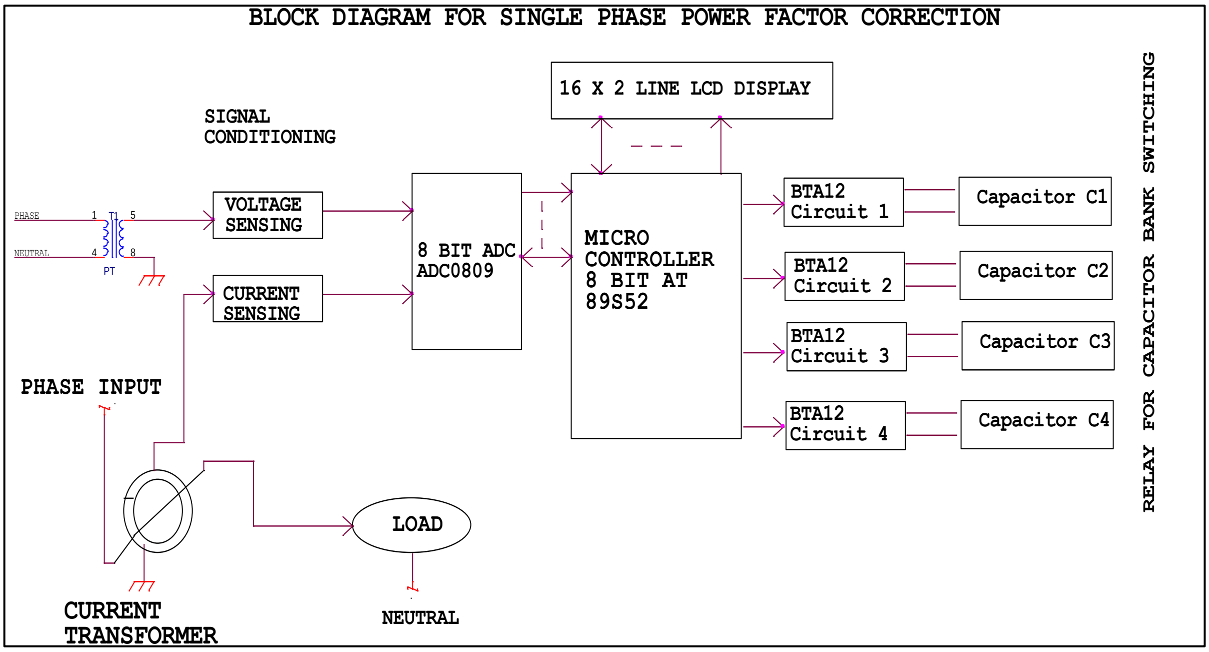

Fig. 2.1: Arrangement of Svc Using Microcontroller

1) System Description

a) Current Transformer

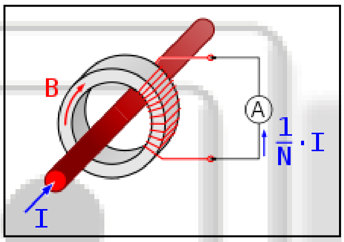

Fig. 2.2: Basic Operation of Current Transformer

A current transformer (CT) is used for measurement of alternating electric currents. Current transformers, together with voltage (or potential) transformers (VT or PT), are known as instrument transformers. When current in a circuit is too high to apply directly to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays in the electrical power industries.

B. Potential transformer


Fig. 2.3: Basic Operation of Potential Transformer

Potential transformers (PT) (also called voltage transformers (VT)) are a parallel connected type of instrument transformer. They are designed to present negligible load to the supply being measured and have an accurate voltage ratio and phase relationship to enable accurate secondary connected metering.

C. Ratio of Voltage Transformer

The PT is typically described by its voltage ratio from primary to secondary. A 600:120 PT would provide an output voltage of 120 volts when 600 volts are impressed across its primary winding. Standard secondary voltage ratings are 120 volts and 70 volts, compatible with standard measuring instruments.

D. Analog to Digital Converter

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. For 16-channel multiplexer with common output (sample/hold port) see ADC0816 data sheet. (See AN-247 for more information)

E. Isolation and Firing Circuit

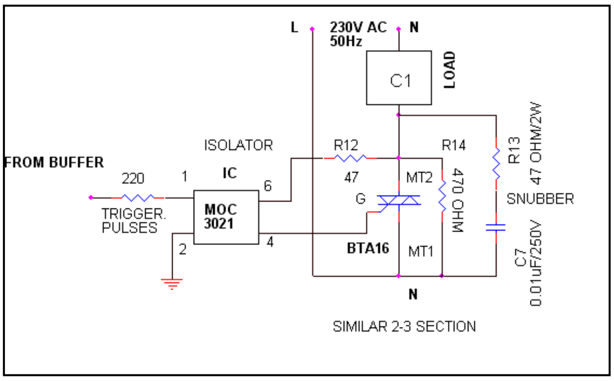

Fig. 2.4: Firing Circuit for TRAIC

While developing a firing circuit it is assumed that our firing circuit may handle an anti-parallel SCR of higher current rating (up to 25A) whose gate drive requirement may be up to 0.5 mA to 1 A. Just we have to replace anti-parallel SCR of higher rating only to handle a load of higher wattages. Isolation is provided between power circuit and controller circuit using opto-coupler MCT2E. Trigger pulse generated from controller applied to opto-coupler. 555 timer is a stable - multivibrator which is driven by a PWM pulse from the part of micro controller through reset of timer. Timer converts single pulse into multi pulse. Gate driving capability is improved using Push-Pull pair of transistor.

Capacitor bank will be selected according to the required demand for pf improvement. For respective bank firing angle is varied to achieve pf close to unity. This provides the VAR compensation for improving the pf.

F. Microcontroller

The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard 80C51 and 80C52 instruction set and pin out.

The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

1) Features of Microcontroller

a) Compatible with MCS-51™ Products
b) 8K Bytes of In-System Reprogrammable Flash Memory
   – Endurance: 1,000 Write/Erase Cycles
c) Fully Static Operation: 0 Hz to 24 MHz
d) Three-Level Program Memory Lock
e) 256 x 8-Bit Internal RAM
f) 32 Programmable I/O Lines
g) Three 16-Bit Timer/Counters
h) Eight Interrupt Sources
i) Programmable Serial Channel
j) Low Power Idle and Power Down Modes.

G. Display unit

1) 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.

VCC, VSS & VEE: - VCC and VSS provide + 5V and ground respectively. VEE is used for controlling LCD contrast.

III. MICROCONTROLLER INTERFACING DIAGRAM

AT89C52 is microcontroller used for the system. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard 80C51 and 80C52 instruction set and pin out.

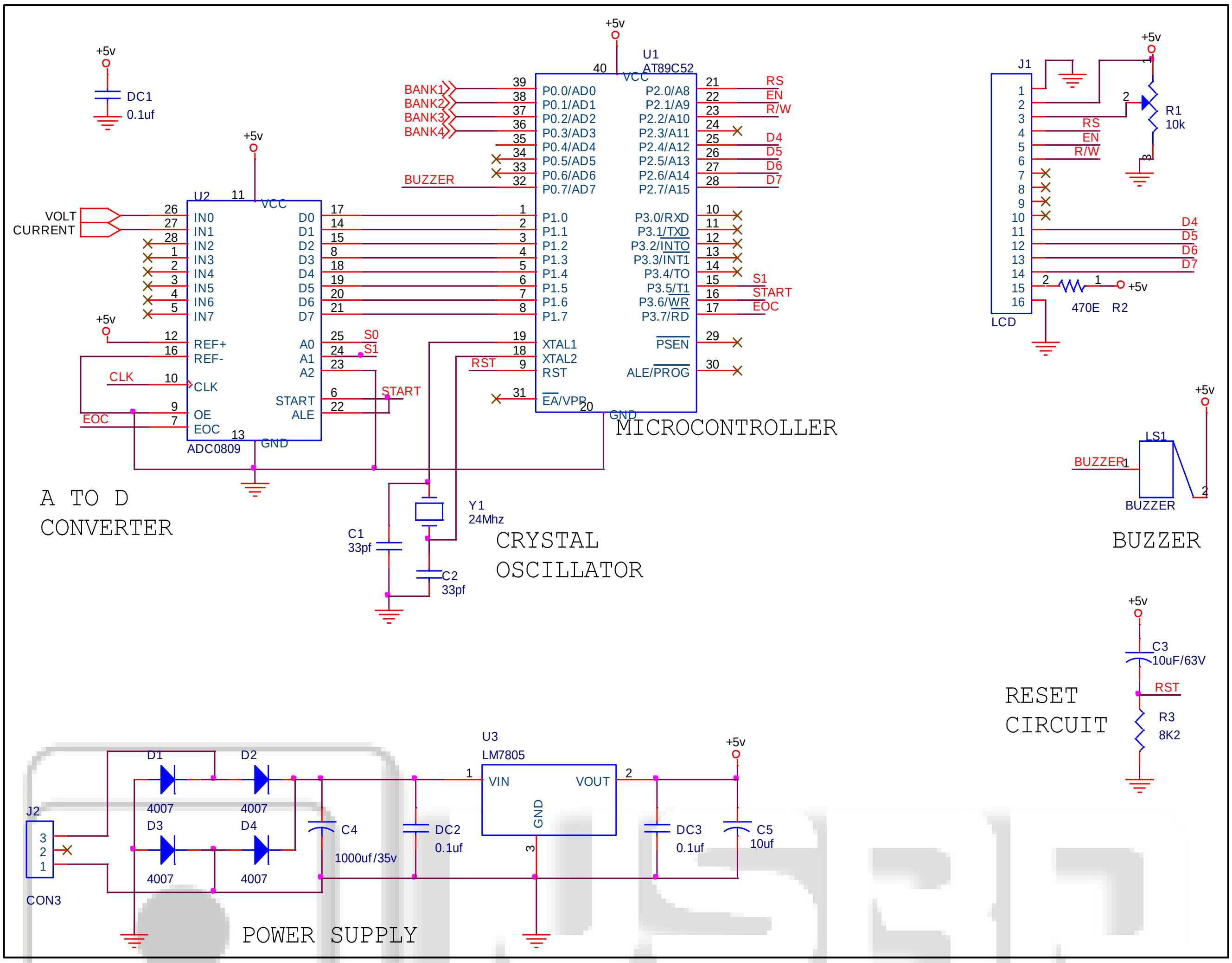

Fig. 4.1: Microcontroller Interfacing For Static Var Compensator

IV. Result

It is clear that the system is able to adjust the power factor from its low initial value to an almost unity power factor. It was also observed that the microcontroller based switching did not introduce any distortions in the output waveform while correcting the power factor. The value of corrected power factor is almost near to unity. The system is able to adjust the power factor from its low initial value to an almost unity power factor.

Sr no.	Load	Voltage	Current	Power Factor
1	Motor 1 100W	230	0.5A	0.99-1
2	Motor 2	230	0.62A	1

Table 1: Observation for Inductive Load with Compensation

V. Conclusion

From this Project 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 for inductive load.

This method is used to

- To improve the voltage at load side.
- To relief in maximum demand and effective utilization of transformer capacity.
- To save the monthly bill on account of poor power factor.
- To maintain the power factor at unity.
- To conserve the energy.

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