Reactive Power Compensation Using SVC

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Abstract - *In this paper, a reactive power compensation system using static VAR compensator is presented. To confine on system stability and reliability, the reactive power compensation is the fundamental way for flexible AC transmission systems (FACTS). The variations of reactive power have an effect on the generating units, lines, circuit breakers, transformers, relays and isolators. It can also cause effective voltage sags and increase losses. In the proposed system, the lead time between voltage pulse and current pulse are measured and fed to the interrupt pins of the microcontroller where the program takes over to bring the shunt capacitors to the circuit to get the reactive power compensated. Back to back SCRs interfaced through optical isolation from the microcontroller are used in parallel for controlling the capacitor.*

***Key Words*: VAR compensator, SVC, TCR, power factor, Reactive Power Compensator etc...**

1.INTRODUCTION

Energy efficiency is a topic that has become more and more prominent as demand for electrical power grows. When inductive loads are introduced to the power system by customers, the voltage at customers point reduces. This is due to the increased load current caused by an increase in the amount of reactive power the utility has to supply to the inductive load. This further increases the systems loss and reduces the efficiency of the power system. To the customer, this will cause them to pay more for the electricity bill and they may receive penalties by the utility company if the required reactive power is significant. This type of problem is typically indicated by the low power factor at the load. A widely used approach to mitigate this problem is through the use of corrective capacitors. Capacitor is an electrical component that can supply reactive power, and hence fits well for the reactive power thirst inductive load.

Using a set of capacitance may be sufficient to correct power factor in predominantly inductively load; however, real world loads vary with time and hence a fixed set of capacitance can potentially lead to overcompensation. This in turn will produce an unnecessary boost in voltage which could further damage the loads. Hence, a better method to improve power factor is needed. In particular, an approach that would match the reactive power requirement of the load as it changes will be desirable.

One known technique to improve power factor or to compensate for reactive power uses power electronics. Power electronics deals with the flow control of electricity through switching or power semiconductors. Through the use solid-state switches in power electronics, continuous adjustment of reactive power may be achieved. There are several ways to compensate for reactive power using power electronics, but one that will be the focus of this paper is the one that is called the Static VAR Compensator or SVC for short. SVC has been used by many utilities in the world, and its use will continue to grow.

1.1 Static VAR Compensator

A Static VAR Compensator consists of a Thyristor-controlled Reactor (TCR) which is an inductance in series with a bidirectional thyristor switch as shown in Figure 1. The reactor is in parallel with a corrective capacitor to adjust for a leading or lagging power factor. The main function of a SVC is to absorb or supply reactive power based on the changing VAR requirement of the load. Hence, the use of an

SVC allows for the application of power factor correction to maintain the unity power factor for a variable load.

The ability of the Thyristor-Controlled Reactor (TCR) to limit current is a vital part of controlling power flow. The current is controlled by the firing angle, which at 0º the switch is permanently closed, then slowly limits current as firing angle increases to 180° where current is then zero. Limiting the current ultimately limits the reactive current which results in how much reactive power can be added to or subtracted from the system.

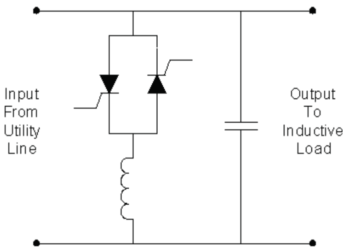

Fig -1: Thyristor Controlled Reactor

With the SVC, when firing angle= 0 the current passes fully through the inductor bypassing the capacitor. Yet as firing angle increases to 180°, current will be forced to slowly pass through the capacitor, and thus raise the lagging power factor of the system. Therefore the firing angle may be directly related to how much power factor correction we need for the system.

2. DESCRIPTION

2.1 Block Diagram Description

The block diagram of reactive power compensation system includes microcontroller, TRIAC, CT, PT, optocoupler, capacitor and inductor.

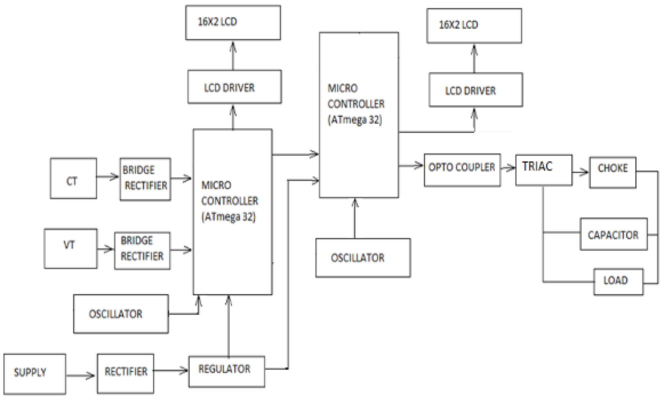

Fig -2: Block Diagram of reactive power compensation system

The block diagram depicts a system for reactive power compensation which includes a TCR and a shunt capacitor for adjusting the power factor. The controlling unit consist of two microcontrollers. The first microcontroller measures the power factor and passes the information to the second microcontroller.

The power factor measurement is done by using a CT and PT. The output from these is used for zero crossing detection of current and voltage waveforms. Using the information from the first microcontroller the second one determines the firing angle at which the triac is to be triggered and hence limits the current passing through the series inductor, thereby controlling the current through the capacitor. In this manner reactive power can be compensated. Two displays are used in this setup. One displays leading or lagging power factor and the angle between current and voltage waveforms. The other displays the amount of capacitance discharged.

2.2 Hardware Description

Here the supply is rectified using bridge rectifier and the output is regulated using 7805 regulator IC to 5V. It is then fed to the microcontroller (Atmega32). A crystal oscillator circuit is also connected to it to generate the internal clock (4MHz).

The current and voltage from the load circuit is fed to a CT and PT to measure current and voltage. The CT used is a 100/5 CT and the PT used is a 12-0-12 V PT. The output of CT and PT are fed to the ADC pins of the microcontroller which is then used for the power factor calculation. A 16x2 LCD is used to display the power factor and angle. A TCR network along with a shunt capacitor is connected in parallel with the load. A BT136 IC is the triac used in the circuit. An optocoupler (MOC3021) is used to supply the triggering pulse to the triac.

3. PROJECT IMPLEMENTATION

3.1 Flowchart

The flow chart of Reactive power compensation system using TCR is shown in figure. The LCDs and microcontroller ports are initialised first. Then CT and PT values are compared to see whether there is any change in phase angle.

If the calculated power factor is less than 0.9 lag or greater than 0.1 lead, then firing angle of the triac is adjusted and the current through the capacitor is varied. Thus the capacitor is added in the circuit and the reactive power is compensated. This process goes on whenever the supply is given.

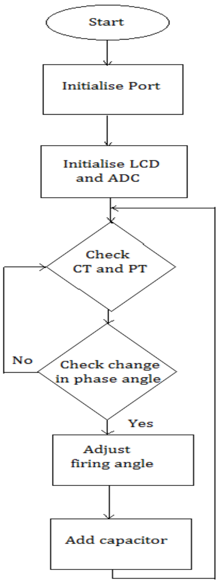

Fig -3: Flowchart of the proposed system

3.2 Simulation

The simulated power factor measurement circuit is shown in figure. From simulation results, it can be seen that a power factor of -.98 lag and an angle of 11.25 is obtained by comparison of voltage and current waveforms using comparators.

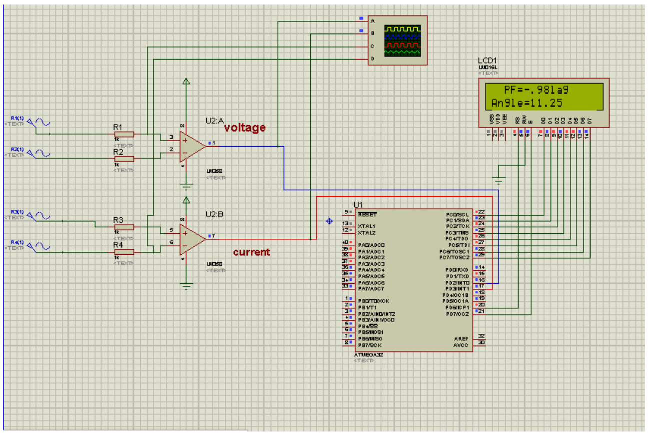

Fig -4: Simulation of power factor measurement

3.3 Hardware Description

The hardware consists of the following main components: two microcontroller circuits, TCR, optocoupler, CT, PT, a resistive load (lamp), inductive load (choke), capacitor used for compensation, bridge rectifiers, regulators etc.

The micro-controller used is the ATmega328. The Atmel AVR ATmega328 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328 achieves throughputs approaching 1 million instructions per second per MHz, allowing the system designed to optimize power consumption versus processing speed.

A regulated power supply is very much essential for several electronic devices due to the semiconductor material employed in them have a fixed rate of current as well as voltage. The device may get damaged if there is any deviation from the fixed rate. The AC power supply gets converted into constant DC by this circuit. By the help of a voltage regulator DC, unregulated output will be fixed to a constant voltage. The circuit is made up of linear voltage regulator 7805 along with capacitors and resistors with bridge rectifier made up from diodes.

The TRIAC used is BT136. The TRIAC is a three terminal semiconductor device for controlling current. It gains its name from the term TRIode for Alternating Current. It is effectively a development of the SCR or thyristor, but unlike the thyristor which is only able to conduct in one direction, the TRIAC is a bidirectional device.

The rating of the current transformer is 100/5 A and that of the potential transformer is 12-0-12 V. A current transformer (CT) is an electric device that produces an alternating current (AC) in its secondary which is proportional to the AC in its primary. Potential transformer or voltage transformer gets used in electrical power system for stepping down the system voltage to a safe value which can be fed to low ratings meters and relays.

An optocoupler is used for isolation between the microcontroller circuit and the load circuit. It is used for providing the triggering pulse to the triac.

The supply to the microcontroller is given through a brideg rectifier and regulator. A crystal oscillator circuit is used for generating the internal clock frequency(4 MHz).The current and voltage measurement for power factor calculation is done by using CT and PT and these readings are given to the ADC pins of the microcontroller. Using these, the power facto r is calculated and compensation is carried out if the pf is less than 0.9 lag or more than 0.1 lead. Depending upon the amount of compensation required, the firing angle of the TRIAC is adjusted and the firing pulse is given to the TRIAC. The power factor is continuously checked as long as the supply is present.

3.4 Hardware Implementation

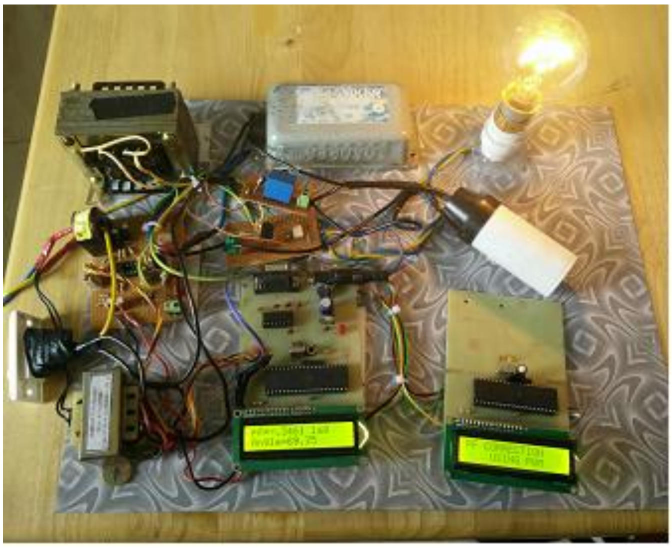

Fig -5: Hardware of proposed system

4. CONCLUSIONS

In this project, a small scale SVC circuit which is both cost effective and reliable was proposed. When the triac controller was connected in series with an inductor, and in parallel with a capacitor, we were able to vary the amount of capacitance or inductance added to the system in order to achieve a unity power factor. This configuration is in fact the basis for the SVC circuit.

The Static VAR Compensator showed that it is capable of improving the power factor of an inductive load. As only a non-varying inductive load was tested, the SVC is still able to accommodate for a varying load with the phase control in the thyristors. Being able to vary the capacitance or inductance of a circuit is very beneficial because it makes the correction more flexible and cost efficient. Yet, adding an overly large capacitor could result in an over-compensation which would require less delay angle for the system to be close to unity power factor.

In closing, the SVC circuit described in this paper is a lab-scale version for what utilities companies used as a way to compensate for a lagging power factor. While more efficient methods are used today, the SVC is still a great cost effective way for power factor correction.

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