

# Design And Application Of Semiconductor Compensation Contactor

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*Abstract* : In this paper, fast compensation which is one of the popular topics of recent years, is mentioned. Because of the importance of fast compensation, a microprocessor controlled fast semi-conductor compensation contactor is designed and produced for this purpose. Properties of the prototype are given and its working principles are explained. Some experimental studies are made on this prototype and the experimental results of on-off states are given in oscilloscope figures.

*Keywords* : Compensation, Static Compensation.

## 1 Introduction

Conventional compensation systems could't solve some problems in systems demanded instantaneous reactive power variation because of working slowly. Due to oscillations in the system, both of the reactive counters exceed limited reactive power rate and companies are often punished to pay fine. One of the solution of this problem is fast compensation. In this study, a microcontroller based Semiconductor Compensation Contactor (SCC) which response fast compensation process is improved and produced. After manufacturing, SCC is compared with standard compensation contactor in its class.

Because of making apparent power (S) nearly equal with active power (P), compensation reduces line losses but unbalanced compensation damages the network. If three phase capacitors are used for compensation in an unbalanced system, power factor in each phase becomes different and some of the phases might be inductive and the others might be capacitive. Three phase reactive power counters measure sum of reactive power of each phase, so even counters don't record reactive power, the system continue to be unbalanced in fact. As a result, voltage of the phase which is loaded inductive decreases on the other hand voltage of the phase which is loaded capacitive increases. Due to unbalanced voltage, unbalanced current occurs in even balanced loads and quality of the network reduces more and more.

In three phase systems, reactive power relays control compensation system by taking only one phase current. So, power factor is never compensated completely and system never works stable. For this reason, many companies often pay

fine for using over reactive power. Power balance is frequently damaged by using one or two phase reactive power loads like welding machine. If the period of the harm is a little big or a little small than response time of the relay, compensation system doesn't work stable. For example if welding works continue less than 5 seconds in a system which has 5 seconds response time reactive power relay, the relay could't sense this process and inductive counter proceeds to record or in a 6 seconds welding work, the relay senses a capacitive necessity and adds capacitors into the system. Although the necessity disappears after one second, capacitors stay 4 seconds more. As a result in 10 seconds period, compensation process is realized smoothly during only one second. During 9 seconds, inductive counter records for 6 seconds and capacitive counter records for 4 seconds.

For terminating mentioned problems, a compensation system must have a small response time and it must be possible for fast compensation. But standard compensation contactors have mechanical parts so they are not suitable for fast operations. If they are forced to operate, they are damaged and needs to be changed. So the system cost becomes expensive.

In this study, a SCC which enables fast compensation is improved, manufactured and tested. It is observed that a 10kVAr capacitor could be switched in 25 milliseconds period. Here, 25 milliseconds time is not response time of SCC, it is an half period time for determining power factor. Switching time is less than 15 milliseconds in the worst conditions.

## 2 Design of Semiconductor Compensation Contactor

The principle scheme of SCC is shown in Fig. 1.

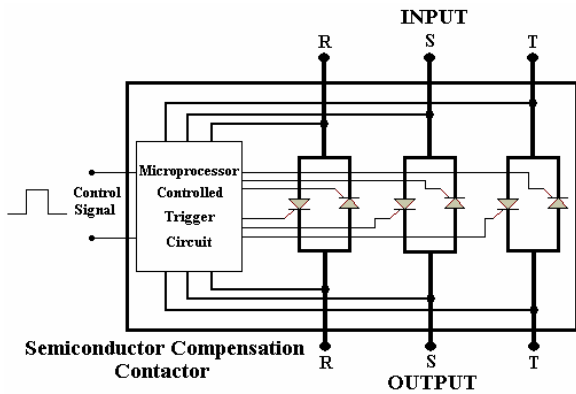


Fig.1 The principle scheme of SCC.

There are semiconductor switches on each phase of SCC. Semiconductor switches are controlled by a microcontroller which is programmed to trigger-on and trigger-off the switches in the right time. The photograph of prototype is given in Fig. 2.



Fig.2 Photograph of Semiconductor Compensation Contactor.

## 3 The Experimental Results of SCC

The circuit shown in Fig. 3 is set up to make some experimental study for testing SCC.

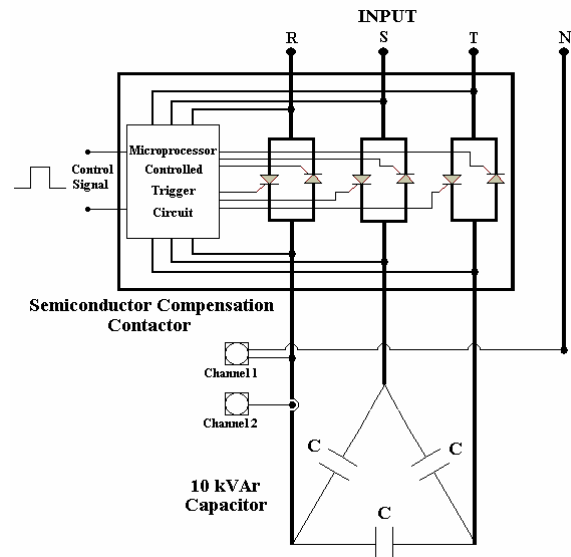


Fig.3 Experimental circuit for testing SCC.

SCC is designed for compensation so three phase 10KVAR capacitors is used as a load in this experimental study. The control signal of SCC is 220V AC voltage such as a standart contactor. A signal generator is used as a control signal in order to prove that SCC is faster than standart contactor. The square wave signal (0-5V) obtained from signal generator is transformed to 220V AC control signal by an amplifier. Thus, the change in frequency of signal generator provides the SCC to work in different frequencies.

The photograph of experimental circuit prepared for testing SCC in laboratory is shown in Fig. 4.

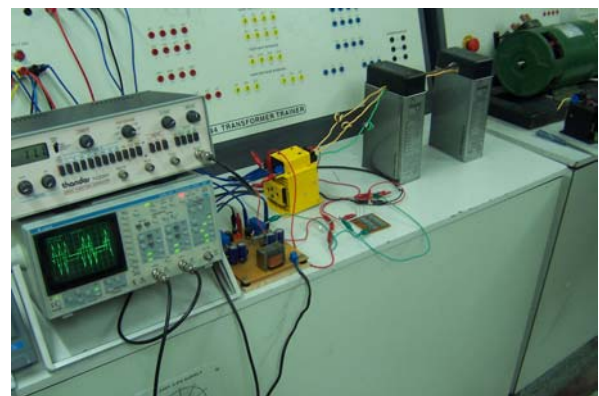


Fig.4 Photograph of experimental circuit of SCC

Before starting tests of SCC, three phase 10 KVAR capacitors are directly connected to the network. The current waveform of the capacitors is shown in Fig. 5.

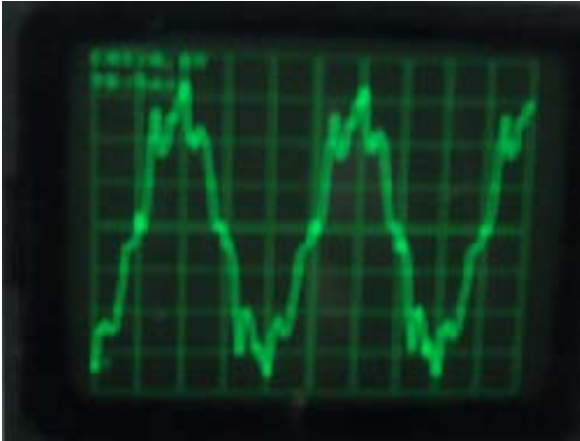


Fig.5 Measured current waveform of the capacitors.

After this step, capacitors are connected to the network as shown in Fig. 3. When 10Hz control signal frequency is applied to SCC, line current waveform and phase neutral voltage waveform are observed in oscilloscope and shown in Fig. 6. It is seen that the capacitors are connected and disconnected to the network at the zero points of the current.

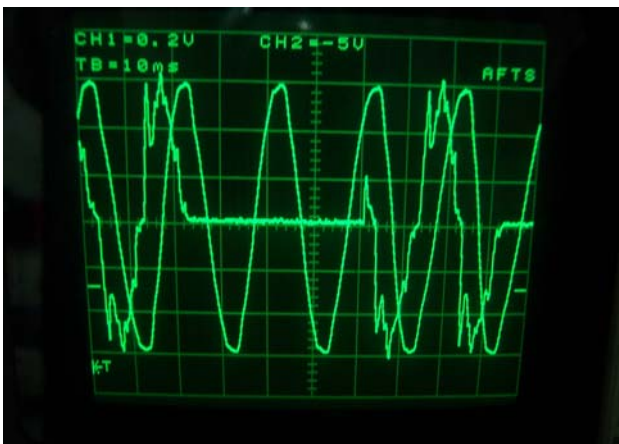


Fig.6 When SCC is used, phase neutral voltage and line current waveforms of the capacitors in 10Hz control signal.

As illustrated in Fig. 7. the capacitors could be switched-on and switched-off by SCC without any problem at 16Hz frequency of the signal generator. When the control signal is applied, the microcontroller waits for the zero points of the line current to add capacitors into the system. This property of SCC makes it different from the standart contactors. So, the SCC provides soft switching to the capacitors and there is no peak current at the line.



Fig.7 When SCC is used, line current waveforms of the capacitors and control signal in 16Hz control signal.

The same experiment is made with standart contactor to show the peak current at the line by using 2Hz frequency control signal. When the standart contactor is connected to the line, a high peak occurs in the current (Fig. 8. and Fig. 9.). Moreover, the snubber resistors above the standart contactor begin to overheat at higher frequencies. After a while the snubber resistors begin to burn.

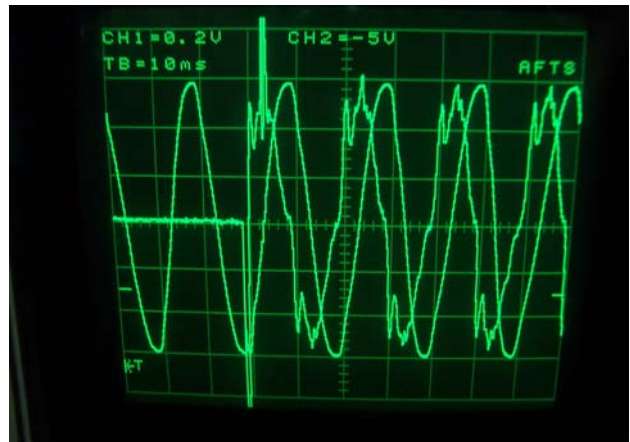


Fig.8 When standart compensation contactor is used, phase neutral voltage and line current waveforms of the capacitors in 2Hz control signal.

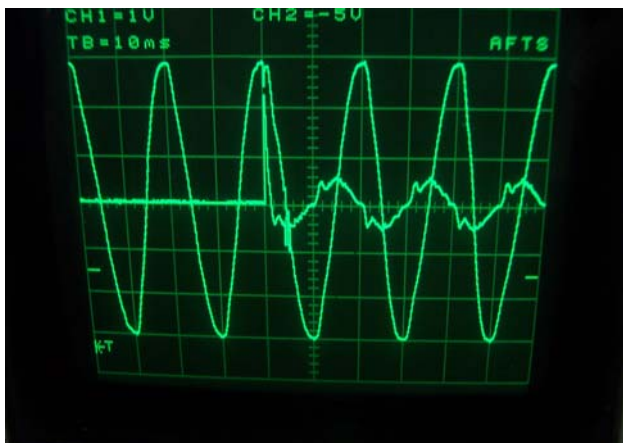


Fig.9 When standart compensation contactor is used, phase neutral voltage and line current waveforms of the capacitors in 2Hz control signal.

## 4 Conclusions

In compensation systems, electromechanic control equipments have still used although technology has been developed. However, these control equipments including mechanical contacts don't work fastly. They are also broken down due to the occurrence of the spark at their contacts. SCC which is designed and produced in this study is rather fast then the classical compensation contactors. It doesn't make any noise when it works due to nonexistence of mechanical contacts. Also, no spark occures unlike classical contactors.

When the control signal is applied, SCC is connected to the line at zero points of the current. When the control signal is turned off, SCC is disconnected at zero points of the current again. The transient condition doesn't appear when SCC is working. It doesn't seen any peak at the current due to this property of SCC. As a result, SCC capable of fast and soft switching is manufactured for a fine compensation in this study.

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