REACTIVE POWER MANAGEMENT BY USING TCR AND TSC

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Abstract: A low-cost composite reactive power compensation model is proposed. The model consists of a Thyristor Switched Capacitor (TSC), a Thyristor Controlled Reactor (TCR). The paper completes the preliminary compensation by the large-capacity TSC+TCR module modules work together to improve the best in performance. Generally, due to the lagging load current when heavy inductive loads are connected to transmission line, an issue of poor power factor is introduced. Also, in some other cases, due to some minor load, very low current flows through the transmission line results in a leading shunt capacitance in the line which causing voltage amplification due to which the receiving end voltage may become twice of the sending end voltage that is Ferranti effect is introduce in long transmission lines. To prevent occurrence of such a fault in transmission system, we have a new concept of reactive power management using TSC & TCR as it will automatically provide efficient current controlling range from capacitive to inductive values by varying the firing angle of thyristor through microcontroller.

***Index Terms* - FACTS, SVC, TSC+TCR, Reactive power compensation, SCR, PIC controller, TRIAC**

I. INTRODUCTION

Recently, stability of voltage and voltage regulation have received tremendous attention because power systems are interconnected to supply loads of large and distant regions. Different types of flexible AC transmission system (FACTS) controllers in AC systems can be used for voltage control, voltage regulation, voltage stability, controlling the phase angle, varying the line impedance, reactive power control and management, steady state stability, damping system oscillations and controlling power flow in the transmission line.

The reactive power requirements increase with the increase in length of transmission line. AC lines require parallel and series compensation in long distance transmission mainly to overcome the problems of line charging and stability limitations. The shunt type of FACTS Controllers is used to either absorb or inject reactive power into the system and provides reactive power management. For this purpose, shunt reactors and shunt capacitors are extensively used. With the help of power electronics, the power transmission network can be utilized more effectively.

Static VAR Compensators is a shunt type of FACTS device which behaves like a shunt-connected variable reactance, which either generates or absorbs reactive power in order to regulate the PCC voltage magnitude. SVC is based on thyristors without the gate turn-off capability and includes separate equipment for leading and lagging VARs the thyristor-controlled or thyristor switched reactor for absorbing the reactive power and thyristor-switched capacitor for supplying the reactive power by synchronous switching of capacitor banks. In most cases, a combination of both will be the effective solution.

Power utilities and their customers are often concerned themselves with three major problems that include increased cost of power, reduced capacity of system and degraded power quality. The corresponding deviations in voltage at the load bus causes due to the continuous change in load bus of distribution system. The dips in rms voltage due to the loads such as repetitive welding operations, tractions, lifts, hoists etc. also the major portion of reactive power is drawn by the other loads such as arc furnaces. Hence For such types of loads the control reactive current needed results in significant voltage drop in the line impedance. The focus of research in project work is on a FACTS device the modifying static VAR compensator. The SVC is basic and based on proven technology for reactive power compensation and power factor correction. Generally, SVC has been used as a shunt device that offers reactive power compensation and voltage stability to the load.

II. REACTIVE POWER COMPENSATION TECHNIQUES

Reactive power compensation is an essential subject in power electronic systems. In recent years, to increase the capacity and controllability of transferred power and to satisfy the reactive power demand of the system efficiently the power electronics components and static controllers are used in compensation. The FACTS (Flexible AC Transmission Systems) devices are used for compensation such as semi-conductor-based switching type inverters and shunt reactive compensators. FACTS (flexible ac transmission systems) controllers, are faster than common mechanical controllers, which are based on high speed power electronics devices. In these systems, to overcome compensation problems static var compensators (SVCs) are used with fast response time characteristics. to produce or absorb reactive power in the compensation of transmission lines the FACTS devices do not need capacitor or reactor groups. Many applications have been developed to boost the stability of power systems with the development of FACTS devices in power transmission systems and utilization. FACTS devices can be used to control power flow and to increase the stability of the system. The main advantages of these devices are their controllability and flexibility. They are mainly implemented to increase the voltage stability, voltage control of power systems and to enhance the stability of power systems. These applications can be done with controlling the voltage level and phase angle.

GENERAL COMPENSATION TECHNIQUES

FACTS technology consists of number of devices such as:

- Static Synchronous Compensator (STATCOM).
- Static Var Compensator (SVC).
- Unified Power Flow Controller (UPFC)
- Inter-phase Power Flow Controller (IPFC).
- Static Synchronous Series Controller (SSSC).
- Thyristor Controlled Series Compensator (TCSC).

The above-mentioned devices may be connected either in series compensation or in shunt compensation depending upon their compensating strategies.

REACTIVE POWER COMPENSATION PRINCIPLES

Series connection or parallel (shunt) connection are the two ways of the implementation of the reactive power compensation. Series connected systems are used to filter voltage harmonics, voltage regulation and harmonic isolation. whereas parallel connected systems are generally used for reactive power compensation and to filter current harmonics.

STATIC VAR COMPENSATION

In this paper the Static Var Compensator (SVC) (This is nothing but thyristor-controlled reactor or thyristor-switched capacitor or combination of both) is used as FACTS device. To provide variable reactive power compensation both during the leading and lagging power factor conditions the thyristor-controlled static var compensators are used. The output of SVC which is shunt connected static var generator or absorber is adjusted to exchange capacitive or inductive current so as to control the various parameters of the electrical power system. SVC includes separate equipment for leading and lagging var and is based on thyristors without the gate turn-off capability; the thyristor-switched capacitor for supplying the reactive power by synchronous switching of capacitor banks and thyristor-controlled or thyristor switched reactor for absorbing the reactive power. In most cases, a combination of both will be the best solution. Effective reactance of TCR is varied in a continuous manner by partial-conduction control of the thyristor valve. In TCR conduction time and current in a shunt reactor is controlled by a thyristor-based ac switch with firing angle control.

THYRISTOR-SWITCHED CAPACITORS

The thyristor-switched capacitor (TSC) type of static compensation is shown in Fig 1. By using bidirectional thyristor switches the shunt-capacitor bank is split up into small steps, it can be made switched in and out individually. Fig 2 shows the single-phase branch, consists of capacitor C and the thyristor switch *TY* and a minor component, the reactor *L*, which is used to limit the rate of rise of the current through the thyristors and to prevent resonance with the network. The capacitor is switched out through the suppression of the gate trigger pulses of the thyristors.

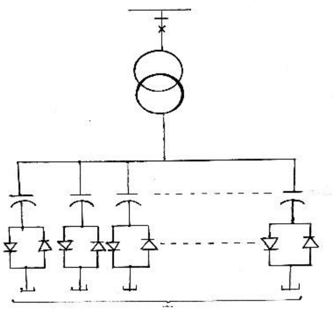

Fig. 1 Thyristor switched Capacitor

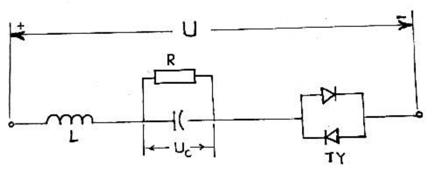

Fig. 2 single branch of TSC

The capacitor in the stand-by state loses its voltage as it is provided by the resistance R and it is immediately get ready for a new connection, even if it has not been completely discharged. Static compensators of the TSC type are characterized by having the following properties:

- Stepwise control
- Very low inrush transients
- Average delay of one half-cycle (maximum one cycle) in the execution of a command from the regulator, as seen for a single phase
- No generation of harmonics
- Low losses at low-compensator reactive-power output.

THYRISTOR CONTROLLED REACTOR

For thyristor-based SVCs, a TCR is one of the most important building block. Although it can be used alone, it is more often used in conjunction with fixed or thyristor-switched capacitors to provide instant, continuous control of reactive power over the entire selected lagging-to-leading range. Fig.1 shows the thyristor-controlled reactor (TCR) type of static compensation. Fig 2 shows the single phase TCR branch.

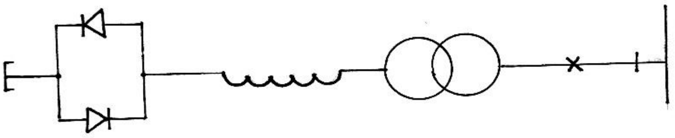

Fig 3 : Thyristor-controlled reactor (TCR)

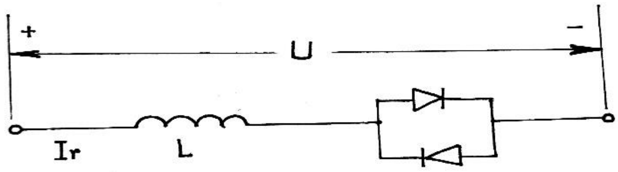

Fig 4 : Thyristor-switched capacitor (TSC)

COMBINATION OF TSC- TCR

Fig. 5 shows Combination of TSC and TCR, which is for good reactive power management. The acceptance of product must be the cost effective and good in quality and in response, which strongly depends on the cost evaluation of the losses. In the thyristor switched capacitor arrangement the total reactive power is distributed into a number of parallel-capacitor banks. The reactive power from the compensator follows the load or terminal voltage variations. A continuously variable reactive power can be obtained by using a thyristor-controlled reactor in combination with thyristor-switched capacitor banks. The harmonic generation will be lower, because the controlled reactor is small as compared with the total controlled power. A continuous change in the control order from fully lagging to fully leading current is obtained by TSC- TCR combination. The operation of the controlled reactor is in perfect co-ordination with the switched-capacitor banks.

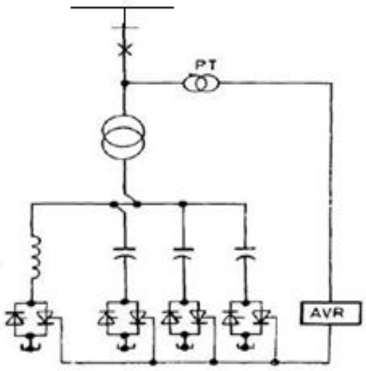

Fig 5: Combination of TSC-TCR

III. Block Diagram

For knowing above concept more practically, fabrication of the TSC-TCR model for scale down laboratory model is done. The block diagram for model to be implemented is shown in Fig.6. The hardware component requires are Thyristors, capacitors, opto-isolators, potential transformer, current transformer. The details of the design, fabrication and test results of TCR and TSC schemes and their capability to improve the system performance will be studied. The design, fabrication and testing of laboratory model of a reactive power management using TSC and TCR will be done. The effect of shunt compensation at light load and heavy load on voltage profile will be improved through this model.

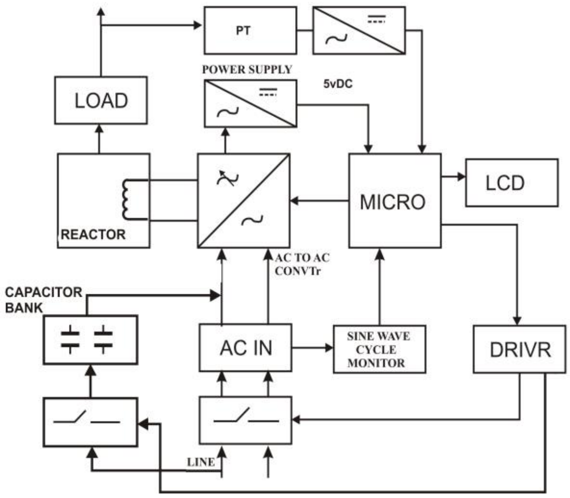

Fig.6 Block Diagram

IV. CIRCUIT DIAGRAM

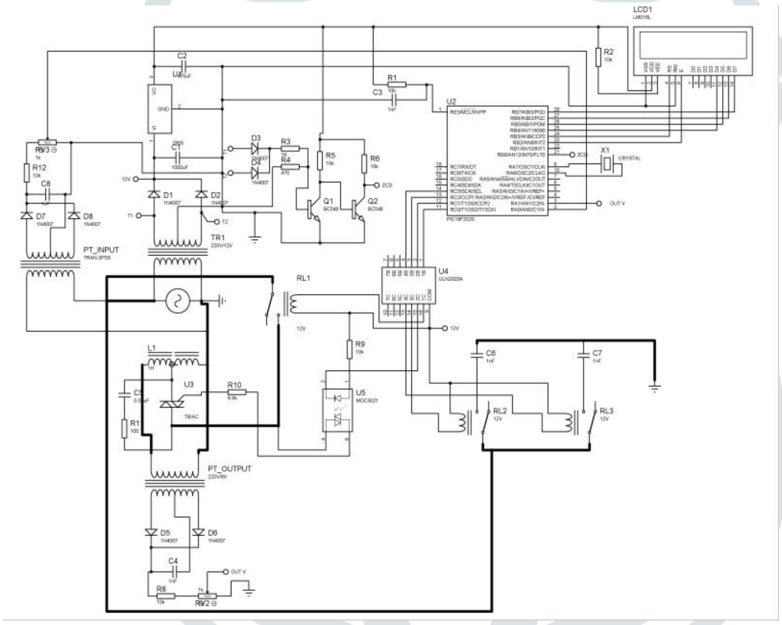

Fig.7 Circuit Diagram

Fig 7 shows model of receiving end point where single phase transmission line voltage is going to be observed continuously by PIC microcontroller. If there is any voltage drop observed then to manage that, PIC microcontroller will send command to Triac (antiparallel arrangement of thyristor) of connected shunt capacitor to come into service and will act as TSC.

If there is any rise in voltage observed, then again PIC-microcontroller will send command to the Traic of shunt capacitor to get out of service and to Traic of shunt reactor to come in service and will act as TCR. Accordingly, voltage at receiving end will get maintained in admirable limit and also the reactive power management is provided.

IV. RESULTS AND CONCLUSION

Thyristor-controlled static compensators is act as a good reactive power absorber as well as generator. Static compensator normally connected through a transformer and can be used with any system voltage. Thyristor- controlled static compensators can be utilized for different applications such as,

voltage control and regulation, voltage balancing and stability improvement. It will be more useful to implement it in power systems, industries, distribution and transmission systems.

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