Hybrid Model of TSC- TCR for Power Transmission

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Abstract - Electric power demand is increasing. Generating unit and the distribution system are connected through Transmission network or lines, as the demand is increasing capacity of the generating unit and the transmission line is also increasing. For increasing the power transfer capability of the existing transmission system, FACT's devices are used. More and more FACTS equipments are being installed in power systems to achieve high flexibility and wide tolerance of load variation, normally by controlling the reactive power generation and absorption to and from the transmission systems. This paper deals with the static Var compensators comprising of thyristor controlled reactor (TCR) and thyristor switched capacitor (TSC). They are designed to apply on the scaled down laboratory Model of a long transmission line

Keywords-SVC,TSC-TCR, reactive power compensation.

1. Introduction

The power loading of lines is restricted due to thermal limit, dielectric limit and stability. Hence, increased in power demand leads to increase in 'demand of installation of new transmission lines' which need excessive cost investment for lines, protective equipments, space, more manpower etc. Above difficulties could be overcome by using FACTS devices.

The shunt type of FACTS Controllers is used to either absorb or inject reactive power into the system and provides reactive power compensation. Shunt reactors and shunt capacitors are, extensively used for this purpose. With the help of power electronics the power transmission network can be utilized more effectively.

The developments of thyristor valves capable of handling large currents, as well as the technique of using them to switch capacitors in and out to control the current through a reactor, have provided the power-system engineer with a new tool to meet reactive power generation and absorption demand

2. Facts Technology

FACTS technology consists of number of devices.
Some of the FACTS devices are:

- 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).
- Super Conducting Magnetic Energy Storage (SMES).

Depending upon their compensating strategies the above mentioned devices may be connected either in series compensation or in shunt compensation.

2.1 Static Var Compensator

The type of FACTS device used in this paper is the Static Var Compensator (SVC) (This is nothing but thyristor controlled reactor or thyristor-switched capacitor or combination of both). Thyristor-controlled static var compensators are used to provide variable reactive power compensation both during the leading and lagging power factor conditions. Static var Compensator is a shunt type of device. SVC is a shunt connected Static var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to control the various parameters of the electrical power system. 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 best solution [1], [2].

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 [1].

2.2 Thyristor-Switched Capacitors

Fig 1 shows the thyristor-switched capacitor (TSC) type of static compensation. The shunt-capacitor bank is split up into small steps, by using bidirectional thyristor switches 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 also to prevent resonance with the network. The capacitor is switched out through the suppression of the gate trigger pulses of the thyristors [2].

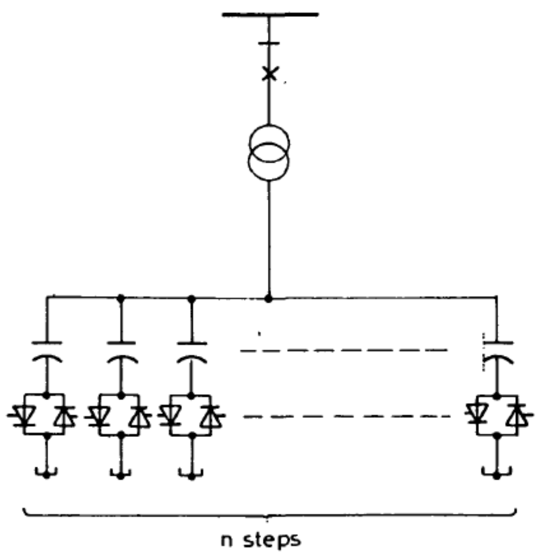

Fig. 1 Thyristor switched Capacitor [2]

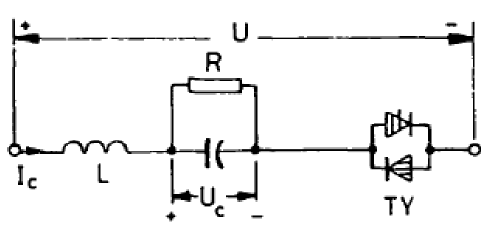

Fig. 2 single branch of TSC [2]

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
- Average delay of one half-cycle (maximum one cycle) in the execution of a command from the regulator, as seen for a single phase
- Very low inrush transients
- No generation of harmonics
- Low losses at low-compensator reactive-power output [2].

2.3. Thyristor-Controlled Reactor

Fig 3 shows the thyristor-controlled reactor (TCR) type of static compensation. Fig 4 shows the three phase branches. each of it, which includes an inductor *L* and a bidirectional thyristor switch *TY,*
Static compensators of the TCR type are characterized by having the following properties:

- Continuous control
- Maximum delay of one half cycles in the execution of a command from the regulator, as seen for a single phase.
- Practically no transients
- Generation of harmonics [2].

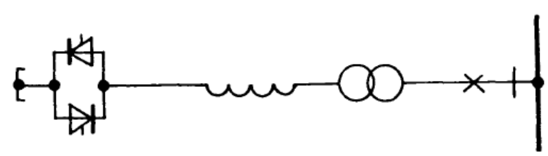

Fig. 3 Thyristor Controlled Reactor [2]

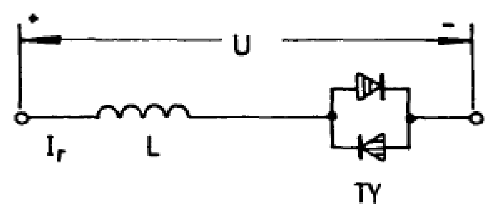

Fig. 4 Single branch of TCR [2]

2.4. Combination of TSC- TCR

Fig. 5 shows Combination of both TSC and TCR, which is good reactive power compensation. The choice of product must be the cost effective and also good in quality and in response, which strongly depends on the cost evaluation of the losses [3]. In the thyristor switched-capacitor scheme the total reactive power is split into a number of parallel-capacitor banks. The reactive power from the compensator follows the load or terminal voltage variations in a step. A continuously variable reactive power can be achieved by using a thyristor-controlled reactor in combination with thyristor-switched capacitor banks. The harmonic generation will be low, because the controlled reactor is small compared with the total controlled power [2].

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. Static compensators of the combined TSC and TCR type are characterized by the following properties:

- Continuous control
- Practically no transients
- Low generation of harmonics
- Low losses
- Flexibility in control and operation [2].

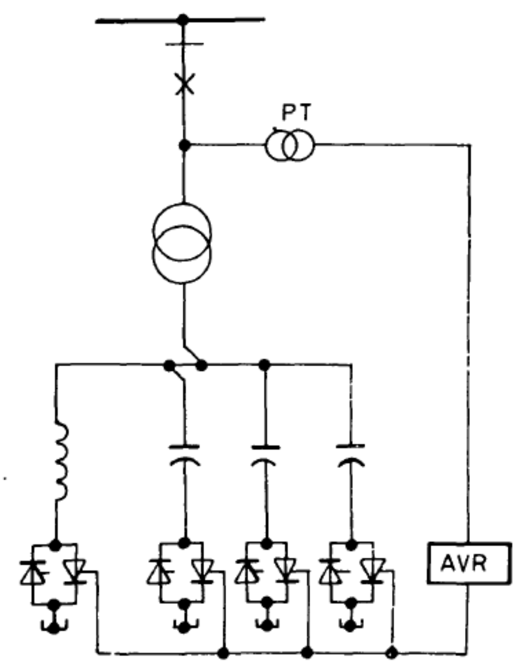

Fig. 5 Combination of TSC-TCR [2]

3. Block diagram

For knowing above concept more practically, I am fabricating the TSC- TCR model for scale down laboratory model of transmission line. The block diagram for model to be implemented is shown in Fig. 6. The hardware component requires are Thyristors, capacitor, opto-isolators, Potential transformer, transformer, digital CRO. 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.

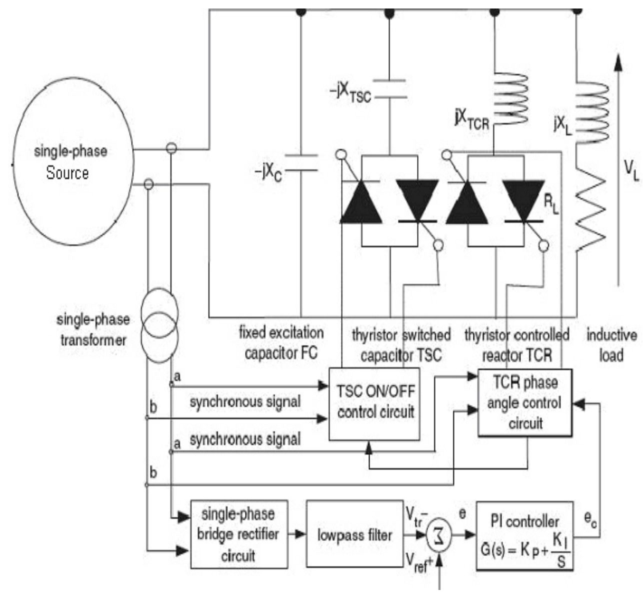

Fig 6 Block Diagram

The design, fabrication and testing of laboratory model of a hybrid static VAR compensators comprising thyristor controlled reactor (TCR) and Thyristor switched capacitor (TSC) will be done on transmission line. The effect of shunt compensation at light load and heavy load on voltage profile will be improved through this model [1].

4. Circuit Diagram

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

If there is any voltage rise observed then again 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 substation will get maintained in permissible limit and also the reactive power compensation is provided.

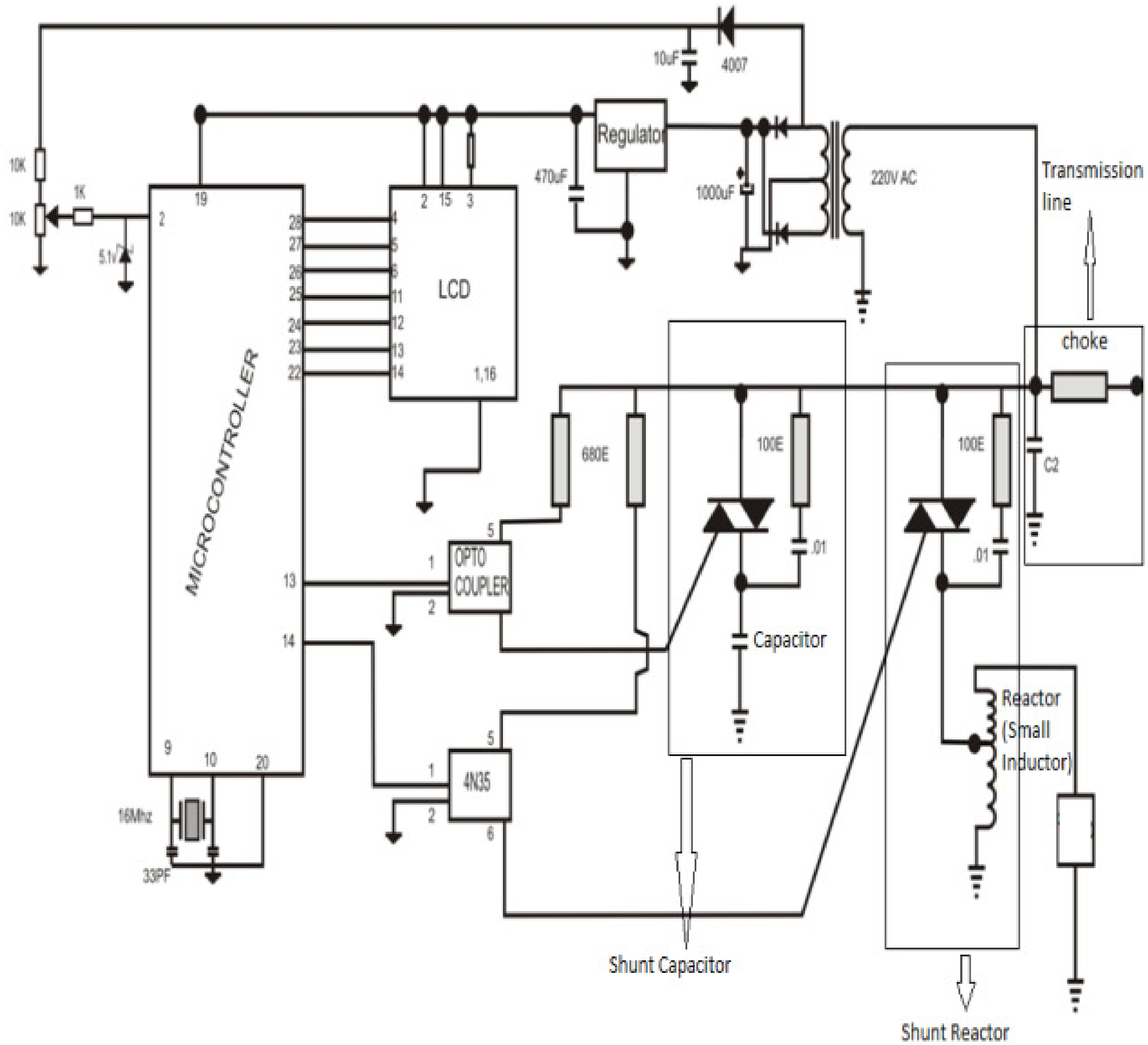

Fig 7 Circuit diagram

4.1 Shunt reactor

In light load condition of the power system, there may rise of voltage at the receiving end bus due to Ferranti effect. Moreover, for higher capacitive charging current, there may be problem in switching of circuit breakers under light load conditions. In such instances installation of shunt reactors in the receiving end bus may offer a technically feasible and economically viable solution by controlling the receiving end voltage. A reactor may or may not remain in service for the entire period of time or may bring in service during light load period only. Reactors may used when system voltage need to be controlled [4].

4.2 Shunt capacitor

Shunt capacitor are used for lagging power factor circuits created by heavy loads. The effect is to supply requisite reactive power to maintain the receiving end voltage at a satisfactory level. Capacitor are connecting either directly to bus bar or to the tertiary winding of a main transformer and are disposed along the route to minimize the losses and voltage drops [5].

5. Conclusions

Thyristor-controlled static compensators will be act as a good reactive power generator and absorber. Static compensator can be used with any system voltage, and is normally connected through a transformer. Thyristor-controlled static compensators can be used for different applications such as, voltage control, voltage balancing and stability improvement It will be more beneficial to implement it in industries, distribution and transmission systems.

References

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