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TRANSIENT FREE TSC COMPENSATOR FOR REACTIVE LOAD WITH CLOSED LOOP CONTROL

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ABSTRACT

The problem related to the transmission system rises due to the voltage stability, voltage regulation. The proposed topology designs the **π** section equivalent circuit for 400 km and produced voltage sag which is eliminate by using switched capacitor. Thyristor switched capacitor in closed loop control system, for transient free operation is carried out by switching the capacitor at positive or negative peak of the voltage or at zero instant. In this paper closed loop control of FACTS devices for reactive power compensation is discussed and simulated using MATLAB. This scheme is also used for minimization of voltage sag of online starting of the 3 phase induction motor. Proposed scheme can achieve the reactive power compensation and problem related to voltage regulation at the receiving end.

Keywords

Thyristor Switched capacitor (TSC), Reactive Power Compensation, voltage sag, closed loop control.

1. INTRODUCTION

Recently development in flexible AC transmission system can improve the power quality of the system and respond to the demand for electrical energy. Now a days the load on the transmission line increase so problem related to power quality arise such as power frequency disturbances, power system transients, electromagnetic interference, poor power factor, harmonics, grounding and bonding problems. In this paper effects of thyristor switched capacitor on transmission line has been investigated .The paper includes details of experimental results analyzed on MATLAB and hardware model. Inductive load is the main reason for affecting the voltage profile of any power system. Due to inductive load the reactive power comes into the picture and hence the voltage stability is lost. With the development of industries and increase in population, there is an increased demand in consumption of electrical power. The generation of reactive power by making use of shunt and series capacitor and reactors, can provide support to an overstressed LV or HV supply system and achieve optimum utilization and higher level of stability. In LV system reactive control is provided mainly to improve the load power factor and hence its load-carrying capacity. The reactive power generation and absorption in power system is essential since the reactive power is very precious in keeping the voltage of power system stable. The main element for generation and absorption of reactive power are transmission line, transformer and alternators. The reactive power not only causes voltage swings but also displaces transmission capacity, increasing energy losses in the system.

2. PRINCIPLE OF THYRISTOR SWITCHED CAPACITOR

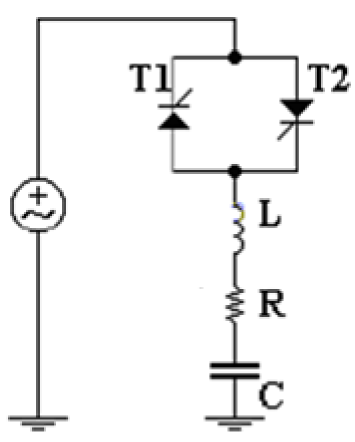
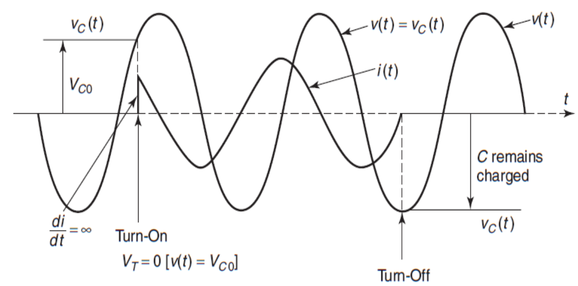


Fig.1. Main Structure of TSC

Thyristor switched capacitor is a capacitor that gets connected or disconnected to a transmission line through a pair of anti-parallel thyristors. The basic circuit is shown in Fig.1. But, this is not the actual circuit which is implemented. Suppose at an instant if TSC is on, then there will be very high di/dt, almost infinite. This can damage the thyristors. So, to limit that, inductor is kept in series ensuring the protection of the thyristors.

As stated earlier, connecting a capacitor in parallel to the line will inject the reactive power into the system which in turn will result in power factor improvement and voltage compensation. This effect will improve the power quality and hence will make the system



reliable. One more reason for selecting TSC as a shunt FACTS controller is that it does not inject any kind of harmonics into the system. Thyristor Switched Capacitor (TSC) is one of shunt FACTS devices. Thyristor Switched Capacitor is a device used for compensating reactive power in electrical power system.

Fig.2. Waveform of TSC

3. TRANSIENT FREETHYRISTOR SWITCHED CAPACITOR

The thyristors switches the capacitor immediately when the difference between capacitor voltage and system voltage equals to zero as shown in Fig.3.Thecurrent starts to flow through the capacitor and increases from zero to its peak value without any inrush current. The switching OFF of thyristor gets naturally when the control signal is OFF and the direct current flowing through thyristors extinguishes. The connection of capacitor banks in the zero-cross voltage minimizes the initial current peak which causes the variation of voltage across the capacitor, extending its life and preventing voltage drops occur in the network due to wiring inductances. This method uses a minimum number of thyristors and provides fast capacitor switching without any disturbances to the network.

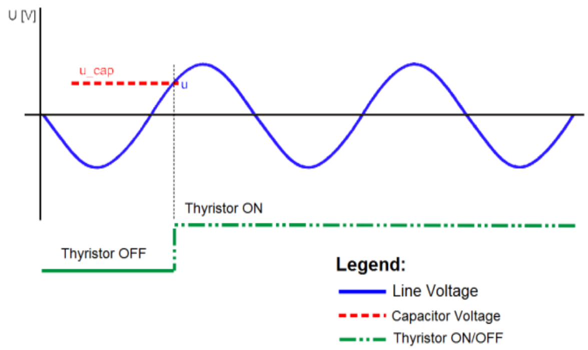


Fig.3. Principle of TSC Switching At Zero Crossing

4. CLOSED LOOP CONTROL OF THYRISTOR SWITCHED CAPACITOR

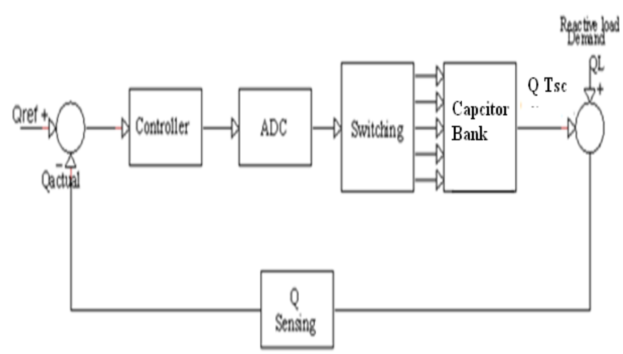


Fig.4.Block Diagram of Closed Loop Control

The closed loop circuit senses the voltage drop, compares it with the reference value, and if it is found lesser than the reference value then it enables the TSC module hence it starts the compensation which increases the voltage instantaneously.

When switching the capacitors, precautions must be taken to ensure that the inrush current is limited to a non-destructive value. The right capacitor switching device is a key to reliable and trouble free capacitor bank performance. This proposed method is to present a solution for capacitor switching based on controlled voltage semiconductor switches which have a large number of operations, and capable of reducing voltage transients and inrush current.

The thyristor switches the capacitor immediately when the difference between capacitor voltage and system voltage equals to zero. Capacitors gets switch ON when a current reaches to zero value of supply voltage. This is carried out by ZCD circuit; Due to this the transient occurrence at the instant of switching of capacitor is avoided.

5. TRANSMISSION LINE MODEL

Transmission line configure into three types.

5.1. Short transmission line: Transmission line is defined as a short-length line if its length is less than 80 km (50 mi). In this case, the capacitive effect is negligible and only the resistance and inductive reactance are considered.

5.2. Medium transmission line: If the length of the line is between 80 km (50 mi) and 240 km (150 mi) long, the line is considered as a medium length. The line single-phase equivalent circuit can be represented in a nominal π or T configurations.

5.3. Long transmission line: If the line is more than 240 km long, the model must consider parameters uniformly distributed along the line.

In this proposed work the transmission line model is configure into different π section. The transmission line design for voltage sag at receiving end. The load bank is designed for RL load. It is so supposed to represent entire length of 400 Km using eight **π** sections consisting of resistance, inductance and shunt capacitances. Thus, each **π** section is representing 50 Km line. By using the following data the various quantities related to transmission line model and load bank are calculated.

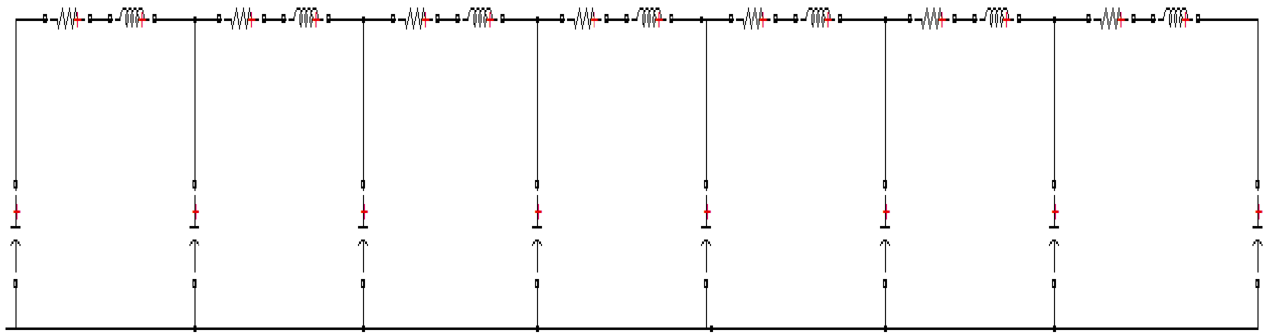


Fig.5. Transmission Line Model

6. TRANSMISSION LINE PARAMETER

Table 1: Transmission Line Parameters

SR.NO.	PARAMETER	VALUE
1	Source voltage at sending end (VS)	230 VOLTS
2	Receiving end voltage (VR)	150 VOLTS
3	Resistance	0.24Ω/50Km
4	Shunt capacitance	2μf/50Km
5	Series inductance	8.045mH/50Km
6	System frequency	50HZ

7. EXPERIMENTAL RESULTS

7.1. Simulation Result

The simulation circuit as shown in Fig.6&8.The open loop operation can be performed by using this model. The load is connected to receiving end. By giving a 230 V supply to a transmission line, due to increase in load voltage, sag problem is produced which also reduces the reactive power. Now to eliminate this voltage sag problem and for reactive power compensation we connect TSC banks in the system. By using different values of capacitors problem related to voltage sag and reactive power compensation is achieved.

7.1.1. Simulation model and result without compensation

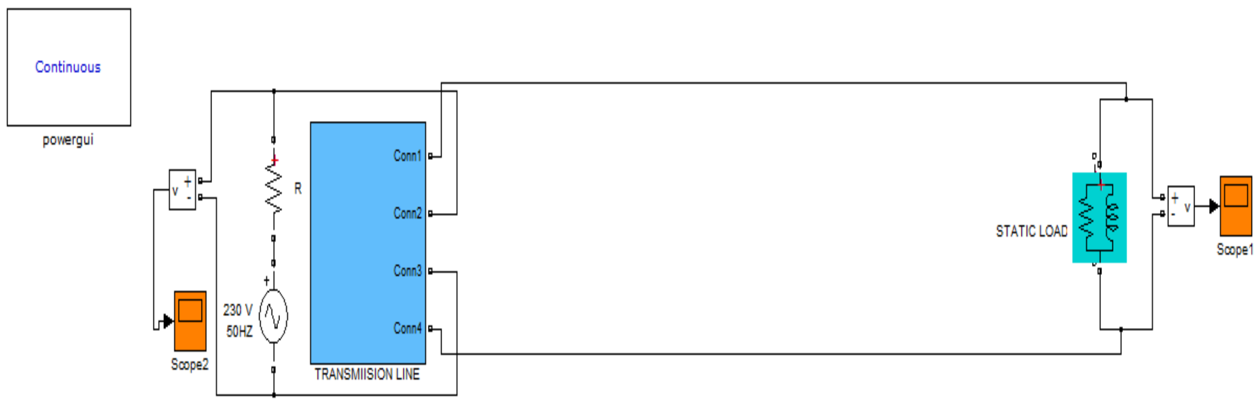


Fig.6. Simulation Model without Compensation

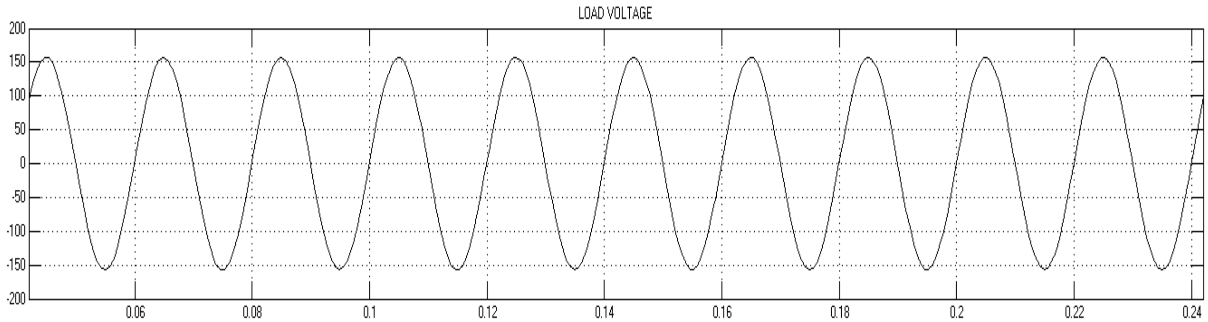


Fig.7.Simulation Result without Compensation

7.1.2. Simulation Model and result with Compensation

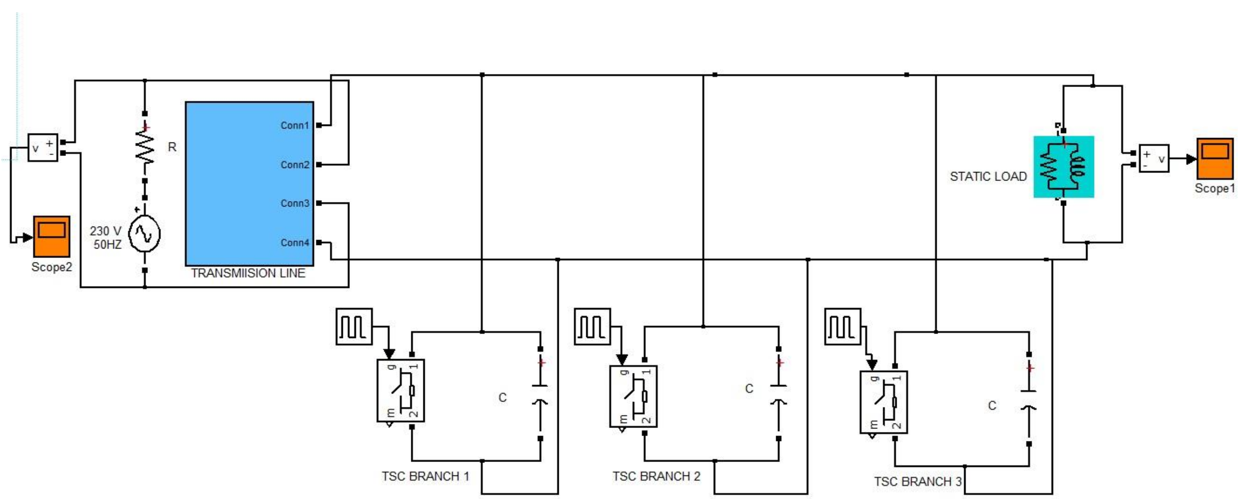


Fig.8. Simulation Model with compensation

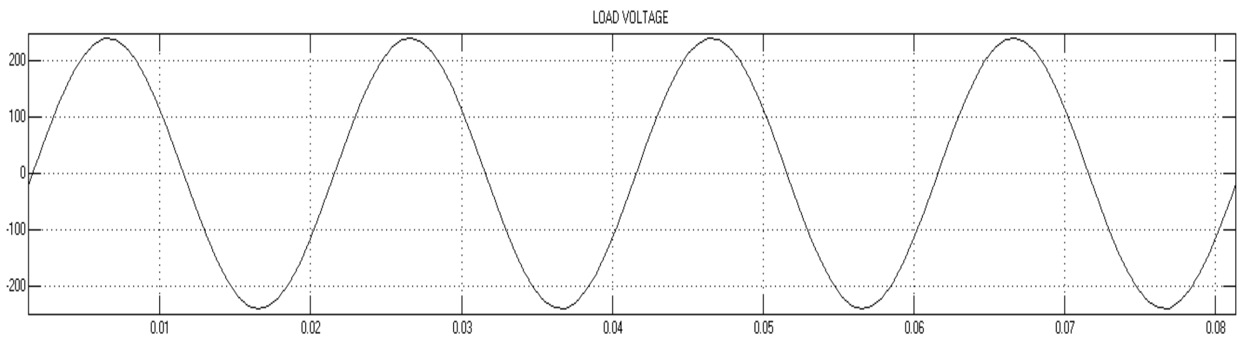


Fig.9.Simulation Result with Compensation

8. RESULTS

For open loop results, Fig.7.shows the 1-phase receiving end voltages which decrease at 0.1s as the load increases.Fig.9.shows the increase in voltage after switching a capacitor. Voltage drop can be seen after 0.1s. Normally, the receiving end voltage is lesser than the sending end voltage, but it is within the permissible limits. The increase in the load of transmission line causes the further decrease in voltage sag now it is going out of the permissible limit. Hence, the suitable compensation is required at that time for concerned transmission line.

8.1. HARDWARE MODEL

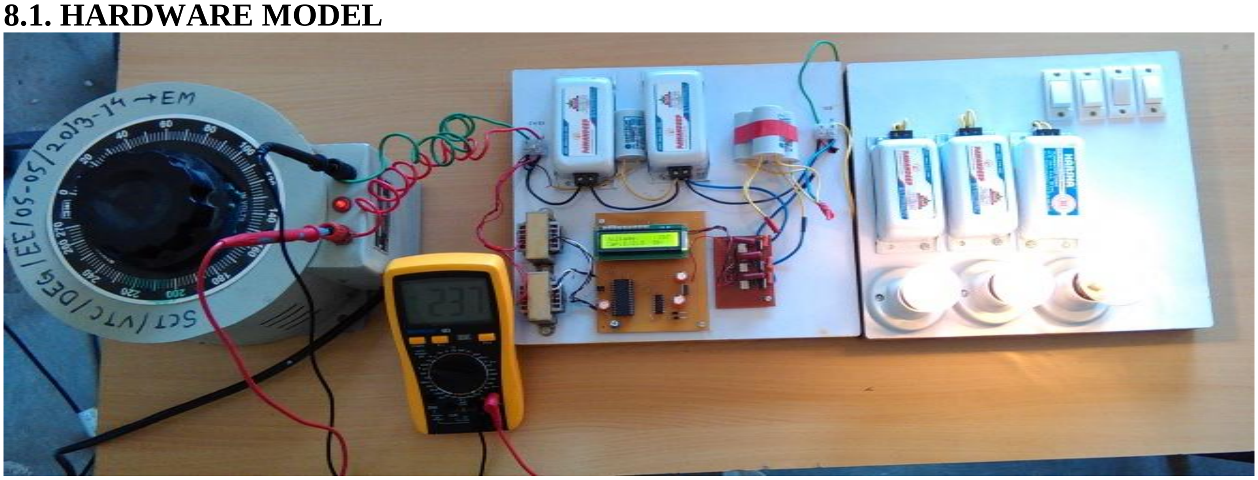


Fig.10. Prototype Model of TSC

8.2. HARDWARE RESULT

In this paper the hardware implementation of TSC is done for reactive power compensation. Here the capacitors are used for compensation. The increase in inductive load causes the generation of problems related to reactive power and voltage sag. As need of reactive power is increased at the receiving end, the particular capacitor bank get switched into the transmission line. The ZCD determines the zero crossing of voltage and current and determine the ‘φ’.

Now according to the need of reactive power and voltage available at receiving end, the closed loop controller switched in the particular capacitor bank into the transmission line. It can also mitigate the problem related to voltage sag, voltage stability and power factor.

Table 2: Hardware Results

SR. NO	Load RL (watts)	Voltage without compensation (Volts)	Status of capacitor bank	Voltage with compensation (volts)
1.	80	190	1 ON	229
2.	130	185	1,2 ON	227
3.	180	179	1,2,3 ON	223

9. CONCLUSION

The work in this paper deals with the analysis, design and implementation of thyristors switched capacitor. The TSC bank is proposed for the reactive power compensation and voltage regulation. In this paper the switching of capacitor is transient free and it does not inject any harmonics into the system. The closed loop control continuously monitors the voltage at receiving end and it switch ON the TSC bank as per requirement of reactive power. The modeling and simulation of TSC has been verified using MATLAB. The TSC in the system caused to improve reactive power, voltage profile and power factor.

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