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Instantaneous Reactive Power Compensation and Voltage Stability with Thyristor Switch Capacitor (TSC) and Static Var Compensator (SVC)

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Abstract

Modern Electrical power transmission system is developing and load demands are increasing, problems of voltage flicker and voltage stability has become important subjects in Power System. Now-a-days Flexible AC Transmission System (FACTS) has become a subject of interest for power System Engineers. In this paper, effects of Thyristor Switch Capacitor (TSC), which is one of FACTS Devices, on load voltage are estimated and checked. By this Technology large and slow, old operating Circuit Breakers are eliminated. The modeling and Simulation of TSC are verified using MATLAB 7.8, SimPower system Block set. Proposed technology allows the steady state and dynamic performance of TSC on transmission system by regulating Voltage through generating or absorbing reactive power and accordingly Compensation is carried out.

IndexTerms: receiving end voltage (Vr); SVC; gate pulse; sending end voltage(Vs) and Thyristor Switched Capacitor(TSC); SVC Controller; Voltage regulator; MATLAB

INTRODUCTION

For any power system, main reason for deterioration of the voltage profile is the inductive (reactive) load .Due to this inductive (reactive) load the reactive power comes into the picture and hence the voltage stability is lost. With the development of industries and increase in population day by day, there is an increased demand in consumption of electrical power.

For a power system to be termed as reliable it should not be affected by temporary overloads ,Voltage should be constant with very less loss in transmission and distribution. Overload conditions should be compensate during appropriate compensators using facts devices. There are mainly two types of compensation, viz .shunt and series .In series compensation, the overall reactance is reduced by connecting a capacitor in series with the transmission line and hence voltage drop is reduced .In shunt compensation, reactive power is injected into the line so as to reduce the amount of reactive power supplied by source. Shunt compensation is a direct acting method which changes the receiving end voltages very fast .It also improves power factor. In this paper, shunt compensation method using FACTS controller is simulated. The FACTS controller is Thyristor Switched Capacitor(TSC) along with Thyristor controlled Reactor (TCR).It is connected or disconnected depending on the loading conditions and compensates the reactive power. The complete simulation is carried out in MATLAB 2013(b).

SVC CONTROLLER

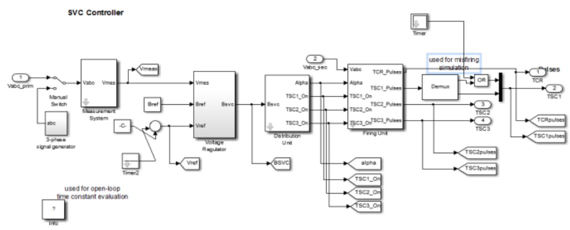


FIG 3: Simulation model of SVC controller

The SVC control system is most important part of the TSC module it regulates supplies of TSC and check status of TRC modules also.

SVC has four main subsystems which consist Measurement System, Voltage Regulator, Distribution unit and Firing circuit. Basically Measurement system measures primary voltage by discrete Fourier computation technique (which changes sample domain to frequency (domain) to check fundamental voltage. PLL Block is used after discrete Fourier transform method because of variations in frequency.

Voltage Regulator comes after measurement unit in picture. It basically regulates measured primary voltage and takes reference voltage as 1.0 pu which has already mentioned. PI controller Technique is used to find error between specified and reference voltages. By regulating voltage, voltage drop is also find out for VI characteristic.

Therefore, SVC operating point changes from fully capacitive to fully inductive. Distribution Unit mainly concerns on (Susceptance) which tells how easily ac flow through capacitive and inductive load which was regulated by Voltage regulator by using primary susceptance to determine the TCR firing angle α and the status (on/off) of the three TSC branches. The firing angle of TCR totally depends on lookup table .In Firing Unit, three subsystems exists. Each subsystem consists of a PLL synchronized. There are pulse generators for each and every TCR and TSC branches. The pulse generator uses the firing angle α and TSC status which comes from the Distribution Unit to generate pulses. The firing of TSC branches can be synchronized pulse is sent at positive and negative Thyristors at or continuous. The synchronized firing mode is the best method because it reduces harmonics quickly.

THYRISTOR SWITCH CAPACITOR (TSC)

In MATLAB Simulation model of The SVC consists of a 735 kV/16 kV, 333 MVA coupling transformer (are used to change level of impedance and works with AC only), one 109 Mvar TCR (Thyristor controlled reactor) bank and three 94 Mvar TSC (Thyristor switch capacitor banks) (TSC1 TSC2 TSC3) connected on the secondary side of the transformer.

On and Off of TSC (Thyristor switch capacitor) give permission of reactive power at second stage in discrete form. Reactive power varies from zero to (3*94) Mvar Capacitive at 16 kV in step format which concludes to 282. Phase control in TCR allows a continuous variation from zero to 109 Mvar (inductive). Taking into account leakage reactance of transformer (0.15 pu), the SVC equivalent susceptance which seen from the primary side and can be varied continuously from -1.04 pu/100 MVA (fully inductive) to +3.23 pu/100 Mvar (fully capacitive).

The SVC Controller monitors the primary voltage and sends appropriate pulses to the 24 Thyristors (6 Thyristors as per three-phase bank) to obtain the susceptance required by the voltage regulator. Each three-phase bank is connected in delta that's why during normal balanced operation; the zero-sequence triple harmonics (3rd, 9th...) remain inside the delta, and reducing harmonic injection into the power system.

POWER SYSTEM

The power system in TSC simulation model is represented by an inductive equivalent (6000 MVA short circuit level) and a 200-MW load. The internal voltage of system can be varied by help of a Three-Phase Programmable Voltage

Source block to observe the SVC dynamic response to changes in system voltage.

THYRISTOR SWITCHED CAPACITOR(TSC)

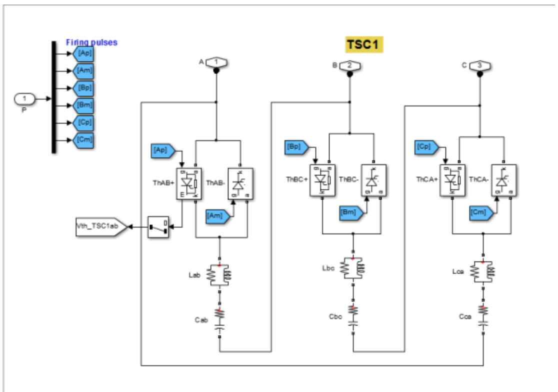
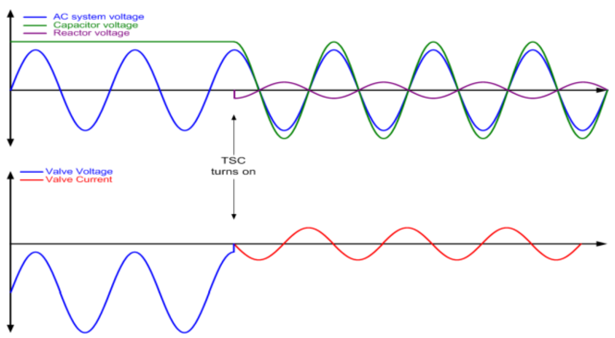


FIG 1: TSC simulation model

A Thyristor switch capacitor (TSC) is a type of equipment used for compensating reactive power in electrical power system that gets connected or disconnected to a transmission line through a pair of anti-parallel Thyristors. The basic circuit is shown in Fig.1.I It consists of a power capacitor connected in series with bidirectional Thyristor valve and usually the current limiting reactor (inductor).The Thyristor switched capacitor is an important component of Static Var Compensator (SVC) which is often used with Thyristor controlled Reactor (TCR).During starting of TSC there will be high rate of di/dt almost infinite so to limit, inductor is connected in series for protection of Thyristor.



As stated earlier, connecting a capacitor in parallel to the line will inject reactive power into the system which in turn will result in the power factor improvement and the voltage compensation. This effect will improve power quality and hence will make the system reliable. One more reason for selecting the TSC as a shunt FACTS controller is that it does not inject any kind of harmonics into the system which is benefictory.

THYRISTOR CONTROLLED REACTOR (TCR)

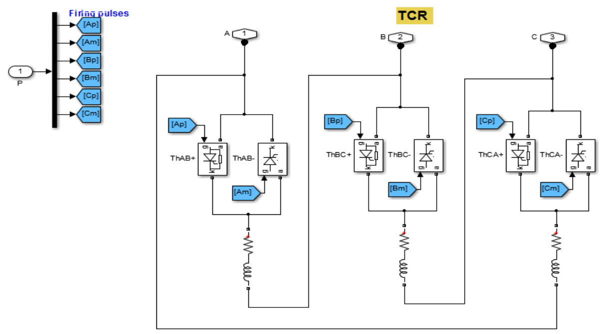
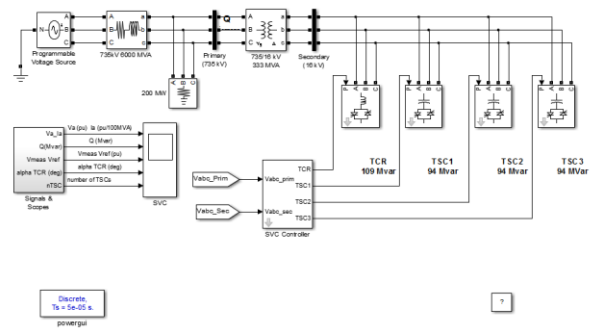


FIG 2: TCR Simulation model

SIMULATION



Simulation model of project

Run simulation and observe waveform in scope block of SVC. Control mode of SVC is voltage Control mode and reference voltage of SVC is Vref = 1.0pu. The voltage drop of regulator is 0.01 pu/100 VA therefore when SVC operating point changes from full

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capacitive (+300 MVAR) to fully inductive (-100 MVAR) the SVC voltage varies between (0.97 pu to 1.01pu).

At starting source voltage is set as 1.02 pu which results in 1.00 pu voltage at terminal when SVC is OFF. Reference voltage is set as 1.00 pu and SVC have initially zero current and this operating point is obtained from when TSC1 in service and TCR are almost full conduction.

At t=0.1s voltage is suddenly increased to 1.024 pu. And SVC reacts by absorbing reactive power (Q=-95 Mvar) to bring voltage back to 1.01 pu. At this point all TSCs are out of service and the TCR is at full conduction.

At t=0.4 s voltage is suddenly lowered to 0.933 pu. SVC reacts by generating 256 Mvar of reactive power and thus increasing the voltage to 0.974 pu. At this point the three TSCs are in service and the TCR absorbs approximately 40% of its nominal reactive power .Observe on the last trace of the scope how the TSCs are sequentially switched on and off. Finally, at t=0.7 s the voltage is increased to 1.0 pu and the SVC reactive power is reduced to zero.

RESULTS

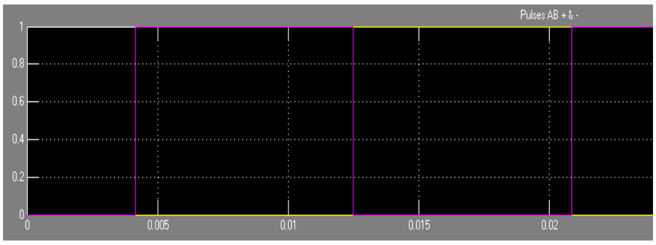

FIG 1.1: TSC waveform of pulses

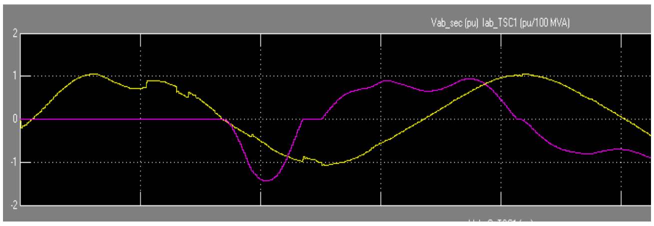
FIG 1.2: TSC waveform

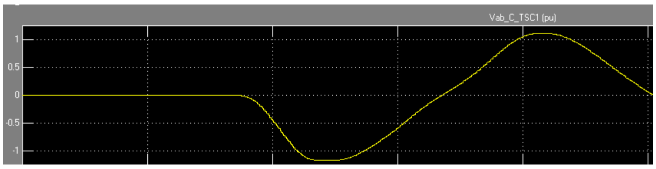
FIG 1.3: TSC waveform of V_{ab}

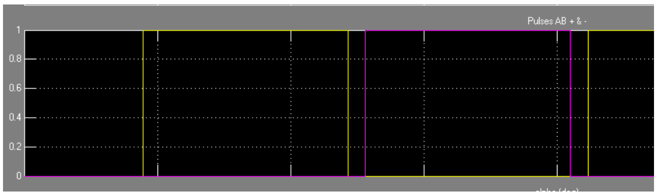
FIG 2.1: Firing angle of TCR

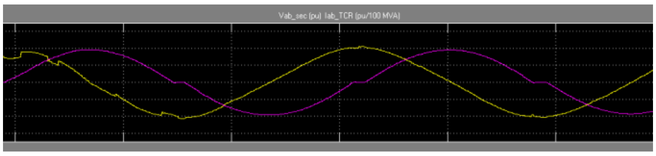
FIG 2.2: TCR waveform of V_{ab}

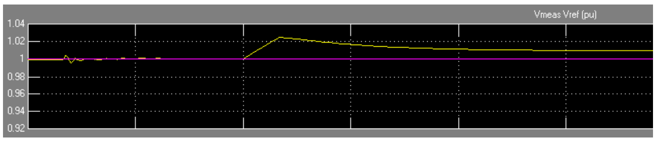
FIG 3.1: V_{ref} in SVC

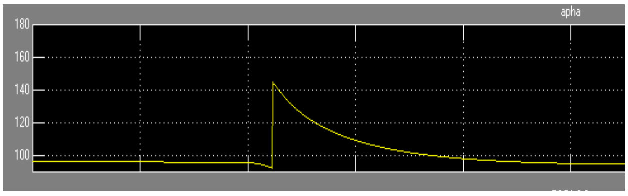

FIG 3.2: Firing angle of SVC

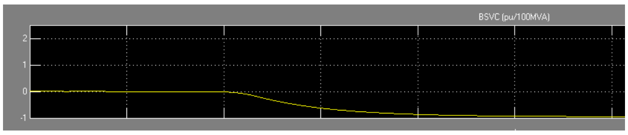
FIG 3.3: Susceptance in SVC

CONCLUSION

From the results seen in it can be seen that the voltage profile is maintained well for given time period and rapid load changes. This results the purpose of a reliable power system, that receiving end voltages should not be change in spite of the load changes. Although there is some unbalance in the system during the switching ,but that does not affect the system too much. The system is continuously monitored for voltage and frequency changes. According to the changes in system, the control is achieved to maintain the voltage profile constant and provide a better quality power to the consumers and industries.The advantage of this system is that it is a very fact acting system, quickly changes the voltages. Also TSC is used because it does not inject any kind of harmonics into the system hence further maintaining the power quality.

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