

## A COORDINATION CONTROL BETWEEN SVC AND BUS/SHUNT REACTORS

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### SUMMARY

Over the years, renewable energy sector in India has emerged as a significant player in the grid connected power generation capacity, especially in western part of country (Rajasthan and Gujarat). It has been realized that solar and wind power generation has to play a much deeper role in achieving energy security in the years ahead. The seasonal, agricultural and industrial load change causes voltage fluctuations and rapid change of demand of active and reactive power every day. Again, there is an immense requirement for the transmission system to be stable in a typical load condition also. The immediate voltage support by a Static Var Compensator (SVC) along with a coordination control between SVC and Shunt/Bus reactor can be a solution. In this paper different scenarios derived of coordination control between SVC and Shunt/Bus reactor has been presented in detail along with the relevant case study for a recently commissioned +400/-300 MVAR Static Var Compensator (SVC) Project at 400/220 kV substation of POWERGRID Kankroli, situated in North Western part of India.

### KEYWORDS

Static Var Compensation (SVC), Flexible AC Transmission Systems (FACTS), Control system, Energy savings



Figure 1.1  
**+400/-300 MVAR SVC**  
**KANKROLI**



Figure 1.2

## **1. INTRODUCTION**

At Kankroli (Rajasthan) substation, the +400/-300 MVAR Static Var Compensator (SVC) was commissioned in month of Dec 2016. At present this is equipped with state-of-the-art technology by POWERGRID. The SVC is providing necessary reactive power to maintain the bus voltage at the Kankroli substation at reference value, hence the transient and dynamic stability of the power system are maintained. The SVC is also providing necessary damping to power oscillations by modulating its output in its entire range (-300/+400 MVAR) as per requirement based on measured rate of change of power at 400 kV bus.

The Sub-Station acts as inter-regional link between Northern Region I and Western Region II of India and plays an important role in Power System Strengthening of south-western Rajasthan. It mainly evacuates Power from Rajasthan Atomic Power Project and supply it to South western Rajasthan

The First section of paper presents a coordination control scheme of Bus Reactors and Shunt Reactors with the SVC operations. Different steps of switching of Bus Reactors/Shunt reactors has shown based on the voltage profile of substation. The next section presents the SVC response during different types of fault, switching of bus reactors, charging of transmission line without shunt reactors followed by the various examples showing requirement coordination control scheme. The Final section demonstrate how SVC coordination control scheme works during different Power system conditions.

## **2. COORDINATION CONTROL SCHEME BETWEEN SVC AND BUS/SHUNT REACTORS**

In conventional practice the EHV long line shunt reactors and bus reactors are kept in service at substation level to control the voltage within the limits. These permanently connected shunt reactors and bus reactors consume active power, which is a continuous loss to the system. This continuous loss to the power system can be controlled if there is a proper coordination between SVC and Bus reactor/ Shunt Line Reactor/. In the coordination control model program, the SVC shall use its own capacity first and if still there is a requirement to provide inductive compensation then it shall initiate a close command to the Bus reactors.

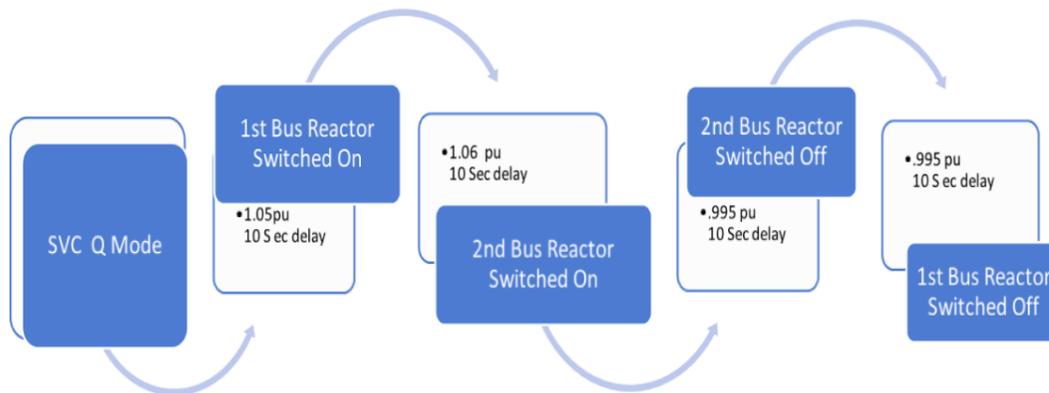


Figure 2.1

During heavy loading conditions the shunt reactors reduces the power transfer capacity of transmission line and if we manually switch off shunt reactor to increase the power transmission capacity, this involves risk of overvoltage during sudden load throw off. In the coordination control model, the shunt reactors shall be kept in service while charging of transmission line and only in loading conditions shunt reactor off command shall be initiated from the coordination control model program of SVC. In this model there is no risk of overvoltage during sudden load throw off as SVC shall use its own Thyristor controlled reactors to avoid such type of conditions.

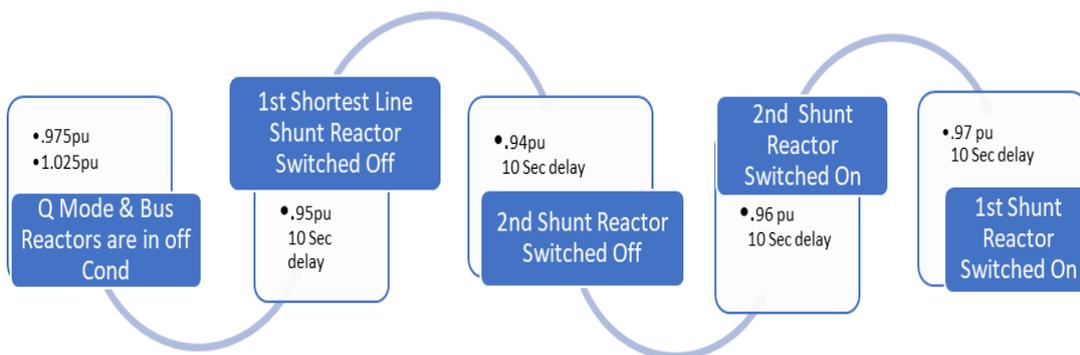


Figure 2.2

The fast response time of SVC makes this model suitable to respond to single phase and three phase faults in long transmission lines during heavy load conditions.

### 3. SVC RESPONSE DURING VARIOUS POWER SYSTEM CONDITIONS

The SVC control system senses the fault and bring the thyristor switched capacitor and thyristor-controlled reactors to full conduction within a short time thus it is fully compatible to single phase auto reclose. (figure 3.1)

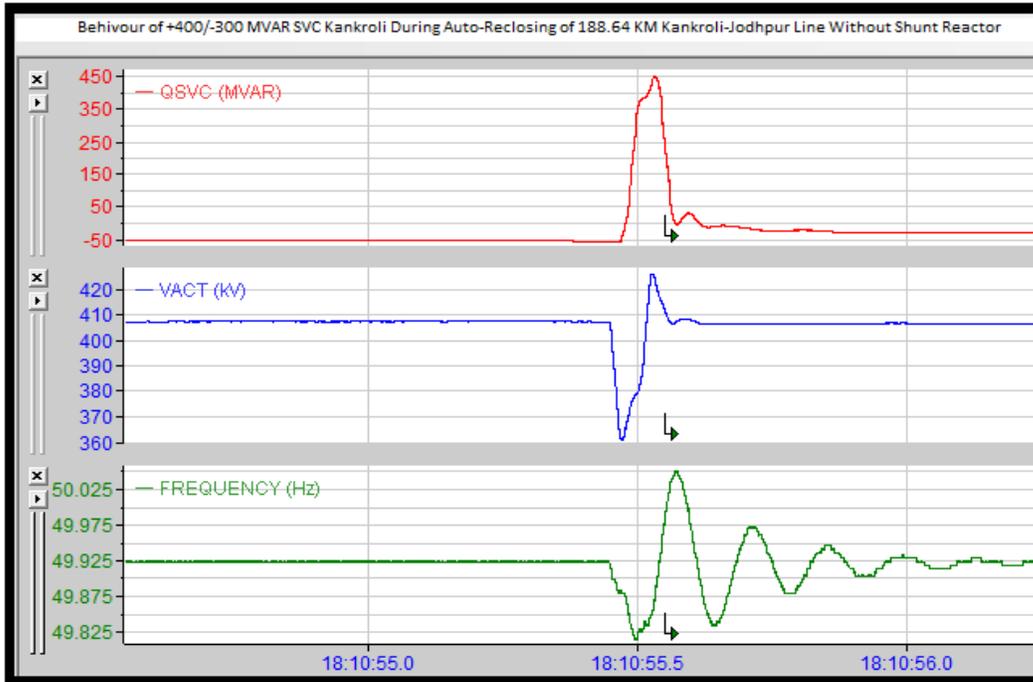


Figure 3.1

We can also see response of SVC during switching of 50 MVAR Bus Reactor in figure 3.2.

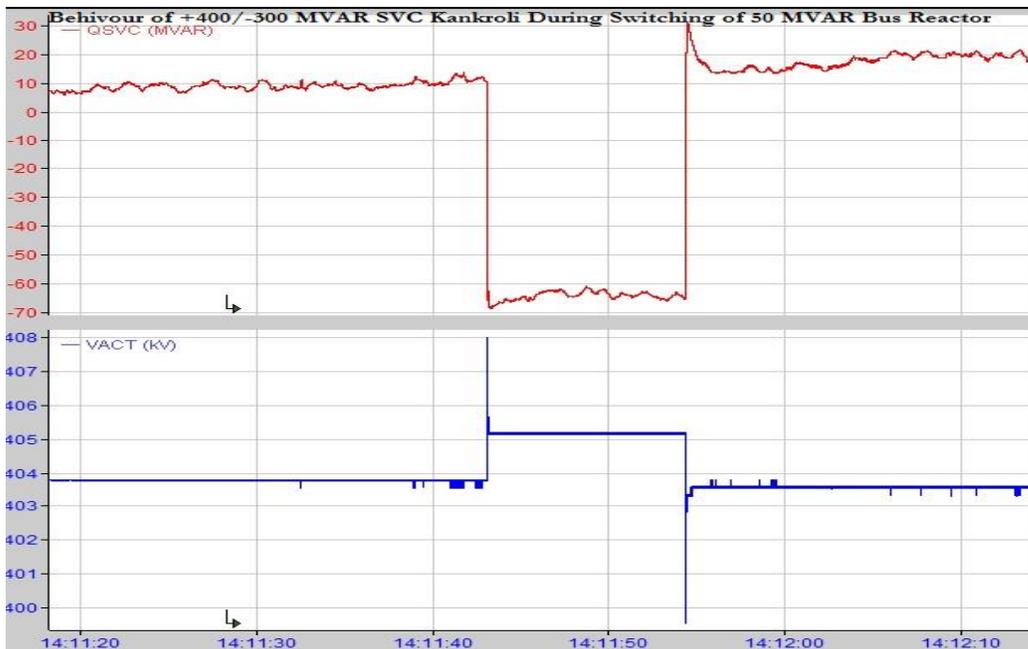


Figure 3.2

The figure 3.3 also shows a response of SVC during switching on a 201 KM long 400 KV line from Kankroli substation with other substation CB open condition. Hence, we can see a very less fluctuation of voltage in a typical condition where a transmission line is switched without shut reactor.

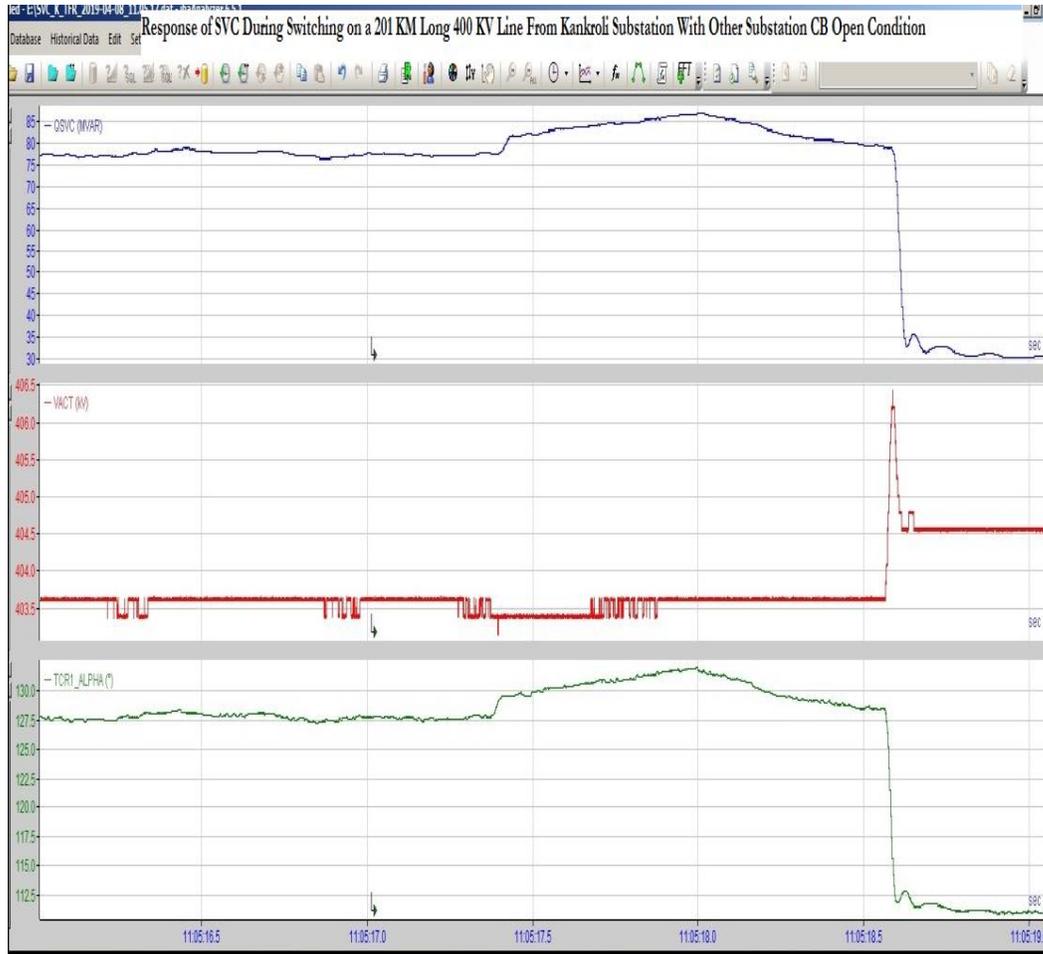


Figure 3.3

#### 4. REQUIREMENT OF COORDINATION CONTROL BETWEEN SVC AND SHUNT/BUS REACTOR

The requirement of coordination control between SVC and Shunt/Bus reactor is also to stop the undesired condition in which SVC connected to the substation bus is providing capacitive MVAR to compensate inductive MVAR provided by Bus reactors connected to the similar bus. It is resulting in overloading of SVC transformers. The case studies show frequent occurrence of such type of conditions at substations. These types of situation can be avoided with the coordination control between SVC and Shunt /Bus reactors. Below mentioned figure 4.1 and 4.2 show the

actual loading pattern of SVC TSC with substation bus reactor loading in a similar time frame continuously for a long period.

### SVC TSC LOADING

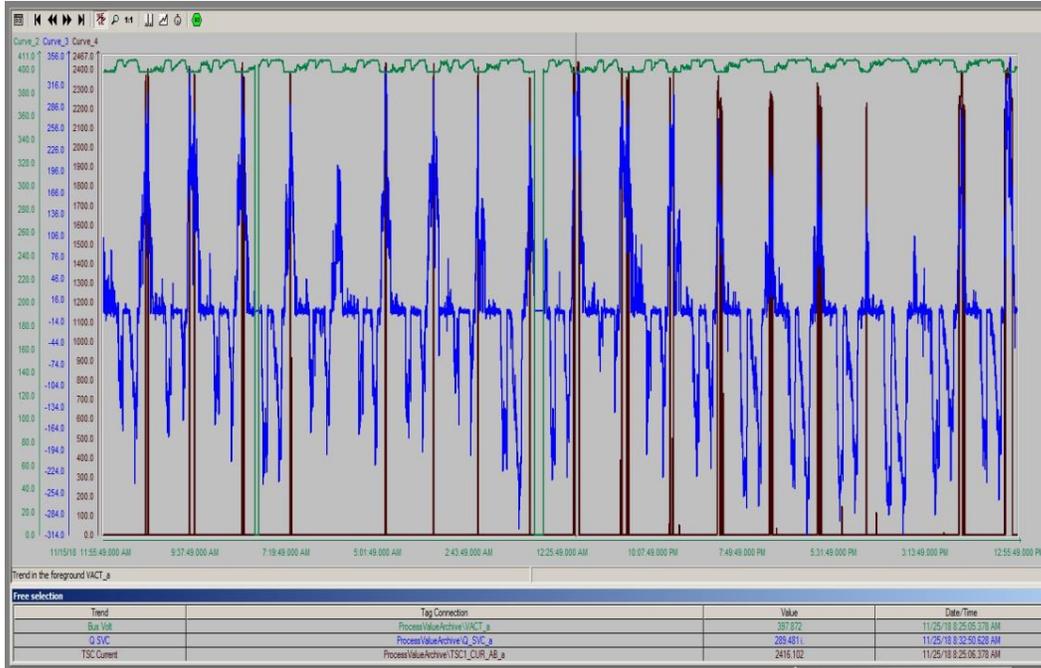


Figure 4.1

### SUBSTATION BUS REACTOR LOADING

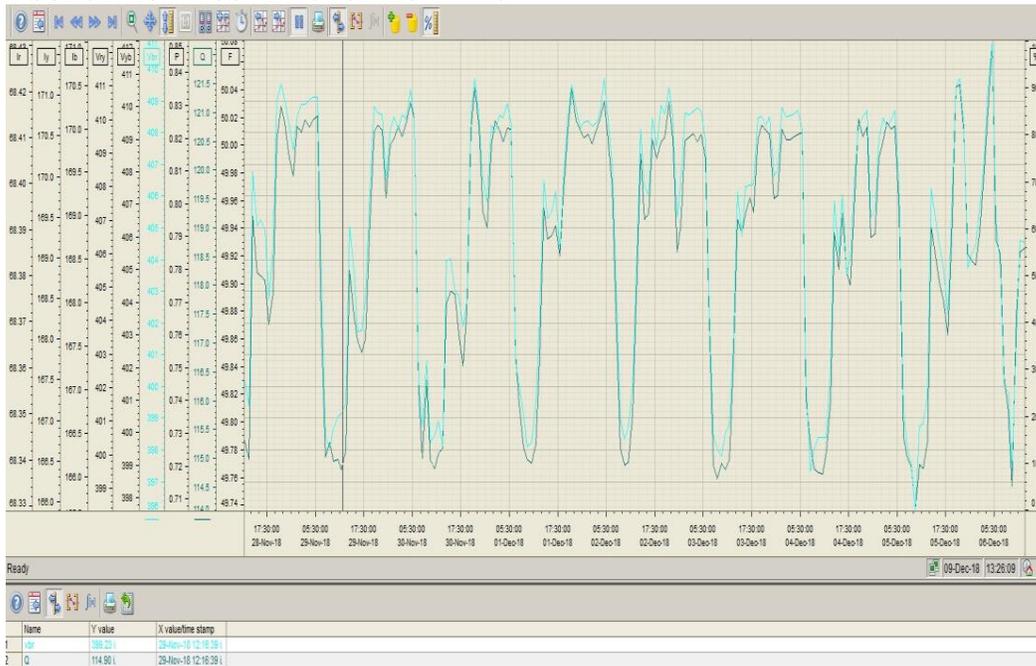


Figure 4.2

## 5. DEMONSTRATION OF SVC COORDINATION CONTROL SCHEME DURING DIFFERENT POWER SYSTEM CONDITIONS

Figure 5.1 shows the steady state behaviour of coordination control scheme with SVC. Initially as the system load decreases, the SVC injects its inductive MVAR to control the System voltage, afterwards a close command was given to first reactor to control the system voltage, but still there was requirement of inductive MVAR so after the set delay closed command was given to second reactor. Now the system is in steady state condition and the SVC is also having some capacity to support any dynamic condition. After some time, the load increases continuously accordingly the SVC start injecting its capacitive MVAR to support the system. Now a situation occurs that SVC is injecting the capacitive MVAR and the reactors are injecting inductive MVAR and creating extra loading on SVC transformers, but due to the coordination control this situation is avoided and a trip command issued to first reactor and still the situation is of no load accordingly the second reactors is opened after a set delay.

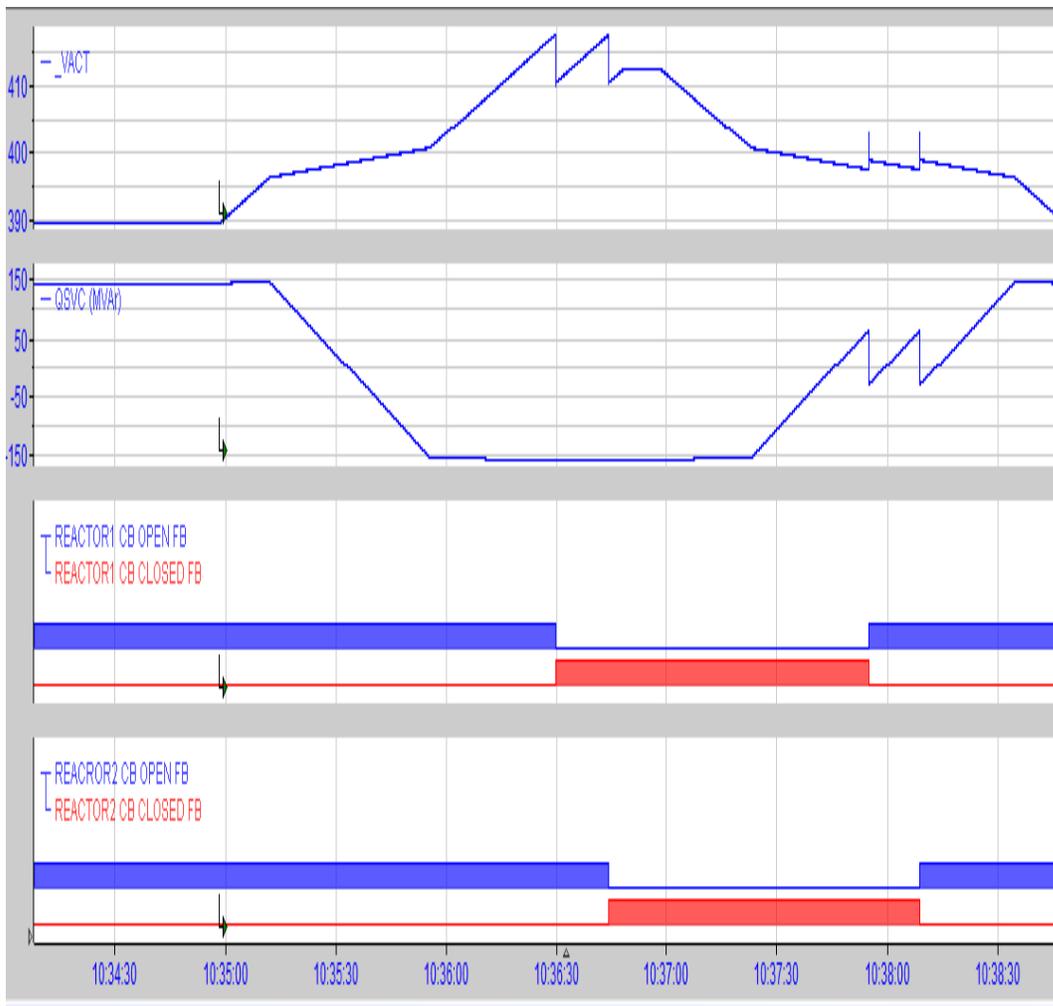


Figure 5.1

Now a question arises that how this coordination scheme behaves in a dynamic condition, we shall refer figure 5.2 example where first shunt reactor opened on low voltage due to heavy loading condition and just after opening of line reactor the concerned line went to no load due to a sudden load rejection of remote end substation.

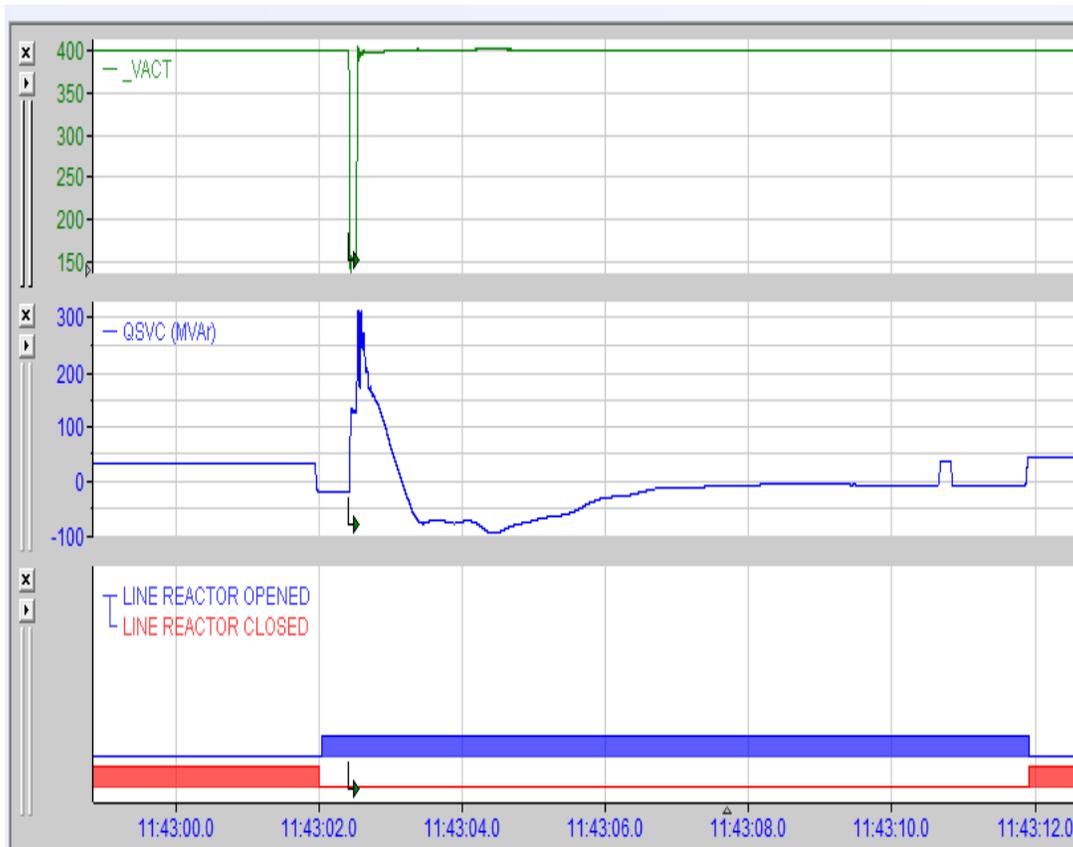


Figure 5.2

In this situation we can see that just after opening of line reactor there was a sudden load rejection, in that condition the SVC takes care of load rejection and control the system and after the set delay the line reactor again switched on.

## 6. CONCLUSION

After reviewing all above-mentioned practical examinations, we can conclude that a coordination scheme can be implemented with SVC between control switching device operated switchable reactors without any threat to the connected Power System and it will be helpful in energy conservation and also it will protect the Power system during dynamic conditions.

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