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Reactive Power Compensation of Transmission Network using FACTS Devices

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Abstract: This paper deals with the reactive power compensation and better mitigation of transmission related problems in today's world for a profound reliability of the offered power quality. we look at the FACTS controller being used for both series and shunt compensation. In that study shunt operation of the STATCOM and its principles of operation, control and how it helps in the better utilization of a network operating under normal conditions. A control system was developed to compensate unbalance reactive power and it was simulated using MATLAB. Simulation results confirm that the STATCOM compensates unbalance reactive power at the load.

Keywords: Flexible AC Transmission Systems (FACTS); Compensation; STATCOM; Control circuit; MATLAB / Simulation; measurement circuit.

I. INTRODUCTION

Rise in the utilization of home appliances and industrial load has produced demand in electricity in various countries. Over the years, Industries mainly equipped with large number of rotating machines, which consume huge amount of reactive power. Due to this reason, established new control strategies to enhance controllability, increase power transfer capabilities and guarantee a better quality of energy produced. To enhance the performance of ac power systems, we need to manage this reactive power in an efficient way and this is referred as reactive power compensation. There are mainly two types of compensation were used: series and shunt compensation. Shunt compensation are frequently put on load side, in a distribution substation or transmission substation.
This paper focuses to give stable, secure and quality power supply to consumer and to utilize available transfer capacities in superior way. Flexible AC transmission systems (FACTS) controllers are used to increase power system stability along with their main application of power flow control. The concept of Flexible AC Transmission System (FACTS) was introduced in 1988, by Hingorani.[1]. FACTS devices divided into four main type.

1) Series
- Thyristor controlled series capacitor (TCSC).
- Thyristor Controlled Series Reactor (TCSR).
- Thyristor Switched Series Capacitor (TSSC).
- Static synchronous series compensator (SSSC).

2) Shunt
- Static synchronous compensator (STATCOM).
- Static VAR Compensators (SVCs)

A) Thyristor Switch Reactance (TSRs).
B) Thyristors switched capacitors (TSCs).
C) Thyristor controlled reactor (TCRs).

3)Series-Shunt
- Unified power flow controller (UPFC).

4)Series-Series
- The Interline Power Flow Controller (IPFC).

STATCOM is broadly used as one of the shunts connected type FACTS device to enhance the power system performance. This quite satisfactory do the job of absorbing or generating reactive power with a faster time response. This allows a rise in transfer of apparent power through a transmission line and far better stability by the adjustment of parameters that govern the power system i.e. current, voltage, phase angle, frequency and impedance.
With the STATCOM the following merits can be achieved in power systems:
- Dominating the power flow in transmission system.
- Improve the power transmit ability.
- Enhance the voltage stability in system.
- Improve security of the power system.

In this paper, we create a STATCOM model using MATLAB/Simulink software.

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II. EXPERIMENT

As STATCOM is shunt compensation device, experimental is describe below.

To commence with the devices used in circuit were power supply, step up and step-down transformers, transmission line, circuit breaker, resistive and inductive loads, capacitor bank, STATCOM (Universal bridge) and measurement block. Complete test setup for STATCOM is illustrated in figure 1.

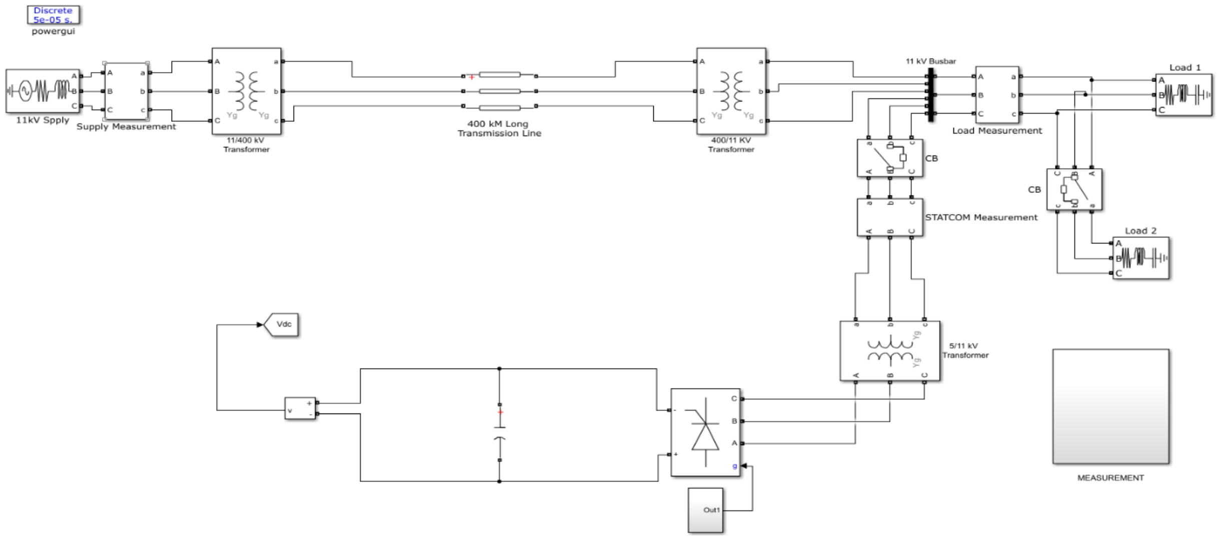

Fig. 1 Experiment Set up

Furthermore, we supplied the system with 3-phase 11 kV line voltage. With the help of step up transformer the 11 kV voltage is step up to 400 kV. This 400 kV is transmitted to 180km with support of transmission line. At the receiving end side, the voltage is step down to 11 kV with the help of step-down transformer. After that, the voltage given to loads. Now, compensator of the system STATCOM is connected to transmission line along with circuit breaker and step up transformer.

STATCOM is a bridge configuration device, which is made up of thyristor. STATCOM power is supplied by the fixed capacitors. STATCOM is Operate with help of control circuit. Control circuit is main part of the experimental setup.

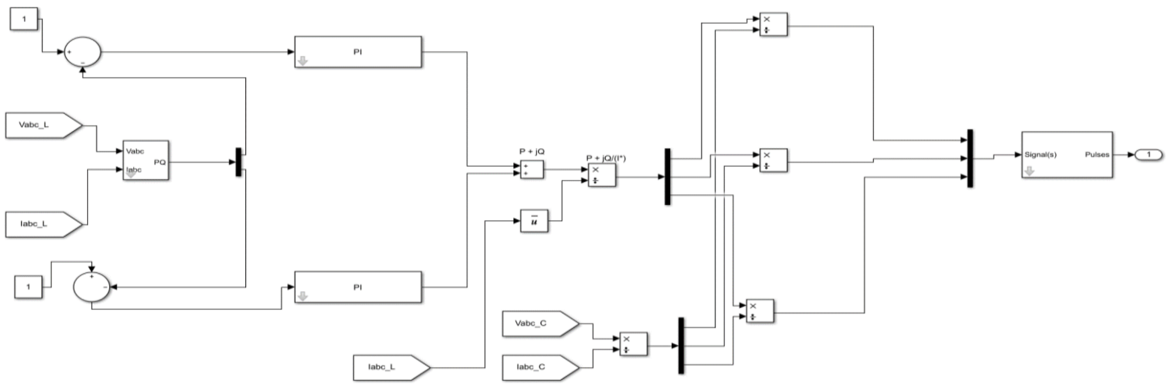

Fig. 2 control circuit of STATCOM

The reason behind this is, Operation of STATCOM is to work in both modes, one is delivering mode and another one is absorbing mode which is done based on control circuit. To operate STATCOM according to control circuit, fixed capacitor is used as a power supplier to STATCOM. This fixed capacitor is automatically charged from the supply line and discharge itself in purpose of power supply to STATCOM. The control circuit is given in figure 2 from the above discussion we need to obtain the result, and result of operation is seen from the measurement block. In measurement block, Current and Voltage measurement is carried out at the sending end, receiving end and STATCOM is taken out for observation. Measurement circuit is illustrated in figure 3.

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From the obtained results the performance analysis is carried out.

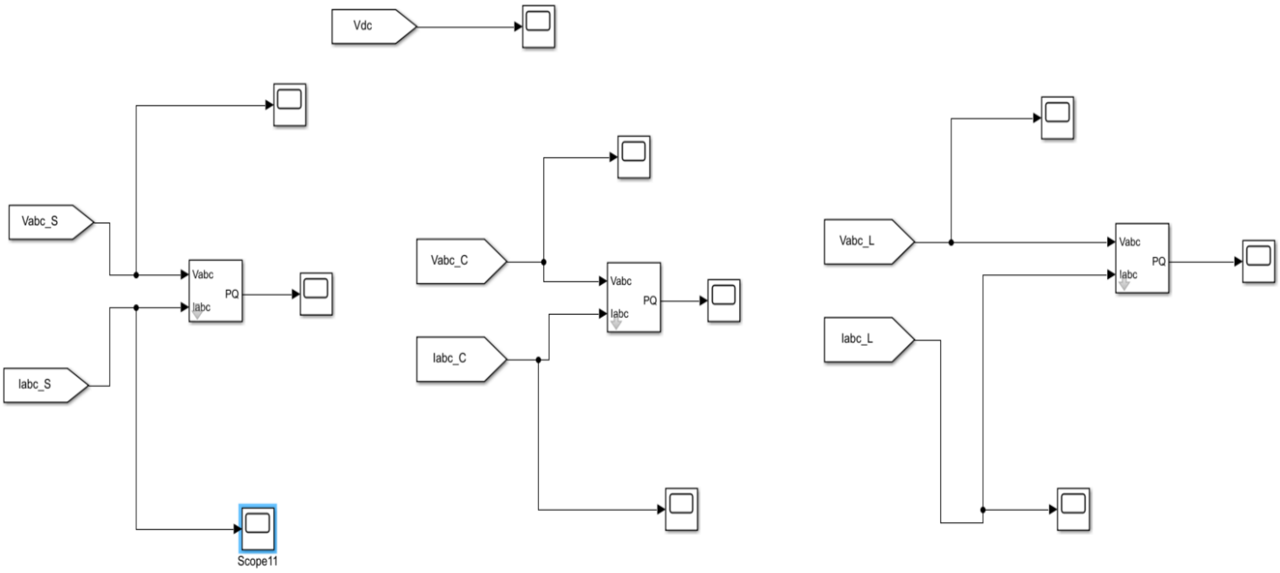

Fig. 3 measurement circuit

III. RESULT AND ANALYSIS

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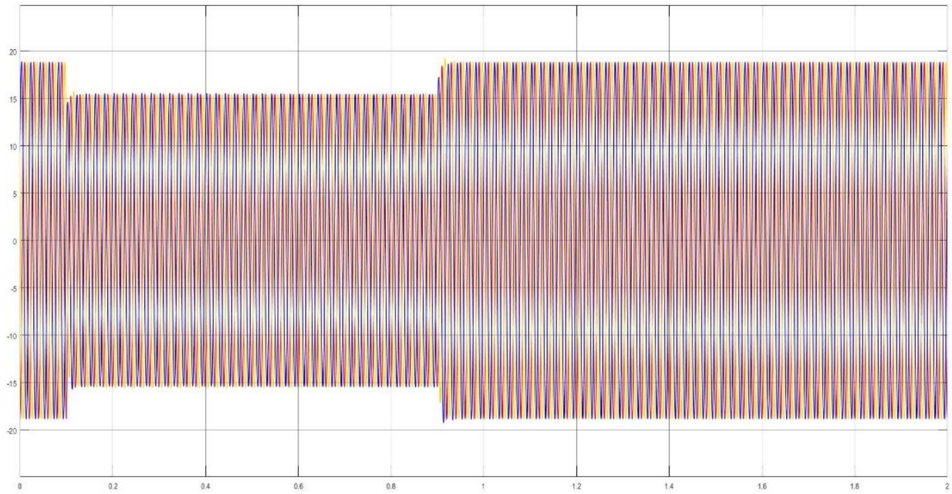

Fig. 4 Wave form of 11kv load Voltage without Compensation

In the view of results, analysis for without compensation and with compensation is described below.

The continuation power flow analysis using MATLAB is run and the voltage profile is obtained. The figure demonstrates the results of experiment which are illustrated in the form of waveform and in the tabular form below.

TABLE I TRANSMISSION LINE PARAMETERS WITH RESULTS

Sending end voltage V_s	**Receiving end voltage without compensation V_R**	**Receiving end voltage with Compensation V_R**	**Firing angle α**
11000	10350	10800	120°
11000	10200	10700	150°
33000	31150	32100	120°
66000	62500	64480	120°

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Here, the firing angle α for a conduction of thyristors is taken 120° (90° < α < 180°), for proper understanding, we have considered a time period of 2 second for switching on and off for the load as well as STATCOM. During this time period the voltage waveform of load, with compensation and without compensation is taken. The results are obtained and after that thoroughly studied whole system.

Firstly, the voltage and current at load side is obtained and through that active power and reactive power at load side is obtained. After that both active power and reactive power separately compared with predefined unity gain system and error signal is generated for both active power and reactive power respectively.

Secondly, this both active power and reactive power of load side is sum up and error apparent power is generated, which one is an error power or a loss power. That error signal of apparent power is then divided by load current and the error voltage signal is obtained.
Furthermore, from initial voltage and initial current of STATCOM, resistance of it is obtained. That resistance is used to obtain error current signal by deciding earlier error voltage signal, which is used for the triggering of the thyristor of STATCOM according to voltage sag. The compensation is done according to this. And we came over the conclusion.

IV. CONCLUSION

The MATLAB simulation results indicates that significant improvement in reactive power compensation and voltage regulations have been achieved by using STATCOM. From the results it is found that STATCOM is effective compensation device. This system enables continuous control and the response time is faster. The STATCOM plays an important role in reducing network losses, stabilizing the grid voltage, improving power quality in power system. So, the FACTS devices play a very important role for reactive power compensation in electrical power system.

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