Design and Fabrication of Prototype Model of STATCOM for Reactive Power Compensation

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Abstract: **This paper presents the basic information related to Flexible AC Transmission Systems (FACTS) device Static Synchronous Compensator (STATCOM). Static synchronous compensator is shunt connected FACTS device, which have been used to verify the performance and determine the power transfer quality. For case studies of academics the hardware model is developed and voltage profile has been studied for uncompensated (without STATCOM) and compensated (with STATCOM).**

Keywords: FACTS, power profile, voltage profile, reactive power, STATCOM.

I. INTRODUCTION

Now a days electricity demand is increases, so the generation end to load end there are transmission losses, power factor improvement, power transfer capability, cost of generation are the major problems. So development of power electronics based device helps to improve all above mention problems of power system [1].

By focusing power transfer capability problem we can use FACTS devices for reactive power compensation, voltage profile can be improved by using shunt controller like SVC and STATCOM[2].Reactive components used in the STATCOM are much smaller than those in SVC. The characteristics of STATCOM are superior like less harmonics, fast operation than SVC[2].The output current of STATCOM can be controlled upto the rated maximum capacitive or inductive range. The basic principle of STATCOM is that the STATCOM generate AC voltage, and corresponding current w.r.t. that generated AC voltage injected in phase quadrature with transmission line [3]. To maintain the voltage profile flat we used STATCOM in this paper.

In this paper we are using 230 V, 1ϕ AC transmission line. In that line we connected STATCOM in shunt.

II. BASICS OF STATCOM

STATCOM is a static synchronous compensator.

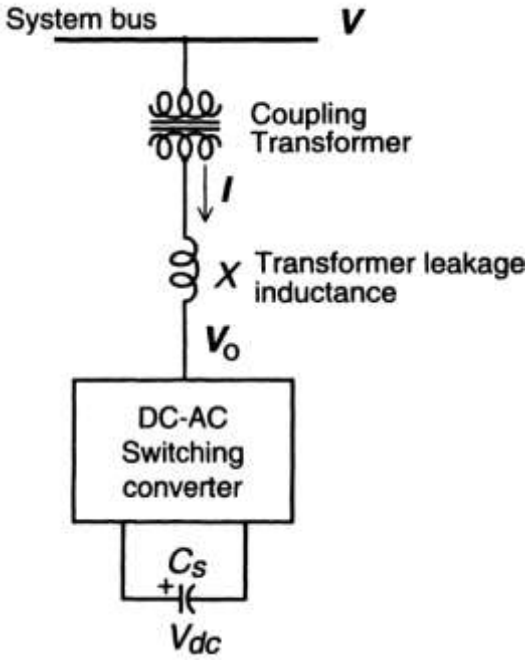
These (dc to ac or ac to ac) converters are operated as voltage and current sources and they produce reactive power essentially without reactive energy storage components by circulating alternating current among the phases of the ac system.

III. PARTS OF STATCOM

DC CAPACITOR / DC BATTERY: supply constant DC voltage to VSC.

VOLTAGE SOURCE CONVERTER: transfer DC input voltage to AC output voltage

INDUCTIVE REACTANCE: connect inverter output to power system.



COUPLING TRANSFORMER: transfer power from VSC to system bus without changing the power and provide isolation between system.

IV. OPERATING MODES OF STATCOM

1. Capacitive mode of Operation:

When Load is Inductive

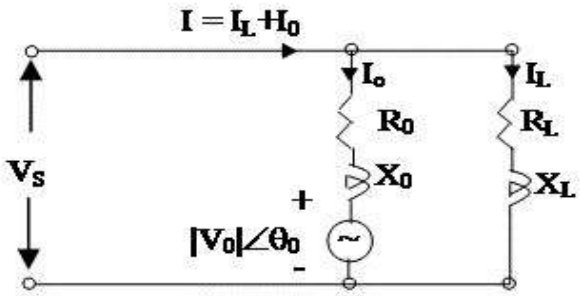


Fig.1 (c) Equivalent circuit of the STATCOM with inductive load

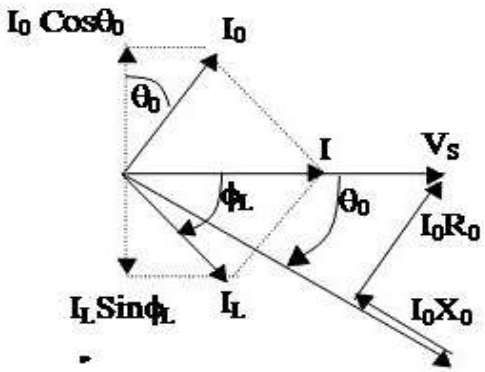


Fig. 1(d) Phasor diagram

2. Inductive mode of Operation:

When Load is Capacitive

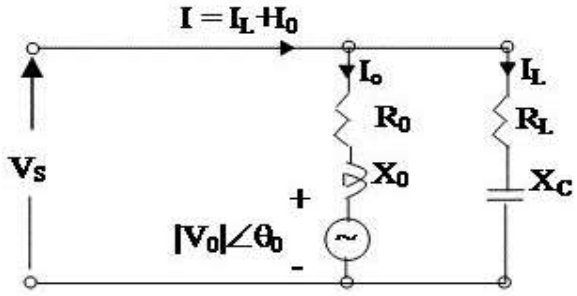


Fig. 1(e) Equivalent circuit of the STATCOM With capacitive load

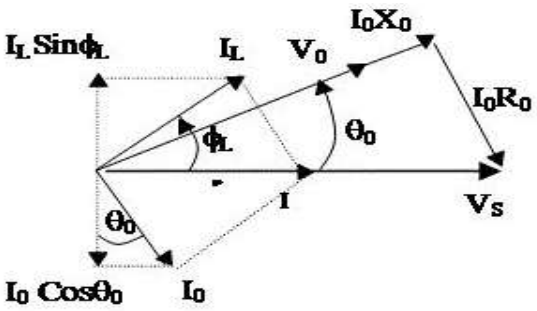


Fig. 1(f) Phasor diagram

V_s =System AC Voltage

$|V_0|$=Magnitude of inverted output voltage

I_0=Current in STATCOM branch

I_L=Current in load branch

R_L= Load Resistance per phase

X_L=Load Reactance per phase

R_0= Equivalent resistance of coupling transformer and inverter switches per phase

X_0= Equivalent leakage reactance of the coupling transformer per phase

$ø_L$=Phase angle of load

$Θ_0$=Phase angle of inverter output voltage

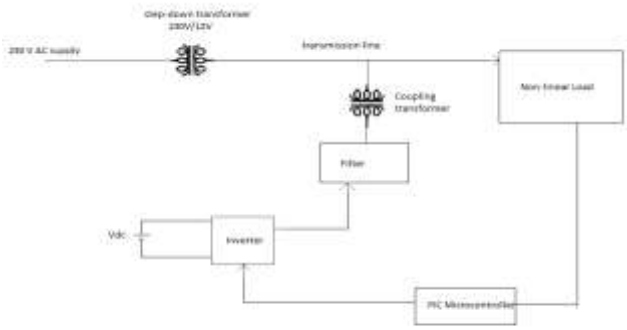
Now,

Reactive power drawn by load= V_s*I_L*Sin $ø_L$

Reactive power absorbed by STATCOM Branch=V_s*I_0*Cos $Θ_0$

Reactive power component of I_0 is I_0*Cos $Θ_0$ And Reactive power component of I_L is I_L*Sin $ø_L$ and they cancel with each other, Hence Resulting in "Unity Power Factor"

V. EXPERIMENTAL STUDIES



VI. METHODOLOGY

230 V, 50 Hz single phase AC supply is step-down to 12 V using step-down transformer. Through transmission line to Nonlinear RL Load consisting of diodes. The output of nonlinear load is feedback to inverter through microcontroller, the control circuit consist of PIC16F877A microcontroller in which the error signal or control signal is generated by the difference of measured voltage ($V_{measured}$) and reference voltage (V_{ref}). The error signal is used in form of triggering angle (δ) for triggering MOSFETS used in inverter. The input to the inverter is DC voltage source supplied through battery. Then its further inverted into AC and by proper triggering action through the coupling transformer it is coupled with the line voltage. Due to the triggering action of MOSFETS harmonics are generated in the output of inverter which are mitigated by using filter.

VII. COMPONENT SELECTION

1. Step-down Transformer: The supply voltage from MSEB is 230Volt is step-down to 12 Volt.
2. Transmission line: Transmission line is a simple copper wire.
3. Nonlinear load: Nonlinear load consist of diodes and resistor, both are in parallel act as load. Diodes are used to produce harmonics in the line.
4. Current transformer: Measure the current across nonlinear load and feedback it to the microcontroller. The rating of CT is 0.5 to 5 A.
5. Microcontroller: In microcontroller kit PIC16F877A used. PIC18F877A have similar function but the cost is high.
6. DC Battery: DC Battery used to supply constant DC Voltage to the voltage source inverter.
   Specifications: 12 Volt, 1.3 Ah
7. MOSFETS: To trigger the pulses for improve voltage in the line. The rating of MOSFET is 5 A.
8. Drive Circuit: The microcontroller gives required voltage to be injected into line in the form of pulse. The drive circuit provides path to the pulses from controller to trigger the MOSFETS.
   IC used for the Drive circuit is IR2110.
9. Isolation transformer: Provide coupling between the STATCOM and the transmission line. The Isolation transformer of having same number of turns on both sides i.e. 12Volt/12 Volt rated transformer.
10. Resistor and inductor : The resistor and inductor will be select on trial and error basis.
11. Voltage Regulator: To regulate the voltage of IC provided for Regulator circuit is 7805.

VIII. HARDWARE RESULTS

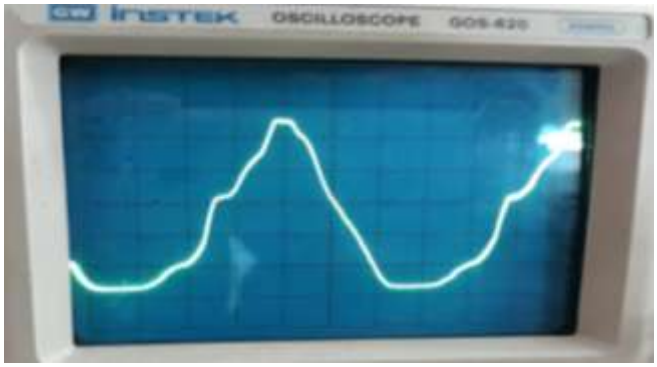


Figure Waveform for output voltage without STATCOM in circuit

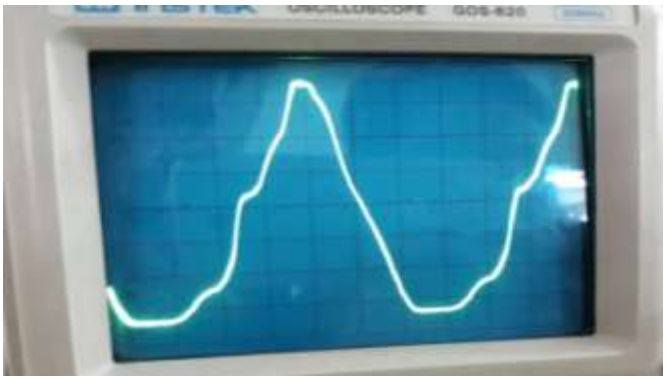


Figure Waveform for output voltage with STATCOM in circuit

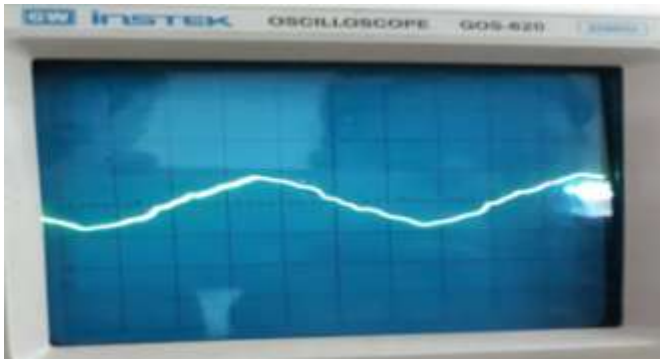


Figure Waveform for output current without STATCOM in circuit

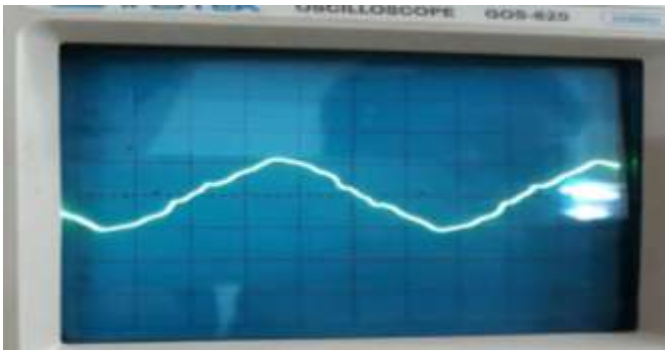


Figure Waveform for output current with STATCOM in circuit

IX. CONCLUSION

This paper presents the performance of shunt compensator called STATCOM which gives the voltage profile improvement at receiving end side by compensating reactive power in transmission line.

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