Effect of Shunt Compensation on Distance Relay Performance

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Abstract— Comparative study is done for the performance of distance relays for transmission lines compensated by shunt connected flexible ac transmission system (FACTS) devices. The objective of this study is to evaluate the performance distance protection schemes on transmission lines with STATCOM devices applied for midpoint voltage control. The impact of static synchronous compensator (STATCOM) on the transmission line distance protection schemes is studied for different fault types, fault locations and system conditions. The power system elements and the STATCOM with their associated controllers are modeled. Matlab / Simulink is used as a simulation tool for the research.

Key words: Distance Protection, MHO relay, Static Synchronous Compensator, Measured Impedance

I. INTRODUCTION

Distance relay has the ability to detect fault within a predetermined distance along a transmission line. Distance relay is designed to operate only for fault occurring between the relay location and the reach point, thus giving discrimination for faults that may occur in different line sections. Distance relay measures the impedance of a line using the voltage and current applied to the relay. At the time of fault on line, the relay current rises rapidly while voltage collapses. The distance relay determine the impedance by Z= V/I. If the impedance is within the reach setting of the relay, it will operate. The current and voltage input to the relay will be given from the CT (Current Transformer) and PT (Potential Transformer) respectively.

II. STATCOM BASIC

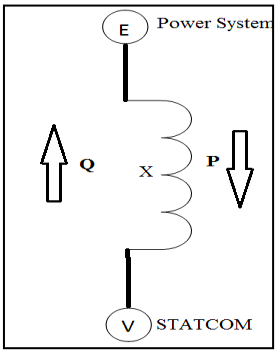

Fig. 1: Basic of STATCOM

STATCOM is one of the key shunt controllers in flexible alternating current transmission system (FACTS) to control the transmission line voltage and can be used to enhance the load ability of transmission line and extend the voltage stability margin. A STATCOM consists of a three phase inverter (generally a PWM inverter) using SCRs, MOSFETs or IGBTs or GTO's. D.C capacitor which provides the D.C voltage for the inverter Filter components to filter out the high frequency components due to the PWM inverter. From the D.C. side capacitor, a three phase voltage is generated by the inverter and this is synchronized with the A.C. supply. The link inductor links this voltage to the A.C. supply side.

III. SIMULATION

A. *STATCOM Model:*

Here STATCOM shown in Fig-2 is modeled in MATLAB using six IGBT switches which will convert the 20kv DC to 18.3kv AC (12.72 rms value). SPWM switching strategy is used to convert DC voltage into AC output voltage. Here filters are used to convert the SPWM waveform into fundamental AC waveform.

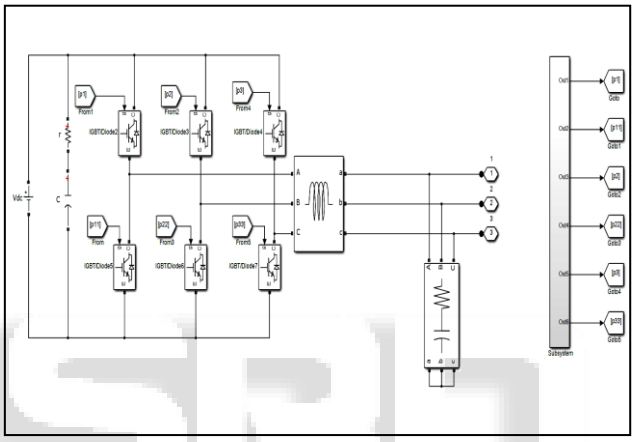

Fig. 2: STATCOM Model

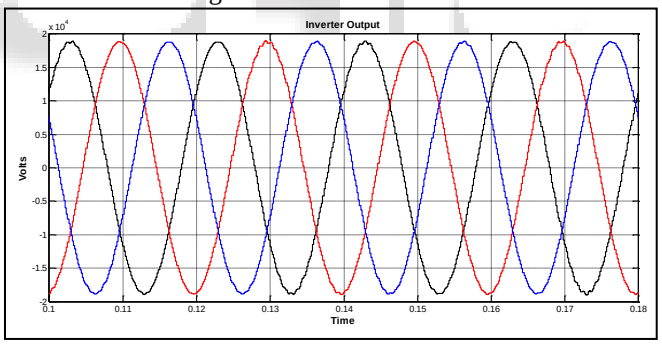

Fig. 3: Inverter Output

Simulation results for STATCOM output are shown in Fig-3. From the waveforms we can see how DC voltage is converted into PWM form and after in AC fundamental waveform by using filters.

B. *System Model:*

Here system model is shown in Fig-4 containing 2 sources, 4 bus, 400 km line which has STATCOM connected at mid-point. STATCOM is connected with line via coupling transformer. Synchronizing of STATCOM with line is done using PLL block.

PLL block is used to generate saw-tooth wave form which is compared with sine wave to generate gate pulses for inverter switches.

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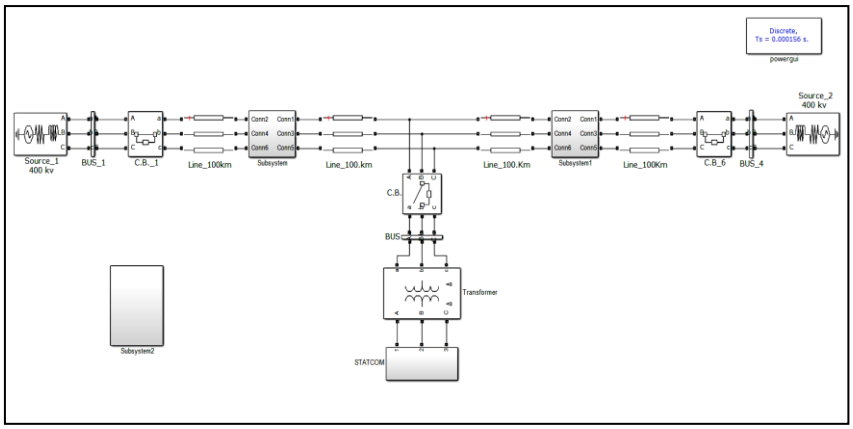

Fig. 4: Line Model

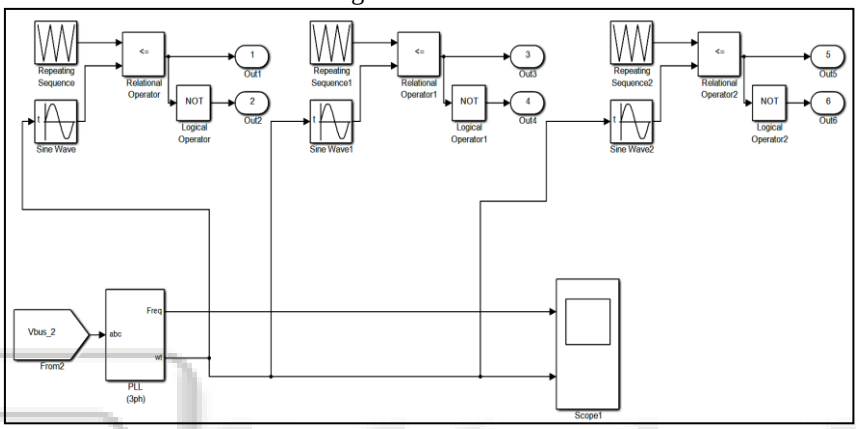

Fig. 5: PLL Block for Synchronism

Here Synchronism is done at 0.2 sec with the help of circuit breaker. Compensating effect of STATCOM is analyzed.

The modulation index is kept at 0.8 for this study which can be varied up to 1.

IV. Relay Modeling & Impedance Calculation

Here mho type distance relay is modeled for distance protection study. Mho type distance relay with transmission line characteristics is developed using .m MATLAB file. Zone-1 of mho relay is developed for study.

Fundamental component for relay input is extracted using FFT analysis. FFT analysis will provide fundamental voltage and current in complex form, these values are stored in work space from where it will be further used for impedance calculation at fault time.

Phase relays and ground relay are used to study different types of faults, both relay will use different input which can be given by following equation,

For phase relays

$$Z_{12} = \frac{V_1 - V_2}{I_1 - I_2}$$

Where

z_{12} = Impedance seen by relay
V_1 = Phase 1Voltage
V_2= Phase 2 Voltage
I_1= Phase 1 Current
I_2=Phase 2 Current

For Ground relays

Where

$K = \frac{Z_0 - Z_1}{Z_1}$

$I_0 = \frac{I_a + I_b + I_c}{3}$

Z_{LG}= Impedance seen by relay
Z_0 = Zero sequence impedance of line
Z_1 = Positive sequence impedance of line
I_a, I_b , I_c = Phase Currents

V. Conclusion

From the Simulation study it is concluded that STATCOM used for shunt compensation does affect the operation of distance relay used for protection. Due to the STATCOM impact we have seen incorrect operation of relay which can be shown from the relay characteristics for different fault types under both conditions. Here study is carried out for two conditions. 1) Without STATCOM 2) With STATCOM

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