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Research Paper

Modelling of Statcom Utilising Cascaded 15 Level Inverter (H Bridge)

Engineering

KEYWORDS : Static synchronous compensator, Cascaded multilevel inverter (H-bridge), ABC coordinates

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ABSTRACT

Among flexible AC transmission system (FACTS) controllers, the STATCOM have shown feasibility in terms of cost effectiveness in a wide range of problem-solving abilities from transmission to distribution levels. A cascade multilevel inverter is a power electronic device built to synthesize a desired AC voltage from several levels of DC voltages. A method is presented showing that a cascade multilevel inverter can be implemented using only a single DC power source and capacitors. To control the reactive power instantaneously, this system is modelled using the ABC transform which calculates the instantaneous reactive power. The simulation result of MATLAB/Simulink software indicates the superior performance of the proposed control system, as well as the precision of the proposed models.

INTRODUCTION

A cascade multilevel inverter can be implemented using only a single DC power source and capacitors.Among flexible AC transmission system (FACTS) controllers, the STATCOM have shown feasibility in terms of cost effectiveness in a wide range of problem-solving abilities from transmission to distribution levels. A cascade multilevel inverter is a power electronic device built to synthesize a desired AC voltage from several levels of DC voltages. To operate a cascade multilevel inverter using a single DC source, it is proposed to use capacitors as the DC sources. A standard cascade multilevel inverter requires 's' DC sources for 2s+1 level. To be able to operate in a high-voltage application, a large number of DC capacitors are utilized in a cascaded multilevel inverter-based STATCOM. To obtain a low distortion output voltage or a nearly sinusoidal output waveform, a triggering signal should be generated to control the switching frequency of each power semiconductor switch.

OBJECTIVE

The objective is to come out with a simulation model of STATCOM based cascaded fifteen inverter and analyzes its operation.

COMPARATIVE ANALYSIS OF CASCADED MULTILEVEL INVERTERS

Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. By increasing the number of levels in the inverter, the output voltages have more steps generating a staircase waveform, which has a reduced harmonic distortion. However, a high number of levels increases the control complexity and introduces voltage imbalance problems. For example, 11-level cascaded H-bridge inverters will have 5 SDCSs and 5 full bridges. Similarly, 13-level cascaded H-bridge inverters will have 6 SDCSs and 6 full bridges. And, 15-level cascaded H-bridge inverters will have 7 SDCSs and 7 full bridges.

Simulation Circuit

It is well known that the amount and type (capacitive or inductive) of reactive power exchange between the STATCOM and the system can be adjusted by controlling the magnitude of STATCOM output voltage with respect to that of system voltage. Figure 1 shows simulated circuit of STATCOM with 15-level cascaded multilevel inverter.

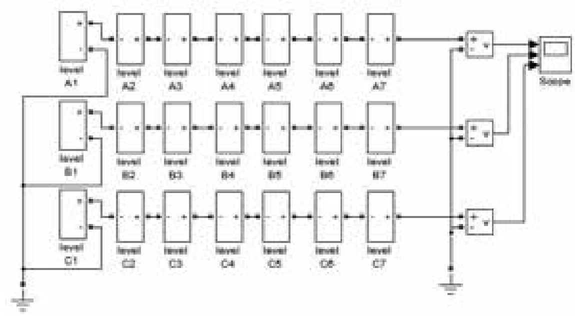

Figure 1 Simulated circuit of the STATCOM with 15-level cascaded multilevel inverter

The reactive power supplied by the STATCOM is given by equation (1),

$$Q = V_{statcom} - V_s \quad (1)$$

Where, $V_{statcom}$ and V_s are the magnitudes of STATCOM output voltage and system voltage respectively and X is the equivalent reactance between STATCOM and the system. When Q is positive, the STATCOM supplies reactive power to the system. Otherwise, the STATCOM absorbs reactive power from the system.

The phase output voltage is synthesized by the sum of individual inverter outputs,

i.e. Vca= Vca1+Vca2+Vca3+............ +Vcan

Therefore, the phase voltage for 15-level cascaded inverter is,

Vca=Vca1+Vca2+Vca3+Vca4+Vca5+Vca6+Vca7

Control of DC Capacitor Voltage

If all the components were ideal and the STATCOM output voltage were exactly in phase with the system voltage, there would have been no real power exchange between STATCOM and system therefore the voltages across the DC capacitors would have been able to sustain.

However, a slight phase difference between the system voltage and the STATCOM output voltage is always needed to supply a small amount of real power to the STATCOM to compensate the component loss so that the DC capacitor voltages can be maintained. This slight phase difference is achieved by adjusting the phase angle of the sinusoidal modulating signal. If the real power delivered to the STATCOM is more than its total component loss, the DC capacitor voltage will rise, and vice-versa. This real

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power exchange between STATCOM and the system is described by Equation (2) below,

$$P = \frac{V_s V_{statcom}}{X} \sin(\delta)$$

(2) Where, δ is the phase angle difference between STATCOM voltage and the system voltage.

SIMULATION RESULT

Figure 2 shows the cascaded fifteen level inverter output phase voltage waveform. It can be seen that the sinusoidal waveform and the fifteen level cascaded inverter output waveform both are approximately same. But the square wave output has a high harmonic content, not suitable for certain AC loads such as motors or transformers.

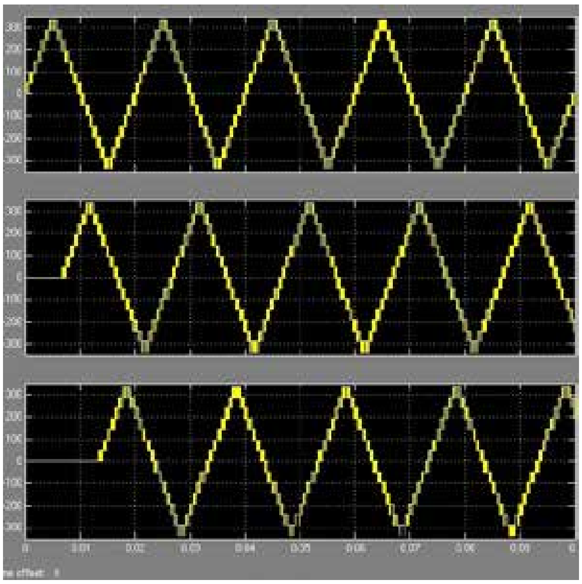

Figure 2 Approximately Sinusoidal Fifteen level inverter output phase voltages

CONCLUSION AND FUTURE SCOPE

Conclusion

To achieve as stable a system as possible, a well-defined model and an effective DC-link-balancing method are necessary. The cascaded seven-level, nine-level, eleven-level, thirteen-level and fifteen-level inverters have been used as the studied system. And, the cascaded fifteen level inverter based STATCOM is designed according to the simplified model in abc coordinates. The simulation results show superior performances of the designed abc coordinates inverter based STATCOM. The STATCOM has the great advantage of a fewer number of devices. The VSI is extremely fast in response to reactive power change. The simulation of the STATCOM is performed in the Simulink environment and the results are presented.

Future Scope

- A multi-level Stat-Com/BESS is more versatile and flexible than a conventional Stat-Com because it can
- Control both active and reactive power simultaneously and independently
- Charge batteries by absorbing active power from the grid
- Be rated higher because of multilevel topology
- Be effective in power oscillation damping

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