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A Novel Controlling of Cascaded H-Bridge STATCOM with Fuzzy Logic Approach

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Abstract - The average power after the completion of one whole cycle of the AC waveform is the real power, and this is the usable energy of the system and is used to do work, whereas the portion of power flow which is temporarily stored in the form of magnetic or electric fields and flows back and forth in the transmission line due to inductive and capacitive network elements is known as reactive power. This is the unused power which the system has to incur in order to transmit power. The controlling of different electrical applications is first and foremost task to maintain the stability as well as reliability of that circuit in various situations. These situations can be any one. This work discussing and working on the h-bridge converter with cascaded STATCOM and star configuration. The following configuration is proposed to control the reactive and compensating currents while controlling different voltage controlling with startup and stopping process of grid. Here to improve the controlling fuzzy approach is utilized and the simulation outcomes are shown in the results. After comparison with the previous controlling method this work is have better voltage and current results.

***Keywords - H-bridge, STATCOM, Fuzzy, Cascaded*.**

I. INTRODUCTION

A multilevel converter can be implemented in many different ways. The simplest techniques involve the parallel or series connection of conventional converters to form the multilevel waveforms. More complex structures effectively insert converters within converters. The voltage or current rating of the multilevel converter becomes a multiple of the individual switches, and so the power rating of the converter can exceed the limit imposed by the individual switching devices.

The elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Capacitors, batteries, and renewable energy voltage sources can be used as the multiple dc voltage sources. The commutation of the power switches aggregate these multiple dc sources in order to achieve high voltage at the output; however, the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected.

Cascaded H-Bridge (CHB) configuration has recently become very popular in high- power AC supplies and adjustable-speed drive applications. A cascade multilevel inverter consists of a series of H-bridge (single-phase full bridge) inverter units in each of its three phases. Each H-bridge unit has its own dc source, which for an induction motor would be a battery unit, fuel cell or solar cell. Each SDC (separate D.C. source) is associated with a single- phase full-bridge inverter. The ac terminal voltages of different level inverters are connected in series.

Issues related to the use of a cascaded H-bridge inverter as a STATCOM are also discussed. It points out the advantage that the cascaded H-bridge has over other multilevel inverter topologies, such as diode-clamped and flying-capacitor, include a simple topology, modularity, and the ability to control each H-bridge separately from one another. Disadvantages include unequal current drains and voltage unbalance, which can make the output of the STATCOM difficult to control. In STATCOM operation, it is the magnitude of the converter output voltage that determines the direction of reactive power flow (a STATCOM is used to provide reactive power for voltage support).

The switching patterns of each H-bridge are rotated every half cycle to achieve proper voltage balance between the SDCSs. It should be noted that, in the wind farm application of the cascaded H-bridge, the power generation of each SDCS would need to be considered when assigning rotations between SDCSs. In experimental verification, the harmonics that were selected for elimination were not eliminated completely because of voltage ripples in the SDCSs (capacitors, in this case). Still, the work presented results that showed that an FFS switched cascaded H-bridge could perform suitably for a STATCOM application.

A primary advantage of this space vector PWM is that it offers possible mitigation when certain switches fail. To understand this at a fundamental level, one must consider the standard topology of a single H-bridge as shown in Figure 1.1.

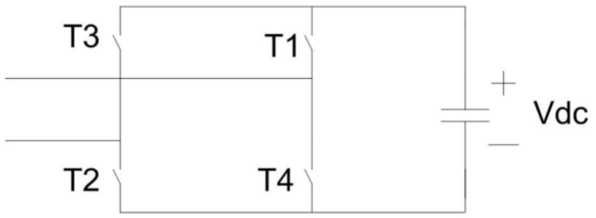

Figure 1.1 The Standard topology of an individual H-Bridge.

II. STATIC SHUNT COMPENSATOR: STATCOM

One of the many devices under the FACTS family, a STATCOM is a regulating device which can be used to regulate the flow of reactive power in the system independent of other system parameters. STATCOM has no long term energy support on the dc side and it cannot exchange real power with the ac system. In the transmission systems, STATCOMs primarily handle only fundamental reactive power exchange and provide voltage support to buses by modulating bus voltages during dynamic disturbances in order to provide better transient characteristics, improve the transient stability margins and to damp out the system oscillations due to these disturbances.

A STATCOM consists of a three phase inverter (generally a PWM inverter) using SCRs, MOSFETs or IGBTs, a D.C capacitor which provides the D.C voltage for the inverter, a link reactor which links the inverter output to the a.c supply side, 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. This is synchronized with the a.c supply. The link inductor links this voltage to the a.c supply side. This is the basic principle of operation of STATCOM.

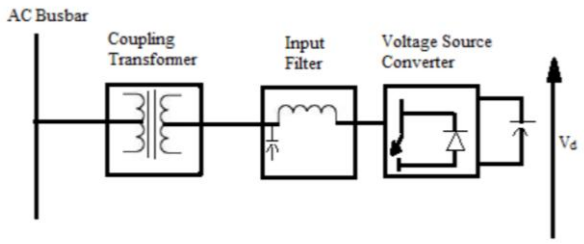

Figure 2.1 Connection of a STATCOM to a bus bar.

For two AC sources which have the same frequency and are connected through a series inductance, the active power flows from the leading source to the lagging source and the reactive power flows from the higher voltage magnitude source to the lower voltage magnitude source. The phase angle difference between the sources determines the active power flow and the voltage magnitude difference between the sources determines the reactive power flow. Thus, a STATCOM can be used to regulate the reactive power flow by changing the magnitude of the VSC voltage with respect to source bus voltage.

III. PROPOSED SYSTEM

A novel controlling of cascaded h-bridge STATCOM with fuzzy logic approach has implemented and simulated on Matlab Simulink.

The fundamental frequency of the converter voltage, modulation frequency, is determined by the frequency of the control voltages, whereas the converter switching frequency is determined by the frequency of the triangular voltage, carrier frequency. Thus, the modulating frequency is equal to the supply frequency in STATCOM.

In this type of PWM technique, observe switching harmonics in the high frequency range around the switching frequency and its multiples in the linear range.

The controlling mechanism for the Cascaded H-Bridge Converter using STATCOM with Star Configuration is explained in this work. The fuzzy controlling approach is integrated with the system to improve the controlling of reactive and compensating current in dynamic conditions and the simulation waveforms of currents and voltages are shown in the below figures.

In a Constant DC Link Voltage Scheme the STATCOM regulates the DC link voltage value to a fixed one in all modes of operation. This fixed value is determined by the peak STATCOM fundamental voltage from the full inductive mode of operation to full capacitive mode at minimum and maximum voltage supply.

Figure 3.1 Shows simulink model of proposed work. Figure 3.2 illustrate the design of Fuzzy controller for STATCOM for regulating the voltage to control the reactive and compensating currents. The merits of using Fuzzy controller system over conventional PI system are as follows.

- Fuzzy control does not require exact mathematical model
- Fuzzy controller is based on simple linguistic information and thus easy to understand
- It does not require precise input, as it can work with imprecise and noisy input
- Fuzzy controller is insensitive to parameter variation as it does not require accurate mathematical model
- Fuzzy controller offers more flexibility as it is easy to modify the functionality

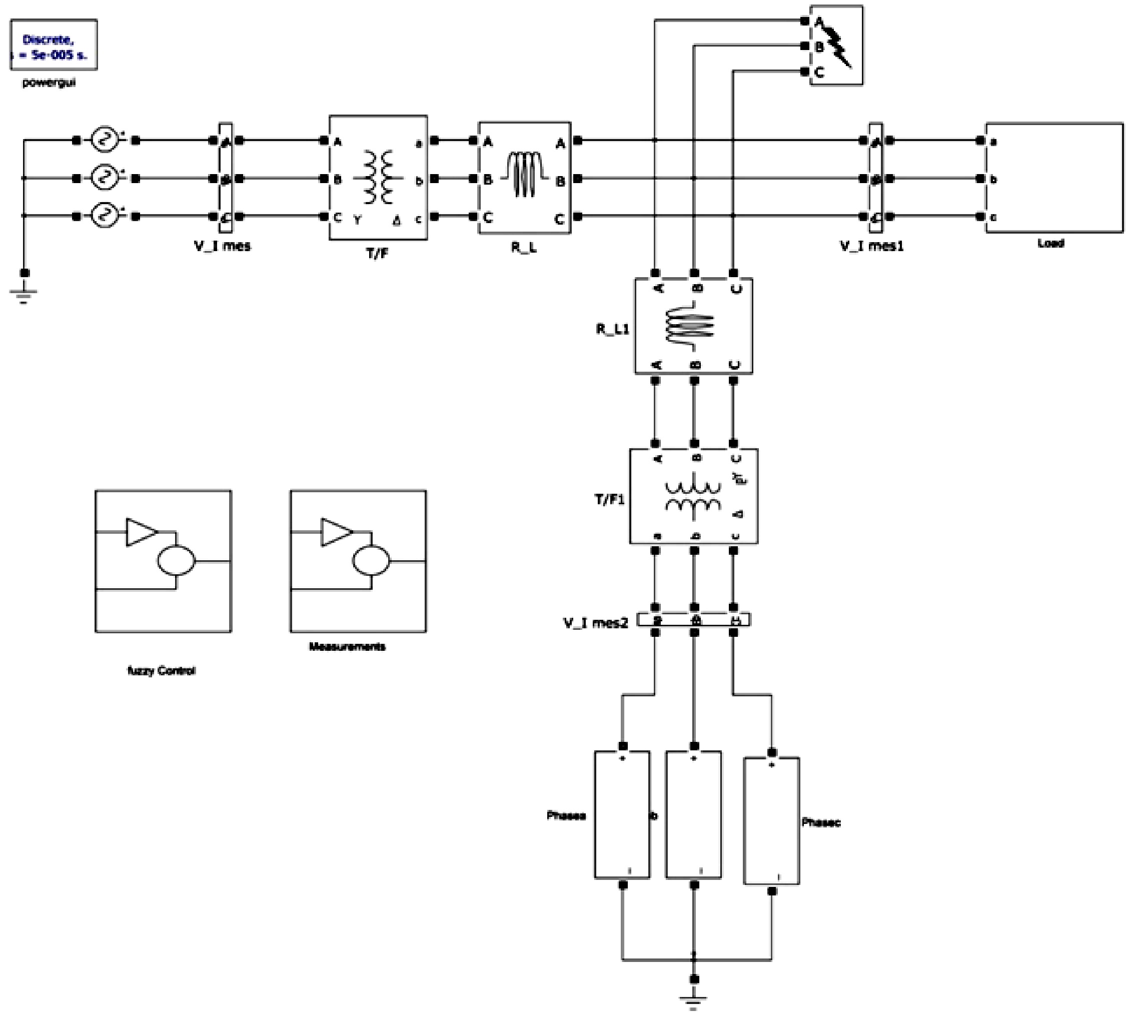

Figure: 3.1 Proposed Model of the Work

a. Fuzzy Controlling

Fuzzy logic is all about the relative importance of precision. You can use Fuzzy Logic Toolbox software with MATLAB technical computing software as a tool for solving problems with fuzzy logic.

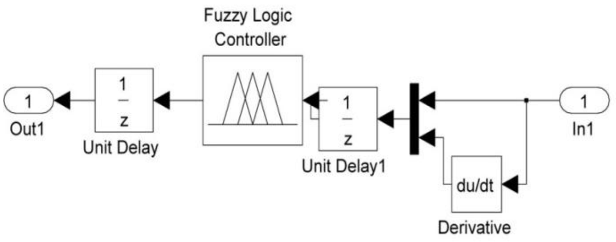

Figure:3.2 Fuzzy Logic Block of Proposed.

Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision—something that humans have been managing for a very long time.

In this sense, fuzzy logic is both old and new because, although the modern and methodical science of fuzzy logic is still young, the concept of fuzzy logic relies on age-old skills of human reasoning.

Step I: Fuzzification

Fuzzy logic converts the numerical variables into linguistic variables. But the variables are available are real numbers. The method of transforming a numerical variable (real number) into linguistic variable is called fuzzification.

Step II: Formation of rule base

This step forms the rule of controller to control the action taken from knowledge of control rules and linguistic variable. It has three different components as follows

a) IF (predecessor and antecedent) –use of fuzzy operator in it.

b) THEN part of rule-suggestion or inference from antecedent part to the subsequent part.

c) Aggregation (accumulation) of the subsequent of all rules.

Step III: Decision making

The rule framed above is required to be processed to take decision based on input information available. Fuzzy operator OR (MAX) is used to process the ‘then’ part. The And (MIN) can also be used.

Step IV: Defuzzification

This is the conversion of linguistic fuzzy control variables to a non-fuzzy control action. The truncated output MFs obtained after implication of each rule are combined or aggregated to obtain final fuzzy output. The fuzzy output obtained after aggregation is converted to crispy value. This step is known as defuzzification.

IV. SIMULATION OUTCOMES

The model of CHB-STATCOM with fuzzy Control is simulated in MATLAB/Simulink simulation environment. Initially cascaded H-bridge CHB is allowed to induce its terminal voltage by excitation capacitors. Then STATCOM is connected to CHB but pulses to VSI controller are not given. The dc bus capacitor gets charges to CHB terminal voltage value. Then load is connected which reduces the CHB terminal voltage, after that gate pulses are given to switches of VSI and voltage is restored to their initial values.

The simulation waveform of proposed system is shown on Matlab scope.

Figure 4.1 shows the reactive and compensation current waveform. in figure there are two waveform are clearly visible represents to reactive and compensation current

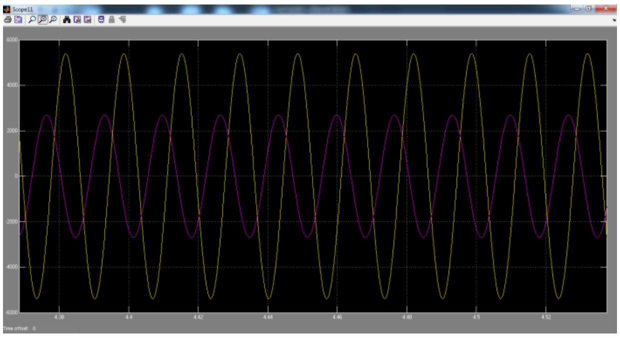

Figure: 4.1 Reactive current and Compensating current.

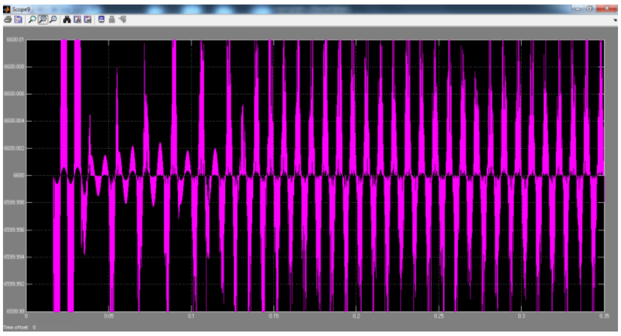

Figure: 4.2 DC mean voltage of all converter cells.

Figure 4.2 shows the DC mean voltage waveform of all converter cells. and DC mean voltage for all converter cell waveform of Matlab Scope is shown in figure 4.3.

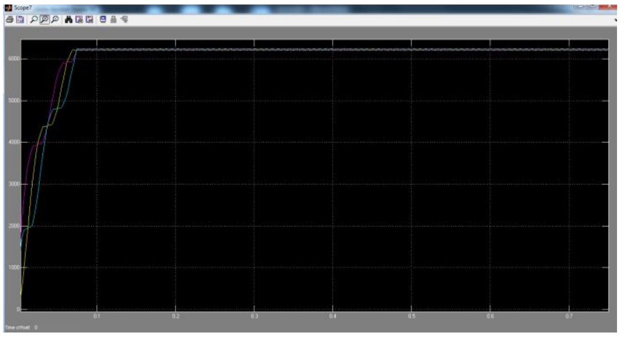

Figure: 4.3 DC mean voltage of all converter cells.

Figure 4.4 shows the simulation waveform of cells in a-phase cluster for testing individual balancing control in the steady-state process and a Dynamic performance of STATCOM in the dynamic process. Reactive current and compensating current is shown in figure.

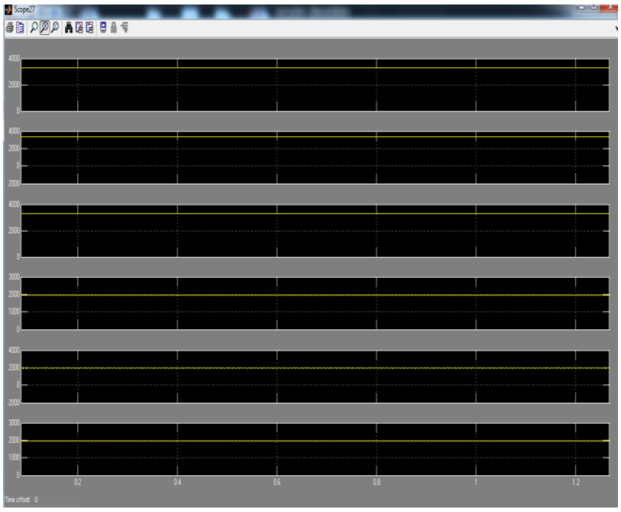

Figure: 4.4 waveforms of cells in a-phase cluster for testing individual balancing control in the steady-state process.

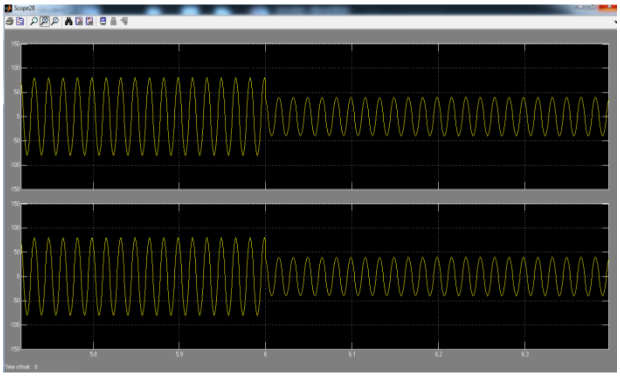

Figure: 4.5 Dynamic performance of STATCOM in the dynamic process. Reactive current and compensating current.

V. CONCLUSION AND FUTURE SCOPE

The above analyzed controlling system is having fundamentals of STATCOM based on H-bridge converter with star configuration. The proposed work having different facts first is fuzzy controlling technique is used for overall improvements which is proved in the simulation results and second is balancing of reactive and compensating currents dynamically. The simulations results have shown that the proposed fuzzy based approach is feasible and more effective for multilevel voltage source converter integrated with cascaded structure. The explained work utilizes new soft computing technique for controlling of different currents and voltages for H-bridge cascaded converters which can be further utilize for the steady state currents and voltages and dynamic state also.

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