Cascaded H-Bridge Multilevel Inverter Based DSTATCOM Using Fuzzy Logic Controller in MATLAB Simulink

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Abstract: **In the electric power system, the static compensator has been recognized as the most effective solution of reactive power compensation, voltage stability enhancement and power quality improvement. This paper presents the 5-Level,11 level and 19 level Cascaded H-bridge Inverter as DSTATCOM for compensation of harmonics by using a Fuzzy logic controlling scheme. MATLAB/SIMULINK results indicate that the THD of the total Circuit is much lesser. The advantage of CHB Inverter is reducing the number of switches and thus switching losses. Finally the results are compared between 5 level,11 level and 19 level inverter based DSTATCOM obtained through MATLAB/Simulink software.**

Keywords: FL- Fuzzy Logic ,PS-Power System, PQ- Power Quality, DSTATCOM- Distribution Static Compensator ,CHB-Cascaded H- Bridge Inverter, VSC-Voltage Source Converter,IGBT- Insulated Gate Bipolar Transistor.

I. INTRODUCTION

Fuzzy controllers are uses for controlling consumer products, such as washing machines, video cameras, and rice cookers, as well as industrial processes, such as cement kilns, underground trains, and robots. Fuzzy control is a control method based on fuzzy logic. Just as fuzzy logic can be described simply as ‘‘computing with words rather than numbers‘‘; fuzzy control can be described simply as ‘‘control with sentences rather than equations‘‘. A fuzzy controller can include empiric al rules, and that is especially useful in operator controlled plants [1].

DSTATCOM is defined as the STATCOM when it is connected to the distribution system. It has the same configuration but small modification is there. It can exchange both active and reactive power with the distribution system by varying the amplitude and phase angle of the converter voltage with respect to the line terminal voltage[6].

There are several types of multilevel inverters: cascaded H-bridge (CHB), neutral point clamped, flying capacitor. In particular, among these topologies, CHB inverters are being widely used because of their modularity and simplicity[2-5]. A multilevel inverter can reduce the device voltage and the output harmonics by increasing the number of output voltage levels. Various modulation methods can be applied to CHB inverters. CHB inverters can also increase the number of output voltage levels easily by increasing the number of H-bridges. This paper presents a DSTATCOM with a proportional integral controller based CHB multilevel inverter for the harmonics and reactive power mitigation of the nonlinear loads. This type of arrangements have been widely used for PQ applications due to increase in the number of voltage levels, low switching losses, low electromagnetic compatibility for hybrid filters and higher order harmonic elimination.

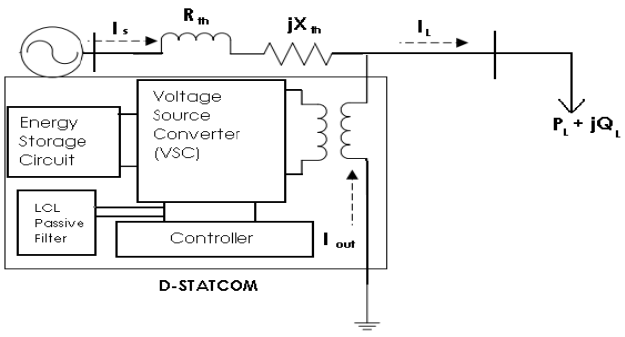


Fig-1:Schematic diagram of a DSTATCOM

II. VOLTAGE SOURCE CONVERTER (VSC)

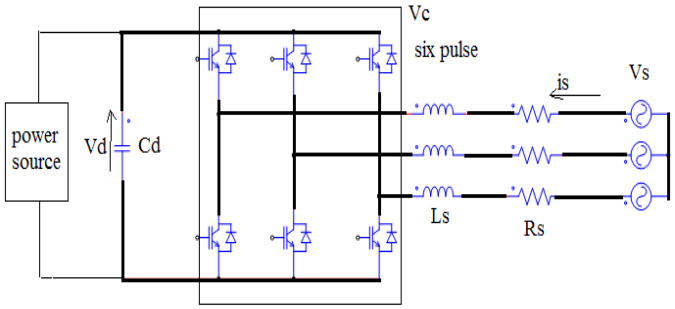


Fig-2: Basic VSC Structure

A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle .A basic VSC structure is shown in Fig where Rs and Ls represent the resistance and inductance between the converter ac voltage (V_c) and the ac system voltage (V) and is is the current injected into the grid[10]. A dc capacitor is connected on the dc side to produce a smooth dc voltage. Each IGBT position is individually controlled and equipped with integrated anti parallel diodes .The IGBTs signals are referred to the Pulse Width Modulation (PWM) that will generate the pulses for the firing of the IGBTs the VSC generates a set of controllable three-phase output voltages at the frequency of the system voltage. Pulse width modulation is used to control the firing of the semiconductor switching devices, generating an "average" sine wave. Pulse width modulation also helps mitigate the amount of harmonics.

III. CASCADED H-BRIDGE INVERTER

Fig. 3 shows the circuit model of a single CHB inverter configuration. By using single H-Bridge we can get 3 voltage levels[9]. The number of output voltage levels of CHB is given by 2n+1 and voltage step of each level is given by Vdc/2n, where n is number of H-bridges connected in cascaded. The switching table is given in Table 1.

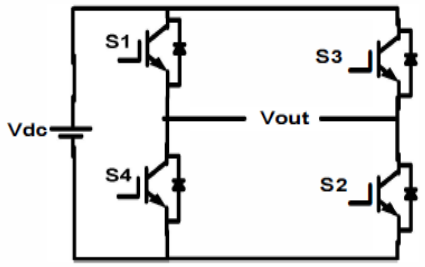


Fig-3: Circuit of the single cascaded H-Bridge Inverter

Table-1:Switching table of single CHB inverter

Switches Turn ON	Voltage Level
S1,S2	Vdc
S3,S4	-Vdc
S4,D2	0

IV. CONVENTIONAL CASCADED H-BRIDGE INVERTER

Fig.4 Shows a five level cascaded H-bridge multilevel inverter. The converter consists of two series connected H-bridge cells which are fed by independent voltage sources.

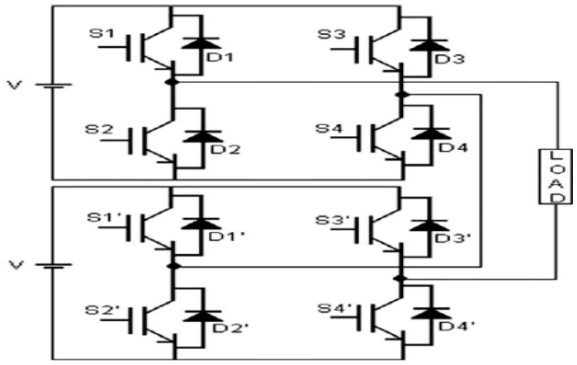


Fig-4: Circuit of the Five-level cascaded H-Bridge Inverter

The switching mechanism for 5-level CHB inverter is shown in table-2.

Table-2 :Switching table for 5-level CHB Inverter

Switches Turn On	Voltage Level
S1, S2	Vdc
S1,S2,S5,S6	2Vdc
S4,D2,S8,D6	0
S3,S4	-Vdc
S3,S4,S7,S8	-2Vdc

Fig.5 Shows an eleven level cascaded H-bridge multilevel inverter. The converter consists of five series connected H-bridge cells which are fed by independent voltage sources.

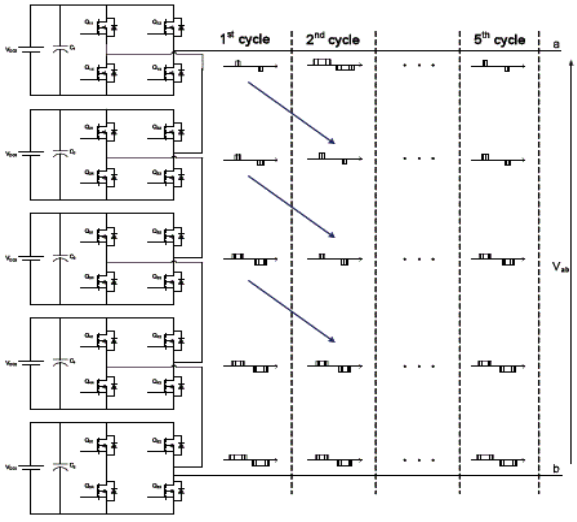


Fig-5: Circuit of the eleven-level cascaded H-Bridge Inverter

V. FUZZY LOGIC CONTROLLER

The unique features of fuzzy logic that made it a particularly good choice for many control problems are as follows, It is inherently robust since it does not require precise, noise – free inputs and can be programme to fail safely is a feedback sensor quits or is destroyed. The output control is a smooth control function despite a wide range of input variations. Since the fuzzy logic controller processes user-define rules governing the target control system, it can be modify and tweakes easily to improve or drastically alter system performance. New sensors can easily be incorporates into the system simply by generating appropriate governing rules.

A. MEMBERSHIP FUNCTION

Fuzzy system uses 4 different shapes of MF's, those are Triangular, Gaussian, Trapezoidal, sigmoid, etc.

B. TRIANGULAR MEMBERSHIP FUNCTION

The simplest and most commonly used membership functions are triangular membership functions, which are Symmetrical and asymmetrical in shape Trapezoidal membership functions are also symmetrical or asymmetrical has the shape of truncated triangle.

C.FUZZY INTERFACE SYSTEM

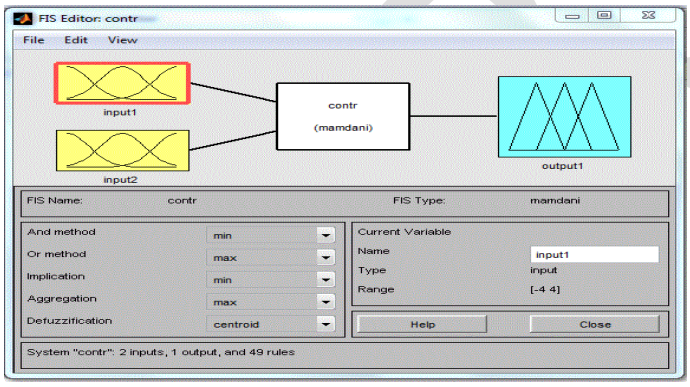
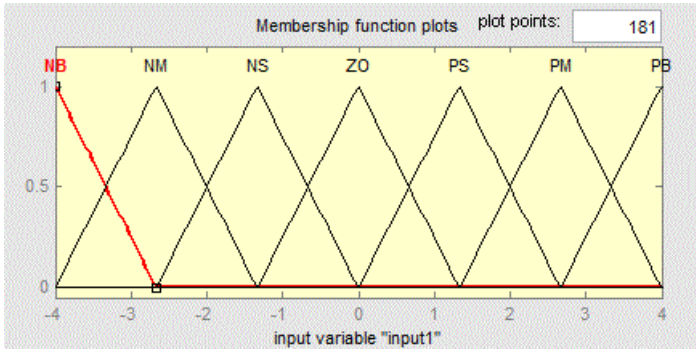


Fig-6 :Fuzzy interface system



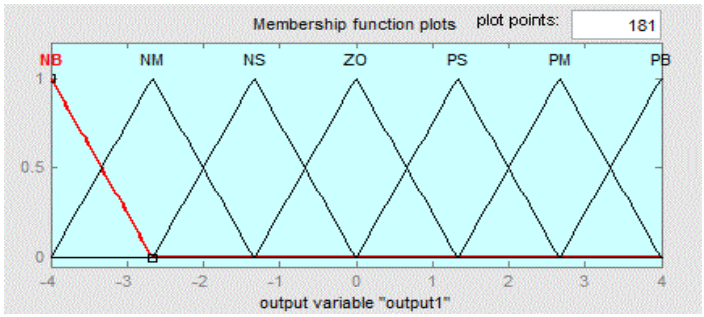


Fig-7 :Membership figures for input and output

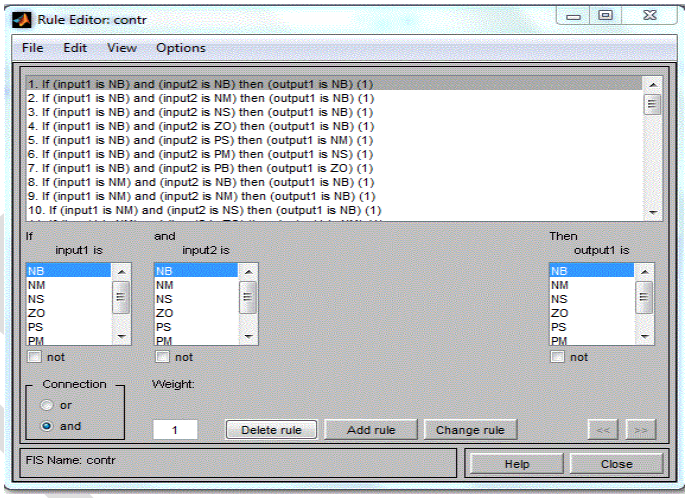


Fig-8:Fuzzy Rule Editor

VI. MATLAB/SIMULINK MODELLING AND SIMULATION RESULTS

Here MATLAB/Simulink model is developed for three level.Those are 5 level,11 level and nineteen level using fuzzy logic controlling scheme .

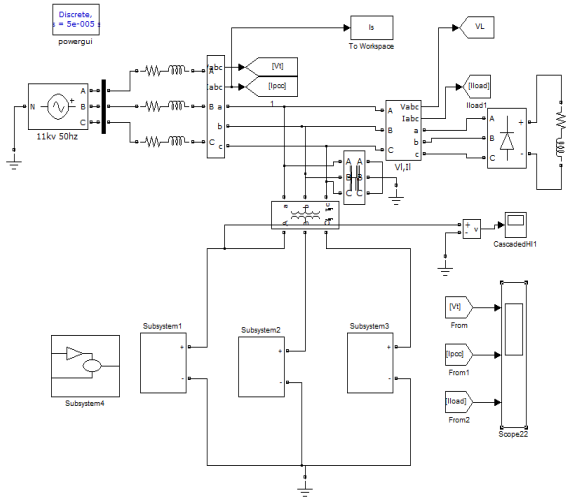


Fig-9: MATLAB/Simulink power circuit model With DSTATCOM

MATLAB/Simulink power circuit model of DSTATCOM shows the phase-A voltage of fivelevel output of phase shifted carrier PWM inverter in Fig-10.

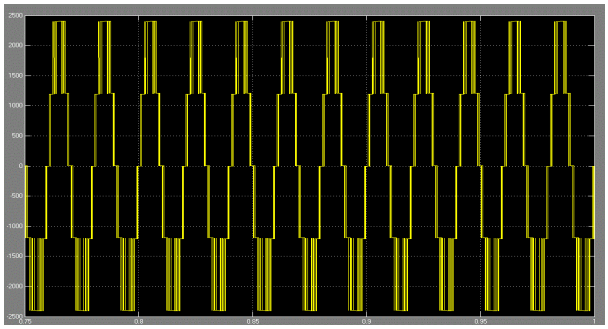


Fig-10: Five Level Output Voltage

Fig.11 shows the three phase source voltages, three phase source currents and load currents respectively with DSTATCOM for 5–level . It is clear that with DSTATCOM load current and source currents are same.

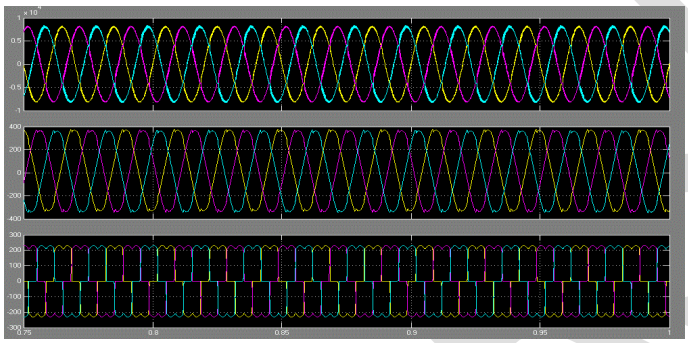


Fig-11: Source Voltage, Source Current, Load Current without DSTATCOM for 5 -level

Fig.12 shows the phase-A voltage of eleven level output of phase shifted carrier PWM inverter.

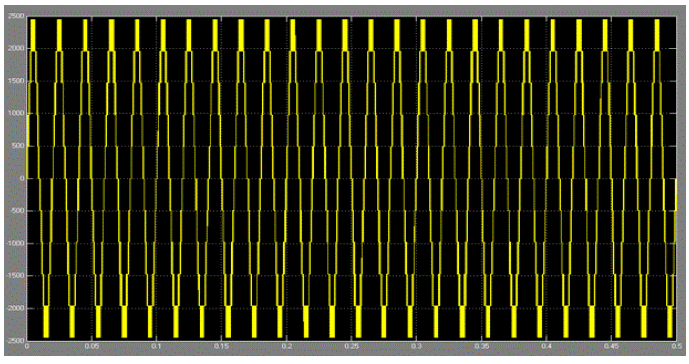


Fig-12: Eleven Level Output Voltage

Fig.13 shows the three phase source voltages, three phase source currents and load currents respectively with DSTATCOM for 11–level .

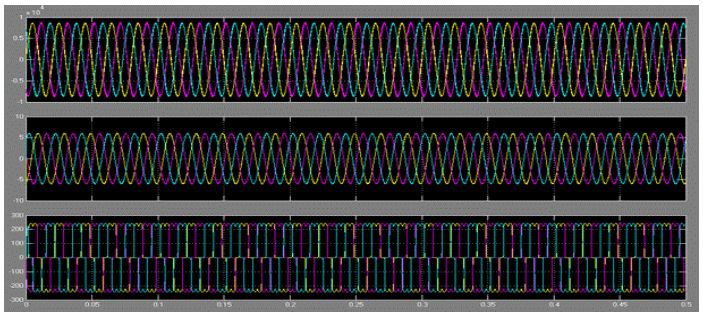


Fig-13: Source Voltage, Source Current, Load Current without DSTATCOM for 11 -level

Fig.14 shows the phase-A voltage of nineteen level output of phase shifted carrier PWM inverter.

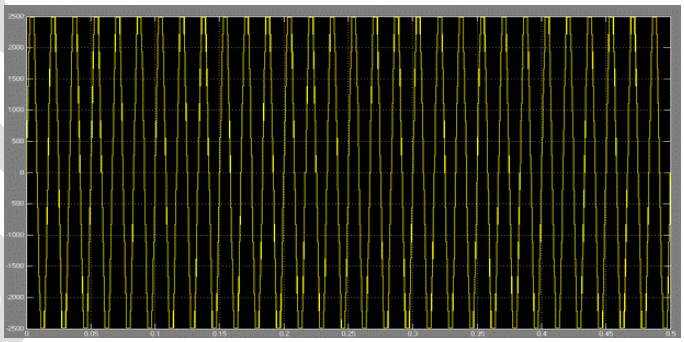


Fig-14: Nineteen Level Output Voltage

Fig.15 shows the three phase source voltages, three phase source currents and load currents respectively with DSTATCOM for 19–level .

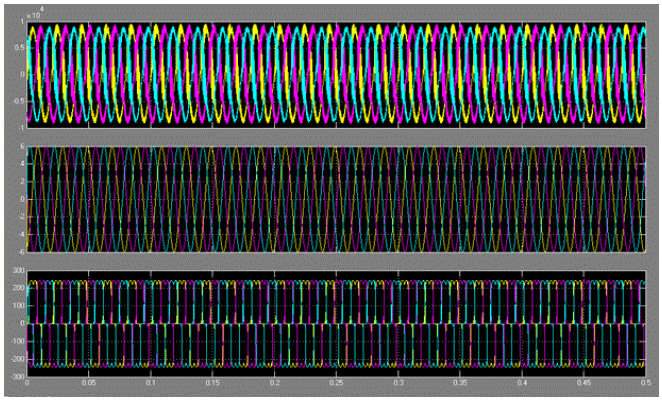


Fig-15: Source Voltage, Source Current, Load Current without DSTATCOM for 19 -level

Figure.16 shows the harmonic spectrum of Phase-A Source current with DSTATCOM for 5-level. The THD of source current is 3.58%.

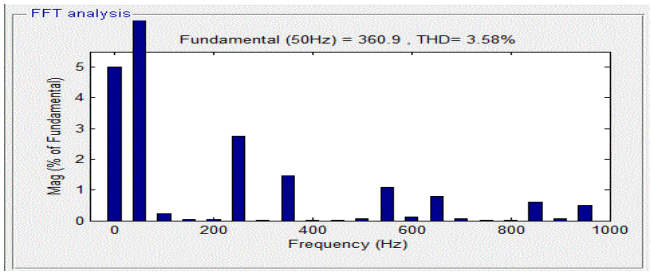


Fig-16:Harmonic spectrum of Phase-A Source current for 5-level

Figure.17 shows the harmonic spectrum of Phase-A Source current with DSTATCOM for 11-level. The THD of source current is 1.05%.

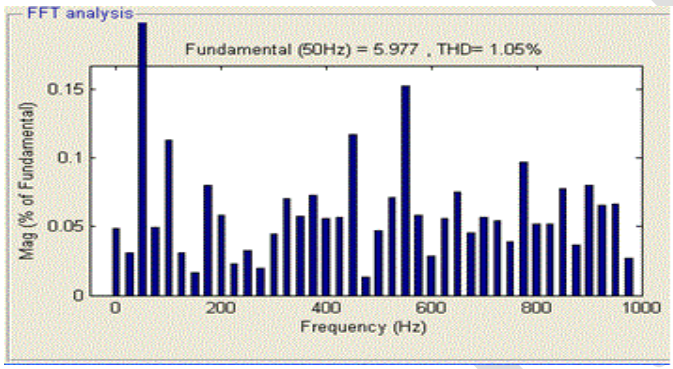


Fig-17: Harmonic spectrum of Phase-A Source current for 11-level

Figure.18 shows the harmonic spectrum of Phase-A Source current with DSTATCOM for 19-level. The THD of source current is 0.42%.

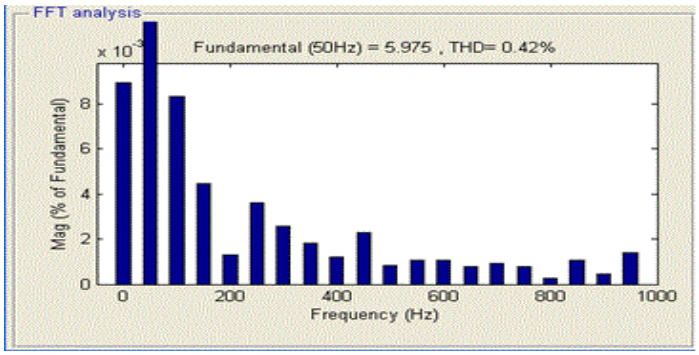


Fig-18: Harmonic spectrum of Phase-A Source current for 19-level

VII. CONCLUSION

This paper studied a five level,11 level and 19 level inverter used in a DSTATCOM using fuzzy logic controlling scheme in power system and has been successfully demonstrated in MABLAB/Simulink. The benefit of different level inverter has low harmonics distortion. The source voltage, source current, load current under non-linear loads are presented. Finally MATLAB/Simulink based model is developed and simulation results are presented for nonlinear loads.

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