International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Designing and Simulation of Multilevel STATCOM on Cascaded Topology

Shri Skant M. Joshi[1], Ganesh Wakte[2]
[1]*Researcher M. Tech Student,* [2]*Asst. Professor, Department of Electrical Engg., Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur University, India*

Abstract: ***This paper present a straightforward strategy to speak to examination of intensity framework for remuneration of receptive power with the assistance of fell H-connect inverter. Whenever we consider any framework which is utilized to compute the immediate responsive power a control approach must be plan for such kind of the framework. To control the staggered inverter, the chose exchanging methods assume a significant job for this. The recreation consequence of MATLAB / Simulink has been proposed to check such model. The STATCOM is one of the realities gadgets which speak to the fell staggered system. We need to utilize PWM for STATCOM for dynamic power channel and for enhancing transient solidness***

Keywords: Multilevel Inverter, PWM, STATCOM, Space Vector modulation, PSPWM

I. INTRODUCTION

Since the utilization of intensity sources builds step by step interest for the minimal effort the vitality additionally inverters as far the heap expands the gadgets are more prone to the fluctuations which causes a high change in the state. The STATCOM utilizing voltage source inverters has been acknowledged as an aggressive option to the conventional static VAR's utilizing thyristor-controlled reactors. By dealing with and controlling the responsive power, a STATCOM can balance out the power framework, The connection while lies between the AC framework voltage and the inverter formed voltage gives the control. When two voltage are synchronized with one another the dynamic just as the receptive power are zero. The primary goal of this converter is to give an AC yield waveform to DC control supply. A bidirectional current directing switch may likewise be utilized for upgraded adaptability and useful enhancements. There are different converter designs available for both single and three stage applications:- The single phasehalf connect is a one-leg convertor comprising of two exchanging elements. The H-connect VSC is most prominent for single stage applications on the grounds that with a similar DC input voltage the yield of the full extension is twice that of the half scaffold Numerous mechanical applications have begun to require high power starting late Some machines in the endeavors in any case require medium or high power for their action. Using an incredible hotspot for each and every mechanical burden may end up being important to a couple of motors requiring high power while it may hurt exchange loads. Inverters are used for certain applications, as in conditions where low voltage DC sources must be changed over with the objective that contraptions can continue running off of AC control. The amazed inverter has been introduced since 1975 as alternative in high power and medium voltage situations. The stunned inverter takes after an inverter and it is used for present day applications as a choice in high power and medium voltage conditions. The amazed inverter involves a couple of switches. In the amazed inverter the course of action switches edges are basic Multilevel inverter goes up to high trading voltage by strategies for a movement of voltage steps, all of which is depend upon the rating of force contraptions independently. For amazed inverter, a couple of topologies are requested in two social events depending upon the amount of self-ruling dc source The most notable working topologies are diode cut (NPC), flying capacitor (FC) and course H-associate (CHB). A NPC inverter is on a very basic level made out of two common two-level voltage source inverter stacked are over the other with some minor changes. The FC topology is some way like the NPC with complexity that the fastening diodes are displaced by flying capacitors. CHBs inverters are described by game plan relationship of something like two single-arrange H-associate inverters. Fundamental trading repeat and high trading repeat PWM procedures are used to work the amazed inverters. It has cut down trading disaster and higher profitability. In the CHB MLI, each measurement requires an alternate dc source and for each dc source a PV cell or battery is to be related

The thyristor-controlled reactor (TCR), thyristor traded capacitors (TSC), static compensator (STATCOM), static VAR compensators (SVR),static synchronous plan compensators (SSSC). Static synchronous compensator is a strong responsive power controller appeared differently in relation to standard VAR compensators Multilevel inverter advancement has ascended starting late as a basic alternative in the domain of high-control medium-voltage imperativeness control. Amazed converters present various

positive conditions when differentiated and customary two-level converters, for instance, capacity to work in high-voltage levels, humbler semiconductors devices and higher number of voltage levels in the yield voltage. Additionally, stunned topology moreover shows a lower total symphonious twisting (THD) and grants a decline of trading repeat [4,5]. Thusly, the usage of amazed topologies united with power quality conditioners, for instance, Static Synchronous Compensator (STATCOM) [5,6], can improve control quality and adequacy in allocation systems [7]. A couple amazed topologies have been represented in the latest decade [8,9]. The Neutral Point Clamped Converter (NPC) is the most create advancement among all available stunned topologies. There are two converter topologies that may battle with the NPC: the Flying Capacitor Converter (FC) , and the Symmetric or Asymmetric Cascade H Bridge Converter (CHB) There are a lot of modification systems, anyway divide move alteration has used in this paper. CHB inverters may similarly expand the quantity of yield voltage orchestrates effectively with the guide of building up the measure of H-ranges cells. This paper gives a STATCOM a PI controller centered eleven phase CHB amazed inverter for the present consonant, voltage flash and responsive power easing of the nonlinear burden.

II. MULTILEVEL INVERTER TOPOLOGIES

There are various multilevel inverter topology that has been incorporated with DSTATCOM for energy requirements. These are

A. Diode clamped multilevel inverter
B. Flying capacitors multilevel inverters
C. Cascaded H bridge multilevel inverter.

The table below shows the comparison of all three multilevel inverters and why we have used the cascaded H-bridge inverter only. This comparison is based on the voltages on each stage, number of output levels and number of switches.

The STATCOM can be utilized in various power levels relying upon the applications. There are fundamentally three-primary regions for the STATCOM application on the premise of various power levels as To actualize the STATCOMs at medium and high power level, high power converter is required that much of the time surpasses the power taking care of ability of a straightforward two dimension converter without 2 Multilevel Converter Topologies for STATCOMs device arrangement/parallel association. Ordinarily, for such high power applications and for boosting up the DC transport voltage past the voltage rating of an individual switch, the two dimension converter needs to utilize arrangement associated gadgets. So also, For this situation, the arrangement associated low appraising gadgets go about as a solitary switch like one of the switches appeared in Fig. 2.1. Nonetheless, because of the diverse dispersing times of semiconductor gadgets, the accompanying issues must be all around considered so as to maintain a strategic distance from voltage-sharing issues among the switches. The electrical and warm qualities of the semiconductor gadgets in a similar change should be matched. The synchronization of the exchanging is extremely troublesome and may result in voltage unbalance between the gadgets. Extra consideration is required for the killing procedure of the switch, just as for its entryway flows. Because of these restrictions, power dissemination amid conduction and exchanging is with the end goal that the exchanging recurrence is seriously constrained. This causes a moderate framework reaction and massive yield channel circuits. Expansive snubber circuit parameters are additionally required to remunerate transient voltage unbalance and to accomplish static voltage adjusting. It might likewise prompt all the more exchanging misfortunes and moderately longer exchanging time. In spite of the fact that the blocking voltage of the switch in the two-level converter is expanded, a stage up transformer is as yet required for coupling to the transmission systems. In addition, additional endeavors are expected to coordinate the symphonious models at the two-level converter outputs.

Another conceivable method for accomplishing such high power necessity is to utilize attractive transformer coupled multi-beat converters [5]. Customary attractive coupled multi-beat converters regularly orchestrate the staircase voltage wave by changing transformer turns proportion with convoluted crisscross associations. For instance, a regular 48-beat converter comprises of eight 6-beat converters associated together through eight crisscross game plan transformers utilizing the symphonious crossing out system, or associated through Wye/Delta and Delta/Delta association transformers and utilizing modern control plans, so as to decrease symphonious twisting and to achieve high voltage. The patent of Unified Power Flow Controller (UPFC) [13] demonstrates that the shunt-side and the arrangement side of the UPFC are based on eight, 2-level, three-stage connect VSCs. A powerful converter course of action is at that point accomplished by combining the voltage waveform utilizing entangled crisscross transformer associations with guarantee that the Total Harmonic Distortion (THD) guidelines are at long last met. In 1995, the first ± 100 MVA STATCOM was introduced at the Sullivan substation of Tennessee Valley Authority (TVA) in northeastern Tennessee [14]. This unit is basically used to control 161 kV transport amid the everyday stack cycle to lessen the activity of the tap changer of a 1.2

GVA-161 kV/500 kV transformer. Its 48-beat power converter comprises of eight two-level VSCs with complex-interface attractive circuits. Since this is a two-level VSC, an arrangement association of five of door kill (GTO) thyristors is utilized as a principle switch. The control conspire utilized in this STATCOM is a 60 Hz staircase. Due to the moderate exchanging rate of the GTOs, the terminating points of the yield waveform are settled; along these lines, the plentifulness of each yield waveform is constrained by trading dynamic intensity of the DC-interface capacitor with the power lattice. Since it started working, a few feeble purposes of the TVA-STATCOM framework have been brought up.

A portion of these powerless focuses were because of the utilization of arrangement associated exchanging gadgets as talked about above. Taking input from the encounters of this installation, in the AEP UPFC establishment, Inez region, eastern Kentucky, USA, the VSCs were intended to make utilization of three-level design rather than a two dimension utilized prior in the TVA STATCOM venture . Be that as it may, this structure still utilized the multi-beat course of action. The confinements with this multi-heartbeat game plan with attractive transformer coupling strategy are : they are pricey, create around 50 % of the complete misfortunes of the framework, involve up to 40 % of the all out framework's land, (iv) cause troubles in charge because of DC polarizing what's more, flood overvoltage issues coming about because of immersion of the transformers in transient states and

(v) are inclined to disappointment. In this manner, the capacitor voltage union technique is liked to attractive coupling strategy for accomplishing higher rating converters. An alluring option in contrast to the above talked about topologies and latest improvement in the field of high power converters is the staggered converter.

III. CASCADED H-BRIDGE MULTILEVEL INVERTER

Beneath a DC control source is changed over to a H-connect inverter. These inverter has no of switches numbering that it can has four switches. These four switches can deliver distinctive mixes. In association with it each period of the fell inverter which necessitate that it should exchange the power. The falling methods associating inverter in arrangement or in parallel. The remarkable highlights of the staggered state fell inverter is that (a)It can work at extremely low mutilation that implies with incredible yield voltage.(b)It can probably draw the info current with exceptionally low all out consonant distortion.(c)They can work at a high recurrence. To structure the fell H-connect we have IGBT/DIODE has been utilized as a power semiconductor switches in every H-connect organize.

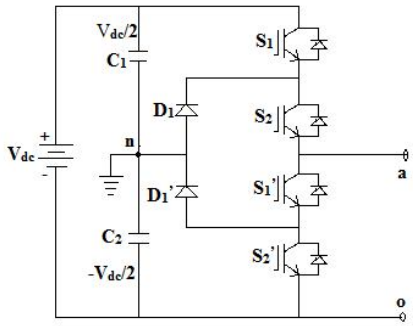


Fig 1 Cascaded h-bridge multilevel inverter

There are numerous routes in which electric power can be of low quality and some more reasons for such low quality power. With the expanding utilizations of nonlinear and electronically exchanged gadgets in dissemination frameworks and enterprises, Power quality (PQ) issues, for example, music, gleam, and irregularity have turned out to be not kidding concerns. Likewise Lighting strikes on transmission lines, exchanging of capacitor banks, and different system flaws can likewise cause PQ issues, for example, homeless people, voltage droop and interference Voltage– source converter (VSC)- based custom power

(CP) gadgets are progressively being utilized in custom power applications to relieve these PQ issues in power dispersion frameworks. A shunt converter (otherwise called the shunt dynamic channel) can make up for contortion and unbalance in a heap with the goal that a reasonable sinusoidal current moves through the feeder. An arrangement converter (otherwise called the dynamic voltage) can make up for voltage list and twisting in the supply side voltage with the goal that the voltage over a touchy load is superbly regulated. Control procedures assume a fundamental job in the general execution of the power conditioner. Momentary power hypothesis is commonly wanted to create reference signals for the shunt converter. An expanded strategy dependent on momentary responsive power hypothesis in a pivoting reference outline is utilized to smother the music and to address the power factor in . Fluffy rationale is used to control the pay flows of the shunt converter

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

IV. METHODOLOGY

STATCOM is a directing gadget utilized on rotating flow power transmission network. It depends on a power hardware voltage source converter and can go about as either a source of sink of responsive AC capacity to a power network. If associated with a wellspring of intensity it can likewise give dynamic AC power. It is an individual from the FACTS group of gadgets and the standard arrangement of STATCOM is appeared in figure 1 and standard setup and schematic chart of DVR is appeared in fig 2 and 3 respectively. One of the fundamental explanations behind introducing a SVC or STATCOM in transmission systems is to expand the power exchange ability where constrained by post-contingency voltage criteria or under voltage loss of burden probability. Determining the ideal blend of dynamic and exchanged pay is a challenge. Control frameworks are intended to keep the typical working point inside the center of the SVC or STATCOM dynamic range. The voltage-sourced inverter (VSC) is the essential electronic piece of a STATCOM, which the dc voltage into a recurrence, and the phase. There are distinctive strategies to understand a voltage-sourced converter for power utility application. Based on music and misfortune considerations, pulse width modulation(PWM) or numerous converters are used. Inherently, STATCOMs have symmetrical rating as for inductive and capacitive receptive influence for asymmetric rating. Equalization strategy chooses the trading limit of a converter. The change technique must guarantee that the created voltage at the yield of the converter resembles the ideal voltage anyway much as could sensibly be normal. The test is to extend regular change methodologies to the amazed case, where the huge number of cells gives unmistakable decisions to direct the converter. Each guideline methodology revolves around the improvement of some converter features for instance, trading hardship decline, uniform trading incident scattering, upgrading consonant shows, typical mode voltage minimization, least computational cost, etc. The most broadly perceived change frameworks for stunned converters . The foremost trading modulators, give a trading limit with the true objective that each cell has only a solitary remuneration for each focal cycle. The trading limit with multicarrier PWM are chose reliant on examination among transporters and a reference banner. Cross breed PWM is a mix of significant and transporter based change. Space Vector Modulation (SVM) considers all the possible trading states and select the best blends in each control cycle to deliver a yield voltage with proportional volt/second as the reference regard. Detail depiction of each modulator is given in this section. It is furthermore worth referencing that the trading headings for the converter are not always chosen by a submitted equalization organize; rather, they can be directed by a prompt consequence of the general converter controller. Hysteresis current controller

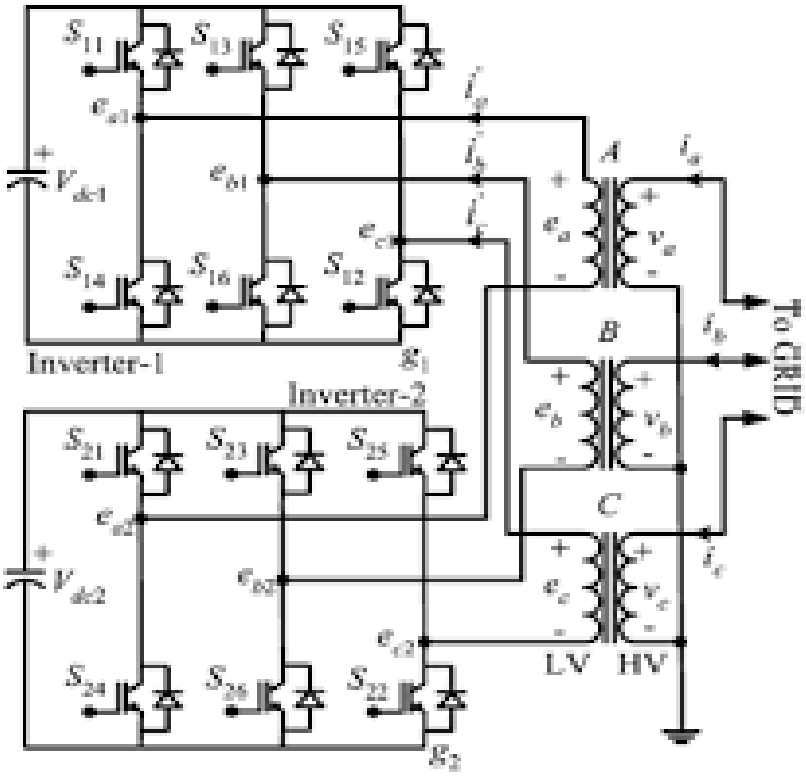


Fig 2 Generalized Diagram

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

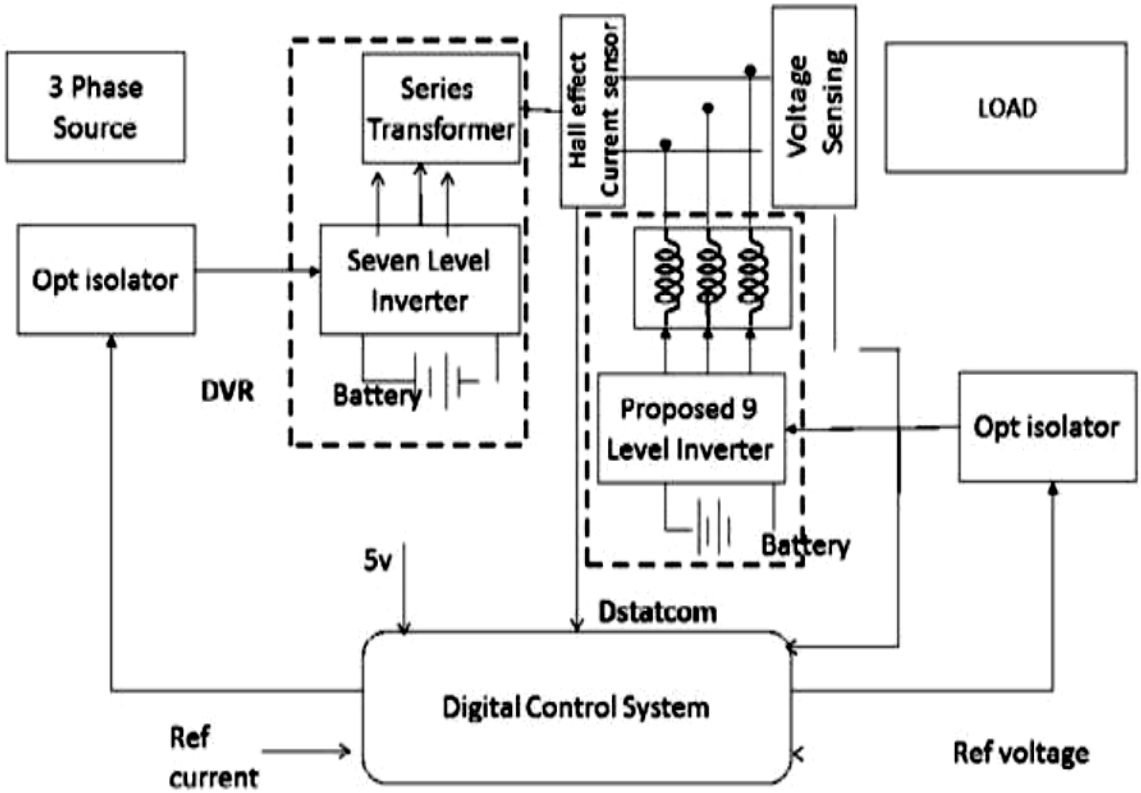


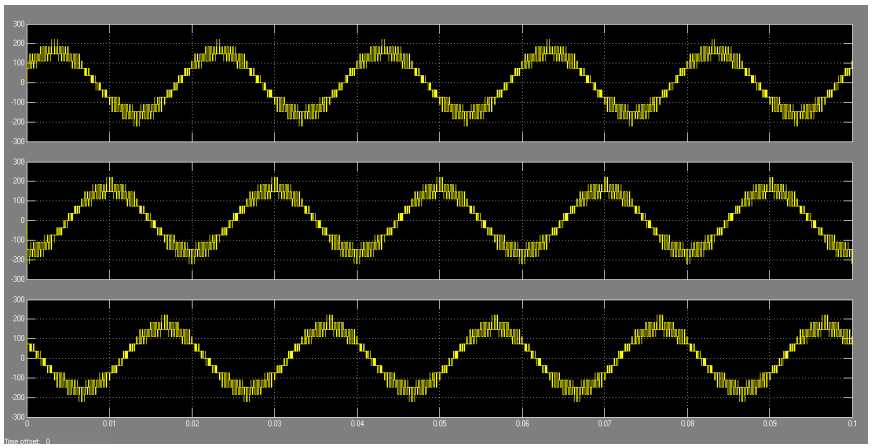
Fig 3 Proposed Diagram of the project

V. CONCLUSIONS

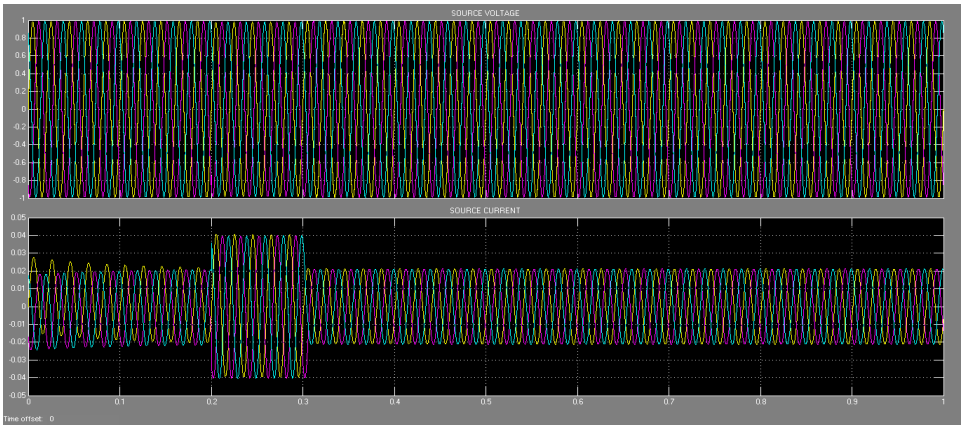
This undertaking has dealt with the control and guideline of Cascaded H-Bridge (CHB) converters for STATCOM applications. With focus on the star and delta relationship of the stage legs that include the converter, the system execution under balanced and unbalanced action have been inspected, endeavoring to highlight the central focuses yet furthermore the troubles and possible entrapments that this kind of topology presents for STATCOM applications. After an underlying audit of the standard amazed converter topologies that are open in the present market, the general control structure for the CHB-STATCOM has been depicted in Guidelines for tuning of the particular control circles have been displayed and the dynamic execution of the system has been attempted through diversions. It has been highlighted that in genuine use, due to the unavoidable deviations from immaculate conditions, the Stage Shifted Modulations (PS-PWM) technique encounters a non-uniform power dissemination among the particular cells that involve the stage legs of the converter, provoking the necessity for additional control circles to guarantee that the different DC-capacitor voltages don't separate from the reference regard. The examination of this miracle is done in where it has been exhibited that the non-uniform unique power assignment is a direct result of the association between the conveyor side-band hints of the cell voltage and the base-band music of the current (when low-trading repeat for the individual cells is picked), similarly as poor annulment of the transporter side-band music (mostly in case of high-trading repeat assurance). Speculative examination exhibits that by fitting assurance of the repeat guideline ratio, an even more even power movement among the assorted cells of a comparative stage leg can be achieved. This decision grants to lessen the modification action required from the individual modifying controller and along these lines to overhaul the general structure security. Another strategy for the individual DC-interface voltage changing discussed in Chapter 4 is the cells masterminding estimation. Regardless, it has been showed up the two methodologies are not prepared to give suitable individual modifying when the CHB-STATCOM isn't exchanging current with the system (here implied as zero-current mode).This condition is especially essential for the star-related CHB-STATCOM, in view of the nonattendance of a shut route for the current, (for instance, in the delta configuration) to exchange essentialness

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

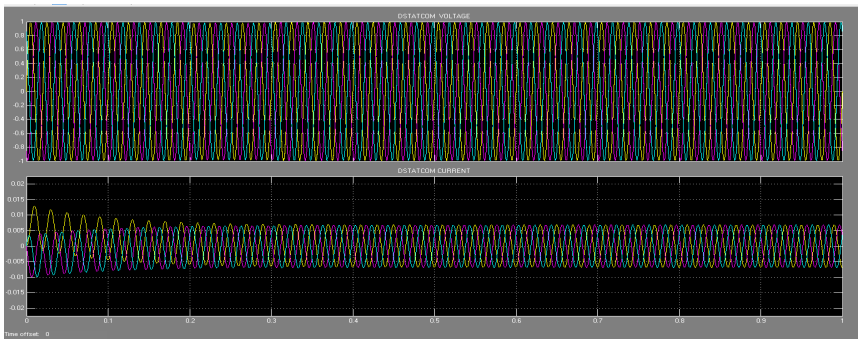
VI. RESULTS



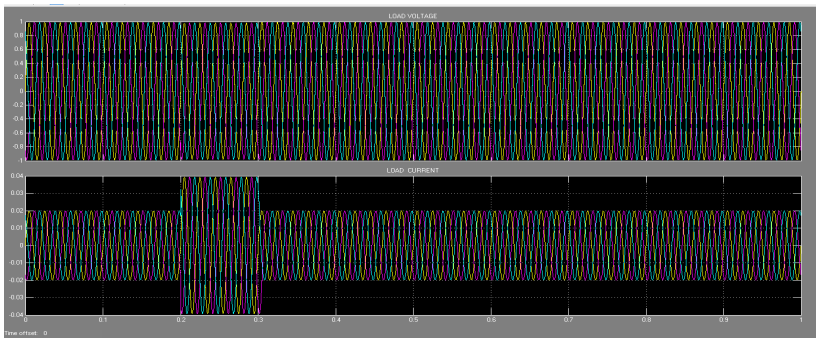
H-bridge output



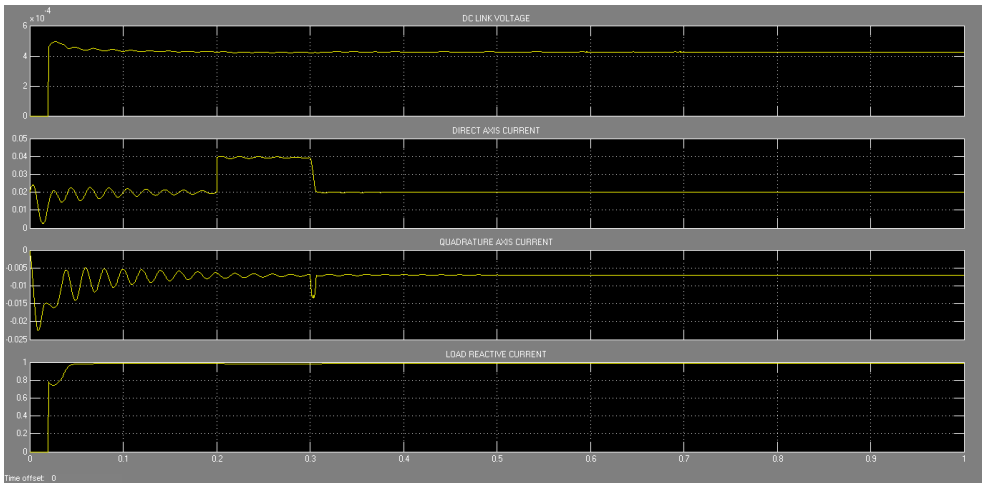
Source voltage and source current



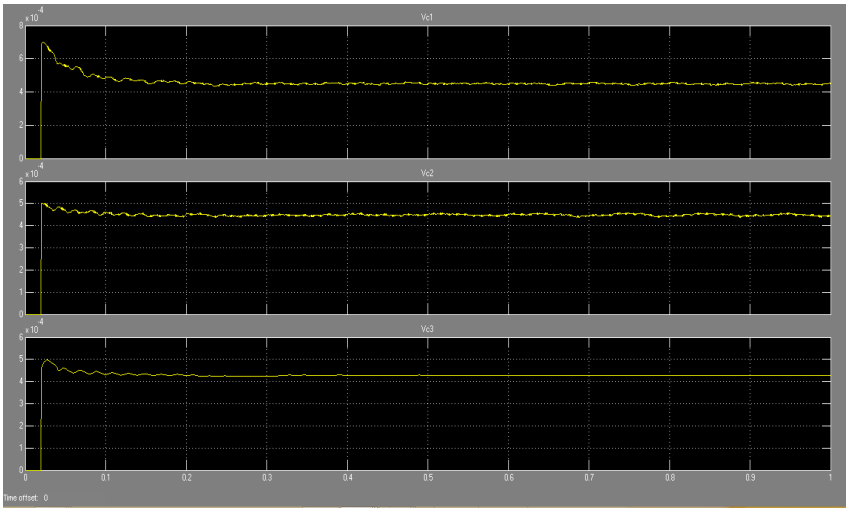
DSTATCOM voltage and DSTATCOM current



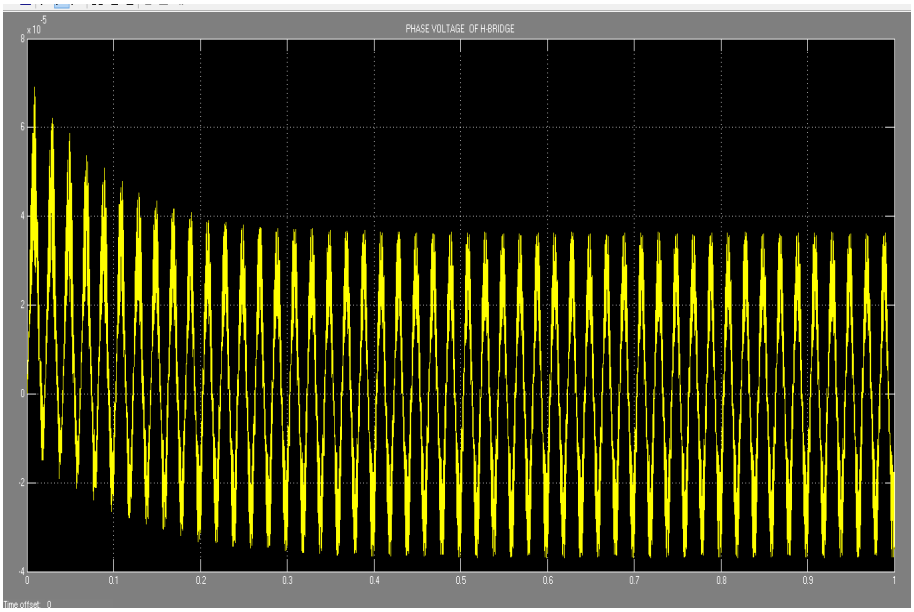
Load voltage and load current



DC link voltage, direct axis current quadrature axis current and load reactive current



Capacitor voltages



Phase voltage of H bridge

REFERENCES

[1] G. Andersson, P. Donalek, R. Farmer, N. Hatziargyriou, I. Kamwa, P. Kundur, N. Martins,J. Paserba, P. Pourbeik, J. Sanchez-Gasca, R. Schulz, A. Stankovic, C. Taylor, andV. Vittal, "Causes of the 2003 major grid blackouts in north america and europe, and recommendedmeansto improve systemdynamic performance," IEEE Transactions on PowerSyst., vol. 20, no. 4, pp. 1922–1928, Nov 2005.
[2] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of FlexibleAC Transmission Systems. New York: IEEE Press, 2000.
[3] X. P. Zhang, C. Rehtanz, and B. Pal, Flexible AC Transmission Systems Modelling andControl. Springer, 2006.
[4] G. F. Reed, M. Takeda, and I. Iyoda, "Improved power quality solutions using advanced solid-state switching and static compensation technologies," in Proc. of Power Engineering Society 1999 Winter Meeting, IEEE, vol. 2, Jan 1999, pp. 1132–1137.
[5] H. Chong, A. Q. Huang, M. E. Baran, S. Bhattacharya, W. Litzenberger, L. Anderson, A. L. Johnson, and A. Edris, "Statcom impact study on the integration of a large wind farm into a weak loop power system," IEEE Transactions on Energy Convers., vol. 23,no. 1, pp. 226–233, March 2008.
[6] C. C. Davidson and G. de Preville, "The future of high power electronics in transmission and distribution power systems," in Proc. of 13th European Conference on Power Electronicsand Applications, EPE, Sept 2009, pp. 1–14
[7] V. K. Sood, HVDC and FACTS Controllers - Applications of Static Converters in PowerVSystems. Boston: Kluwer Academic Publishers, 2004.
[8] H. Akagi, S. Inoue, and T. Yoshii, "Control and performance of a transformerless cascade pwm statcom with star configuration," IEEE Transactions on Ind. Appl.,, vol. 43, no. 4,pp. 1041–1049, July 2007.
[9] A. Lesnicar and R.Marquardt, "An innovativemodular multilevel converter topology suitable for a wide power range," in Proc. of Power Tech Conference, 2003 IEEE Bologna,vol. 3, June 2003, p. 6 pp.127
[10] C. D. Townsend, S. M. Cox, A. J. Watson, T. J. Summers, R. E. Betz, and J. C. Clare,"Voltage balancing characteristics for a cascaded h-bridge multi-level statcom employing space vector modulation," in Proc. of 15th Intern ational Power Electronics and MotionControl Conference (EPE/PEMC), Sept 2012, pp. DS3b.3–1–DS3b.3–7.
[11] K. Ilves, L. Harnefors, S. Norrga, and H.-P. Nee, "Analysis and operation of modular multilevel converters with phase-shifted carrier pwm," IEEE Transactions on Power Electron.,vol. 30, no. 1, pp. 268–283, Jan 2015.
[12] J. Yutaka Ota, Y. Shibano, and H. Akagi, "A phase-shifted pwm d-statcom using a modular multilevel cascade converter (ssbc); part ii: Zero-voltage-ride-through capability," IEEE Transactions on Ind. Appl., vol. 51, no. 1, pp. 289–296, Jan 2015.
[13] Q. Song and W. Liu, "Control of a cascade statcom with star configuration under unbalanced conditions," IEEE Transactions on Power Electro., vol. 24, no. 1, pp. 45–58, Jan2009.
[14] N. Hatano and T. Ise, "Control scheme of cascaded h-bridge statcom using zero-sequence voltage and negative-sequence current," IEEE Transactions on Power Del., vol. 25, no. 2,pp. 543–550, April 2010.
[15] L. Tan, S.Wang, P.Wang, Y. Li, Q. Ge, H. Ren, and P. Song, "High performance controller with effective voltage balance regulation for a cascade statcom with star configuration under unbalanced conditions," in Proc. of 15th European Conference on Power Electronics and Applications (EPE), Sept 2013, pp. 1–10.
[16] M. Hagiwara, R. Maeda, and H. Akagi, "Negative-sequence reactive-power control by a pwm statcom based on a modular multilevel cascade converter (mmcc-sdbc)," IEEETransactions on Industry Appl., vol. 48, no. 2, pp. 720–729, March 2012.
[17] R. Betz, T. Summers, and T. Furney, "Symmetry compensation using a h-bridge multilevel statcom with zero sequence injection," in Proc. of 41st Industry Applications Conference(IAS) Annual Meeting, vol. 4, Oct 2006, pp. 1724–1731.
[18] S. Du, J. Liu, J. Lin, and Y. He, "Control strategy study of statcom based on cascaded pwm h-bridge converter with delta configuration," in Proc. of 7th International Power Electronics and Motion Control Conference (IPEMC), vol. 1, June 2012, pp. 345–350.
[19] H. Akagi, "Classification, terminology, and application of the modular multilevel cascade converter (mmcc)," IEEE Transactions on Power Electron.,, vol. 26, no. 11, pp. 3119–3130, Nov 2011.
[20] S. Du and J. Liu, "A brief comparision of series-connected modular topology in statcom application," in Proc. of ECCE Asia Downunder (ECCE Asia), 2013 IEEE, June 2013, pp.456–460.