International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
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IJIEMR Transactions, online available on 27[h] Nov 2018. Link :http://www.ijiemr.org/downloads.php?vol=Volume-07&issue=ISSUE-12

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Volume 07, Issue 12, Pages: 373–378.

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International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
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SINGLE PHASE CASCADED H-BRIDGE LEVEL LC-STATCOM FOR PASSIVE REACTOR COMPENSATION

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Abstract- Power converters for mobile devices and consumer electronics have become extremely lightweight and compact over the past few decades. High power density drives have become more desirable in modern industrial plants because of limited space. Size and weight considerations are very important in certain specialized industries as offshore oil drilling and marine/subsea systems that employ adjustable speed drives (ASD). Typical ASD topology consists of a three phase diode rectifier front-end. It is also common to specify a dc-link inductor and/or ac line reactors to reduce utility line current harmonics to acceptable levels. However, the required dc-link inductor/ac line reactors contribute to additional weight and volume. In this paper an active inductor approach is explored to emulate a large size dc-link inductor.. The required inductance value is commanded and current control regulates the active inductor current to match inductor behavior. It is shown that the proposed active inductor topology is similar in weight/volume as the smaller inductor while emulating a higher per unit inductance. The proposed active inductor meets the required compact and lightweight specifications of ASDs in retrofit and special applications. Furthermore, the active inductor is tunable to achieve high performance operation during faults. The proposed model is to be simulate in MATLAB/SIMULINK platform

Index Terms- DC-link voltage, Voltage source Inverter, power quality (PQ), Adjustable Speed Drives.

I. INTRODUCTION

An adjustable speed drive is equipment designed to control the speed of an induction motor, generating sinusoidal voltages and currents with the necessary frequency and magnitude. The common ASD structure for medium and low power equipments is an indirect converter. This device first converts the power supply ac voltage, of fixed magnitude and frequency, into dc voltage by a rectifier. This dc voltage is then converted by the inverter in three-phase adjustable ac voltage with adjustable frequency and magnitude. Insulated Gate Bipolar Transistors (IGBT) are the power switches most used in the inverter. IGBT allow high switching frequencies resulting in a high dynamic control of the current, which is not possible with lower switching frequencies. To analyse the sensitive elements an ASD will be divided in four main sections (Figure 1):

- AC/DC Rectifier
- DC link and precharge circuit
- DC/AC Inverter
- Control system

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The different methods applied in each of these sections by the manufacturers of ASD, affect the susceptibility of the converter in relation to its electrical environment, its performance and also its cost, although the most expensive is not necessarily the least susceptible.

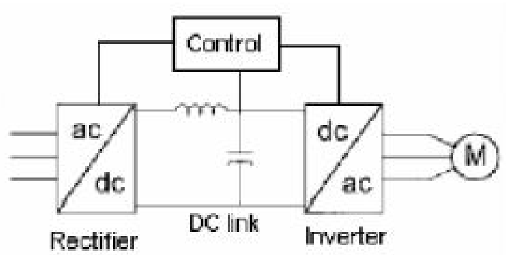

Fig 1. Schematic diagram of Adjustable Speed Drive

The front end of a typical ASD consists of a diode bridge rectifier (6 pulse or 12 pulse) resulting in low frequency grid current harmonics. Usually they employ LC filters to filter out current harmonics and improve overall power quality. A DC-link reactor of 0.1-0.2 p.u. improves grid current quality tremendously. However, for high power ratings, it tends to be bulky, increasing the weight/volume and cost. On the other hand, a smaller inductor up to 0.01 p.u. renders the grid current quality unsatisfactory. Power densities of such inductors may be increased by employing better materials and newer geometries but they add to cost. In addition to weight and volume considerations, the impedance value of passive inductors cannot be dynamically adjusted and is susceptible to changes in temperature, and saturation. Active inductors had been proposed for several applications as power flow control by varying the inductance [4, 5]. However, for such applications during fault conditions, the voltage across the active inductor will be the entire line voltage and the DC link voltage of the active inductor and the switch ratings have to be kept high, making the system very expensive. Also, the topology requires a high switching frequency which increases the size of heat sink and makes the solution impractical. However, with recent advancement in semiconductor materials as SiC and GaN, switching losses can be reduced and a compact system can designed for high power applications. In the paper an active inductor for the DC link reactor of an ASD is proposed. The desired inductance value, Lref , can be selected at a 0.1 p.u. and is externally commanded. A simple control strategy regulates the current to emulate the commanded inductance value. The overall control is much simpler compared to a series active filter which has a similar topology.

II. PROPOSED ACTIVE INDUCTOR IN A 2 – PORT CONFIGURATION

Fig. 2 shows proposed adjustable speed drive system with an active inductor as DC link reactor. The passive inductor used for smoothening of dc link current is replaced by H bridge based active inductor for adjustment.

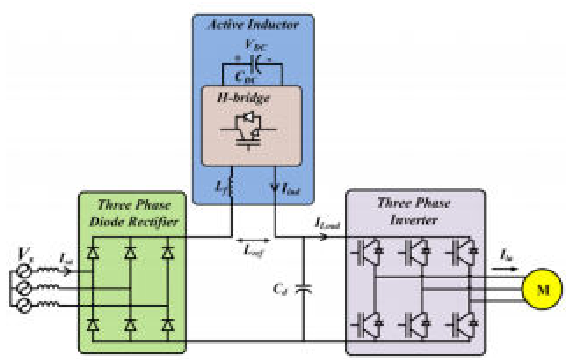

Fig 2: Proposed ASD with an Active Inductor as DC-link reactor

A. H-Bridge Converter

The power converter chosen for this application has to meet several requirements. It has to operate at a high switching frequency without adding to losses significantly. It needs to keep the capacitor charged to the desired value. At the

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same time, it has to convert the energy of the system to emulate inductive behavior. The power converter has been chosen as an H-bridge topology to obtain three level output and produce both positive and negative voltage across its terminals. The proposed active inductor block consists of a small inductor, Lf , a high frequency DC-link capacitor, CDC , and the H-bridge converter. The H-bridge converter can consist of SiC or GaN devices capable of switching at high frequencies (≈50 kHz) with lower losses than Si IGBTs. The DC link capacitor could be selected as a metalized polypropylene film capacitor to reduce capacitance drift for high temperatures and increased reliability. The DC link capacitor supplies the energy required to emulate the inductance as shown in (1). The filter inductor could be built with a nanocrystalline core which has low loss characteristics at high frequency [7]. It determines the high frequency ripple on the current envelope by (2) and facilitates power transfer.

$$L_{ref} I_{load}^2 = C_{dc} V_{dc}^2 \quad \text{.....................} 1$$

$$V_{dc} = L_{filter} \frac{\Delta I_{ripple}}{DT_{switch}} \quad \text{.....................} 2$$

B. Control Strategy for H Bridge Active Inductor

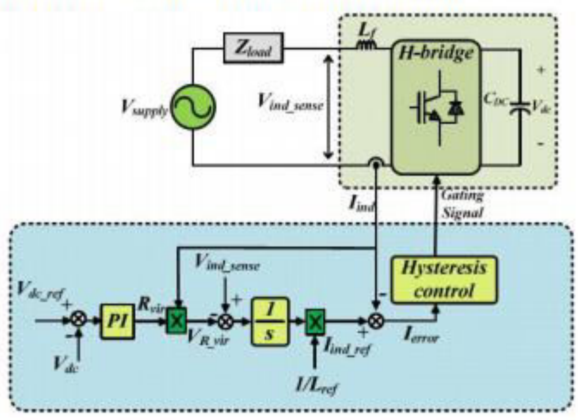

Fig 3: Proposed control strategy with outer voltage control and inner current control

The block diagram for the control of the proposed active inductor is shown in Fig. 2. The active inductor topology is similar to a series active filter topology. A series active filter has complex control structure to determine the harmonics present and generate a voltage reference to cancel them out [8]. The proposed active inductor has a simple control strategy to emulate an inductor and high frequency harmonics are automatically attenuated. The controller structure consists of the inner current loop using hysteresis control and the outer DC bus voltage control loop employing a PI controller. The inner loop calculates the commanded value of inductor current, Iind_ ref by using the relationship in (3). Resultant current error, Ierror , is fed to a hysteresis controller to generate the H bridge gating signals to emulate the inductance

$$I_{ind\_ref} = \frac{1}{L} \int (V_{ind\_sense} - V_{R\_vir}) dt \quad \text{............} 3$$

III. ZERO VOLTAGE SWITCHING (ZVS) OF H –BRIDGE CONVERTER

A ZVS turn on can be achieved for inductor by using the parasitic capacitance can reduce the switching losses in the ac half. A model of the H-bridge with capacitances is shown in Fig.14. The modes of operation are as follows: Mode I In this mode switch S2 and S3 are turned on and the current flows to discharge the DC link capacitor as shown in Fig. 15. The output capacitances across switches S1 and S4 are charged to value, Vc and once across the S2 and S3 are discharged.

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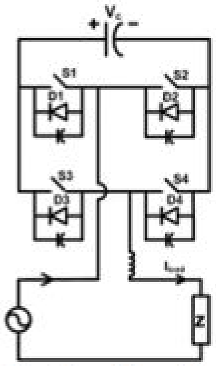

Fig 4. Parasitic model for ZVS scheme

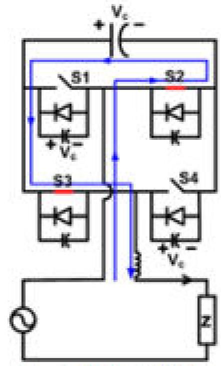

Fig 5. Mode I of ZVS Operation

Mode II Now, S2 is turned off and S3 is kept turned on as shown in fig. Now the current, which was earlier passing through switch S2 is forced to take either of the 2 paths according to (4), either charging the output capacitance of switch S2 or discharging the output capacitance of switch S1.

$$V_{S1}+V_{S2} = V_C \quad ....4$$

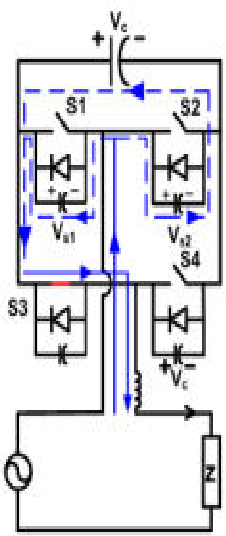

Fig 6. Mode II of ZVS operation

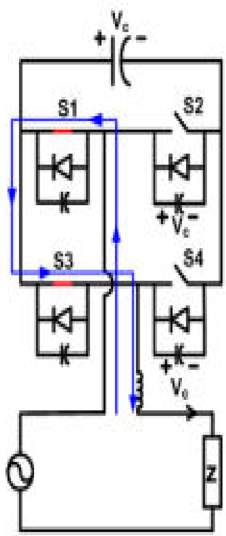

Fig 7. Mode III of ZVS operation

Mode III

Now, the switch S1 is turned on with ZVS as shown in fig. The current which was flowing through the body diode of S1 is now shared by both D1 and S1. The current starts to flow bypassing the DC link capacitor.

Mode IV

Now switch S3 is turned off and the current passing through S1 has two paths it can take as shown in fig, either charge the output capacitance of switch S3 or discharge the output capacitance of switch S4. Once the output capacitance of S4 is discharged, all the current can now pass through body diode of S4.

Mode V

Once diode D4 is conducting, switch S4 can be turned on in ZVS and then current will flow as shown in fig charging the DC link capacitor. The similar process can be used to turn on switch S2 and S3 by repeating the modes explained for these switches.

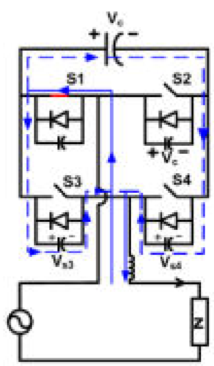

Fig 8. Mode IV of ZVS operation

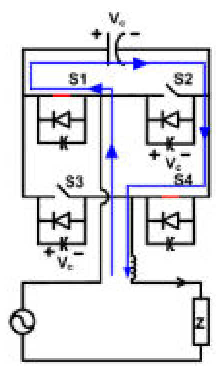

Fig 9. Mode V of ZVS operation

III. SIMULATION RESULTS

The proposed H bridge based active inductor for adjustable speed drive system performance is studied in is studied using MATLAB/ SIMULINK. The overall system configuration and controller are shown in fig 4(a), (b) & (c) for steady state and transient conditions. The system parameters are given in Table I. Inverter output voltages has the total harmonic distortion of 1.92%. The improved output characteristics of

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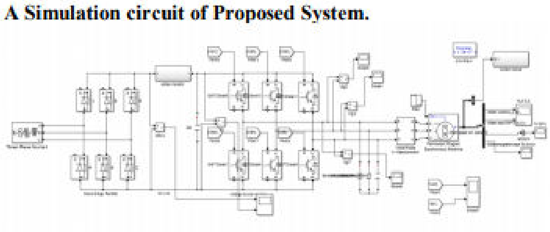
BLDC Drive are presented. The speed, torque, back emf and stator currents has been shown.

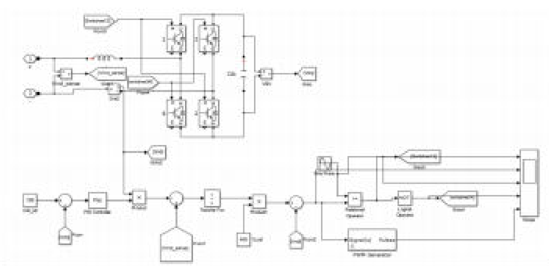
Table: 1 Simulation parameter

Input Voltage	400V
Output Power	5kW
DC Current	7A
Active Inductor	500µH, 2.5mH
Filter Inductor	500µH
Active inductor DC bus capacitor	1mH
DC bus voltage reference	200V
ASD DC link capacitor	220µF
Switching frequency	1920Hz

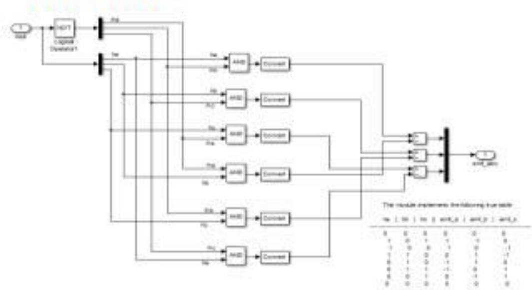
A Simulation circuit of Proposed System.



B Simulation Circuit of H bridge Active Inductor



C. Control Circuit



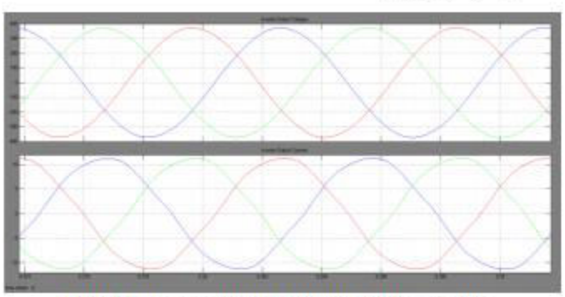


Fig 10 Inverter output voltages and currents

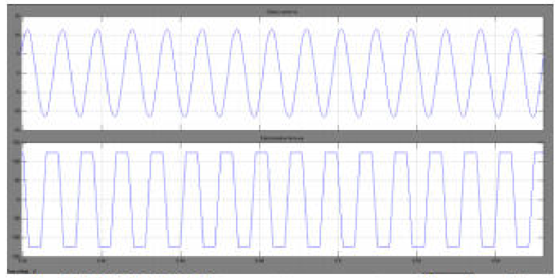


Fig 11 PMBLDC Motor stator current and back emf

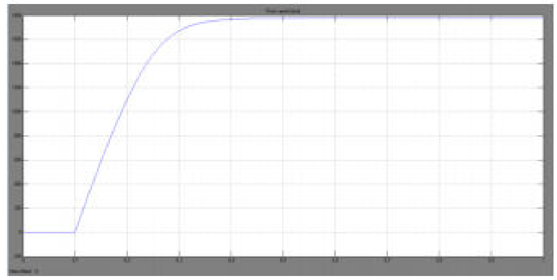


Fig 12 Steady state speed of the Drive.

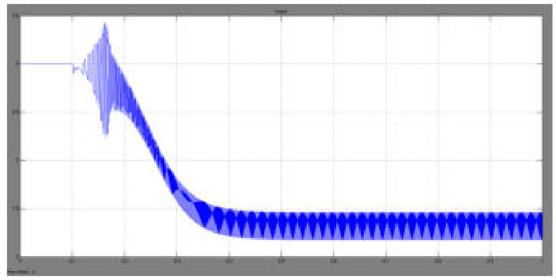


Fig 13 Drive Torque

IV. CONCLUSION

A simple STATCOM scheme using a cascaded two-level inverter-based multilevel inverter is presented in this paper . The proposed topologies have two VSI based two-level inverters are connected in cascade through open-end windings of a three-phase transformer and filter elements. Converter fed dc-link voltages is regulated at different levels to obtain four-level operation. The proposed STATCOM multilevel inverter has operated under MATLAB/SIMULINK environment and the results are verified in balanced and unbalanced conditions. Further, stability behavior of the topology is investigated. The dynamic model is developed and transfer functions are derived. The system behavior is analyzed for various operating conditions.

REFERENCES

[1] Dibyendu Rana, Bahaa Hafez, Pawan Garg, Somasundaram Essakiappan, Prasad Enjeti" Analysis and Design of Active Inductor as DC-Link Reactor for Lightweight Adjustable Speed Drive Systems"IEEE Transactions on Power Electronics, 978-1-4799-5776-7/14/$31.00 ©2014 IEEE

[2] Ericsen, T. Engineering "Total Electric Ship". in Petroleum and Chemical Industry Technical Conference, 2007. PCIC '07. IEEE. 2007.

[3] ABB. Offshore Drilling Vessels:Total electrical systems for safe, efficient and environmental drilling operations. Available from: http://goo.gl/y5rgk0.

[4] Ishikawa, T., et al. Transmission power control using variable inductance with feedforward- and feedback-based power controllers. in Power Electronics and Drive Systems, 1999. PEDS '99. Proceedings of the IEEE 1999 International Conference on. 1999.

[5] Funato, H., A. Kawamura, and K. Kamiyama, Realization of negative inductance using variable active-passive reactance (VAPAR). Power Electronics, IEEE Transactions on, 1997. 12(4): p. 589-596.

[6] Sabate, J.A., et al. Design considerations for high-voltage high-power full-bridge zero-voltage-switched PWM converter. in Applied Power Electronics Conference and Exposition, 1990. APEC '90, Conference Proceedings 1990., Fifth Annual. 1990.

[7] Rylko, M.S., et al., Revised Magnetics Performance Factors and Experimental Comparison of High-Flux Materials for High Current DC-DC Inductors. Power Electronics, IEEE Transactions on, 2011. 26(8): p. 2112-2126.

[8] Peng, F.Z., H. Akagi, and A. Nabae, Compensation characteristics of the combined system of shunt passive and series active filters. Industry Applications, IEEE Transactions on, 1993. 29(1): p. 144-152.

[9] J. L. Duran-Gomez and P. N. Enjeti, "A new approach to mitigate nuisance tripping of PWM ASDs due to utility capacitor switching transients (CSTs)," Power Electronics, IEEE Transactions on, vol. 17, pp. 799-806, 2002.