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A Novel Hybrid Converter Based Motor Drive System with Improved Power Quality and Dynamic Response

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ABSTRACT:

In this paper combination of a load-commutated inverter (LCI) and a voltage-source inverter (VSI) are employed for performance analysis of induction motor drive. Performance of the drive has been evaluated through the different variations. proposed LCI-based induction motor drives include the following Advantages: 1) sinusoidal motor phase current and voltage based on the instantaneous motor speed control; 2) fast dynamic response by the VSI operation; and 3) elimination of motor torque pulsation. LCI system improves the quality of output current and voltage waveforms and provides the faster dynamic responses. Matlab/Simulation results show the validity of the employed drive system. Index Terms- Diode rectifier, Induction motor, Load commutated inverter (LCI), SVPWM technique, Voltage source inverter(VSI)

I.INTRODUCTION:

The squirrel cage induction motor is basically a simple, less costly and reliable drive and can provide excellent characteristics at a constant shaft speed. Voltage source inverter fed induction motor drives are probably the cheapest and most reliable scheme of speed control [1].The voltage source inverter fed Induction motor drives most commonly controlled through the pulse width-modulation technique. The voltage source inverter ensures simple and effective motor control since the power circuit can be operated over wide ranges of load frequency and voltage [2]. Yet, the VSI, based on fast-switching insulated-gate bipolar transistors (IGBTs), has shown an intrinsic weakness for high-power applicationsdue to substantial switching losses and high of the pulse width-modulation (PWM) operation, leading to hazardous over voltages[3]-[4]. Load-commutated inverter (LCI)-based induction motor drives have been used in high-power applications, because of an economical and reliable current source inverter using IGBT-diode and the rugged induction motors [5]. The LCI-based drive employs converter grade thyristors and utilizes soft switching by natural commutation of the IGBT-diode. Therefore, it provides simplicity, robustness, cost effectiveness, and very low switching losses, resulting in a favorable topology in high-power areas [6]- [8]. Moreover, has the current-source inverter (CSI) topology, it has inherent advantages of CSI, such as embedded shortcircuit protection, improved converter reliability, and instantaneous regeneration ability [9]. Due to all of these features the LCI-based induction motor drive improves its performance, especially in medium-to-high-power applications [10]. The schematic circuit diagram of the LCI and VSI fed induction motor drive as shown below in Fig.1.

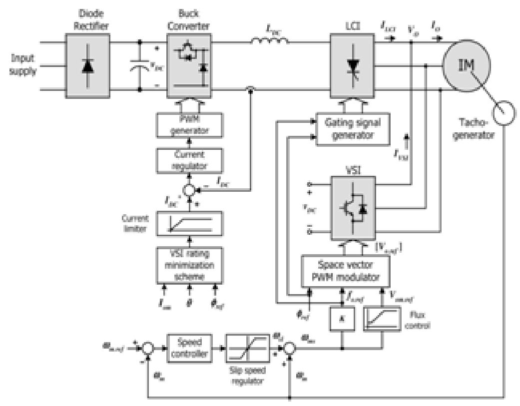

Fig.1 Basic circuit configuration of LCI and VSI fed induction motor drive.

II. SYSTEM DESCRIPTION:

The proposed drive system consisting of a diode rectifier, an LCI, a VSI, an LC filter and three phase induction motor are shown in Fig. 1. The VSI is connected with the LCI in parallel through capacitor DC link.LCI and VSI energized through the same DC link output but the different element. A largeinductor DC link is employed for the load commutated inverter. LCI, in order to convert uncontrolled DC voltage to controlled DC current.

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The DC-link current regulated by the inductor is supplied to the LCI. As a result, both the VSI and the LCI can be fed from the single -diode rectifier. The VSI generates sinusoidal phase voltage to the induction motor. The amplitude and frequency of the VSI output voltage is continuously regulated by the motor speed control. In addition, the phase angle of the VSI output voltage is set from adjusting the firing angle of the LCI to provide a safe LCI commutation angle. Therefore, the leading power factor for the LCI operation is entirely obtained by the VSI over the whole speed range of the induction motor. Based on the leading power factor by the VSI, the presented system can operate the LCI without the dc-commutation circuit as well as output capacitors. Therefore,the employed system can successfully solve all problems caused by the output capacitors and the forced dccommutation circuit of the conventional LCI-based induction motor. Another advantage by bringing the VSI is to generate sinusoidal motor currents for all speed regions to large induction motor drives. The parallel assembly of the LCI and the relatively small-size VSI is expected to fulfill the highpower applications, where a stand-alone VSI cannot be utilized to generate sinusoidal motor currents. In addition, thesinusoidal motor voltages are also achieved through the LC filter.

III. CONTROL STRATEGY:

A controlled block diagram of the LCI and VSI fed induction motor drive is shown in Fig. 3. It is composed of a three-phase diode rectifier, a load commutated inverter followed by a DClink inductor, and a three-phase voltage source inverter. The voltage source inverter is connected with the load commutated inverter in parallel. Basically, the proposed system has a combined inverter topology of a load commutated inverter and a voltage source inverter. The load commutated inverter operates in the square-wave mode with converter-grade thyristors. Consequently IGBT-diode in the load commutated inverter turn on and off only once per cycle of the output current and their switching loss is negligible. The main function of the voltage source inverter is injecting sinusoidal phase voltages to the induction motor. The proposed scheme can generate sinusoidal motor voltages and currents, leading to a reduction in the low-order harmonics injected into the motor. The output power distribution between them, given a certain motor power requirement, is important.

A rating factor η is defined as the ratio of the load commutated inverter rating and the voltage source inverter rating. Note that two inverters are connected with the same motor phase voltagein their output terminals; by assuming that voltage drop due to the Output LC filter for the VSI is negligible. Therefore, the rating factor is directly proportional to the ratio of rmsvalues of the VSI output current and the LCI output current.

$$\eta = \frac{S_{VSI}}{S_{LCI}} = \frac{I_{VSI.rms}}{I_{LCI.rms}} \quad (1)$$

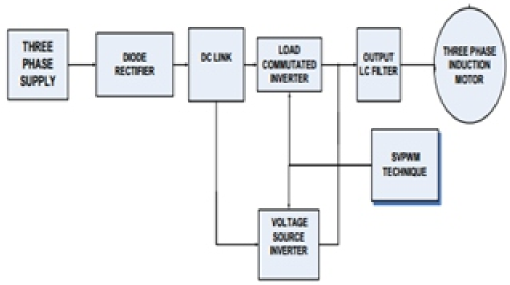

Fig.2 Control block diagram of LCI and VSI fed induction motor drive.

Large power voltage source inverter required for the drive results in a very high system cost. Which will limit the proposed system? From cost point of view, the load commutated inverter is not comparable to the voltage source inverter. Since the motor currents are sinusoidal quantities and the load commutated inverter currents have no ripple components in the dc link, the LCI output current and the motor output current are expressed by:

$$I_o(\omega t) = I_{mo}\cos(\omega t + (\phi + \theta)) \quad (2)$$

The rating factor can be derived, using (1) and (2), by

$$\eta = \sqrt{1 - \frac{3I_{mo}}{I_{dc}}\{\frac{\sqrt{3}}{\pi}(\cos\phi + \theta) - \frac{I_{mo}}{4I_{dc}}} \quad (3)$$

In addition, is the lagging power factor angle of the induction motor, which is detectable. Then, the dc link current value which minimizes the voltage source inverter rating can be obtained by setting the derivative of η with respective to the dc link current to zero,

$$\frac{d\eta}{dI_{dc}} = 0 \quad (4)$$

This yields an dc link current command Idc * given by:

$$I_{dc} = \frac{I_{mo}}{2\sqrt{3/\pi}}\cos(\phi + \theta) \quad (5)$$

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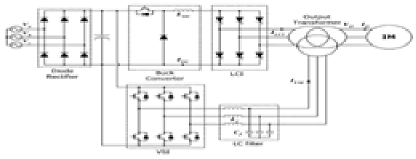
Equation (5) allows the dc link current control to achieve the minimum voltage source inverter power based on the motor current and phase shift between the motor current and the LCI output current. This dc link current control algorithm is implemented by the dc link inductor.

IV.SIMULATION RESULTS:



A pc reenactment of the proposed hybrid system was performed utilizing a 500-hp induction motor whose parameters are given in the informative supplement. The dc-link inductance was set to 5 MH. The switching frequencies for the VSI and the buck converter were 3 kHz and 300 Hz, individually. Demonstrates the LCI output current, the motor current, and the VSI output current at steady state, separately. The motor current has a phase delay concerning the LCI output current, which compares to the entirety of driving point and the load angle. A leading angle between the motor phase voltages and the gating moments of the LCI was utilized. Load angle between the motor phase voltage and the motor current is dictated by the motor qualities, which spoke the truth in this reproduction.

The dc-link current command was set by to minimize the VSI rating. The dc-link current is controlled to a marginally higher quality than the motor current amplitude with z stage movement point between the LCI and the motor currents, prompting a 56% rating factor . To accept the proposed topology and control calculation, the model hybrid system was created utilizing the LCI, the buck converter, and the VSI. An IGBT-based commercial inverter (SEMIKRON) was utilized for the VSI. Then again, models of the buck converter and the LCI were created in the research facility.

A 3-mH dc-link inductor was utilized for the investigation. The proposed control structure was actualized on the single TMS320LF2407 DSP to control the VSI, the LCI, and the buck converter. A 20-kHz pulse train was created utilizing the advanced input/output (I/O) ports of the computerized sign processor (DSP) board and the 20-kHz oscillator because of confinement of the PWM ports in the DSP board.

The produced pulse train through the pulse transformer board (FCOAUX60) turned on the thyristors in the LCI. In the investigation, a 230-V, 60-Hz, 1-hp broadly useful induction motor was utilized as the load. A three-phase output filter was actualized utilizing a 0.5-mH inductor and a 50- capacitor. The steady state operation of the proposed framework with a 35-Hz output frequency is outlined in. The engine current is sinusoidal with little harmonics and the VSI infuses output current relating to the contrast between and the LCI and the motor current demonstrates the dc-link current controlled by the buck converter. The dc-link current is directed by the phase angle data between the LCI output current and the motor current. It is shown that the precise current regulation of the dc-link current is accomplished with the little dc-link inductor. The LCI output current and the motor phase voltage. A main force variable point between the LCI output current and the engine stage voltage was set to 15 to guarantee safe load commutation for comparing thyristor switches. In light of this point, the LCI works effectively. With no recompense disappointments.

WITH OUT LCI RESULTS:

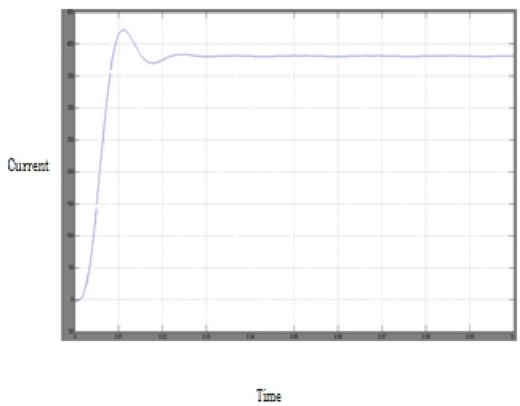


Fig: 3 DC-link voltages at steady state

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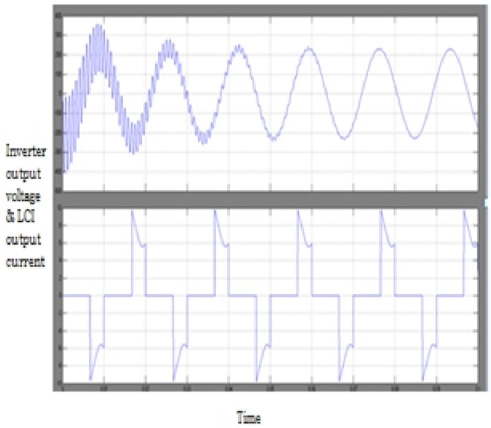

Fig: 4 Inverter output voltage and LCI output current

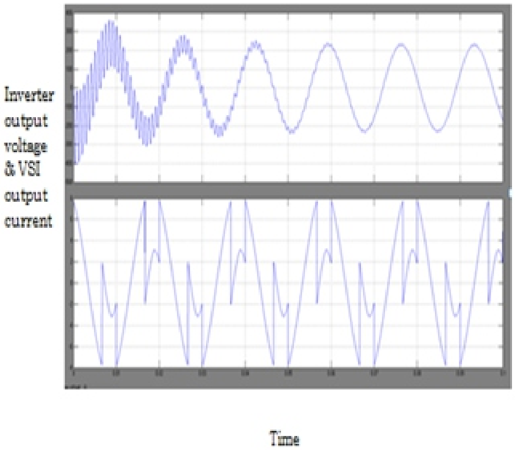

Fig: 5 Inverter output voltage and VSI output current

WITH LCI RESULTS:

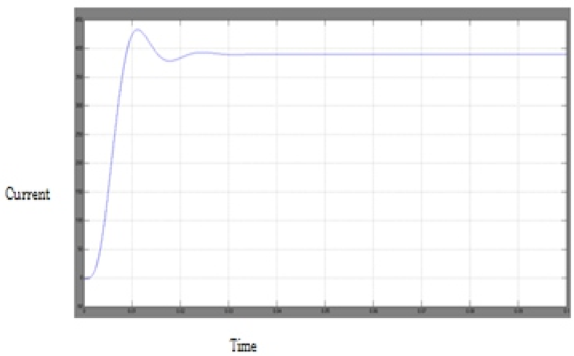

Fig: 6 DC-link voltages at steady state

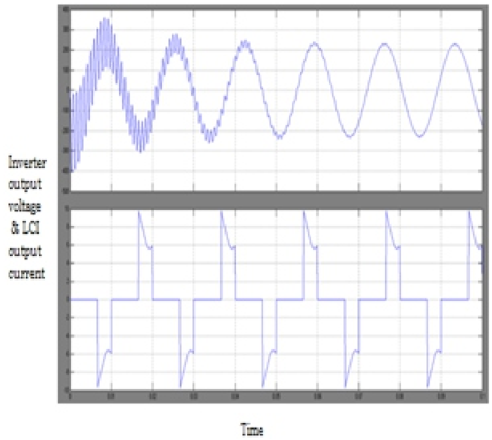

Fig: 7 Inverter output voltage and LCI output current

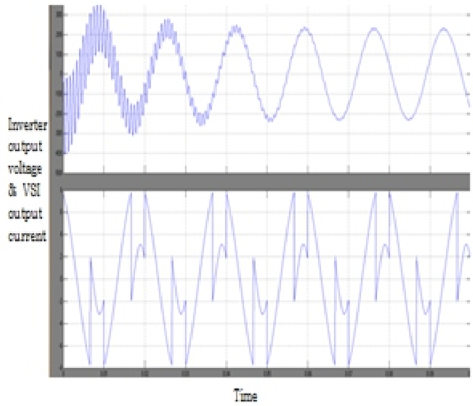

Fig:8 Inverter output voltage and VSI output current

The LCI output current and the motor phase voltage. A main force variable point between the LCI output current and the engine stage voltage was set to 15 to guarantee safe load commutation for comparing thyristor switches. In light of this point, the LCI works effectively. With no recompense disappointments. Demonstrates the LCI output current and the motor current at steady state. Since the 50 phase angle between the LCI and the motor current was recognized, the dc-link current charge was controlled to around 40% higher worth than the motor current amplitude by the proposed control procedure to minimize the VSI power rating. This guarantees that the power rating component speaks the truth 78%.

TOTAL HARMONIC DISTORTION FOR WITH OUT LCI AND WITH LCI

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	WITHOUT LCI	WITH LCI
THD	58.70	58.10

V.CONCLUSION:

In this paper an induction motor drive based on the parallel assembly of the LCI and the VSI has been discussed. The performance of the Load Commutated Inverter fed induction motor drive has been investigated through the MATLAB/Simulation for the different alteration in reference speed and load torque. Simulation results shows that the presented drive system provides the more satisfactory results than the conventional CSI and VSI

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