SIMULATION OF MULTI-PULSE CONVERTER FED MULTILEVEL INVERTER BASED IM DRIVE USING MODIFIED CARRIER LEVEL SHIFTED PWM

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ABSTRACT:

The ever-growing demands for electrical energy and continuous enhancement in the energy price enforce to utilize an efficient electric drive system because high power medium voltage induction motors (MVIMs) are the major consumer of electricity in various industries like ship transport, oil, and gas, etc. These industries have adopted medium voltage induction motor drive (MVIMD) in more than 80% of crucial applications. Generally, a 3-ø voltage source inverter (VSI) is used to operate the adjustable speed induction motor drive. For this, a 3-ø VSI is supplied by a 3-ø diode bridge rectifier (DBR), which is fed from a grid-connected stepdown transformer. Here, a step-down transformer is an essential element because the grid supply either has 11kV or 33kV. This project presents a 36-pulse converter and 5-level cascaded H-bridge multi-level inverter (CHB-MLI) fed medium voltage induction motor drive system. The multi-winding transformer (MWT) for a 36-pulse AC-DC converter is designed in such a way that it requires the least number of windings and enhances power quality at the grid end. This is helpful to reduce the size, weight, and cost of the presented medium voltage induction motor drive (MVIMD). The modified carrier level shifted pulse width modulation (MC-LSPWM) is used to control 5-level CHB-MLI fed induction motor (IM), total circuit is simulated using MATLAB SIMULINK.

Keywords: Cascaded H-bridge multilevel inverter(CHB-MLI),Modified carrier level shifted pulse width modulation(MC-LSPWM),Induction motor(IM).

I INTRODUCTION

The ever-growing demands for electrical energy and continuous enhancement in the energy price enforce to utilize an efficient electric drive system because high power medium voltage induction motors (MVIMs) are the major consumer of electricity in various industries like ship transport, oil, and gas, etc. These industries have adopted medium voltage induction motor drive (MVIMD) in more than 80% of crucial applications. Generally, a 3-ø voltage source inverter (VSI) is used to operate the adjustable speed induction motor drive. For this, a 3-ø VSI is supplied by a 3-ø diode bridge rectifier (DBR), which is fed from a grid-connected stepdown transformer. Here, a step-down transformer is an essential element because the grid supply either has 11kV or 33kV. Whereas, the medium voltage drive has a voltage range from 2.3kV to 13.8kV. For this medium voltage range, a better power quality supply for the drive system is a serious technical challenge due to the harmonics injection by the traditional DBR at the grid end. Therefore, the multi-pulse converter is an inevitable building block of today's MVIMD system to overcome this technical challenge at the grid end. For which, the multi-pulse converter is designed by the implementation of the phase shift technique on the multi winding transformer (MWT), which is connected to several DBRs. Hence, the methodology to implement the phase shift technique on the MWT should have an influential effect so that the grid end power quality can be improved for MVIMD. Due to this, the power electronics research community has paid attention to the development of different configurations of multi-pulse converter. Apart from this, different manufacturing industries like Yaskawa, Delta-Electronics, Hitachi, ALSTOM Rockwell, Weg , ABB and TMEIC have adopted various configurations of multi-pulse converter like 12-pulse, 18-pulse and 36-pulse . Many industries have adopted multi-pulse converter configurations, in which, the MWT covers 30-50% size and 50-70% weight of the drive system [4], [5]. Apart from thisa single unit of the isolated transformer has been utilized with the several numbers of the secondary windings, which creates a technical challenge for the manufacturer to design a small phase displacement. Another side, the installation, and transportation of the single unit transformer are problematic work. Followings are the technical hindrances, which restrict to employ of a high number of pulse converter with the multi-winding transformer.

- The number of transformer windings escalates as the number of converter pulses increases.

- The weight, size, and cost of the MWT are enhanced as the number of converter pulses increases.

- The winding connection of MWT becomes more complex as the number of converter pulses increases. Hence, autotransformer-based multi-pulse configurations are reported to decline the size of the multi-pulse converter.

Moreover, these configurations could not be adopted for medium voltage drive because isolation from the grid end is an essential factor to enhance the reliability of the MVIMD system for the crucial application of industries. So, the renovation is still needed in the isolated MWT based multipulse converter configurations. To overcome these drawbacks of the reported AC-DC pulse converter, in this work a 36-pulse converter configuration is presented, which is depicted in Fig. 1(a). These are the main attributes of this MWT, which can be claimed from Table-I and Fig.1(a). Rohit Kumar, Member, IEEE, Piyush Kant, Member, IEEE, and Bhim Singh, Fellow, IEEE Modified PWM Technique for a Multi-Pulse Converter fed Multilevel Inverter Based IM Drive

- The number of pulses becomes double with the same number of transformer windings

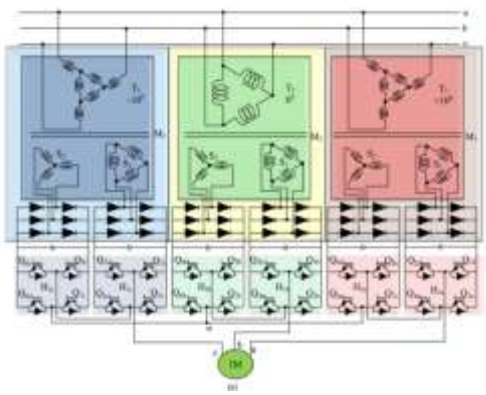


Fig.1 Schematic diagram of vector-controlled induction motor (a) structure of presented drive system

- A 9.09% less numbers of transformer windings are required for a 36-pulse converter.

- As this MWT saves the conductor material, the overall cost, size, and weight of the MVIMD are reduced. Moreover, the issue in the MVIMD is not only with the grid end, it has some issues with the drive end also, such as high voltage stress across the converter switch, low power quality, etc. It degrades the insulation strength of the motor. Therefore, the multilevel inverter (MLI) has been a research hotspot in MVIMD systems in recent years for the power electronics research community. It has inherent characteristics to produce a high-quality synthesized staircase AC voltage waveform, which is supplied to the motor in the drive system. Hence, different drive manufacturing industries have adopted conventional MLI topology like neutral-point clamped (NPC), flying-capacitor (FLC), and cascaded H-bridge (CHB) to enhance the power quality at the drive end. It has been concluded in the literature that CHB type MLI is superior rather than FLC and NPC because CHB is free from voltage balancing issues, which is associated with NPC and FLC.

To take care of this characteristic of CHB-MLI, a 5-level CHB-MLI is used in this paper. However, a countless modulation techniques are developed with the aim to generate synthesize step waveform with the adjustable magnitude, frequency for adjustable speed drive power converters, where the main target of these techniques is to develop high-power quality with less power converter losses. However, these two obligations are conflicting with each other. Therefore, it is one of the major hindrances in MLI. Generally, multi-carrier-based pulse width modulation (PWM) is utilized. As the implementation and design of the space vector technique are more complex, the selective harmonic elimination has low switching losses and gives better efficiency . Nevertheless, offline calculations are mandatory, which enhances the computational burden during the closed-loop implementation and dynamic operation of the drive system. Therefore, multi-carrier-based pulse width modulation (PWM) techniques are very popular to overcome these issues, because PWM techniques can be implemented easily and they do not need any bioinspired algorithm to solved no-linear trigonometric equations for optimized switching. Generally, PWM techniques have been classified into phase-shifted pulse width modulation (PSPWM) and level-shifted pulse width modulation (LSPWM). Moreover, the research community has shown attraction in LSPWM due to better power quality performance rather than

PSPWM. Apart from this, LSPWM is associated with a technical challenge, when implemented on the CHB-MLI. The continuous conduction period of one H-bridge is larger than the other. Due to this, the conduction loss in one H-bridge is high in comparison to other H-bridge in CHB-MLI, when the LSPWM technique is employed. Due to this, an external arrangement for rotating switching pattern is required among the H-bridges to balance the conduction losses of them. Therefore, to mitigate aforementioned issues of LSPWM, here MC-LSPWM is presented. This technique has an inherentrotating switching pattern scheme so that conduction from one H-bridge to shift another bridge is during the same voltage step without any external arrangement. Therefore, all bridges contribute some portion of power in each step of the synthesized waveform. In a nutshell, the salient features of the implemented system are as follows, which are simulated

. • It offers the least number of MWT configuration for a 36- pulse AC-DC converter.

• The most prominent feature of this MWT is that it saves conductor material.

• It offers a compact size, less complex, and low weight multi-unit isolated MWT for the MVIMD system.

• This MC-LSPWM offers a rotating switching pattern for symmetrical configured CHB-MLI.

• This MC-LSPWM offers the balanced conduction losses profile among H-bridges of CHB-MLI during continuous operating applications.

• It offers an excellent power quality profile at both ends of the grid and the drive, respectively.

• The indirect field-oriented control (IFOC) control provides satisfactory performance during the dynamic stage of the drive system.

II.SYSTEM CONFIGARATION: Here, the system flow diagram of the presented 36-pulse AC-DC converter fed 5-level CHB-MLI based MVIMD is demonstrated in Fig.1(a). A 36-pulse converter is designed to obtain six isolated symmetric DC sources for six isolated bridges of 5-level CHB-MLI. For whom, it has three isolated MWTs (T1, T2, T3). Whereas, each transformer is configured as a separated type 12-pulse converter module (M). Moreover, the phase-shift technique is implemented at the primary side of the MWTs (T1, T2, T3) to design a 36-pulse converter from an isolated 12-pulse converter module. Therefore, +10º and -10º phase shifts are given by the utilization of extended delta connection of the primary winding in the transformers (T1, T3). In another set, the transformer T2 has delta configured primary windings. Each transformer has two secondary windings in this configuration. In which, one winding is in the delta (S1) and another is in the star (S2) configuration. Therefore, secondary windings have 30º phase displacement to each other. Here, each secondary winding is connected to a six-pulse DBR, so that, modules (M1, M2, M3) of converters outputs are connected to phases (a, b, c) H-bridges of CHB-MLI, respectively. Therefore, a symmetric configured 5-level CHB-MLI topology is used to efficiently utilize six isolated DC voltage sources.

Whereas, DC-link voltages of H-bridges H1 and H2 are Vdc.

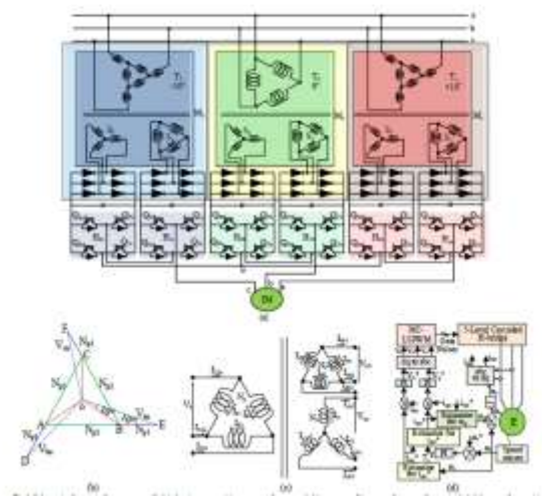
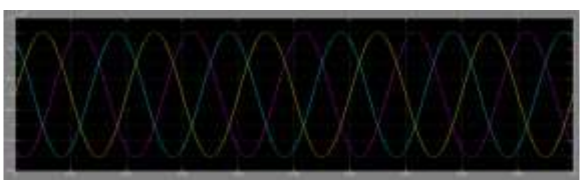
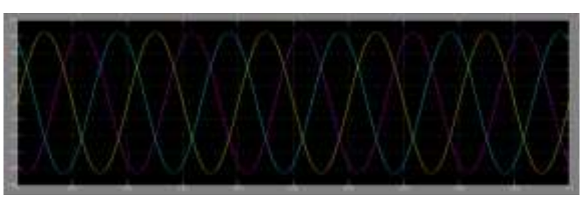


Fig.1 Schematic diagram of vector controlled induction motor (a) structure of presented drive system (b) vector diagram of an extended delta transformer (c) configuration of delta-star transformer (d) block diagram of IFOC

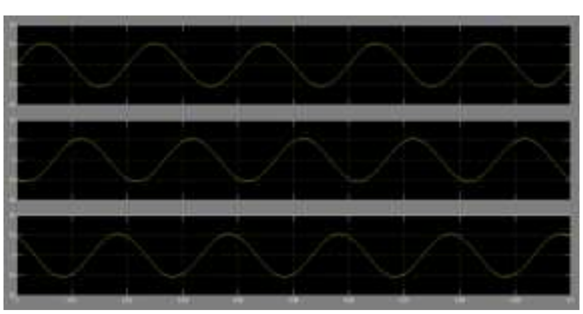
III.SIMULATION RESULTS



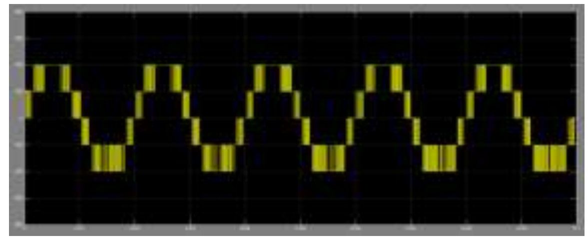
Input voltage vs time



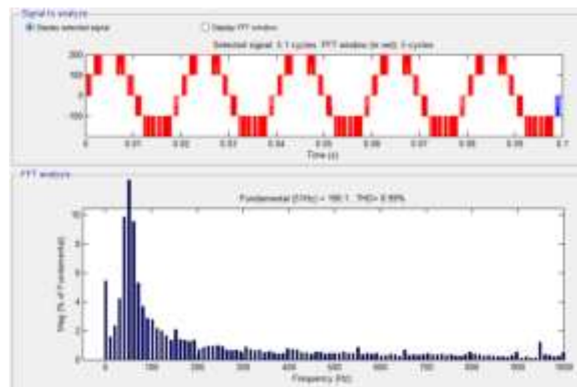
Input current vs time



Transformer current vs time



Multi level inverter output voltage vs time



Total harmonic distortion

IV. CONCLUSION

In this project, detailed analysis and design of a 36-pulse ACDC converter fed 5-level CHB-MLI based MVIMD have been presented. The merit of the investigated 36-pulse converter is that this MWT has the required least number of windings. Due to this, it is economical both in size and weight compared to the other topologies those are reported in the literature. The presented MC-LSPWM scheme has the capability to enhance the power quality and to maintain the uniform conduction loss profile among the H-bridges of the 5-level CHB-MLI, which is helpful to improve the service life and the system reliability. In addition, performance of MC-LSPWM is not only compared with the conventional LSPWM on the experimental setup but it is also compared with PWM reported in the literature. The presented drive system has the capability to successfully adhere to the international power quality standards at the grid end as well as the drive end. Moreover, this drive system has good performance in terms of starting, steady-state, dynamics and power quality.

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