A Survey on Multi Level Inverter and Induction Motor Drives

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Abstract: In recent years, the need for a high power apparatus has been derived from numerous industrial applications. Multilevel inverters have been attracting increasing interest recently the main reasons are; increased power ratings, improved harmonic performance, and reduced electromagnetic interference (EMI) emission that can be archived with multiple DC levels that are synthesis of the output voltage waveform. Medium voltage grids, motor drives and utility applications are some examples, where it is required to convert DC power into AC power. As a consequence, several multilevel power converter structures have been presented. A multilevel inverter is a device that synthesizes near sinusoidal voltage from various DC voltages. This paper presents a comprehensive survey on Multi level inverters and induction motor drives with the different controlling mechanisms.

Keywords: Multi Level Inverter, Controlling strategy, Induction Motor Drive, Total Harmonic Distortion (THD), Scalar Control, Vector Control.

INTRODUCTION

Inverter is a Power Electronic module, which is a DC to AC converter. DC input to an inverter could be from batteries, fuel cells, solar cells or rectified dc [1-3]. The output of these dc sources can be utilized on AC loads using Inverters. For some AC loads it is required to have variable voltage and variable frequency power supply, but available supply voltage levels and frequency are limited, for these Variable Voltage and Variable Frequency power supply 'Inverters' are used. While comparing a basic two level inverter and multi level inverter, the multi level inverter always have better Total Harmonic Distortion (THD). The concept of multilevel inverter was first introduced back in 1975. The term "multilevel" in multilevel inverters was associated with the voltage levels observed in output voltage waveform. A basic two Level Inverter have only two voltage levels i.e. +Vm, while an 'n' level inverter will have n levels for example: If n = 5 then, +2Vm,+Vm,0, — Vm,—2Vm will be the output voltage levels. Early Inverters used Thyristor switches, having switching frequency a few hundred Hertz, while the present day switches like IGBT have switching frequency of several Kilohertz. Also Thyristor requires a commutation circuit while using with DC, so self commutated switches like IGBT are preferred over Thyristor. Normally electronic switches have unidirectional current carrying property; to make them bidirectional an antiparallel diode is connected.All the electrical company who works in power system and drives system the multi-level inverter has play very important role. Specification of MLI is normalized power, reduced the noise and enhances the power quality. We can easily change only structure without harm of circuit also gives high power and high voltage. Inverter is a static device structure which converts DC Power into AC Power with required frequency level but in this, produces power with some harmonic element. Now MLI is also type of inverter which reduces the total harmonic element in output power. Multilevel inverter Input is DC but output AC power. Output having different level which comparatively sine wave. If we increase levels of inverter, thenwe approach sinusoidal voltage with minimal harmonic distortion. Inverter design by without transformer to receive the high voltage level and low harmonics content.

The basics of multi-level inverters are given below:

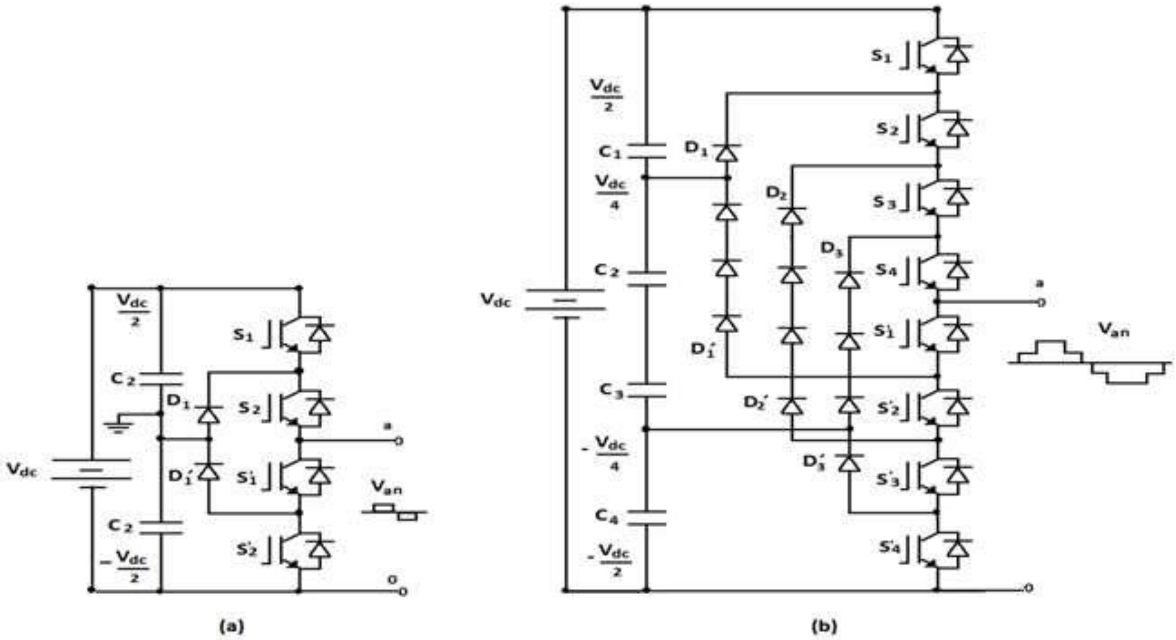

Fig.1 (a) Three Level Inverter (b) Five level inverter

Fig.1 (a) shows a three-level diode-clamped converter in which the dc bus consists of two capacitors, C_1, C_2. For dc-bus voltage V_{dc}, the voltage across each capacitor is $\frac{V_{dc}}{2}$ and each device voltage stress will be limited to one capacitor voltage level $\frac{V_{dc}}{2}$ through clamping diodes. To explain how the staircase voltage is synthesized, the neutral point n is considered as the output phase voltage reference point. There are three switch combinations to synthesize three-level voltages across a and n.

1) Voltage level $V_{an} = \frac{V_{dc}}{2}$ turn on the switches S_1andS_2.
2) Voltage level $V_{an} = 0$, turn on the switches S_2 and S_1'.
3) Voltage level $V_{an} = -\frac{V_{dc}}{2}$ turn on the switches S_1', S_2'.
4) Fig.1 (b) shows a five-level diode-clamped converter in which the dc bus consists of four capacitors, C_1, C_2, C_3, and C_4. For dc-bus voltage V_{dc}, the voltage across each capacitor is $\frac{V_{dc}}{4}$ and each device voltage stress will be limited to one capacitor voltage level $\frac{V_{dc}}{2}$ through clamping diodes. To explain how the staircase voltage is synthesized, the neutral point n is considered as the output phase voltage reference point. There are five switch combinations to synthesize five level voltages across a and n. Switching states of the five level inverter are summarized in table-2.2.
5) Voltage level $V_{an} = V_{dc}$,turn on all upper switches S_1 , S_2 , S_3 and S_4.
6) Voltage level $V_{an} = \frac{V_{dc}}{2}$, turn on the switches S_2, S_3, S_4 and S_1'.
7) Voltage level $V_{an} = 0$, turn on the switches S_3, S_4, S_1' and S_2'.
8) Voltage level $V_{an} = -\frac{V_{dc}}{2}$, turn on the switches S_4, S_1', S_2', S_3'.
9) Voltage level $V_{an} = -V_{dc}$, turn on all lower switches S_1', S_2' , S_3' and S_4'.

Now these day MLI used in many applications in industry for the convert voltage or sustain the power quality such as all types FACTS devices STATCOM, UPQC, SCV, and UPFC etc. The different types of multi level inverters are shown below:

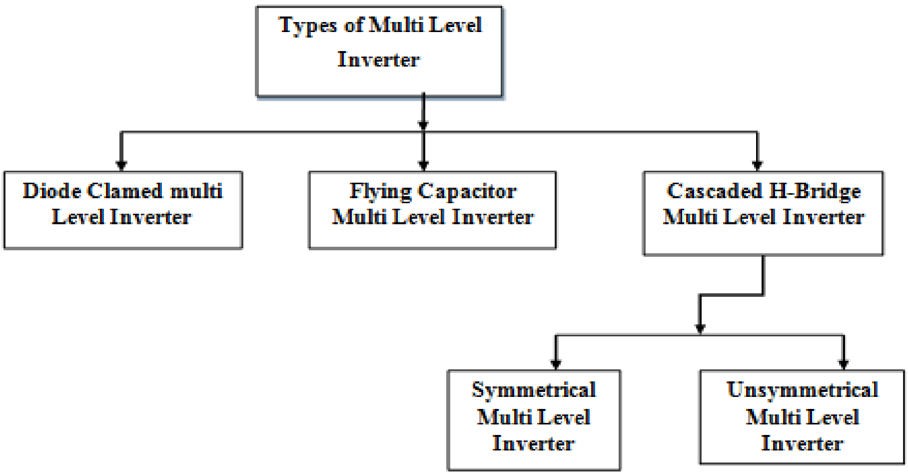

Fig.2 Different Types of Multi-Level Inverters

There are different controlling techniques for Multi-Level inverters which are depicted in figure 3.

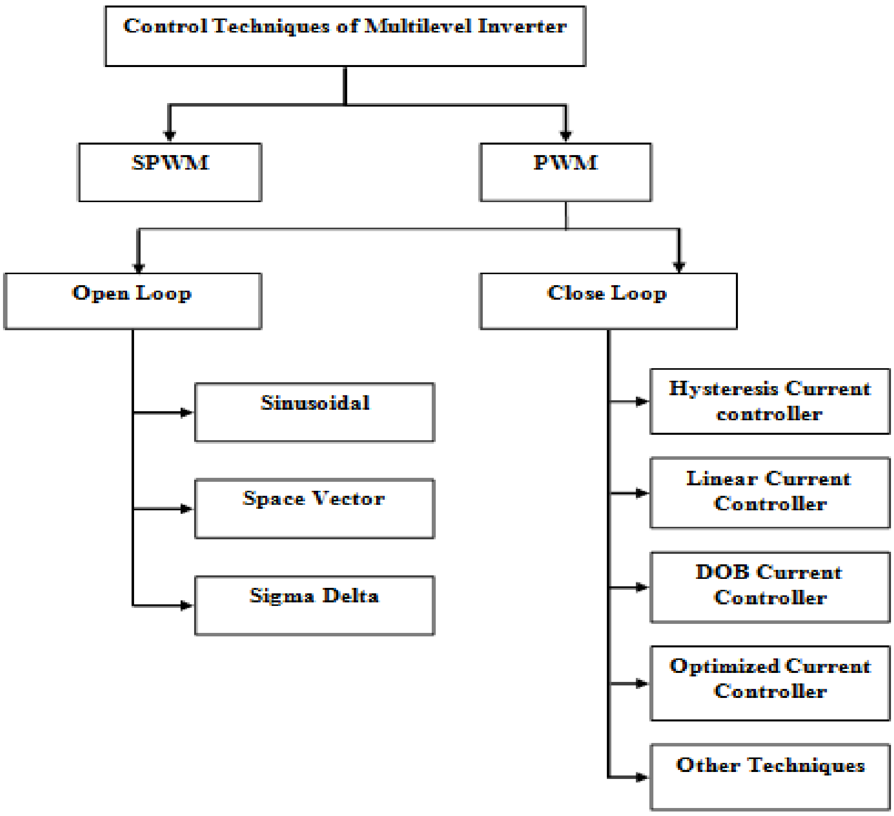

Fig.3 Different Controlling techniques for multi-level inverters

Out of the different controlling techniques, the sinusoidal pulse width modulation technique is one of the most effective techniques, which has several variants depicted below.

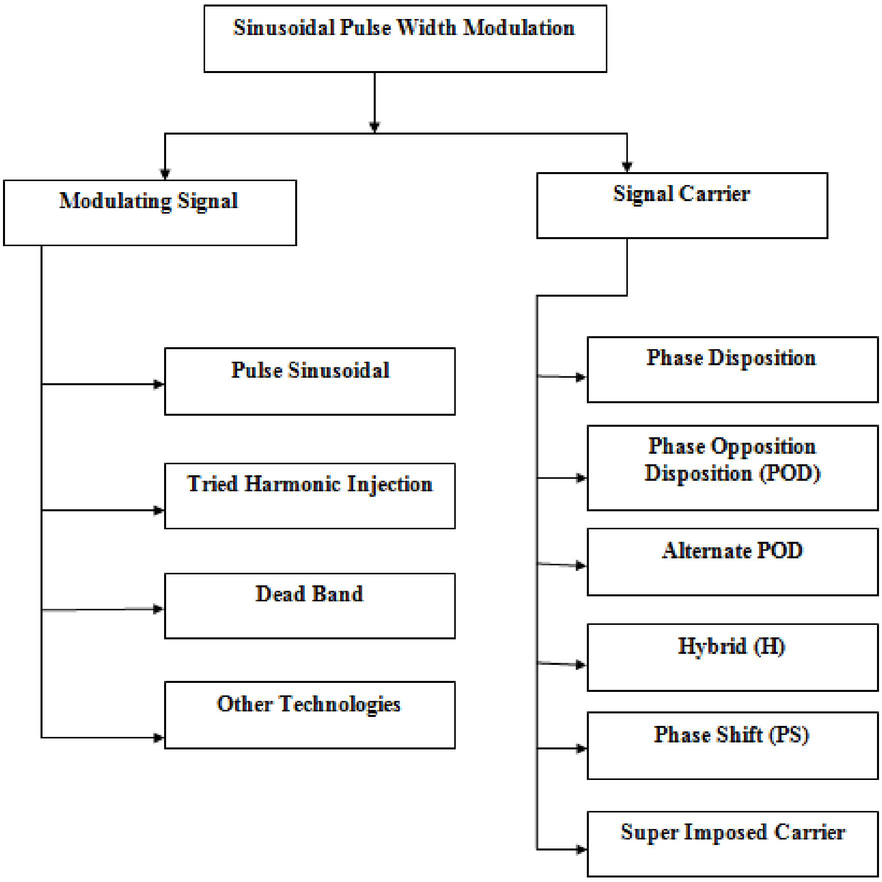

Fig.4 Different variants of sinusoidal pulse width modulation

The peak magnitude of the sinusoidal signal (Vm) is less than or equal to the peak magnitude of the carrier signal (Vc). An important parameter of Sine PWM is Modulation Index.

$$Modulation\ Index = \frac{V_m}{V_c} \qquad (1)$$

Modulation Index controls the harmonic content of the output voltage waveform. The magnitude of the output fundamental component is proportional to the Modulation Index, but Modulation Index is always less than unity.

II. INDUCTION MOTOR DRIVES

The induction motor drives are effective in controlling multi-level inductors. A basic introduction to induction motor drives is presented in this section. The motor consists of rotor which has copper bars. Copper bars are placed in rotor slots. In order to complete the path of rotor circuit these copper bars are short circuited with the help of end rings from both the sides. The solid end rings usually use copper, brass or aluminium for completing the rotor path. As a substitute of copper bars, in wound rotor motor the idea of placing winding as that in stator slots is used. That means rotor bars are replaced by rotor windings. These windings are considerate in rotor slots. It is usual practice to keep rotor slots less than stator slots. These three-phase winding are brought to use rend where they are connected to slip rings mounted on shaft. Slip rings are made of brass or phosphor bronze. They are insulated from shaft.The achieve variable speed of Induction Motor is derived from the formula given as

$$N_r = N_s(1-s) \quad (2)$$

Thus, in IM speed can be controlled by controlling two parameters i.e. synchronous speed and slip s. There are so many different methods of control speed of IM, i.e. Stator Voltage Control, Frequency Control Method, Rotor Resistance Control, Electromagnetic force Injection Method, Pole Changing Method and Cascading of Two Induction Motors shown in fig.5.

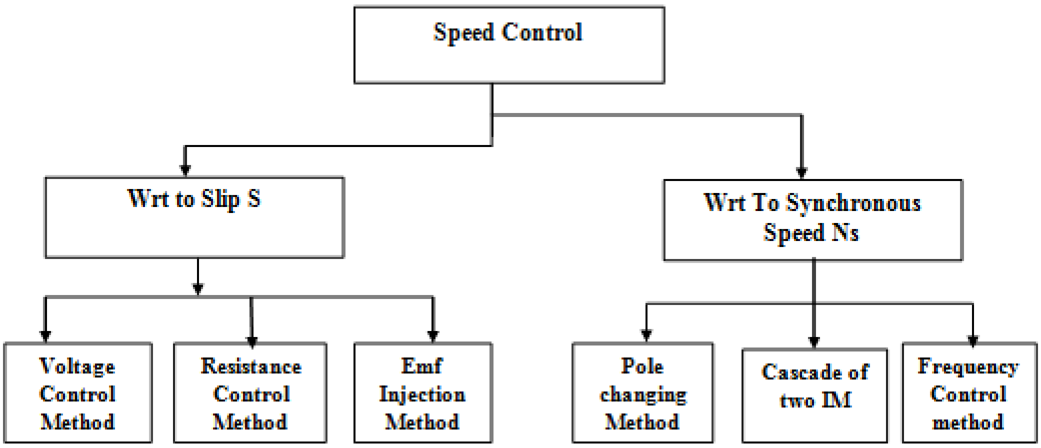

Fig.5 Control Strategies of IM Drives

The governing factor for the design of multi-level inverters and the performance evaluation is done on the basis of total harmonic distortion given by:

$$THD(\omega) = \frac{\sqrt{\sum_{i=1}^{n} Y_i^2(\omega)}}{Y_1} * 100\,\% \quad (3)$$

Here,

THD represents total harmonic distortion

Y1 represents fundamental harmonic

n are the number of harmonics in the output waveform

ω represents the angular frequency

III. PREVIOUS WORK

In [1] Bharath K et al.discusthyristor-based stator voltage control technique to match with direct variable AC voltage control technique with the input current increase or decrease via IM speed. The paper verifies by experimental result with study result.

In [4], J. Rodriguez et al. present a survey on scalar control method based nominal cost of without feedback current sensor scheme. Paper has two system implemented named as stator resistance drop and slip frequency both systems required stationary part parameter. Varying in the load and supply frequency that maintain the dropping voltage of Resistor by stationary voltage with same obtain suitable flux.

In [5]J. S. Lai et al. show the comparative analysis of two control strategy one is direct and indirect vector-control i.e. also called slip frequency and field oriented respectively. Both methods by analysis some parameter with slightly deference and both controlled are same. Analysis via Direct control scheme and obtain high end feature and value of given system and compare with indirect control algorithm find same high-end feature of machine.

In [6]L. M. Tolbert et al. design a Cage IM drive with fuzzy controller in feedback system. Unlike normal research consider vector scheme with has current controlled scheme inverter which consider variable unique frequency fed in four quadrant works. Along with vector control method, the author also wrote for advanced scalar control method. This advanced method helps scalar techniques to sustain in competitive and cost-effective environment. Optimal and adaptive controls are also discussed.

In [7] H. Stemmler et al.propose an alternative method of speed-control of single-phase induction motor. This is depending on AC/DC and DC/AC converter. That means this is the first supply is Alternative current, transformed into DC by three arm bridge and it has DC link connected to inverter which is again converting nature of supply in to AC. AC/DC portion is controlled by space vector control and DC/AC controls the induction motor by stator flux-oriented vector control. Generally, rotor flux orientation is done. But it is unique by stator flux orientation control. The drive so designed not only runs below synchronous speed but also works for above synchronous speed. Drive also controls reactive power.

In [8] Y. Yoshioka et al.implemented three phase PWM IM drive on the based Indirect Current measure controller. We can obtain unity power factor without any harmonics present in sinusoidal current. Here author has not implemented current sensor scheme. Paper represent space vector technique which obtains mathematical expression and discuses about indirect current algorithm. The experiments are performed and evaluate result with both vector control scheme where direct current technique and indirect current technique.

In [9] L. Gyugyi et al. designed a zero current switching series resonant converter. Unwanted signal in series resonant power system show the DC voltage ratio with implementing the basic operation. Losses in IGBT and uncontrolled switch, which are members of nominal current which do not follow the firing frequency component. Ratio of DC voltage and firing frequency both are show the RMS Current loss.

In [10] Peter W. Hammond et al. implemented initial value of current and bidirectional current algorithm and obtain losing in DC link frequency to overcome noise in output wave which feed into the IM drive system. Resolved the other problem of Drive like sag, swell and do not sense of zero crossing of input AC voltage with DC link inverter.

In [11], H. Fujita et al.presented a technique for the PWM rectifier with resolve the problem in that converter and develop good level of component. When perform the operation in abnormal condition of PWM rectifier than involve some very dangers unwanted signal i.e. harmonics. Numbers of techniques available in electrical power electronic system to reduce less order of harmonics content in output and input voltage with recode high performance parameter component in PWM AC-DC converter.

In [12], Jagadish Chandra Pati el al.proposed the field of AC-DC Converter with overcome lower harmonic content and maintains the unity power factor. The demand of good quality of power which is obtains by the current control Pulse width modulation AC/DC converters. Some drives are required more good quality of power with less harmonics and variable Input voltage. In case rectifier is draw unusable output Voltage than fed from DC output power into Input side power. This scheme has significant because, rectifier operated power KW to MW of voltage and current.

CONCLUSION

From the previous discussions, it can be concluded that multi-level inverters are critical components of power systems trying to emulate pure sinusoidal waveforms from dc sources. However, the design is challenging and has several constraints. The different controlling mechanisms have been discussed with a special focus on induction motor drives. The evaluation parameters are discusses out of which the total harmonic distortion is shown to be the most prominent. A comprehensive survey on related work is done with the pros and cons. It is expected that the work will pave the path for future work on the topic.

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