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A 19-Level Variable Frequency Switched DC-AC Converter fed Induction Motor Drive for Bench Grinding Applications

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Abstract- The development of inverters with more than two layers to reduce distortion from the fundamental sinusoidal waveform gave rise to the concept of a multilayer inverter. For bench grinder applications, the induction motor drive has to be powered by AC. Therefore, a multilayer inverter is used to boost the sine wave nature of the inverter output, and an asymmetrical H-bridge type inverter is used to decrease the bulkiness and cost of the system. The MATLAB platform is used to construct the concept, and analysis is then conducted to ascertain the end product's value.

Index Terms-19-Level Inverter (19-LI), Pulse Breadth Modulation (PBM), Switches

I. INTRODUCTION

Bench grinding is the process of shaping items, sharpening tools, and removing paint or rust from metal using a bench grinder. For a range of applications, from sensitive to coarse, a bench grinder is a wheeled tabletop grinding equipment.
Two grinding wheels, one coarse and one fine, make up a bench grinder, a multipurpose sharpening tool. In garages and workshops, it is often used to sharpen blades and equipment. Bench grinders come with a rotary or reciprocating table, an abrasive wheel, and a chuck to hold the workpiece. The wheel produces a smooth, flat finish by removing material from the workpiece's surface. There are numerous uses for a bench grinder, such as:

- **Sharpening:** honing chisels, tools, and other metal items
- **Shaping:** Sculpting metal items
- **Woodworking:** Activities related to woodworking
- **Smoothing:** Making metal edges smooth
- **Removing:** Taking off paint or corrosion.

The motor usually used in such applications is single phase Induction motor. The motor is a type of AC motor that needs to be fed from AC supply/grid. The rigidity in the specimen draws the variable power from the supply which harnesses the power quality as well as performance of the motor (bench grinder). Low power quality operation not only affects the performance of the bench grinder motor but it also affects the performance of other motors or appliances connected to same utility. So, in present work a DC source operated Bench grinder drive with better performance is proposed utilizing a low switch count 19 level inverter.

An inverter converters DC source output into AC with very less harmonics. The harmonics in the system are responsible for heating effect that eliminates the energy in the form of heat and makes the system less efficient. The main motive of the inverter is to provide low harmonic AC supply to the motor so that it can perform better. So, In this work the low harmonic supply is examined at the output of inverter that is to be fed to the bench grinding motor.

Direct current (DC) is changed to alternating current (AC) using a power electrical equipment known as an inverter. This inverting device does not produce any power; it just inverts. Large volumes of power may be managed via electronic inverters. This conversion device converts dc power to ac power in order to get the required voltage and frequency [1-2]. Because it is a power electronic gadget, it is much more dependable and efficient. IGBT (insulated gate bipolar transistor), MOSFET (metal oxide semiconductor field effect transistor), GTO (gate turn off thyrister), and other electronic components limit its use for much higher power applications but increase the switching frequency.

Since a fundamental inverter only has two levels, the output wave of a basic sine wave with the same period and frequency is somewhat distorted.

This lowers the overall efficiency of the system by increasing the likelihood of a breakdown and adding harmonics into the circuit [3], [4]. Harmonics are detrimental to both the load and the power system overall because they induce distortion and system heat. In order to lessen the distortion of the outgoing wave, the concept of a multilayer inverter was created, in which the inverter's levels are increased. As the level increases, the output wave becomes more sinusoidal, which lowers the harmonic content [4]–[6]. Devices known as multilevel inverters use DC voltage sources to measure the voltage across the load and calculate the levels. Additionally, utilising various switching topologies, the circuit is completed via many routes in a single full wave cycle for varied times.

Dual level inverters have the drawback of having higher harmonic distortion, while multiple level inverters can prevent this. This artwork displays a 19-level inverter with fewer switches (19-LI). Compared to a traditional 19-level H-bridge inverter, the presented 19-LI has less components even if it looks like an H-bridge. A multiple voltage level inverter with two symmetrical blocks and four distinct level DC sources is shown in Figure 1.

The current arrangement has twelve switches. A distinct pulse must be sent to each of the 12 switches in order to analyse the varying voltages under load at various intervals. The control of this system is designed with KVL in mind to guarantee that the necessary voltage is available during load. Present work is only concerned with the H-bridge type multilevel. As other topologies produce the voltage of half magnitude so, studying the H-bridge type multilevel inverter and have made modification in same in order to achieve the same wave form with some benefits over the other topological model like fly capacitor and other.

The multilevel inverter is having voltage sources and decided level of the wave form is 19 levels to increase the sine wave nature and reduce distortion.

On extension of new topology to 19 level with asymmetrical arrangement with 4 sources and 12 switches but as we have seen that in the lower circuit one has maintained symmetry by having equal magnitude of source as a result the level increases one will disturb the symmetry in lower circuit if increases a source and two switch and maintain same magnitude of source that is twice of source in first to get 7 level above. A 19-level inverter with a lower switch count is shown in this work of art (19-LI). Compared to a standard 19-level H-bridge inverter, the presented 19-LI inverter contains fewer components, despite its H-bridge-like appearance.

This section of the article provides a detailed explanation of how the 19-level inverter that is being presented operates.

The inverter's voltage levels are +90 V, +80 V, +70 V, +60 V, +50 V, +40 V, +30 V, +20 V, +10 V, 0V, -10V, - 20V, -30V, -40V, -50V,-60V, -70V, -80V, -90V. These four values are used to verify these topologies: 10V, 10V, 20V, and 50V. to explain the operation of the inverter that is being displayed.

All nineteen modes are elaborated as under and the network for all modes are deployed in Fig.3.6 (a)-(s).

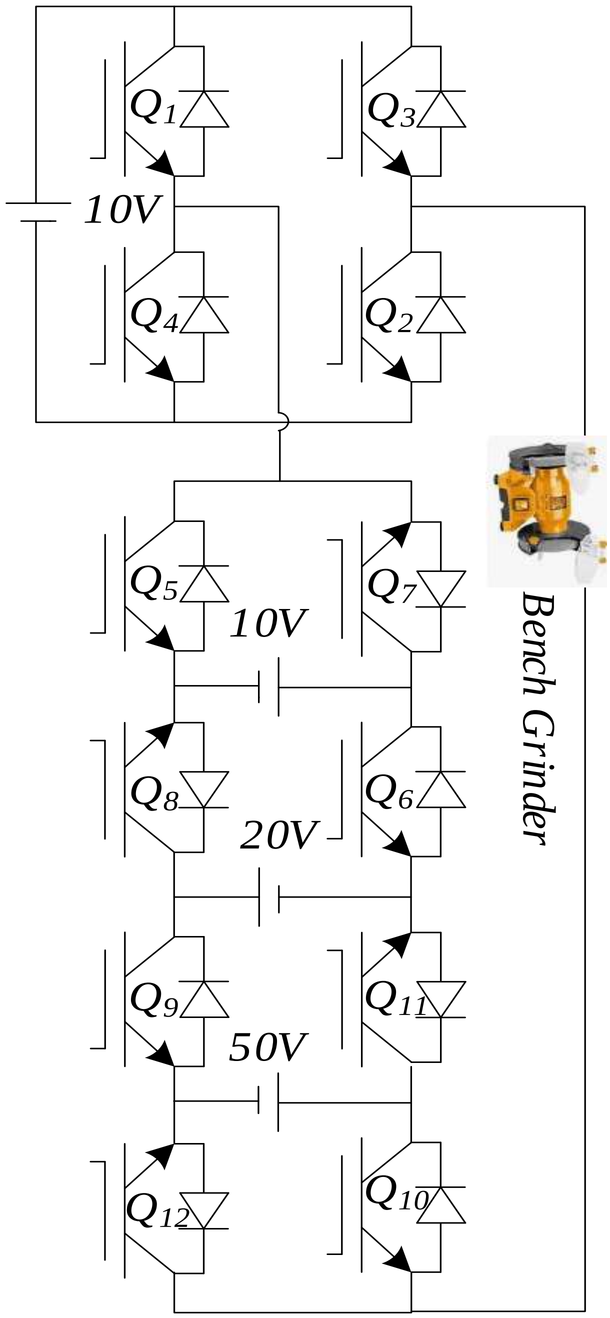

Fig. 1 Presented 19-LI

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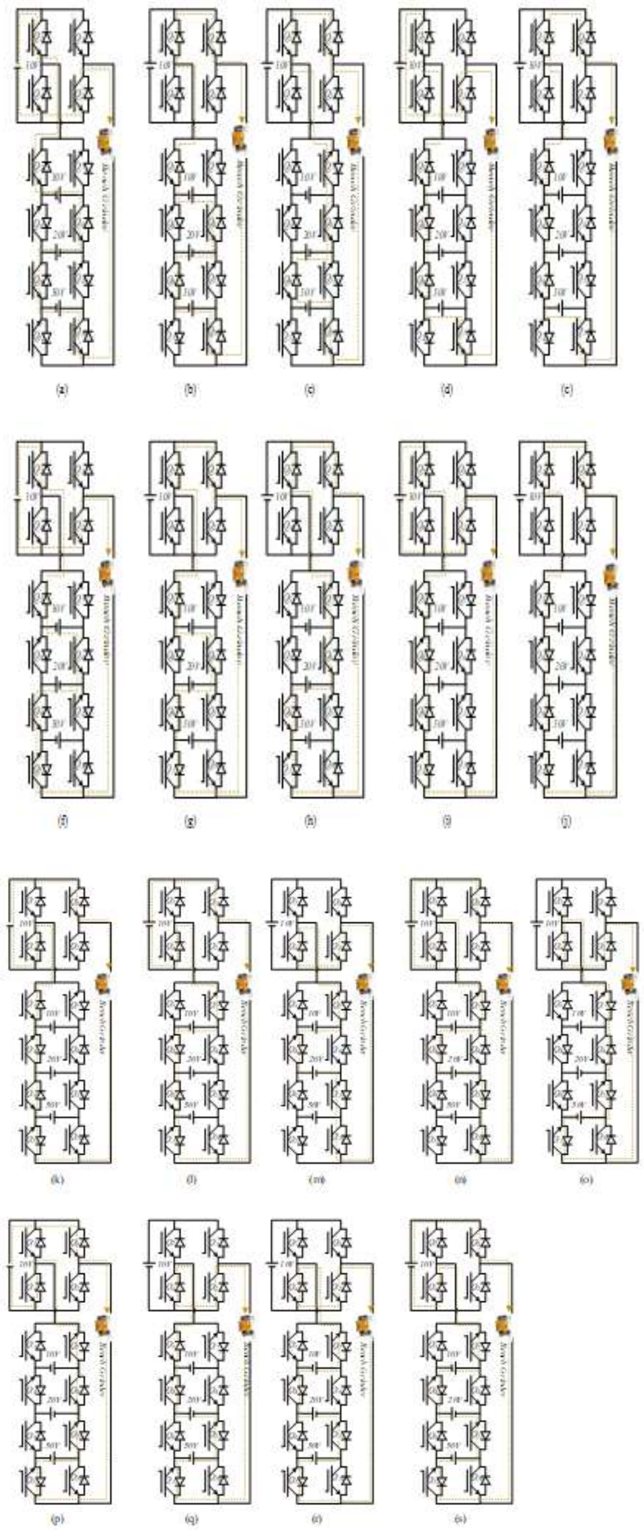

Fig.2 A 19-level inverter working during different load voltage levels (a) +90V, (b) +80 V,(c) +70 V, (d) +60V, (e) +50V, (f) +40V, (f) +40V, (g) +30V, (h) +20V, (i) +10V, (j) 0V, (k) -10V, (l) –20V, (m)-30V, (n)-40V, (o)-50V, (p)-60V, (q)-70V ,(r)(-80), (s)-90V.

- **Mode A:** Q10, Q9, Q6, Q5, Q1, and Q2 switches are activated during mode-A. The potential across the load is measured using Kirchhoff's rule for voltage, yielding +90 V.
- **Mode B:** Q10, Q9, Q6, Q5, Q1, and Q3 switches are operational during mode-B. The potential across the load is measured using Kirchhoff's rule for voltage, yielding +80 V.
- **Mode C:** Q10, Q9, Q6, Q7, Q1, and Q3 switches are operational during mode-C. The potential across the load is measured using Kirchhoff's rule for voltage, yielding +70 V.
- **Mode D:** Q10, Q9, Q8, Q5, Q1, and Q2 switches are operational during mode-C. The potential across the load is measured using Kirchhoff's rule for voltage, yielding +60 V.
- **Mode E-** Q1, Q3, Q5, Q8, Q9, and Q10 are the active switches during mode-E. When the voltage is calculated using Kirchhoff's law, the potential across the load is found to be + 5 V.
- **Mode F-** Q1, Q2, Q5, Q6, Q9, and Q12 are the active switches during mode-F. When the voltage is calculated using Kirchhoff's law, the potential across the load is found to be + 4 V.

Kirchhoff's voltage rule can thus be used to compute the voltage across the load in various modes. The voltage for each mode is listed in the table below.

II. CONTROL

As The variable frequency Pulse width modulation technique is proposed in which the alternate approach makes use of the 180 degree phase opposition variable frequency pulse span modulation technique to enhance the observed waveform's sine character at load as shown in Fig.3.

Several level-shifted variable frequency waves with 180 degree phase differences in negative levels are used in the phase deposition approach to get perfect sine wave interception in order to derive the gate pulse for the 19-LI.

The approach presents a variable frequency wave with same frequency at same magnitude of voltage irrespective of sign. The density of line or frequency of levels near by zero is more however the frequency decreases as the level magnitude increases.

To maintain the symmetry of intersection for positive and negative half a phase opposition approach is clubbed with variable frequency concept.

The proposal provides less harmonics as on increasing the amplitude the deviation for all 3 mentioned approached is

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more so, increasing the frequency will not have any intersection with pure sine wave.

That results in less distortion at higher levels. This concept is being plotted with 19 level MLI and the results are being aliased to validate the concept.

A phase opposition technique is used with the variable frequency notion to preserve the symmetry of intersection for the positive and negative halves.

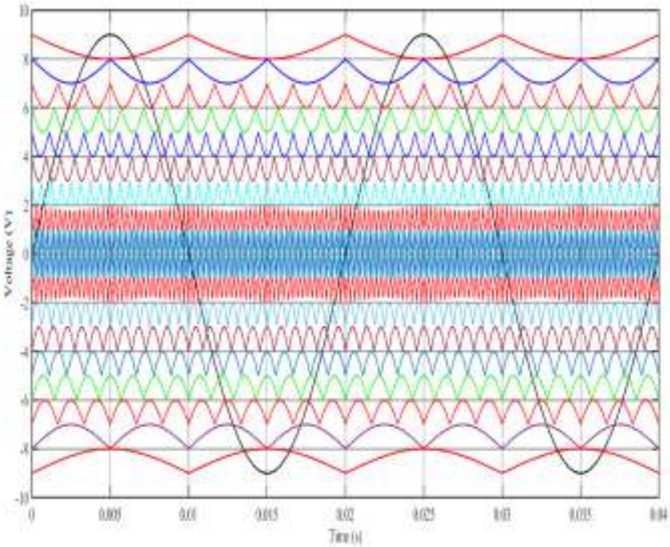

Fig.3 Variable Frequency Phase Opposition scheme

To provide interception with a perfect sine wave for the extraction of the gate pulse for the 19-LI, the phase deposition technique employs a number of level-shifted waves with 180 degree phase variations between positive and negative levels. The waveform for inverter control using the same level-shifted, phased pulse width modulation is shown in Figure 3.

III. RESULTS

This section illustrates and describes the output wave shape of the 19-LI-based phase deposition level shifting pulse breadth modulation technique. The output waveform of the seven-level inverter is displayed in Fig. 4.

The output clearly shows an increase in sine nature when compared to the square wave output of a two stage inverter. The harmonic disturbances are displayed in Fig. 5. A two-level inverter produces a square wave as its output, however the image above shows how the output wave's sine nature has changed. The lower THD is similarly found to be 4.72%.

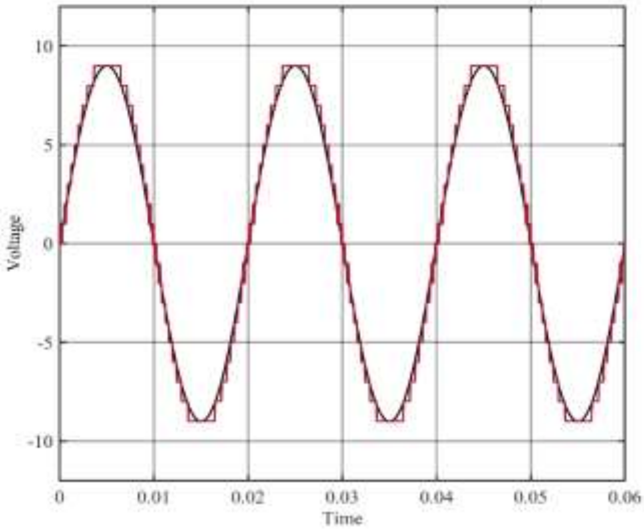

Fig. 4 19-LI outcomes

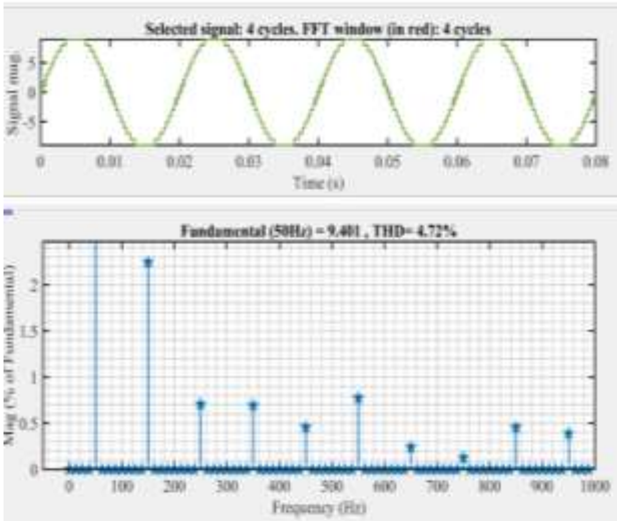

Fig.5 THD Profile

IV. CONCLUSION

This section looks at the inverter's output waveform, which appears to be getting close to a sine waveform. At approx. 5%, harmonic disturbances are found which will be just like an AC input to an induction motor i.e. bench grinder and thus performance of bench grinder will increase due to much approach of inverter output to sine wave nature.

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