Improve the Stability of the Segmented Traction Drive by Reducing the Harmonics with Controller

G. Kishor Babu, B. Madhu Kiran, V. Matthew, T. Suneel

Abstract*: This paper represents, reduced harmonics in the three phase three module inverter. If the module number increases the Total-harmonics-distraction (THD) value of the traction drive reduced. And the THD value is tremendously reduced by using controller with three phase three module inverter. Here Proportional Integral (PI) is used as a controller. The THD values for the three modules with controller and simulink results are placed below. The performance a characteristic of the traction drive is improved compared with and without controller. And the simulink results are placed below.

***Keywords* : Voltage Source inverter (VSI), Interleaving technique, Space vector pulse with modulation (SVPWM), PI Controller, Fast Fourier Transform (FFT).**

I. INTRODUCTION

Harmonics are present in realistic inverters output and not pure sinusoidal signal. For some applications square wave or quasi-square wave voltage may be acceptable and except high power applications like traction drive and other industrial drives the sinusoidal signal with low buckle are essential. Disturbance content there in the result of a DC to AC inverter can be removed either by employing a capacitive-filter or pulse-width-modulation (PWM) system [1]. Use of PWM technique with multilevel inverter is one of the methods for harmonic reduction [19]. Another method is used for reduction of harmonics i.e., multilevel-multimodal inverter for traction drive. [19-20]The traction drive starts at heavy loads. Due to this reason large amount of harmonics are induced in the traction drive at the time of starting. So the heat will increases tremendously in the traction drive.

The heat produced by the harmonics will reduces the life time of the traction drive and also efficiency of the traction drive, this will increases the burden on the other auxiliary equipment in the traction drive[8].

So these harmonics must be reduced to a safe value. Several methods are used to reduce the content of harmonic has been presented; There are two schemes:

(a) Inverter Topology Scheme

(b) PWM Modulation Scheme

The harmonic content is reduced by modifying the inverter topology [2]. Increasing the number of parallel modules in the traction inverter is one of the harmonic reduction methods in voltage source inverter. It is known as interleaving method. In the interleaving method, single voltage source is used but the module of the inverter is increased. The advantages of this method is, increase the rating of the converter i.e., as input current gets divided in two paths so the current stress on switches gets reduced, better efficiency. If the number of modules increases the harmonics will further reduces in the traction drive. If the number of modules increases, the winding of the traction drive is also increases. And the PWM is used as the switching technique for the three phase voltage source inverter. It is used because of high power factor, high efficiency and lowest order harmonics are significantly reduced [3].

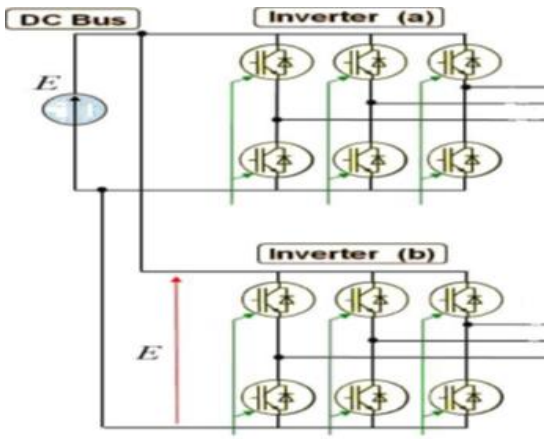

Fig.1 Structure of interleaved technique

The above fig. 1 represents the basic structure of the three phase two module inverter. The output is taken from the each phase leg of the three phase inverter. And the phase legs of the inverter 1 and inverter 2 are connected to the same load. Similarly the number of modules are increased in the parallel and connected to the same load. Here load is taken as traction drive. If the number of switches increases the switching angle of the IGBT decreases. It is depend on the number of switches present in the entire inverter topology.

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While bring up past the employ of between point in 3-Φ voltage source inverter (VSC)s to decrease the undulation current pass to the DC link capacitors [14-15]. Switching angle is gained by with the pulse-width-modulation scheme [3].

When the increase no. of modules is increases system complexity and increase switching frequency. To limit the number of modules, controller places a vital role. If the controller is used, the harmonics are reduced without adding the no. of parallel modules in the inverter. The performance characteristics of the traction drive can be improved by using the controller in the traction drive. So using of controller can leads to better THD value compare to the without controller.

II. DESCRIPTION OF INCREASING MODULE NUMBER

Method in a voltage source inverter system DC link capacitors by convinced element are necessary to offered DC link capacitor charged occupation [16]. In accumulation output of pulse with modulation to reduce the ripple currents with capacitance [3, 10-13].

The traction inverter with DC link capacitor is required more space because bulk and expensive component. To develop the power bulk and dependability of traction-inverters and the obligatory DC link has to be concentrated. The duration of the capacitor is mostly resolute by the internal-temperature [2]. Harmonics is one of the causes of praise of temperature in the traction drive [7-8, 18]. So if the harmonic distortion is reduced then the temperature of the traction drive reduces. To obtain the necessary capacitor value and helpful technique is used to enlarge the life span of DC link capacitor. As a result reducing the power-loss and inner heat of the capacitor is possible. In the existing technique mainly focused on the change inverter-topology [17]. Study in present, is about the current-ripple is abridged by technique. Interleaving technique is nothing but, the number of inverter modules increases as shown in below Fig., it represents the 3-Φ three module inverter. If the numbers of parallel modules are increased the harmonic distortion is also reduced. So by reducing the harmonic distortion the quality of the DC link capacitor improves. If the no. of module increases, the winding of the traction drive is also increases. It is beneficial for less number of modules.

Drawbacks of the existing technique:

- The complexity and size of the system is increases, if the more number of modules are increases.
- Even if the number of modules increases leads to less amount of reduction in harmonic distortion.

Proposed Technique:

In the proposed technique, the drawback of the existing technique is overcome. For better THD values and performance of the traction drive, without increasing the module number a Proportional Integral (PI) controller is placed. The pulse-width-modulation technique is replaced with the space-vector-pulse-width-modulation (SVPWM). [4] It is the most excellent pulse-width-modulation-technique for a 3-Φ voltage-source-inverter as give less harmonics and good power factor [5].

In space-vector-pulse-width-modulation condensed controlling dead are as of the varying of any one controlling condition which outcome in one 1-Φ voltage modify all time. If structure requires new drop in switching-losses than another technique could be used for switching-loss reduction based on ending the control-pulses of space-vector-pulse-width-modulation for some interval and this interval depends upon angle of the load PF. For different modulation-indexes (MI), further controlling can be removed in space-vector-pulse-width-modulation [9].

Because of easy design, low cost and simple structure the Proportional Integral (PI) controllers are widely used in industries. Essential exploit removed steady-state-error. However it has very deprived transient-response. Using multi exploit raises the vacillations in the production of the control system. As on-off controller the proportional integral controller eliminates forced oscillations and steady state error. The detailed description about the proposed technique is given [6].

III. REVIEW SIMULATION RESULTS

This The simulink results are shows the simulink diagram and total harmonic distortion reduction of 3-Φ three module-inverter. The Fig. 2 represents the simulink representation of the 3-Φ three module-inverter without controller. The THD value for the inverter is shown in Fig. 3 and the value is obtained from the FFT analysis of the simulink. The simulink results for the performance of the traction drive are also exposed in fig. 4. The output current of the three module inverter is exposed in Fig. 5. Fig. 6 represents the voltage waveform of the three module inverter.

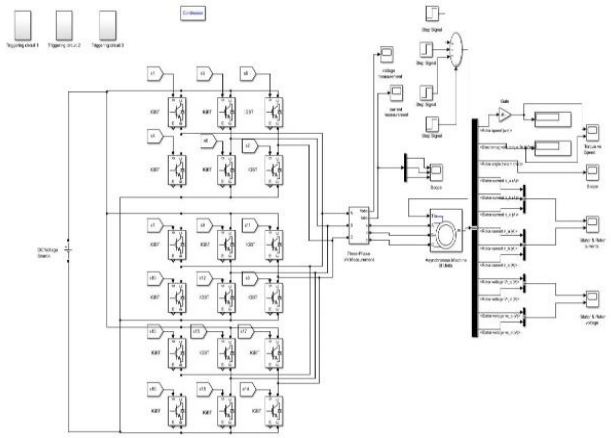

Fig.2 Three phase three module inverter

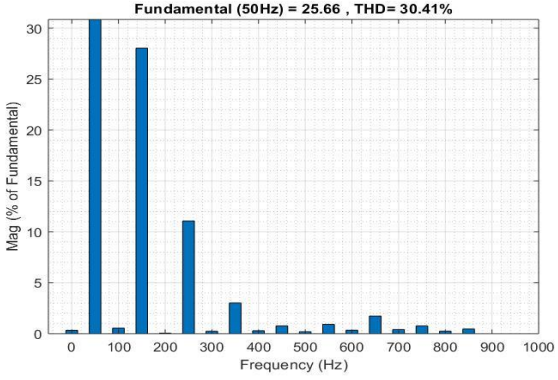

Fig.3 THD value for three module inverter

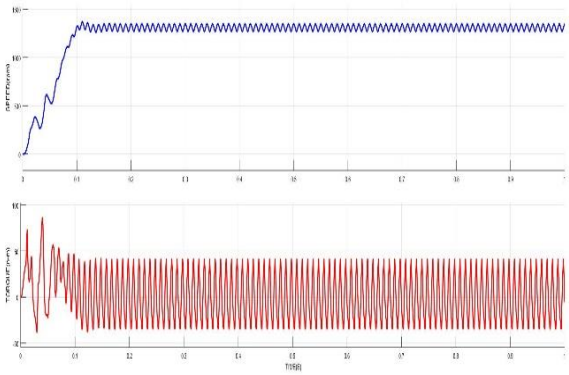

Fig.4 Speed and Torque characteristics of three module inverter without controller

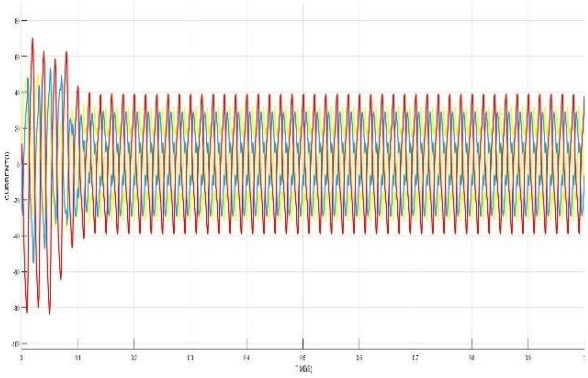

Fig.5 Current waveform of three module inverter without controller

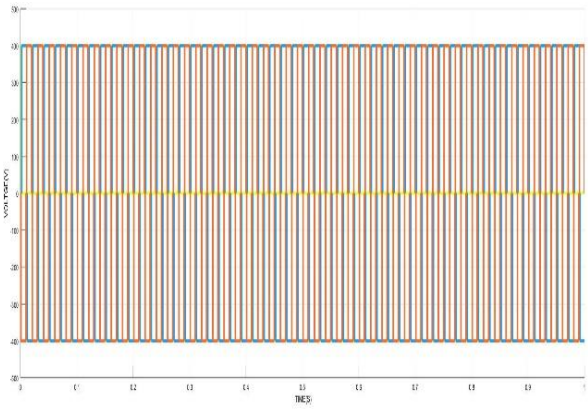

Fig.6 Voltage waveform of three module inverter without controller

Table.1 THD values for different modules in %

S. NO	Module number	THD Value in %	Reduction of harmonic in %
1	1 module	55.24%	-
2	2modules	38.59%	30.14%
3	3modules	30.41%	44.94%
4	4modules	26.27%	52.44%
5	5 modules	23.32%	57.78%

The results show the % reduction in the inverter if the module number increases. It is clearly shows that the less % of harmonic reduction even if the number of modules increases. This kind of nature leads to increase in cost, size and reduction of efficiency. In proposed concept, this drawback is overcome by using the controller (PI).

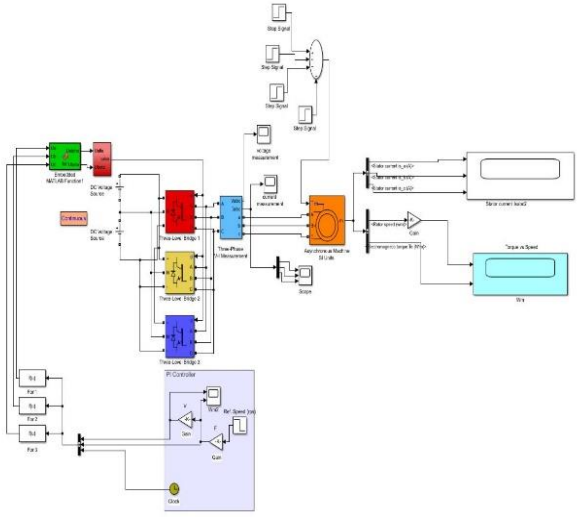

Fig.7 Three phase three module inverter with controller

The Simulink of the 3-Φ three section inverter with controller is exposed in Fig. 7. The speed from the traction motor take as reference speed and it is given to the pulse width modulation technique. Based on comparison of these two reference signals, a signal is generated and used for generation of gate signal for the traction inverter. The output of the 3-Φ three module inverter output is given to the induction motor. Fig. 8 represents the THD value for the three module inverter with controller. The respected Fig. 9 & 10 represent the inverter voltage and current waveforms.

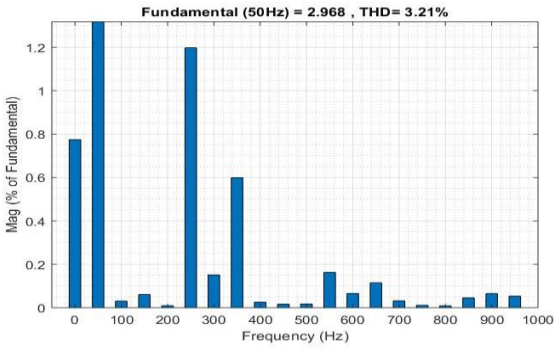

Fig.8 THD value for three module inverter with controller

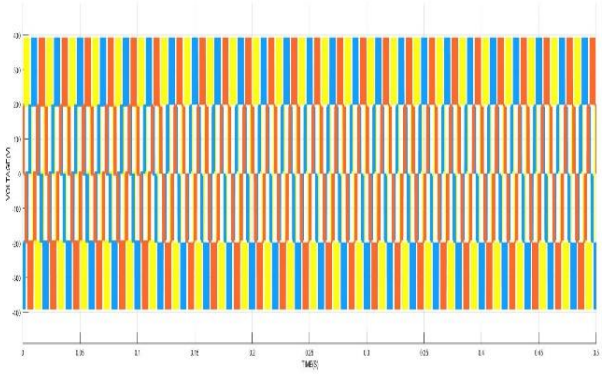

Fig.9 Voltage waveform for three module inverter with controller

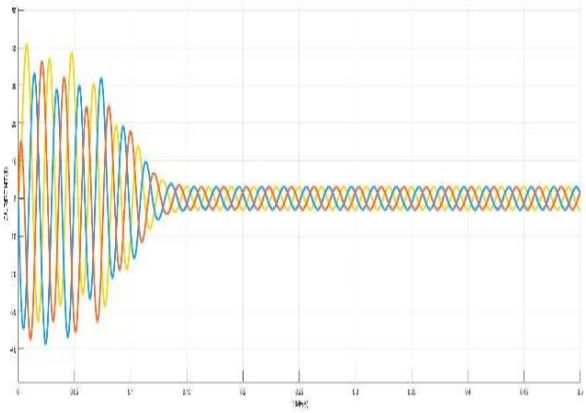

Fig.10 Current waveform for three module inverter with controller

The performance characteristics of traction drive are shown in Fig. 11. From the characteristics of the drive it is observed that, it takes less time to reach the steady state response of the traction drive. It is also observed that after reaching the steady state, the torque is maintained constant.

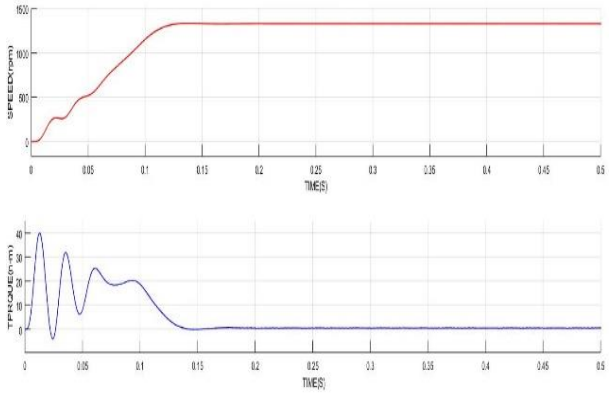

Fig.11 Speed and Torque characteristics of the inverter

IV. CONCLUSION

By comparing the simulation results of the existing technique and proposed technique, claimed that the THD value is reduces. The performance characteristics of the traction drive are also improves by using the controller and space-vector-pulse-width-modulation technique. It may further decrease the THD by increasing the number of the modules. But it is not practiced due to less reduction of THD value, if the number of modules increases in the traction inverter. To overcome the drawbacks of the existing technique a controller (PI) is used without raising the no. of parallel modules in the traction-inverter. By connecting the controller not only the THD value reduces but also the performance characteristics of the traction drive improves. The corresponding simulink results are also placed in the paper.

Day by day the usage of the Induction Motor in industrial purpose & commercial purpose increases, due to variable speed compact ability. Hence the controlling over the harmonics in the induction motor is very necessary for smooth operation. This paper helps to achieve smooth operation by reducing the harmonics by increasing the number of the modules. This may applicable to any type of AC Machines (i.e., synchronous motor) to control the operation and reduction of harmonics for achieving smooth running conditions.

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