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Analysis of THD in Three phase PWM Inverter Drive with Diode Neutral point method using Dual-Stage Common mode filter-A simulation work

Dr. Manjesh and Ananda A S
Bangalore University,
Bangalore, India.
manjesh1972@gmail.com and a.sananda@yahoo.com

Abstract— **Power electronic system working in faulty conditions, the ratings and protection of power electronic converters and inverters are very important parameters to be monitored under erotic conditions. The industry attracts power electronic system to work under any faulty conditions, the researchers done good reforms in drastic change the scenario of these problems in power electronic systems. Most of the researchers working on power converters and inverter system, the power converters working with linear and loads generate harmonics these harmonics disturb the line voltage and line currents and also adversely affect on power factor. In this paper a simulation work has been carried out to study and compare the total harmonic distortion (THD) and power factor of a normal three phase PWM drive and dual stage inverter filter with diode neutral point method.**

Keywords- ***Three Phase Inverter, THD, Power Factor, Commom mode filter***

I. INTRODUCTION

Adjustable speed drives (ASD) are frequently used in the industries and it attracted many researchers to design efficient drives. Three phase induction motor are widely used in industries because of its enormous advantages such as low cost, low maintenance, higher efficiency and high reliability. PWM inverter drives are widely used in many industries for various operations. The PWM drive is usually prefer to use IGBT switches. The use of non linear devices as load it produces EMI noise in the line output of the PWM inverter, due to switching actions of the IGBT's produce nth harmonics in the line output which are super imposed on the fundamental harmonic frequency.

The capacitor between the bridge rectifier and PWM inverter draws more current, this input current is rich in low order harmonics. The power electronics applications are increasingly used in power conversion and inversion, they inject low order harmonics into the line output. Harmonics in power applications is the current or voltage which is the multiple of fundamental frequency. Due to the presence of these harmonics, the total harmonic distortion is high and the input power factor is poor. Common mode voltage in power converters and power inverters introduces many problems in power electrical systems. This common mode voltage can interfere with nearby systems and can disturb the performance. In motor drives common voltage can harm the motor performance especially in bearing current loss. The inverter produces the common mode voltage and it passes through all the components in the circuit and degrades the performance. In order to reduce this common mode voltage a common mode filter is used to prevent these common mode voltages. Common mode voltage exists between the load neutral and earth ground. CM noise voltage flows in the same direction on both power conductors and returns via the ground conductor and can be suppressed by the use of inductors. These common mode voltages create EMI noise and can disturb the motor torque ripple.

General common mode noise voltage is given by (1)

$$V_{CM} = \frac{V_p}{} \qquad (1)$$

Where V_{CM} = Common mode voltage

V_p = Phase voltage

V_n = Neutral Voltage

In this paper a diode clamped neutral point with dual-stage common mode filter is proposed for three phase induction motor and simulated for harmonic analysis. The common mode voltages at the motor terminals can be described as

$$V_{CM} = \frac{1}{3}\left[Rf\, i + \frac{1}{Cf}\int i + V_{NE}\right. \qquad (2)$$

Where V_{CM} = Common mode voltage

R_f = Filter resistance

C_f = Filter capacitance

V_{NE} = voltage between neutral point and motor earth ground.

If C_f = , R_f = 0, then V_{CM} V_{NE} from Eq. 2. This shows that common mode voltage is equivalent to the DC link neutral point. [1-12]

II. THREE PHASE PWM INVERTER DRIVE

The traditional three phase PWM inverter is as shown in Figure.1. The PWM inverter topology used here is the voltage source inverter VSI topology. It comprises of 6 IGBT switches. Each IGBT will conduct for a period of 180^0, with a phase shift of 120^0 out of phase with each other. Pulse generator generates the gate signals for the 6 IGBT's. Initially, THD and Power factor is noted for traditional three phase PWM inverter.

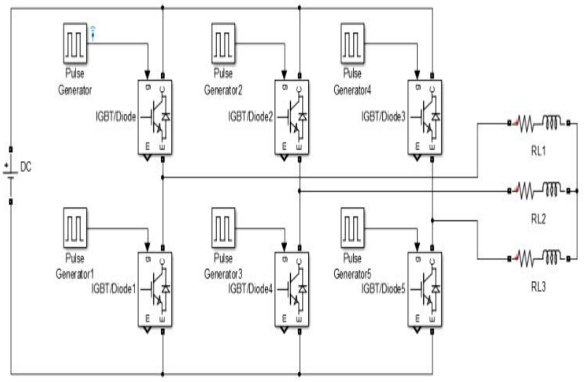

Figure 1. Construction of Three phase PWM Inverter with RL load

III. THREE PHASE PWM INVERTER WITH DIODE NEUTRAL POINT DUAL-STAGE COMMON MODE FILTER

The constructional block diagram is as shown in Figure.2. It consists of bridge rectifier with dc link capacitor C_1 and 2 diodes are clamped between the dc link capacitor C_1 and the PWM inverter, D_1 and D_2 are connected after the dc link capacitor. Dual–stage common mode filter comprises of L_1, L_2, L_3 connected at each line at the output of the PWM inverter.

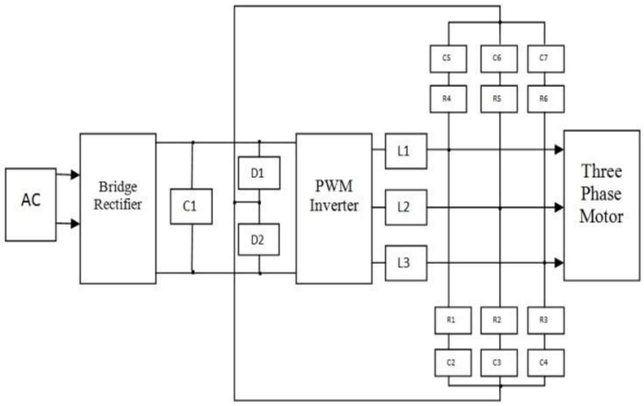

Figure 2. Constructional block diagram of three phase PWM inverter with diode neutral point dual-stage common mode filter.

The dual stage filters are constructed with Resistors R1, R2, R3, R4, R5 and R6 and capacitors C2, C3, C4, C5, C6, and C7, which are connected to output of the three phase lines for the PWM inverter. Figure.2. This common mode filter does not have the design, but varying the values of L1,L2 and L3 to obtain better result relevant to THD. The complete setup is as shown in Figure.3.

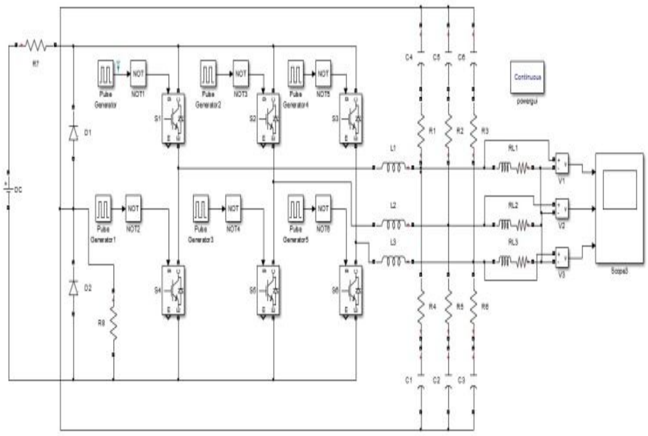

Figure.3. Complete setup using simulink

IV. EXPERIMENTAL RESULT

Simulation has been done for the input frequency of 10 Hz with a Three phase RL load with R= 11.3Ω and L= 45.8 mH, V_{dc}= 586 V. The line output voltage is measured and plotted for traditional inverter without filter and with common mode diode neutral point filter. THD is measured for both traditional inverter without filter and with common mode diode neutral point filter. Power factor is also compared between traditional inverter without filter and with common mode filter. The R and C values used in the common mode filter are as shown in table I.

TABLE I. VALUES OF R AND C USED IN THE COMMON MODE FILTER

Components	Values
R_1-R_6	100 Ω
C_2-C_7	1000µF

The line voltage waveforms of traditional PWM inverter are as shown in Figure.4. The line voltage waveforms of PWM inverter with filter are as shown in Figure.5.

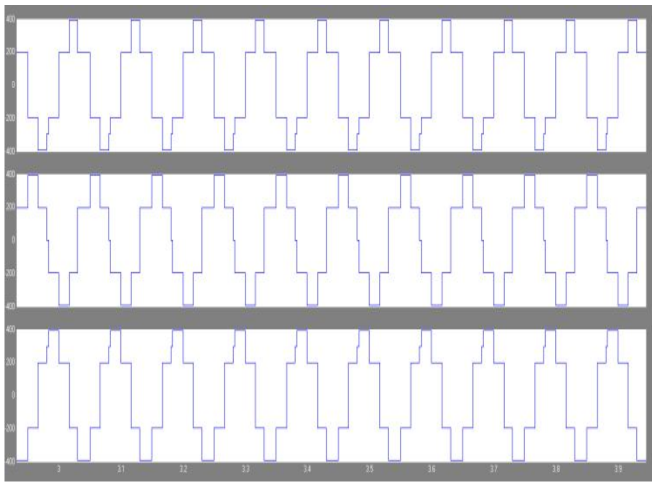

Figure 4. Line voltage waveforms of traditional PWM inverter

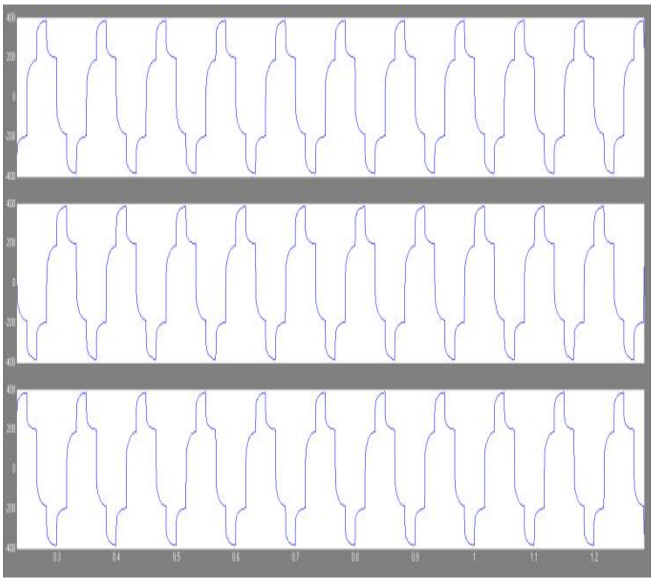

Figure 5. Line voltage waveforms of PWM inverter with common mode filter

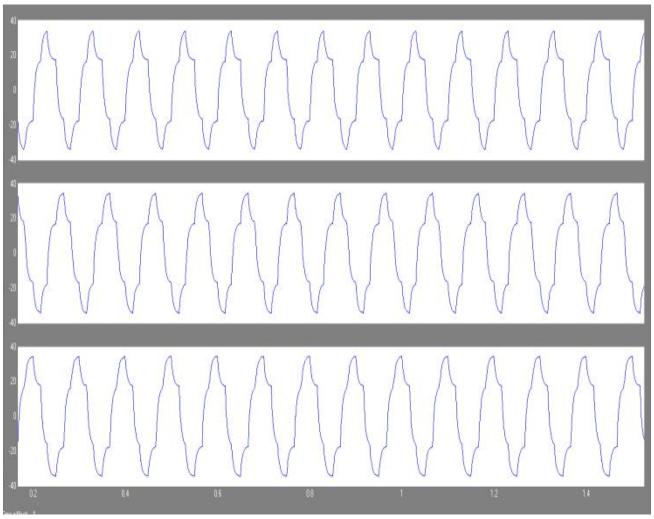

Figure 6. Line current waveforms of Traditional PWM inverter

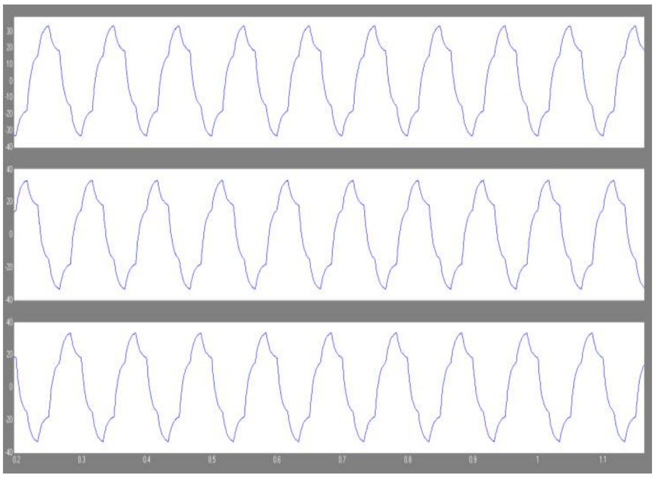

Figure 7. Line current waveforms of PWM inverter with common mode filter

THD for both traditional inverter without filter and with common mode diode neutral point filter. The overall THD for both traditional inverter without filter and with common filter are as shown in table II.

TABLE II. THD COMPARISON BETWEEN TRADITIONAL INVERTER WITHOUT AND WITH FILTER

Modes	**THD %**
Traditional Inverter without filter	33
Inverter with Common mode filter	23.11

For different values of L_1, L_2 and L_3 THD are noted and are as shown in table III.

TABLE III. THD FOR DIFFERENT VALUES OF INDUCTORS IN COMMON MODE FILTER

Values of L_1-L_3	**THD %**
5 mH	28.38
18 mH	23.11
70 mH	13.96

Power factor is measures for both traditional inverter without filter and with common mode diode neutral point filter. It is as shown in table IV.

TABLE IV. POWER FACTOR COMPARISON BETWEEN TRADITIONAL INVERTER WITHOUT AND WITH FILTER

Modes	**Power Factor**
Traditional Inverter without filter	0.9966
Inverter with Common mode filter	0.9918

The FFT sequences of the traditional inverter without filter and with filter are as shown in fig 8 and 9 respectively.

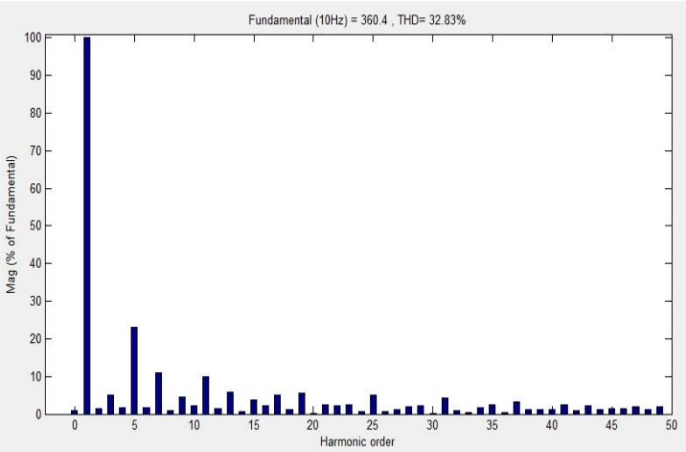

Figure. 8 FFT sequence of traditional inverter without filter

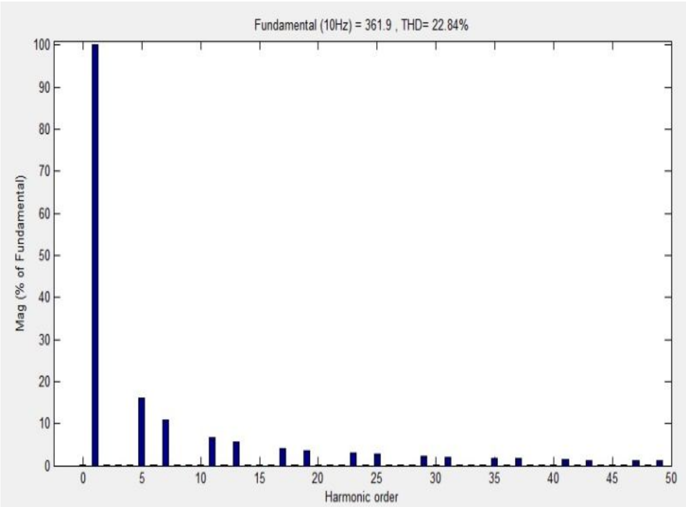

Figure. 9 FFT sequence of inverter with common mode filter

Table V shows the individual n^{th} harmonic content voltages of three phase inverter with common mode filter compared with traditional PWM inverter.

TABLE V. INDIVIDUAL HARMONIC CONTENT VOLTAGES COMPARISON BETWEEN TRADITIONAL INVERTER WITHOUT AND WITH FILTER

Harmonics Order	Traditional Inverter without filter (V)	Inverter with Common mode filter (V)
1^{st} (Fundamental)	358.91	361.52
5^{th}	84.77	58.13
7^{th}	38.15	39.78
11^{th}	37.79	24.18
13^{th}	19.58	20.22
17^{th}	20.02	15.09

V. CONCLUSION

Three phase PWM inverter with diode neutral point dual-stage common mode filter has been simulated in simulink/matlab. Its performance is studied by comparing THD and Power Factor with the traditional PWM inverter. A drastic reduction in content of harmonics and THD using diode neutral point dual stage common mode filter is found. this is done by varying the values of the load inductors at the output of the PWM inverter. This reduction of harmonics may be extended to study and to minimize the heat in the windings of the motors for future PWM motor drives.

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