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Variation of THD in Output Quantities of Three Pahse SPWM-VSI by Varying the Parameters of RLC Filter Connected at Output of Inverter

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Abstract*: Paper deals with the analysis of three phase Sinusoidal pulse width modulated (SPWM) Voltage source inverter output in term of total harmonic distortion (THD). Analysis is done by implementing the model in MATLAB/SIMULINK platform. By implementing filter at the output terminals of inverter, its current and voltage wave becomes purely sinusoidal. Analysis is carried out by varying RLC filter parameters and due to their variation, effect on THD in inverter filtered line voltage, line current & phase voltage is measured. Filter inductance 'L' & capacitance 'C' are varied one by one keeping other parameters constant & effects has been plotted on various graphs & listed in tables. It has been observed that by varying the RLC filter parameters THD in output quantities of SPWM VSI inverter shows a remarkable change in its value. This work may provide one of the best alternative solutions to design a filter for SPWM VSI inverter feeding to any drive.

***Keywords* : THD, harmonics, filter, inductor, capacitor, SPWM , MATLAB/SIMULINK**

I. INTRODUCTION

Electric drives draw the attention of various researchers towards it due to its large potential in various applications in last few years. Three phase drive may get its input from three phase inverter, which converts DC voltage to AC for it [1]. These inverters may vary their output voltage by adopting various voltage control techniques in them. Pulse width modulation PWM is one of voltage control technique implement in inverter by which inverter devices switches at higher frequencies [2]. Also by PWM technique inverter output voltage & current gets improved [3]. Through this technique the output voltage of inverter is easily control but its one of the drawback is that it introduces undesirable harmonics in fundamental waves [4]. When this input is given to motor drive than its performance Detroit's though the drive get its control voltage from the inverter [5]. This problem can be resolved by filtering the output quantities of the inverter in which PWM technique is implemented [6-7]. For achieving this active filters are installed in between the Motor drive and inverter which filter out all the undesirable harmonic contents from the inverter output [8-9]. Also by filtering, the rectangular voltage waves of inverter approaches towards the sine waves of desired frequency [10] and the performance of the drive get improved [11-12]. By getting highly improved inputs, torque ripples in motor drive get reduced which increases the drive efficiency [13] as the efficiency somehow depends on the quality of input of the motor drive [14-15]. Thus performance of any electric drive which get its input from inverters is highly improved by installing a filter in between it and inverter [16]. Due to improved input the rotor harmonics of the motor drive also settled downs to low values [17]. PWM inverter-fed drives applications in variety of fields [18-19].

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II. METHODOLOGY

For measuring the total harmonic distortion THD in output quantities of three phase inverter feeding induction motor drive, a model is implemented in MATLAB/SIMLINK platform. Block diagramme is shown in fig 1. As shown in the block diagram a three phase SPWM-VSI is feeding a three phase induction motor drive via RLC filter[20]. It has been observed that due to switching of devices in three phase inverter it produce several harmonics in its output current & voltage waves, thus the amount of total harmonic distortion is more in inverter output waves. These harmonics along with the fundamental component produces undesirable effects in the performance of the drive connected. For reducing the harmonics contents from the output of inverter an RLC T-filter is connected at its output terminals. This filter filtered out most of the harmonics from the output waves of inverter . The effect of filter parameters variations is studied in this paper. Since inductance and capacitance are the two major component of the filter used, they are varied one by one keeping other parameters of filter constant and due to their variation amount of THD in inverter output quantities is recorded.

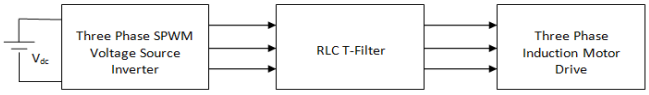

Fig. 1: Block diagram of PWM based VSI feeding three phase induction motor with RLC filter

III. VARYING THE VALUE OF FILTER INDUCTOR 'L'

This section measures the effect on Total Harmonic Distortion (THD) in inverter output waves when the value of filter inductor 'L' is varied keeping the values of resistance 'R' & capacitor 'C' constant at R=5ohms & C=1e-3F.

A. *Effect on Phase Voltage*

From table I it is seen that when the filter inductor increases from L=1e-1H, amount of THD first increases & than decreases in output phase voltage. When the value of filter inductor decreases from L=1e-1H, it is measured that THD increases rapidly. Variation of THD in phase voltage by varying the filter inductance is shown in fig.2.

Table I: Effect on THD in phase voltage by varying the value of filter inductor L

S.No.	Inductance L (Henry)	THD in %	Fundamental Component
1	1e-1	0.55	11.26
2	2e-1	0.43	5.801
3	3e-1	0.35	3.899
4	4e-1	0.43	2.935
5	5e-1	0.55	2.354
6	1e-2	0.77	45.06
6	1e-3	4.27	50.37
7	1e-4	6.84	50.59
8	1e-5	6.92	50.61

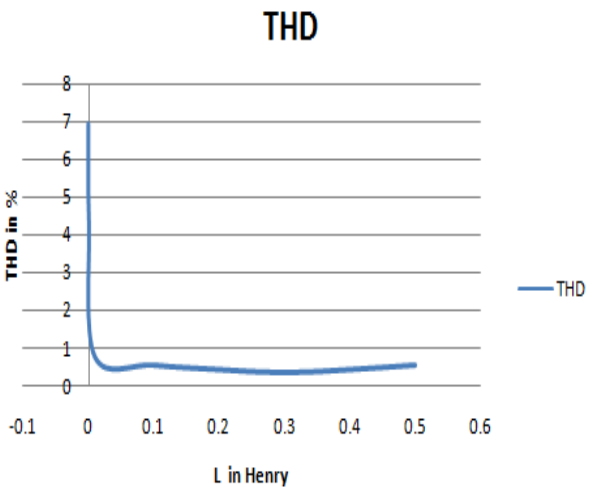

Fig.2: Graph between THD & L for phase voltage

B. *Effect on line voltage*

Table 1.2 list the effect on THD in line voltage by varying the filter inductor 'L'. It is observed from the table that as we increase the value of filter inductor 'L' from 1e-1 to 5e-1 , THD in line voltage first decreases & than increases. Similarly, when the value of inductance of filter decreases from 1e-1 to 1e-5 , the amount of THD in line voltage increases. The variation of THD with respect to different values of filter inductance for line voltage is shown on the graph in fig.1.2.

From table 1.2 it is also observe that the amount of fundamental decreases when we increase the filter inductor 'L' value, while it is increases on decreasing filter inductor 'L' value & become 87.70 when L=1e-5H.

Table 1.2: Effect on THD in line voltage by varying the value of filter inductor L

S.No	Inductance L (Henry)	THD in %	Fundamental Component
1	1e-1	0.37	19.53
2	2e-1	0.33	10.09
3	3e-1	0.57	6.796
4	4e-1	0.84	5.127
5	5e-1	1.06	4.118
6	1e-2	0.73	78.09
7	1e-3	4.26	87.29
8	1e-4	6.84	87.67
9	1e-5	6.91	87.70

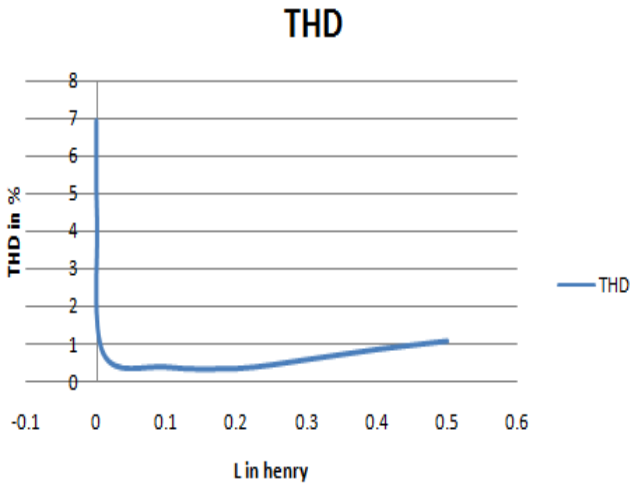

Fig. 3: Graph between THD & L for line voltage

C. *Effect on Line Current*

The effect on THD by varying the filter inductance 'L' for line current is listed in table III & its variation is shown on the graph in fig.4.

Table III: Effect on THD in line current by varying the value of filter inductor L

S.No.	Inductance L (Henry)	THD in %	Fundamental Component
1	1e-1	0.28	6.622
2	2e-1	0.73	3.402
3	3e-1	1.08	2.28
4	4e-1	1.27	1.713
5	5e-1	1.35	1.372
6	1e-2	0.19	26.25
7	1e-3	0.41	29.26
8	1e-4	0.54	29.38
9	1e-5	0.54	29.39

Here it is measured that the amount of THD in line current of inverter increases from 0.28 to 1.35 when the filter inductor 'L' increases.

On decreasing filter inductor 'L' from 1e-1 to 1e-5 , THD become minimum when L=1e-2 H & again increases when we further decrease the value of filter inductor 'L'.

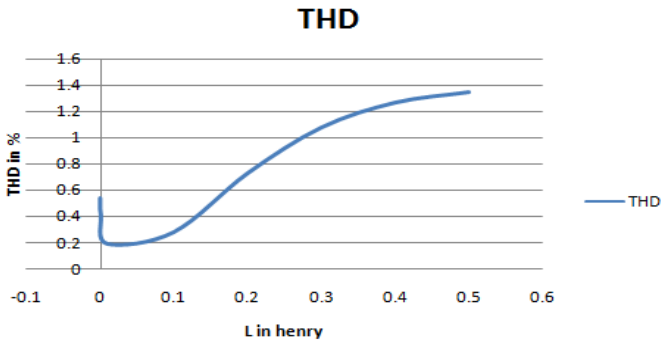

Fig.4: Graph between THD & L for line current

From Table III it is also observed that the value of fundamental component changes in accordance with the variation of filter inductance 'L'.

IV. VARYING THE VALUE OF FILTER CAPACITOR 'C'

This section record the results on the amount of THD in output voltage and current of inverter when filter capacitor 'C' is varied by keeping the values of filter resistance 'R' & inductance 'L' constant at R=5 ohm & L=1e-1 H.

A. *Effect on phase voltage*

Effect of varying the value of filter capacitor on phase voltage is recorded in table IV. From Table IV it is clear that the amount of THD in inverter output phase voltage become minimum when the value of filter capacitor is C=2e-3 F. While it become maximum when C=1e-1 F. The variation of THD with respect to filter capacitor 'C' is shown on the graph in fig.5.It is also measured that when the THD is maximum in phase voltage the amount of fundamental component is reduced very low & become 0.2235.

Table IV: Effect on THD in phase voltage by varying the value of filter capacitor C

S.No.	Capacitor C (farad)	THD in %	Fundamental Component
1	1e-3	0.37	19.53
2	2e-3	0.22	19.35
3	3e-3	0.30	13.4
4	4e-3	0.34	9.396
5	1e-2	1.53	3.037
6	1e-1	23.66	0.2235

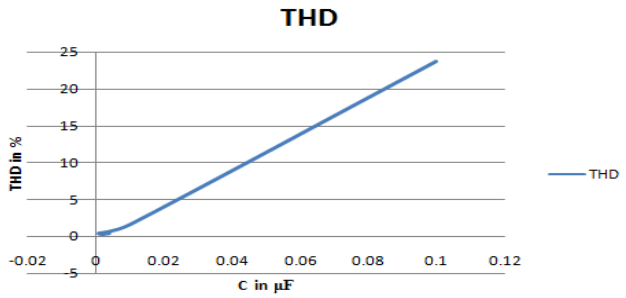

Fig.5: Graph between THD & C for phase voltage

B. *Effect on line voltage*

Table V list the effect on amount of THD in line voltage when the value of filter capacitor is varied & it is observed that the amount of THD in line voltage first decrease & than increases when we increase the value of filter capacitor. We get minimum THD at C=3e-3 F. The variation of THD with Filter capacitor C is plotted on the graph & is shown in fig 6.

Table V: Effect on THD in line voltage by varying the value of filter capacitor C.

S.No.	Capacitor C (farad)	THD in %	Fundamental Component
1	1e-3	0.55	11.26
2	2e-3	0.20	11.17
3	3e-3	0.17	7.75
4	4e-3	0.29	5.449
5	1e-2	0.35	1.782
6	1e-1	39.26	0.105

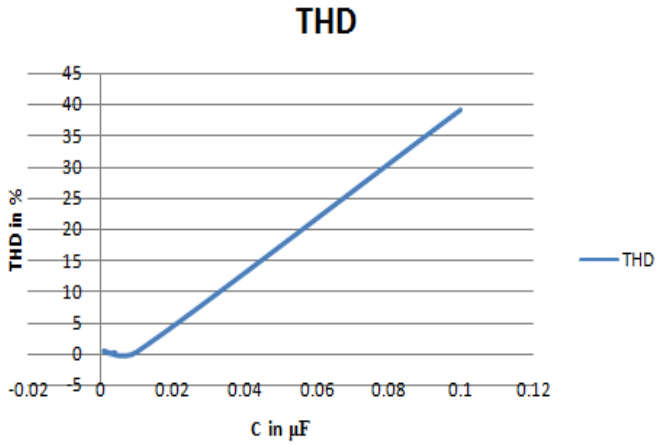

Fig 6: Graph between THD & C for line voltage

C. *Effect on line current*

Variation in the amount of THD in inverter output line current after its filtration by RLC filter by varying the filter capacitor 'C' is listed in Table VI while its variation is shown on the graph in fig.6.

Table VI: Effect on THD in line current by varying the value of filter capacitor C

S.No.	Capacitor C (farad)	THD in %	Fundamental Component
1	1e-3	0.28	6.622
2	2e-3	0.39	6.544
3	3e-3	0.28	4.535
4	4e-3	0.33	3.181
5	1e-2	2.31	1.021
6	1e-1	6.30	0.09729

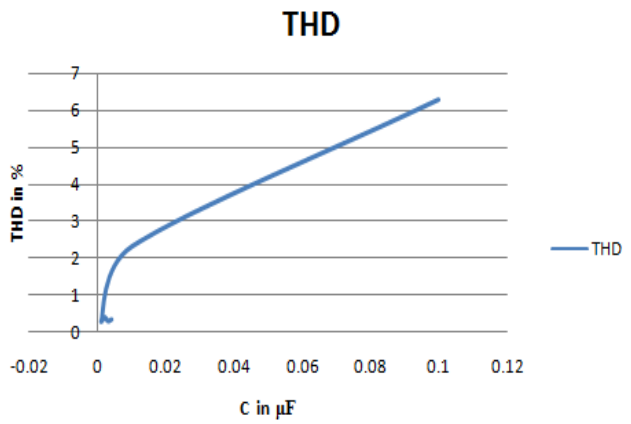

Fig.7: Graph between THD & C for line current

V.CONCLUSION

It is measured that due to the filtration process the pused waves of inverter is converted in the sinusoidal waves. Also they contains significant harmonics in them whwn these quantities are not filtered. Harmonics are presents along with the fundamental wave. the measurement of total harmonic distortion (THD) , output of inverter is analyzed . Harmonics in output quantities of three phase inverter can be reduced by connecting a RLC filter at its output terminals. The effects on total harmonic distortion THD has been measured by varying the filter parameters which is installed at the output of three phase SPWM inverter one by one keeping other parameters of filter & drive constants. It is observed that on decreasing the value of Filter inductor 'L' keeping 'R' & 'C' constant, the fundamental component of Phase as well as line voltage increases along with THD. Similarly fundamental component of line current & THD in it also increases with the decrease of Filter inductor 'L'. When Filter capacitor 'C' decreases keeping the values of 'R' & 'L' constant, THD in phase voltage decreases whereas fundamental component increases. But in line voltage on decreasing the value of filter capacitor, THD first decreases & than increases whereas fundamental component of wave increases. THD in line current decreases on decreasing the value of filter capacitor while its fundamental component increases..

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