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Analysis of Harmonic Distortion by applying various PWM Techniques in Grid connected Photovoltaic Systems

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Abstract

In the last decades, it has been observed that the harmonics distortions generated by the PV inverter are reduced by using Pulse with modulation technique. Harmonics reduction is the main consideration in three phase inductive load circuit.The performance of the three phase squirrel cage Induction motor was improved by the reduction of voltage harmonics and current harmonics. In this paper, the harmonic distortion of the three phase induction motor was measured in terms of THD by Simulation model and the results of the Multiple Pulse With Modulation and Sinusoidal Pulse With Modulation inputs were compared to find out the lowest THD value. By using the PWM technique on the Three Phase Induction motor there was reduction in the VTHD by 6. 98% and CTHD by 3.12%. By reducing the harmonics level we can increase the life time of motor, cables and capacitor.

Keywords: SPWM Inverter, MPWM Inverter, Mat lab, Induction Motor, THD.

1. Introduction

In several countries, an increasing number of PV generation systems are connected to the distribution network as a result of strong government support. The power electronics interface is essential to connecting renewable energy sources to the grid. PV systems incorporate power electronic interfaces, which generate a level of harmonics, potentially leading to current and voltage distortion. Inverters are widely used in drives, UPS. This project presents a comparative study of performance between Sinusoidal Pulse Width Modulation (SPWM) and Multiple Pulse Width Modulation (MPWM) inputs. These techniques has been designed and analysed using Mat lab Simulink model. The performance comparison are analysed in terms of THD and Fast Fourier Transformation (FFT). Approximately, 60% of loads in all over the world were motor loads, which creating heavy harmonics under normal and unbalanced load condition which pollutes the transmission network.In three phase induction motor, the electrical losses such as iron, winding and stray load losses will depend on order and magnitude of harmonics. Hysteresis loss and eddy current loss that take place in the Iron vary with the square of the air-gap voltage. The harmonic currents are proportional to the magnitude of voltage harmonics, i.e. the stray load loss and winding loss vary with the square of the voltage harmonic.

2. Proposed Work

In three phase induction motor THD was analyzed by using various PWM techniques. In order to reduce the THD value produced in the Inverter circuit, the SPWM and MPWM techniques are used. The reduced THD values are find out at SPWM technique. At this lowest THD value, we can connect the PV systems to the grid system

3. Development of Inverter with MPWM and SPWM Technique

SPWM is commonly used in industrial application. In this scheme the width of each pulse is varied in proportional to the amplitude of a sine wave evaluated at the center of same pulse. The gating signals are generated by comparing a sinusoidal reference signal with a triangular carrier wave of frequency. The frequency of reference signal determines the Inverter output frequency and its peak amplitude controls the modulation Index. The number of pulses per half cycle depends on the carrier frequency.

The following Figure1 shows the simulation model of three phase Induction motor, in this the output from the Sinusoidal Pulse Width Modulation Inverter is given to the motor.

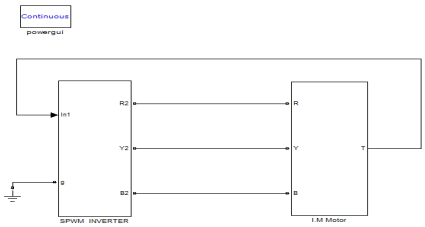

Figure.1 Simulation model of SPWM and three phase Induction motor

The following Figure 2 shows the simulation model Inverter Circuit diagram. In this Inverter, unidirectional triangular carrier wave is compared with absolute value of reference sinusoidal wave. This output after comparison is then multiplied to 50% duty cycle signal.

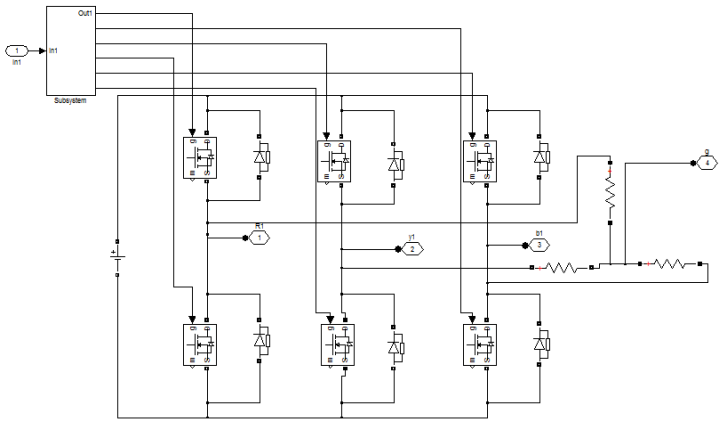

Figure.2 Simulation model of SPWM Inverter

The following Figure 3 shows the simulation model of three Phase Squirrel Cage Induction motor. In the Inverter circuit diagram MOSFET are mainly used. The output from the inverter is given to the input of the motor.

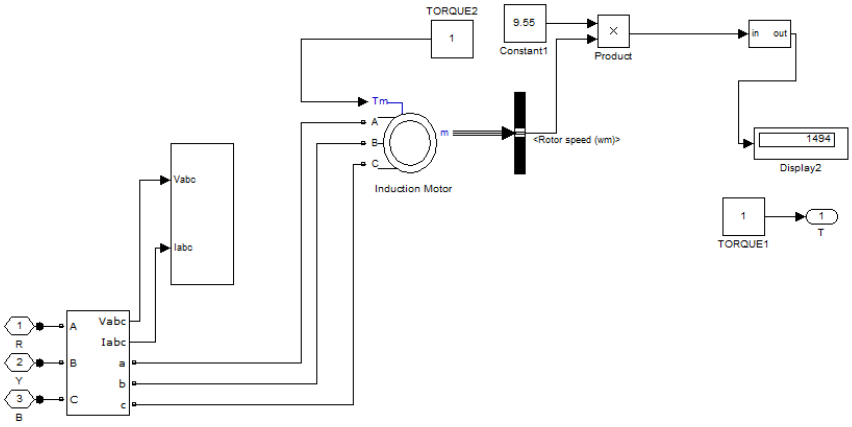

Figure.3 Simulation circuit diagram of three Phase Squirrel Cage Induction motor

The following Figure 4 shows the output wave form of the reference DC signal and ramp carrier signals which provides PWM pulses and Figure 5 shows the Inverter input gate pulse signal.

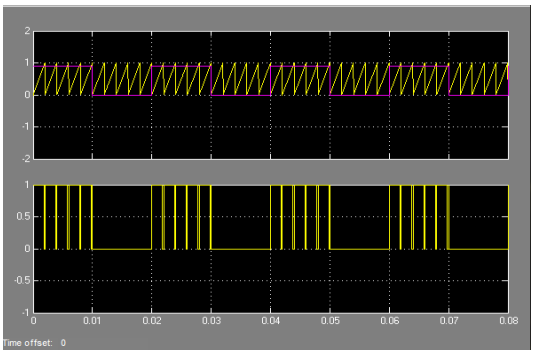

Figure. 4 Waveform of PWM signal

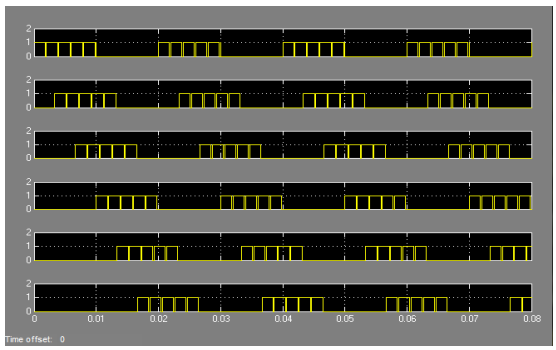

Figure. 5 Waveform of Gate Signal

4. Performance Analysis of SPWM Techniques

The frequency of reference signal determines the Inverter output frequency and its peak amplitude controls the modulation Index. The modulation Index value of the reference signal and frequency of the triangular carrier signal are varied to find out the different VTHD and CTHD values. The reduced THD values are observed at the frequency rate of 6000 hz and value of modulation index is 1.The following Table 1 shows the Analysing Result of VTHD and CTHD value by applying various Modulation Index value and Frequency.

Table.1 VTHD and CTHD Analysis of SPWM Technique by using triangular carrier signal

Frequ - ency	Modulation Index=1.0		Modulation Index=0.9		Modulation Index=0.8		Modulation Index=0.7		Modulation Index=0.6		Modulation Index=0.5	
	VTHD (%)	CTHD (%)	VTHD (%)	CTHD (%)	VTHD (%)	CTHD (%)	VTHD (%)	CTHD (%)	VTHD (%)	CTHD (%)	VTHD (%)	CTHD (%)
500	39.41	49.85	45.78	67.75	55.71	76.47	67.28	73.87	79.45	98.09	92.59	90.25
1000	43.07	27.09	51.15	34.38	59.09	41.64	70.67	44.2	80.91	50.68	92.46	50.54
1500	24.91	11.93	36.9	17.59	49.48	23.67	62.59	31.33	75.64	38.47	90.16	39.09
2000	42.86	13.55	51.11	15.91	59.82	18.7	71.53	21.11	81.68	24.11	92.79	24.03
3000	14.14	3.94	20.87	5.42	29.23	7.27	37.42	9.7	45.27	11.47	52.38	11.64
4000	43.17	7.64	50.66	8.36	58.89	9.88	68.02	10.11	79.08	13.19	89.52	13.08
5000	41.52	5.79	49.94	6.67	59.32	7.86	71.27	9.3	82.31	11.38	92.85	10.72
6000	13.16	2.88	18.18	3.52	21.6	3.66	21.67	3.54	22.31	3.56	31.04	3.92
7000	**6.79**	**3.12**	8.37	5.37	9.42	2.96	10.94	3.49	13.25	3.95	16.1	7.28
8000	40.47	4.3	49.42	4.58	58.27	5.39	69.74	9.34	82.52	8.97	92.84	8.39

The following figure 6 and 7 shows the measurement of Current THD and Voltage THD at Inverter.

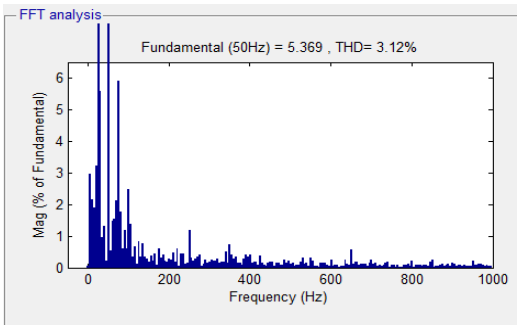

Figure.6 Simulation result of Current THD

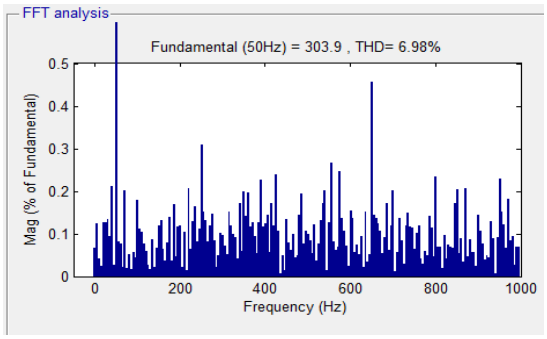

Figure.7 Simulation result of Voltage THD

5. Total Harmonics Distortion

The total harmonic distortion was a measurement of the harmonic distortion present and was defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD was used to characterize the linearity of audio systems and the power quality of electric power systems. In power systems, lower THD means reduction in peak currents, heating, emissions, and core loss in motors. Total harmonic distortion was measured as the percentage. Lower percentages were better. In reality, total harmonic distortion was hardly perceptible to the human ear.

5.1 VOLTAGE THD

Voltage distortion consists of very sharp notches and spikes in voltage. When applied to the equivalent circuit, that high frequency voltage does not cause much change in the inductive magnetizing current, but causes a change in the load current.

5.2 CURRENT THD

Current THD was caused by the motor itself due to non-linearity of the magnetizing current. The current THD will be higher when the motor was unloaded.

5.3 THD ANALYSIS

The THD was the means to express the distortion affecting a current or voltage flowing at a given point as a single number. THD analysis was done according to the standard IEC 61000-2-2.

6. Acknowledgement

Thank God for blessing and to my project Guide for his valuable Guidance to finish this research work.

7. Conclusions

The results show that the harmonics distortion generated by the PV inverter was reduced by using Sinusoidal Pulse Width Modulation technique, there was reduction of VTHD by 6. 98% and CTHD by 3.12% which in turn reduces the Iron, winding and stray load losses occur in induction motor. At this condition we can connect the inverter line to grid system.

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