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Analysis of Harmonics of PWM Controlled Induction Motor Using Fast Fourier Transform Tool

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Abstract—*This paper proposes design and simulation of a Pulse Width Modulation Controlled induction motor and analysis of the fundamental component and the total harmonic distortion using Fast Fourier Transform. The system has studied on different loading conditions with Simulated results are obtained in order to achieve better performance of the Induction Motor for the application of Industrial operations. Here two level pulse width modulator is implemented and the results are discussed. If three level inverter is used for space vector pulse width modulation, the additional advantage is of superior harmonic quality and larger under-modulation range that extends the modulation factor to 90.7% from the traditional value of 78.5% in sinusoidal pulse width modulation. The version of MATLAB used is R2011b.*

1. INTRODUCTION

The technology advancement in the past few decades has resulted in the development of modern techniques of position control of Motor with help of Drives. The aim of the drive system is speed control over wide speed range. Drives can be classified according to the application or the kind of operation to be performed. Hence DC and AC drives came into the picture. On the other hand these drives can be described on the basis of parameters which contribute for controlling of speed and position. Earlier Dc machine played an important role in industries gives high performance in electrical drive systems, since the magnetic flux and torque are easily controlled by the stator and rotor current respectively[1].whereas The induction motor is well known as the work horse of industry. It is estimated that induction motors are used in seventy to eighty percent of all industrial drive applications due to their simple mechanical construction, reliability, ruggedness, low cost and low maintenance requirement compared to other types of motors. Also it operates at essentially constant speed. The advancement of power electronics had made it possible to vary the frequency of the voltage or current relatively easy using various control techniques and thus has extended the use of induction motor in variable speed drive applications [2].

Modulation Techniques -PWM

As discussed above, with the development in power electronics the basic controlling parameter is frequency. The controlling unit which work on this known as variable frequency Drives. In Ac Machines like as Asynchronous, electronic switches are used which are force commutated, to control speed variably. The commonly used devices are GTOs, IGBTs, MOSFETs.In Association of these devices asynchronous machine uses voltage source converter fed by pulse width modulation. Dc motor drives and use of thyristor bridges are replaced due to evolution of such kind of techniques. With pulse width modulation we get the same flexibility in speed control like DC motor. Pulse width modulation is a technique in which a fixed input dc voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components [3]. To reduce the harmonic distortion and to obtain the constant switching frequency operation of the inverter, nowadays many researchers have focused their interest on pulse width modulation (PWM). Among the various PWM techniques sine wave Pulse Width Modulation (SPWM) is considered as one of the most popular technique [4]. SPWM uses sine-triangle method to generate pulses with desired frequency [5]. In this pulse width modulation technique we are comparing a triangular wave known as carrier wave with the sinusoidal wave taken as a reference which determines the switching instant. The output of the inverter contains harmonics. These harmonics can be analyzed with the help of MATLAB tool known as FFT analysis tool which perform Fourier analysis of signal stored in a structure with time format.

Modeling and Simulation

To perform the analysis as discussed above modeling and simulation need to be done. This model contains mainly a test induction motor 3 phase, of squirrel cage rotor type, 3HP, two poles. A universal bridge which is basically a 3 phase power converter, The Universal bridge block allows simulation of converters using both naturally commutated and line-commutated power electronic devices like IGBT. It is basic block for building two-level voltage-sourced converters. The universal block contains a gate input which is for controlling of switching devices. This gate is fed by a PWM generator which generates carrier wave pulses P1 and P2, Externally or internally, in our model we are using it in internally two level unsynchronized mode the modulation index we kept here is 0.9 which is the ratio of amplitude of two waves i.e. wave to be modulated and a carrier wave .To load the induction motor and observe the torque speed characteristics we assumed a quadratic function, hence square of rotor speed is proportional to electromagnetic torque. Now we are applying a fourier analysis on output voltage from universal bridge and stator current from induction motor.

2. SIMULINK SCHEMATIC

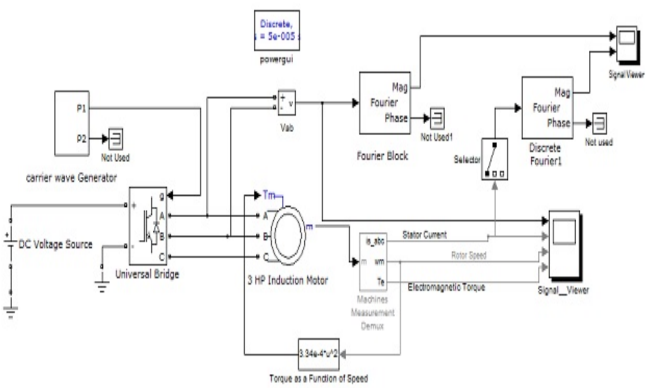

Fig. 1: Schematic Simulink circuit with FFT Analysis Tool for Induction Motor

Parameters Considered

Table 1

Machine/Device	Parameters	Values
IGBT	Rs, Cs, Ron	1e5,inf,1e-3 ohm
Induction Motor	Stator resistance and inductance	1.115, 0.005974
	Rotor resistance, inductance, Mutual inductance	1.083, 0.005974 0.2037 ohm.
	3 hp Squirrel cage , 2 pole	
Pulse Generator	Type	2 level
	Mode of operation	unsynchronized
	Carrier Frequency	900 Hz
	Modulation Index	0.9

3. RESULTS AND HARMONIC ANALYSIS

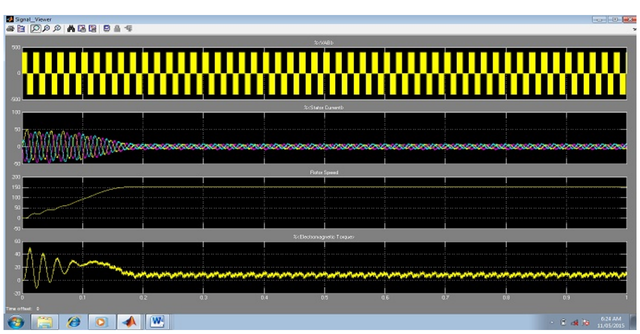

Fig. 2: Simulation Output Results

The motor starts and reaches its steady-state speed of 181 rad/s (1728 rpm) after 0.2 s. At starting, the magnitude of the 50 Hz current reaches 90 A peak (64 A RMS) whereas its steady-state value is 10.5 A (7.4 A RMS). Also strong oscillations of the electromagnetic torque at starting. On the torque in steady state, a noisy signal is observed with a mean value of 11.9 N.m, corresponding to the load torque at nominal speed. The three motor currents, it's observed that all the harmonics (multiples of the 1080 Hz switching frequency) are filtered by the stator inductance, so that the 50 Hz component is dominant.

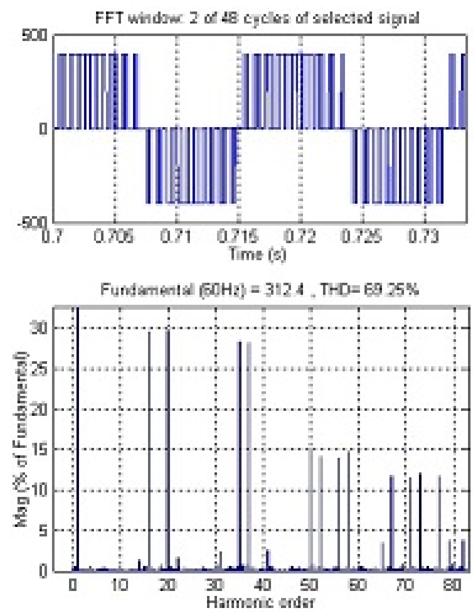

Fig. 3: FFT Analysis of Harmonics

The fundamental component and total harmonic distortion (THD) of the VAB voltage are displayed above the spectrum window. The magnitude of the fundamental of the inverter voltage (312 V) compares well with the theoretical value i.e.311 V for m=0.9.Harmonics are displayed in percent of the fundamental component. As expected, harmonics occur around multiples of carrier frequency (n*18 +- k). Highest harmonics (30%) appear at 16th harmonic (18 - 2) and 20th harmonic (18 + 2).

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