Study of Stator winding Temperature in Five Phase Induction Motor Drive using LC Filter at low frequency

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Abstract—Five phase induction motor drive is the outcome of the advanced power electronic technology. Five phase will be preferred over three phase induction motor due to its technical advantages. Harmonics and temperature are the major issues in induction motor drive. In order to overcome these issues an LC filter is proposed to use in this experimental work. Temperature has been measured in five phase induction motor drive with normal load and compared with LC filter with a torque load at low speed. Experimental results have been obtained and presented in this work.

Keywords— Five Phase; Harmonics; PWM Inverter Drive; LC Filter;

I. INTRODUCTION

Induction Motors are widely used in the industries, since the high torque applications. Industries use three phase induction motor because of consumer friendly advantages such as simple, robust and rugged in construction; can operate in any condition, less maintenance. In today’s electric drive & generation technology multi phase machine has several advantages over the traditional three phase machine. The Advances in power electronics a five phase induction motor has gained more interest in researchers. Five phase induction motors are preferred over the conventional three phase drive because of its unique advantage of torque mismatch. Earlier Multiphase motor were not used because of the non availability of the multiphase inverter drives and generation of multiphase signals were complex. The difficulties of constructing multi phase inverter drives have been overcome by production of power intelligent modules, and various control circuitry.

The main application areas of multiphase induction motor drives are ship propulsion, traction (including electric and hybrid electric vehicles) and the concept of more-electric aircraft, locomotive traction, and aerospace, high power applications[1-5]. The technical applications of Multi-phase machines have been increased tremendously as high power electronic devices are used as a switch in voltage source inverter (VSI). The VSI generates the ‘n’ number phase voltage and current harmonics which are superimposed on the fundamental harmonic frequency. Harmonics are the current and voltage multiples if the input frequency which affects the system performance, poor power factor, overheating in the systems. Harmonics are represented in terms of Total Harmonic Distortion (THD) in percentage, lesser the THD percentage better the performance, THD should be minimum for the safety and efficiency of power electronic systems.

Harmonic mitigation has become a major concern while designing any motor drives. Many researchers have followed different methods to suppress harmonics, such as using filters, designing multilevel inverter. Inverter generates odd harmonics which are multiple of the fundamental frequency. In five phase 5th and its multiple like 15th, 20th, 25th etc are absent. The leading harmonic order in five phase induction motor drive is the 3rd order harmonic i.e. if 50Hz is the input frequency then 3rd harmonic order is the 150Hz. LC filters are the commonly used filter to minimize the harmonics, in this work LC filter is used in five phase Induction motor drive to suppress the harmonics. Harmonics leads to overheating at the various parts of the induction motor such as stator windings, inner frames, damaging their insulation. THD leads to even machine failure therefore reduction of harmonics is crucial. Limiting the heat in the motor, its lifetime can be increased. In order to study the temperature at the various parts of five phase induction motor a five phase induction motor drive has been constructed experimentally. The LC filter is employed to suppress the harmonics, the current or voltage harmonics can drained out to low impedance device like filter [6-18].

II. FIVE PHASE INDUCTION MOTOR DRIVE

The constructional block diagram of five phase induction motor drive is as shown in Fig.1. The function behind the control of speed in induction motor is the V/F method. Five phase inverter is constructed using 10 IGBT switches S1-S10 and the five phase signal are generated using microcontroller. Each switch will be designed to conduct for a period of 180° conduction mode with each phase difference of 72°. Five phase inverter comprises of five legs, each leg consists of 2 IGBT’s, these 2 IGBT’s will conduct complement to each other.
Fig 1. Block diagram of five phase induction motor drive

Converter drive with input AC mains applied to generate DC power then the adjustable voltage to frequency is obtained by control circuitry to drive the motor and operated at low speed. J-type thermocouples are used to measure the temperature at various parts of the induction motor.

III. FIVE PHASE INDUCTION MOTOR WITH LC FILTER

Filter is a circuit that removes unwanted signals. Filter is connected at the output of the inverter as shown in Fig. 2. Filter is designed using the resonant frequency of 150 Hz to remove the dominant 3rd harmonic order, by using the relation as shown in (1).

\[ f_0 = \frac{1}{2\pi\sqrt{LC}} \] (1)

For \( f_0 = 150 \text{ Hz} \), the LC values are \( L = 0.1765 \text{ H} \) and chosen \( C = 1000 \mu\text{F} \). So \( L_1- L_5 = 0.1765 \text{ H} \) and \( C_1-C_5 = 1000 \mu\text{F} \).

Motor Parameters:
- Voltage = 200 V
- Current = 3.2 A
- Hp = 1Hp
- Speed = 1400 RPM
- Frequency = 50Hz

IV. EXPERIMENTAL RESULTS

The motor is operated at low frequency of 6 Hz and voltage of 24 V using the V/F method with torque load of 0.1565 Nm. Motor is subjected to run for a period of 4 hours and the temperature is measured for normal five phase drive (without filter) and five phase drive with filter, a graph has been plotted Time versus temperature as shown in Fig.3 and Fig.4 respectively. Table I shows the maximum temperature at various parts of the induction motor without and with filter.

![Fig 2. Five phase inverter with LC filter](image)

![Fig 3. Measurement of temperature at various parts of induction motor without filter with V= 24 V, f= 6Hz, torque load=0.15Nm](image)

![Fig 4. Measurement of temperature at various parts of induction motor with LC filter with V= 24 V, f= 6Hz, torque load=0.15Nm](image)

<table>
<thead>
<tr>
<th>Induction Motor Parts</th>
<th>Five phase drive (Without Filter) in °C</th>
<th>Five phase drive with Filter in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of the stator windings</td>
<td>34.22</td>
<td>30.37</td>
</tr>
<tr>
<td>Bottom of the stator windings</td>
<td>34.29</td>
<td>30.28</td>
</tr>
<tr>
<td>Inner frame 1</td>
<td>34.68</td>
<td>28.94</td>
</tr>
<tr>
<td>Inner frame 2</td>
<td>32.17</td>
<td>30.05</td>
</tr>
<tr>
<td>Body</td>
<td>33.64</td>
<td>29.83</td>
</tr>
<tr>
<td>Ambient</td>
<td>33.28</td>
<td>27.44</td>
</tr>
</tbody>
</table>

V. CONCLUSION

A Five phase induction motor drive has been constructed and operated at low frequency to study temperature at various parts of five induction motor with normal drive and with LC filter. The motor has been run...
for 4 Hr duration, graph is plotted. The rate of rise of temperature has been recorded without filter and with filter, it is concluded that the rate of rise of temperature at various parts of five phase induction motor is found to be less with LC filter has been presented in this experimental research work.

REFERENCE


[16] “Analysis and Study of Total Harmonic Distortion in Five Phase PWM Inverter using LC filter with neutral point DC link capacitor voltage balancing scheme”, Dr. Manjesh and Ananda A S, ICMMD 2014
