SPEED ESTIMATION OF INDUCTION MOTOR USING LABVIEW

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***Abstract*— The induction motors are widely applied due to their low price and ruggedness There are several methods for speed estimation in the literature. The optical tachometer is an expensive and less reliable method for the speed measurement. Hence sensorless method for speed estimation is an important topic of research. . In this paper a comparative analysis of different speed estimation methods is done. The comparative study of different methods shows that the motor current signature analysis (MCSA) is more accurate in speed estimation. This technique is experimentally verified on a 5HP , 3.7kW, 1430rpm 415V, 50Hz, 7.5A, 3Ø squirrel cage induction motor using Labview .The experimental and simulation results shows that the overall speed estimation error is within 5 rpm.**

***Keywords*— Induction motor, motor current signature analysis, observer method, speed**

I. INTRODUCTION

AC drives are more economical and popular due to advancement in digital technology and power semiconductor devices, more over they are cheap and easy to maintain. Commercially available speed measurement devices require direct contact with the shaft of the motor and are often inaccurate and unreliable after prolonged use. In almost all the developed countries, more than 50% of the electric energy generated is consumed by electric drives. The induction motors are generally used due to their low price and robustness. Large savings in energy usage can be achieved if high efficiency motors are universally used.

Field efficiency can be evaluated using several methods. The direct measurement of rotor speed is hard to detect, so sensorless rotor speed estimation is required. Several sensorless schemes includes [4,5] model reference adaptive control (MRAC) method and rotor slot harmonics (RSH) method. MRAC method requires information of equivalent circuit parameters of machine and this can be obtained from the standard test which is an intrusive task. Observer based method is an example for such method which is a parameter dependent method. The current and voltage drawn by the induction motor is applied to both the machine model and the observer .The derivation of the observer equations is based on the coupled circuit dq equations of the motor. But for motor current signature analysis (MCSA) method the sensorless speed estimation scheme does not require information of motor equivalent circuit parameters, structures of machine, switching frequency, and switching pattern.

II. LITERATURE SURVEY

In paper [1] an economical method that can help the plants to make right decision in replacing the inefficient induction motors with more efficient ones is discussed. The use of a few sets of measured data from field test coupled with the genetic algorithms for evaluating motor equivalent circuit instead of using the no load and blocked-rotor tests is proposed. In the past many methods were used to calculate the efficiency of induction motors, one common method is to test the motor under load conditions and then monitor the input and output at different load points using a dynamometer and torque transducer. This is the most straightforward method to measure the output power directly from the shaft without any need to calculate losses. Conventionally, the shaft torque method offers the most accurate field efficiency evaluation method, however, this is not suitable for the field evaluation because this process involves the removal of motor from service to place it on a test stand and couple it to the dynamometer. It can be seen that this method is impractical and costly.

The blocked-rotor test procedures require reduced voltage and frequency in addition to preventing the rotor from rotating which is a difficult task. The proposed method for estimating efficiency of induction motor in the field has been described.

In paper [2] different methods for evaluating field efficiency is discussed. Usually field efficiency is found by testing the motor under load conditions and then monitoring the input and output at different load points. This is the most straightforward method to measure the output power directly from the shaft without any need to calculate losses. Another efficient method depends on the no load and blocked-rotor test results. The engineers may estimate the motor efficiency based on manufacturer information which is given in the nameplate and measurements from slip method, current method etc. Hence, the error in estimated efficiency could be very high.

The paper [3] proposes a sensorless speed detection method based on the fast Fourier transform (FFT) spectral analysis. It is mainly concerned with the extraction of the speed information contained in the rotor slot-ripple harmonics using digital signal-processing techniques. This method has restrictions in terms of its dynamic performance due to the limited processing power and sampling rate of the hardware used.

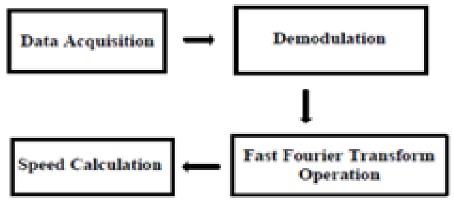
In the proposed paper[4] the speed of an induction motor (IM) can be estimated from the motor currents with Motor Current Signature Analysis (MCSA) using labview. This method consists of three steps. They are data acquisition, demodulation and FFT spectrum analysis. Motor Current Signature Analysis was developed by the Oak Ridge National Laboratory (ORNL). It is a highly sensitive, selective, and cost-effective means for online monitoring of a wide variety of heavy industrial machinery. It can be implemented using time domain or frequency domain analysis.

III. WORKING AND DESIGN

In this paper we have developed a Labview implementation of motor current signature analysis for 3Ø induction motor. It is known that a three-phase stator windings fed from a power supply will generate a resultant forward rotating magnetic field at synchronous speed which can induce voltage in rotor windings. The rotor induced voltage depends on the speed of rotor relative to the rotating magnetic fields. The Induced rotor currents produce an effective rotor magnetic field that can induces small currents in the stator windings having frequency in the range of sub-harmonic of the rotating magnetic field. As a result, the rotor frequency can be detected from the stator current spectrum. Then, the rotor speed can be calculated by this detected rotor frequency. This proposed technique requires the stator current waveform to be sampled and collected. Motor current signals can be obtained from the outputs of current transducers which are placed nonintrusively on one of the power leads. Since MCSA technique utilizes results of spectral analysis of the stator current of an induction motor to spot a speed of operating motor, thus it requires an accurate spectrum analysis. This technique consists of four main parts, i.e. data acquisition, demodulation, fast Fourier transform operation and speed calculation. It must be noted that this application requires only the frequency components of the signal and not of magnitude.

A. Block Diagram

The technique consists of four main parts, i.e. data acquisition, demodulation, fast Fourier transform operation and speed calculation. In this method the magnitude of the signal is not necessary only frequency components are required.



B. Design

5HP , 3.7kw, 1430rpm 415v, 50Hz, 7.5A, 3Ø squirrel cage induction motor was used to perform MCSA.

Samples to read = 32768

Samples/sec= 5120

Δf=0.1563

$$f_{low} = \frac{n_{low}}{60}$$

$f_{syn}= \frac{12}{6}$ where f_1= 50Hz

C. Components used

TABLE I
Components used

USB-6008	32 terminal, 12 bit device
La 55p	15V
Induction motor	5HP , 3.7kw

IV. Results

A. Simulation Results

The figure 1 represents the simulation model of observor based method.

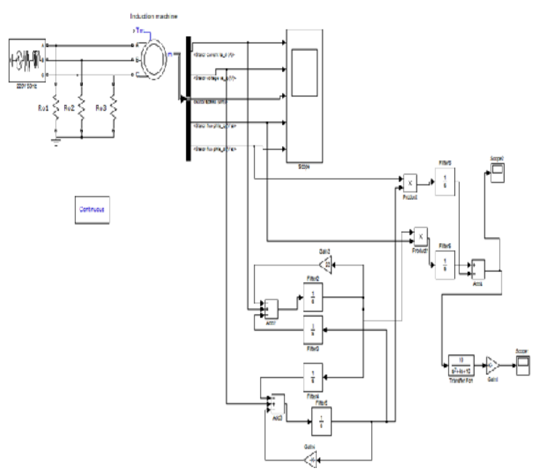


Fig 1. Simulation model of observor based model

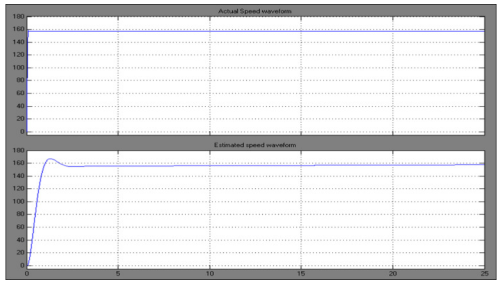


Fig 2. Simulation result

The simulation results of observer model based system is shown in figure 2 and error in speed was found to be 18 rpm. The simulation model and results for motor current signature analysis is shown in figure 3, 4, 5,6 and 7 respectively.

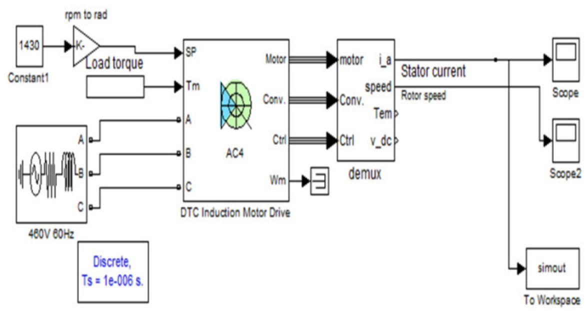


Fig 3. Input model of motor current signature analysis method.

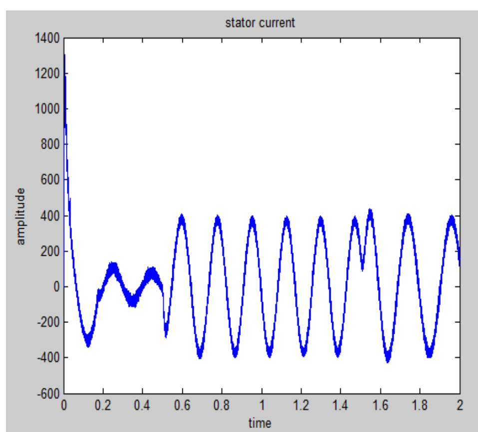


Fig 4. Stator current waveform

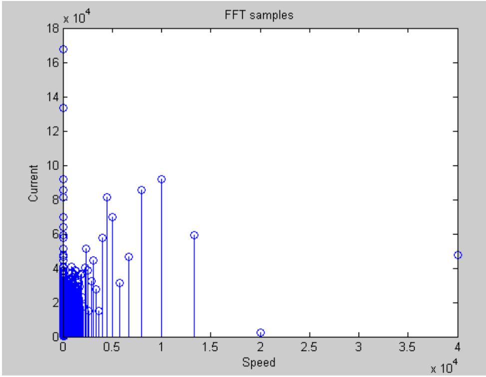


Fig 5. FFT analysis of stator current

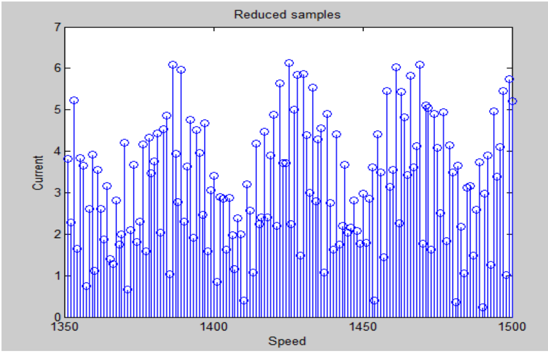


Fig 6. FFT of Stator current after FFT from N_{LOW} TO N_{SYNC}

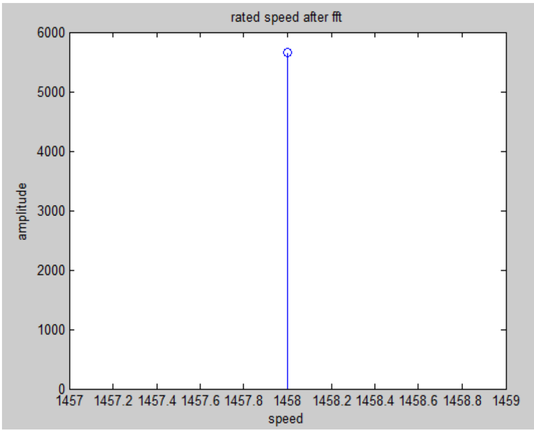


Fig 7. Maximum Rotor speed from FFT analysis

The simulation result of MCSA method shows that the error is less than 5rpm.

B. *Hardware implementations*

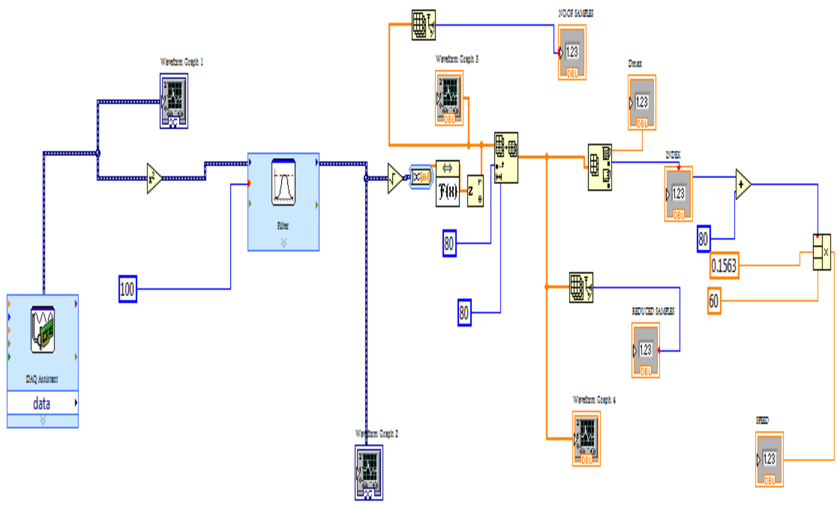


Fig 8. Simulation model of MCSA using Labview

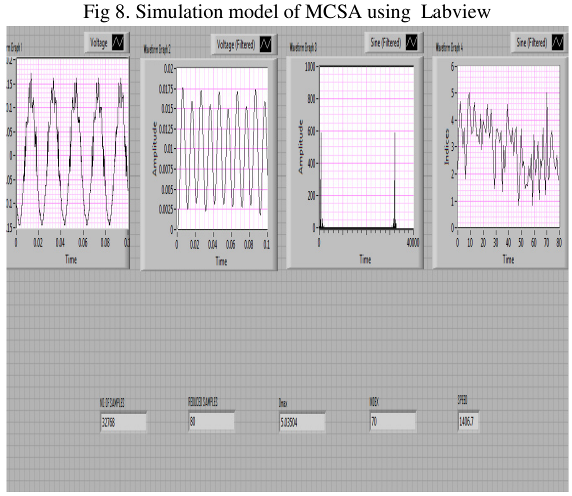


Fig 9. Simulation result using Labview

The comparision of actual speed and estimated speed for MCSA method using labview is shown in table 1. The error is less than 5 rpm.

Table 1

Actual speed Vs Estimated speed

ACTUAL SPEED	ESTIMATED SPEED	ERROR
1451	1453.09	-2.09
1452	1453	-1.00
1458	1454	4.00
1467	1462	-5.00
1474	1472.35	1.65
1480	1481.30	-1.70
1484	1482	2.00

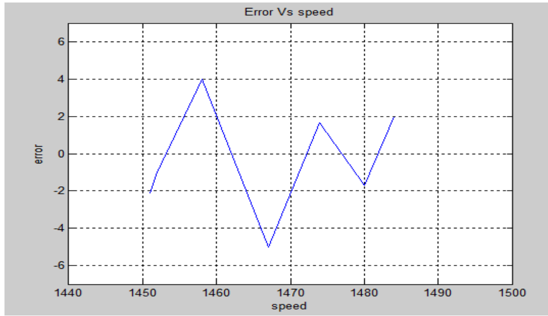


Fig9. Graph showing error Vs speed

V. CONCLUSION

The speed estimation of induction motor can be done using observer based method and motor current signature method. Observer based method is an intrusive method where as motor current signature method is nonintrusive method. Software simulation on MCSA using matlab simulink has been done. Labview implementation and its hardware implementation were done and it was compared with the observer based speed estimation. From the speed estimation the error was found to be 18rpm and 5rpm for Observer based method and motor current signature analysis respectively. The MCSA scheme can improve the performance of induction motor without any machine information or speed sensor.

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