Wireless communication that relies on data acquisition system including real-time monitoring of induction motor parameters

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ABSTRACT:
With MATLAB (Matrix Laboratory) software, an Arduino UNO and a Node Micro Controller Unit (Node MCU) Wi-Fi module are used in this paper to demonstrate techniques and procedures for wirelessly monitoring the parameters of a commonly used induction motor. The parameters that can be monitored using the methods described in this paper are current waveform, voltage waveform, temp (Celsius), rms value of both current and voltage, peak to peak value of current and voltage, power ratio, and magnitude spectrum of induction motor. The process of doing Motor Current Signature Analysis (MCSA) to evaluate motor health has been addressed in this study.

KEYWORDS: Induction motor, motor current signature analysis, MATLAB, magnitude spectrum
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1. INTRODUCTION

Induction motors are currently being utilised in several kinds of applications due to their many benefits. Induction motors are needed for pumping, drilling, pressing, linear actuators, and other applications. The gathering of information of the parameters of an induction motor is necessary for monitoring and assessing the motor to maintain flexibility and safe operation because it has numerous applications. In the manufacturing and industrial sectors, failures and flaws in motors might result in notable losses.

The flaw must be found as soon as possible in order to protect the motor. Prior to a serious malfunction and unexpected failure, induction motor condition tracking can identify possible vulnerabilities in the motor. The parameters of an induction motor while it is operating are one of the online health monitoring techniques described in this paper. The techniques described in this paper will contribute to a decrease in significant failures, unexpected closures, and service expenditures. [1]

Gathering data is a technology that is mentioned in this work that enables users to do automation tests and quickly check the performance of the motor using a user interface. [2]. This method uses data collecting software called MATLAB (Matrix Laboratory). The Arduino UNO platform (for cable connection) and the Node Micro Controller Unit (NodeMCU) ESP8266 Wi-Fi module (for wireless communication) are used to interface with MATLAB. The MySQL structure and phpMyAdmin were employed for the management of databases. [3].

This work has examined the use of Motor Current Signature Analysis (MCSA) to identify motor defects. In order to prevent production from stopping and quickly address deviations from ideal operating conditions, the parameters of the induction motor are tracked in real time and displayed on a laptop. To achieve the intended outcome, a microcontroller, laptop, temperature sensor,

the current transformer (CT), & potential transformer (PT) are utilised.

2. SYSTEM PERFORMANCE CHART

A generalised flow diagram for induction motor health monitoring and defect identification using intelligent techniques is shown in Figure 1. The induction motor use sensors and microcontrollers to detect signals from the issue area. These signals are then presented on a laptop for the operator to view and utilise in making decisions.

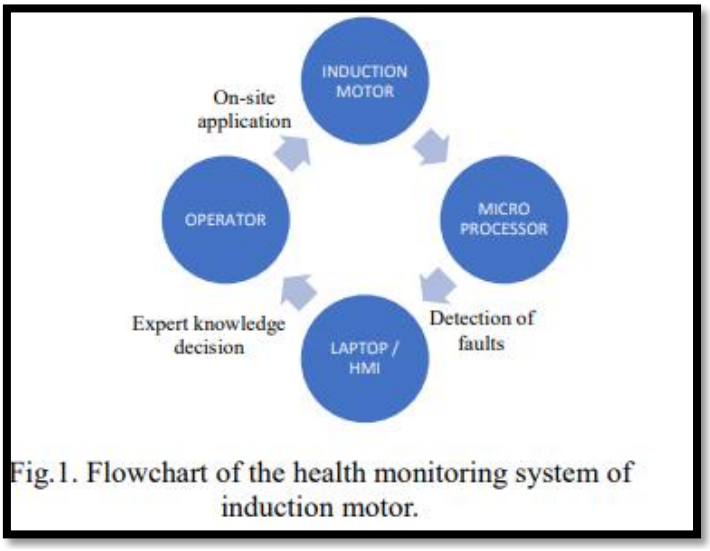

Fig.1. Flowchart of the health monitoring system of induction motor.

3. SYSTEM SETUP

3.1 HARDWARE SETUP

A normal, functioning 12 HP (373 Watts) single phase induction motor, a 12 HP single phase induction motor with a bearing fault, a 12 HP single phase induction motor with a rotor fault, a Direct Online (DOL) starter, a current transformer for sensing current flowing through the motor, a potential transformer for sensing voltage across the motor, and a Negative Temperature Coefficient (NTC) thermistor for Infrared (IR) sensor for measuring temperature.For wired and wireless communication, respectively, the analogue pins of the Arduino UNO and Node MCU ESP8266 pick up all four signals (current, voltage, temperature, and speed). Using a WIFI module (Node MCU ESP8266), we were able to wirelessly receive data on the laptop screen.

3.2 SOFTWARE SETUP

The system stores all information obtained via the analogue pins of the microcontroller in the MySQL (My Structured Query Language) database at intervals of ten seconds [4]. A free and open-source database management system is MySQL. SQL, or Structured Query Language, is employed. Data manipulation and storage are done with it.The system stores all information obtained via the analogue pins of the microcontroller in the MySQL (My Structured Query Language) database at intervals of ten seconds [4]. A free and open-source database management system is MySQL. SQL, or Structured Query Language, is employed. Data manipulation and storage are done with it.Fig. 2.

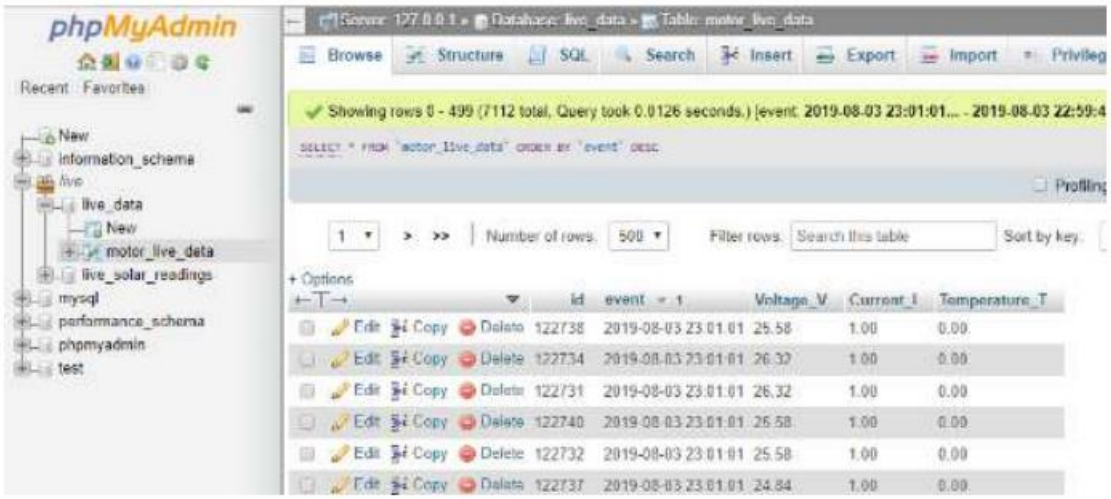

Fig.2.Data in PHP My admin

XAMPP (Cross-platform Apache MariaDB PHP and Perl) is used to send the data from MySQL to MATLAB for signal analysis. Developers can set up a local web server using the free, open-source XAMPP web server solution. The system uses MATLAB code to scale, filter, and amplify the raw data. Using the flowchart in Fig.3, the entire procedure is generalized.

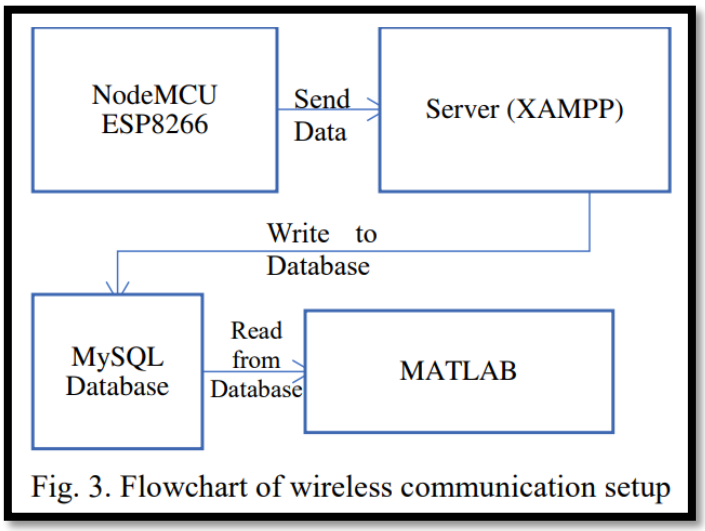

Fig. 3. Flowchart of wireless communication setup

Fig.4. shows the frequency spectrum of an induction motor in decibels (dB). Figure 5 depicts the single-sided amplitude spectrum of a current pulse. In Fig. 6, the current waveform of an induction motor is displayed on the screen of a smartphone.

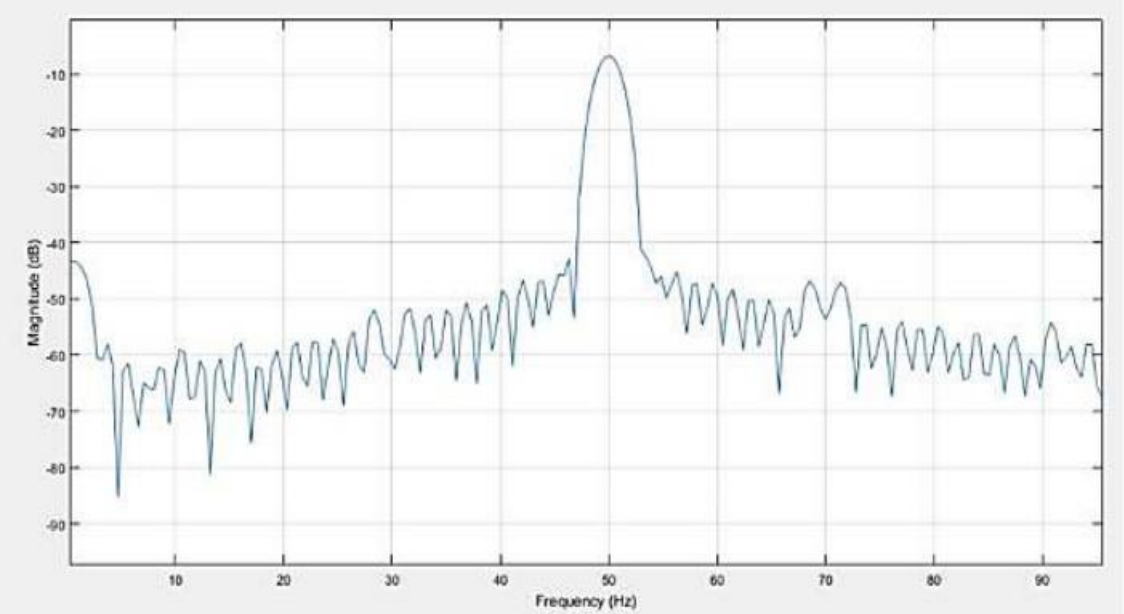

Fig.4. Frequency Spectrum in dB displayed on laptop

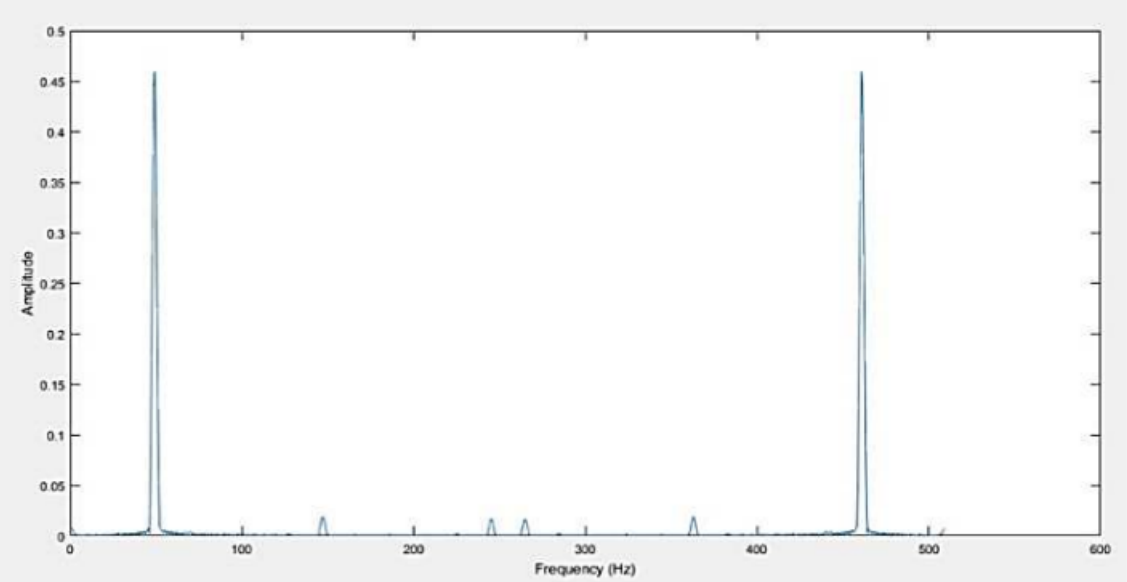

Fig.5. Single Sided Amplitude Spectrum of current signal displayed on laptop

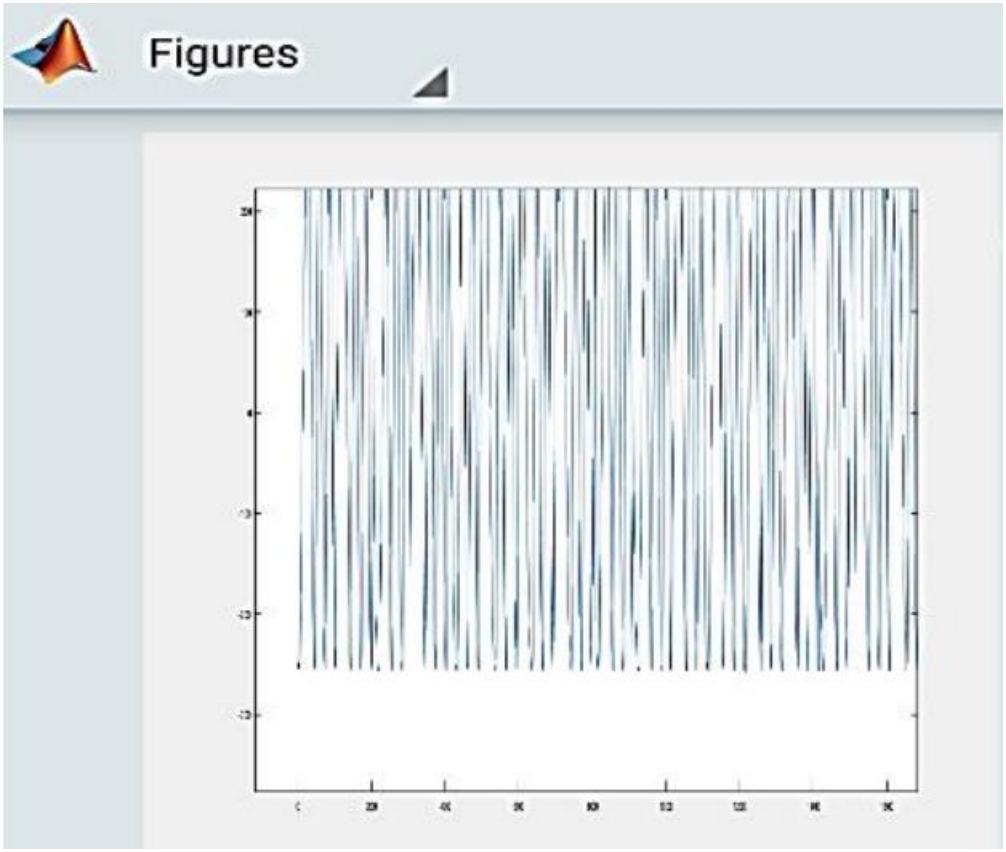

Fig.6. Current waveform on MATLAB on smartphone screen

Following the data collection, metrics like magnitude spectrum, power factor, power, rms value of voltage, peak to peak value of voltage, and current are extracted using MATLAB code. In order to make motor monitoring more user-friendly, a GUI (Graphical User Interface) is also developed, as shown in Fig. 7.

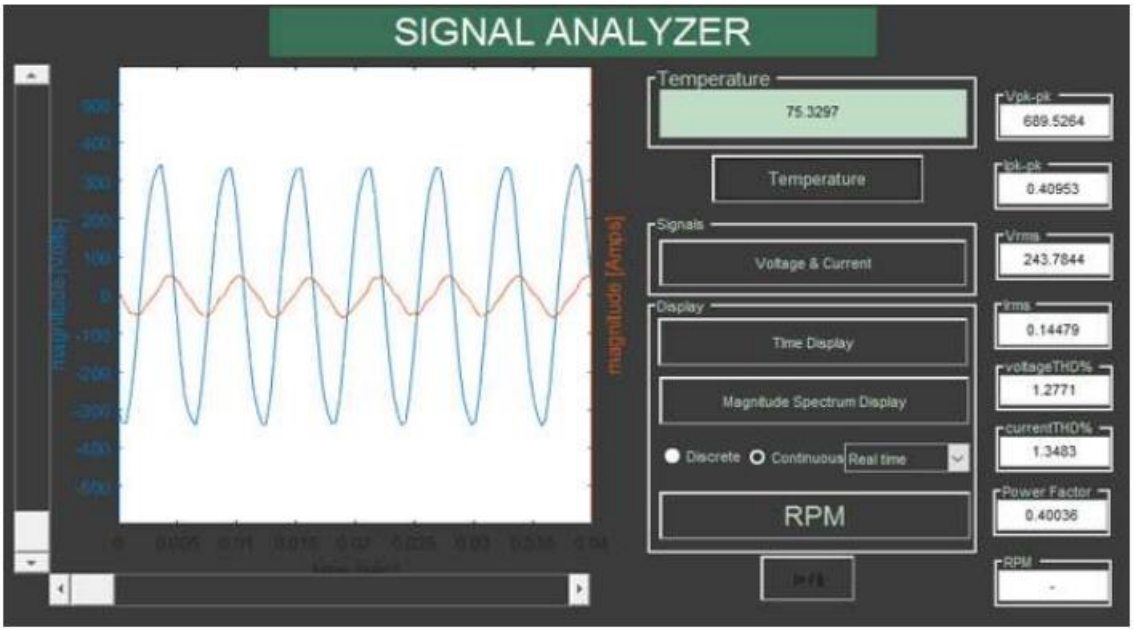

Fig. 7. GUI of Signal Analyzer

4. MOTOR CURRENT SIGNATURE ANALYSIS (MCSA)

MCSA is an approach for logging and analysing frequency-domain motor current measurements. It is a motor repair tool. It is used to test transformers, induction motors, generators, and other electrical equipment. MCSA detects the signal from the rotor and uses a current sensor to measure the stator current of the motor. The spectrum analyzer is then given the current signal. By examining current when the induction motor is running, MCSA may detect problems in the motor. [5].

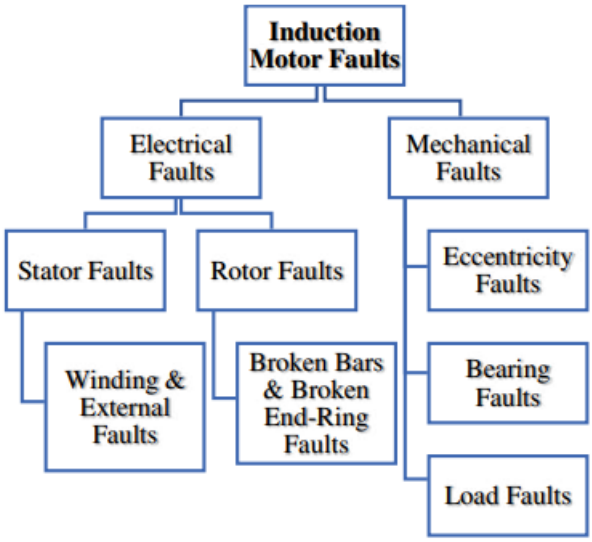

Fig.8. Various issues in induction motor

The MCSA can spot abnormal static and dynamic airgaps, broken or damaged rotor bars or end rings, stator flaws, abnormal stator winding connections, bearing issues, and gearbox issues. We concentrated on two failure types in this article: rotor faults and bearing faults [6]. For this, three single phase induction motors are used. First, the functioning motor was assessed. The inoperative gadgets were then tested.

4.1 ROTOR FAULTS

The MCSA can spot abnormal static and dynamic airgaps, broken or damaged rotor bars or end rings, stator flaws, abnormal stator winding connections, bearing issues, and gearbox issues. We concentrated on two categories of failures in this article: Rotor and bearing problems [6]. This is accomplished by using three single phase induction motors. First, the functioning motor was assessed. The troublesome motors were then put to the test. [7]. This system's rotor fault was brought about by drilling into the rotor bars. Figure 9 shows a separation of twice the slip frequency between the top and lower side bands or supply frequencies:

$$fb = f1\ (1 \pm 2s) \quad (1)$$

where,

fb = broken rotor bar frequency

$f1$ = supply frequency

s = per unit slip

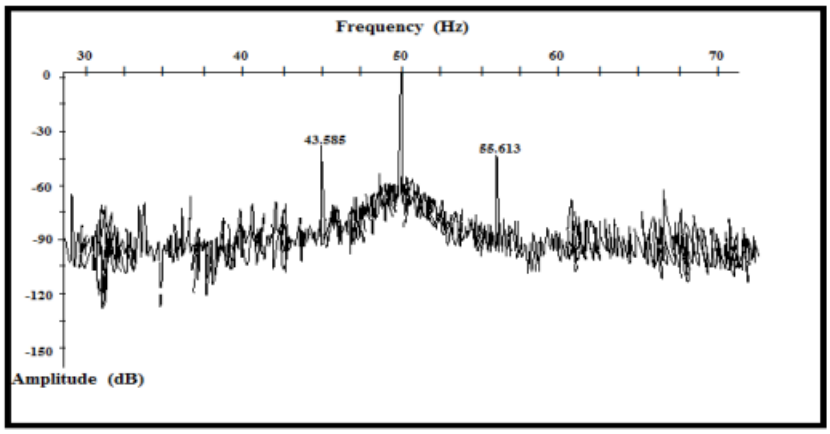

Fig.9. Frequency spectrum of a motor with broken rotor bars

During broken rotor bar fault the current components in stator windings can be detected at frequencies given by the following formula:

$fb = f1\ [k\ (1-sp\ ) \pm s]$ (2)

where, fb = broken rotor bar frequency

$f1$ = supply frequency

p = number of pole pairs

s = per unit slip

k = 1, 2, 3, …n

4.2 BEARING FAULTS

In order to achieve this, three single phase induction motors are used. First, the motor's health was assessed. Then tests were performed on the faulty motors. [7]. Drilling through the rotor bars caused the rotor fault in this system. In Fig. 9, the supply frequencies for the upper and lower side bands are separated by twice the slip frequency. [8].

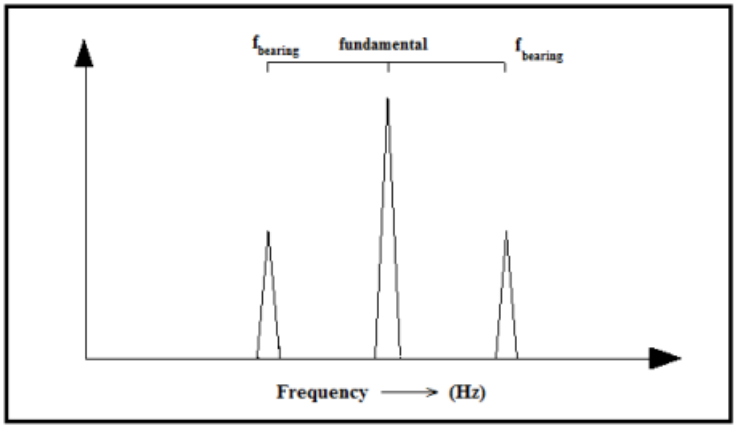

Fig.10. Frequency spectrum of motor with damaged bearings

For finding bearing fault the current components can be detected at frequencies given by the following formula

e. $f0 = 0.4nfm$ (3)

$f1 = 0.6nfm$ (4)

where, $f0$ = lower frequency

$f1$ = upper frequency

n = number of balls in the bearings

fm= rotor's mechanical frequency

5 FAULT DETECTION

For the purpose of locating defects, the spectrum of an induction motor's supply current and various frequencies are studied. A backward rotating field occurs in the airgap as a result of the harmonic portion of the supply current reforming when a motor fails [9]. This paper discusses one of the fault detection techniques, which is described below.

Fast Fourier Transform (FFT)

MCSA analyses the new rotational flux components that create current harmonics in the stator current. To measure motor current, a current sensor (CT) and data collection (FFT on stator current) are needed. As a function of first harmonic amplitude, the data are computed and assessed. Thus, the impacts of high motor load circumstances are reduced. The current readings are time-domain-recorded, and after that, they are digitalized. A frequency domain signal analysis method is the FFT. The number of computations is reduced with this technique. FFT is best suited for invariable signals, not variable signals. [10].

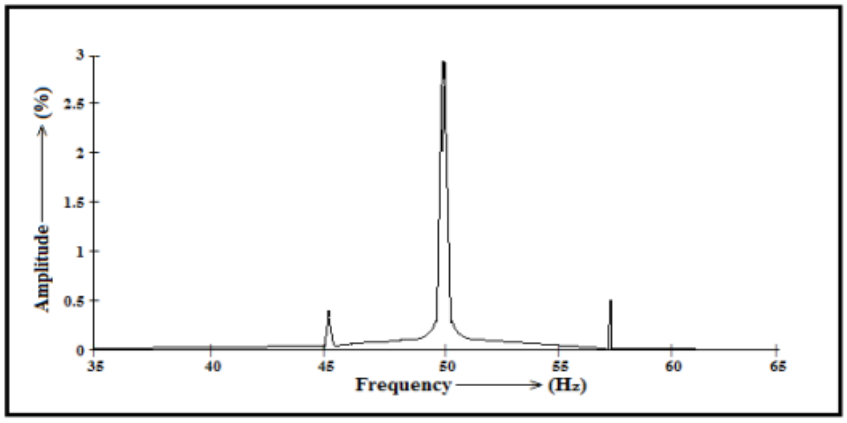

Fig.11. FFT with initial condition for broken bars

6. CONCLUSIONS

The purpose of this work was to develop an IOT-based induction motor parameter, health monitoring, and analysis system. An induction motor's health may be accurately and promptly monitored, which helps improve system dependability and stop catastrophic or developing defects. MCSA is a highly effective and economical tool for diagnosing induction machinery faults.

This device can be used to identify and pinpoint a variety of mechanical and electrical problems with induction motors. Machine flaws can be found using the stator current magnitude spectrum. The sidebands and harmonics that surround the fundamental frequency shed light on the defect's characteristics. The assessment of wear and tear on remote motors that are unavailable during plant operations is made easier with the help of MCSA's online motor health monitoring.

REFERENCES

[1] K. M. Siddiqui, K. Sahay and V.K.Giri, "Health Monitoring and Fault Diagnosis in Induction Motor," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 3, no. 1, pp. 2320-3765, 2014.

[2] Cakir, H.C. and G. T., "Remote Controlling and Monitoring of Induction Motors through Internet," TELKOMNIKA Indonseian Journal of Electrical Engineering, vol. 12, no. 12, pp. 8051-8059, 2014.

[3] Bayindir and S. V. R., "Real-Time Monitoring and Control of the Parameters of an Induction Motor," ELEKTRONIKA IR ELEKTROTECHNIKA, vol. 19, no. 10, 2013.

[4] S. Liu, Z. Ji, Y. Wang and Z. Zhang, "Real time state monitoring and fault diagnosis system for motor based on LABVIEW".
[5] S. A. A. R., A. A. and G. Ibrahim, "A More Reliable Method for Monitoring the Condition of ThreePhase Induction Motors Based on Their Vibrations," vol. 9, 2012. 5
[6] Duan and F., "Induction Motor parameters estimation and fault diagnosis," vol. 1, 2014.
[7] T. Neelam, "Fault Diagnosis of Induction Motor using MCSA," International Journal of Electrical and Computer Engineering, vol. 8, no. 1, pp. 13- 18, 2016.
[8] K. S. Gaeid, H. W. Ping, M. Khalid and A. L. Salih, "Fault Diagnosis of Induction Motor Using MCSA and FFT," Electrical and Electronic Engineering, 2012.
[9] N. Mehla and R. Dahiya, "An Approach of Condition Monitoring of Induction Motor Using MCSA," 2007.
[10] C. Marcelo, J. P. Fossatti and J. I. Terra, Fault Diagnosis of Induction Motors Based on FFT, Intech, 2012.