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Electrical Current Signature Analysis

Abhishek Singh
Department of Electrical and Electronics Engineering
PSIT, Kanpur India
abhisheksingh450@yahoo.com

Deepak Singh
Department of Electrical and Electronics Engineering
PSIT, Kanpur India
deepaksingh1729c@gmail.com

Narendra Singh
Department of Electrical and Electronics Engineering
PSIT, Kanpur India
nsrbusy@gmail.com

Pulkit Gupta
Department of Electrical and Electronics Engineering
PSIT, Kanpur India
pulkit.bigking@gmail.com

Abstract: Induction motors have become the "workhorses" of industry and are the most widely used electrical machines. They can typically consume between 45 to 55% of all the generated capacity of an industrialized nation. This article focuses on the industrial application of Electric Current Signature Analysis (ECSA) to diagnose faults in three-phase induction motor drives. ECSA is a non-invasive, on-line monitoring technique for the diagnosis of problems in induction motors. Reliability based maintenance (RBM) and condition- based maintenance (CBM) strategies are now widely used by industry, and health monitoring of electrical drives is a major feature in such programs.

Keywords: Arduino, GSM Module, Internet of Things.

I. INTRODUCTION

Many operators use CBM strategies in parallel with the conventionally planned maintenance schemes. This can reduce unpredicted failures and shutdown, increase the time between planned shutdowns for standard maintenance, and reduce maintenance and operational costs. The operation of electrical machines in an over limit condition can also be avoided. Failure surveys have reported that the percentage failure of components in induction motors is typical:

a) Stator related: 38%
b) Rotor related: 10%
c) Bearing-related: 40%
d) Others: 12%.

During the past 15 years, there has been a substantial amount of research into the development of new condition monitoring techniques for induction motors. This article presents a selection of industrial case histories that verify ECSA can diagnose problems such as broken rotor bars, shorted turns in low voltage (LV) stator windings, and air-gap eccentricity in three-phase induction motor drives

II. INTERNET OF THINGS

Internet of Things generally means providing network connectivity and computing capability to various objects, sensors and everyday items which are not normally considered computers and allowing these devices to generate data, exchange data on the network and consume data with minimal human intervention. There is, however, no single, universal definition.

The IoT allows objects to be controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When sensors and actuators are augmented to IoT, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart homes, smart cities, smart grids and intelligent transportation. Every object is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that go beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid, and expanding to the areas such as smart cities.
The concept of the Internet of Things was invented by and the term coined by Peter T. Lewis in September 1985 in a speech he delivered at a U.S. Federal Communications Commission (FCC) supported session at the Congressional Black Caucus 15th Legislative Weekend Conference.

III. CURRENT SIGNATURE ANALYSIS

The Motor Current Signature Analysis system consists of two units:

- Sensing unit
- Control unit/ Switching Unit

A. *Sensing unit*

The block diagram for sensing unit is shown below.

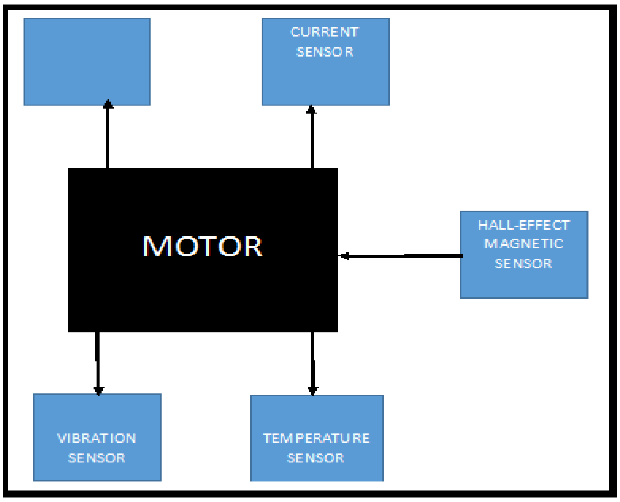

Fig. 1 Block diagram of sensing unit

Sensing unit comprises of the voltage sensor, a current sensor, temperature sensor, hall effect magnetic sensor and vibration sensor for sensing the various current signatures of the motor.

The voltage Sensor used here is a Bridge Rectifier Type. The four diodes labeled D1 to D4 are sort in "series pairs" with only two diodes conducting current throughout each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

The smoothing capacitor transfigures the full-wave rippled output of the rectifier into a smooth DC output voltage. Predominantly, for DC power supply circuits the smoothing capacitor is an Aluminum Electrolytic type that has a capacitance value of 100uF or more with repeated DC voltage pulses from the rectifier charging the capacitor to peak voltage.

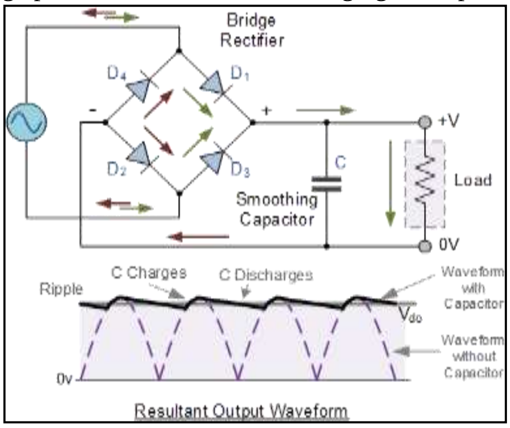

Fig. 2 Voltage sensor using Bridge Rectifier

The current sensor used here is Hall Effect Current Sensor. Sensing and controlling current flow is a fundamental necessity in a wide variety of applications including, over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, programmable current sources, etc. This ACS721 current module is established on the ACS712 sensor, which can exactly detect AC or DC current. The maximum AC or DC that can be recognized and can reach 5A and the present current signal can be read via analog I / O port of Arduino.

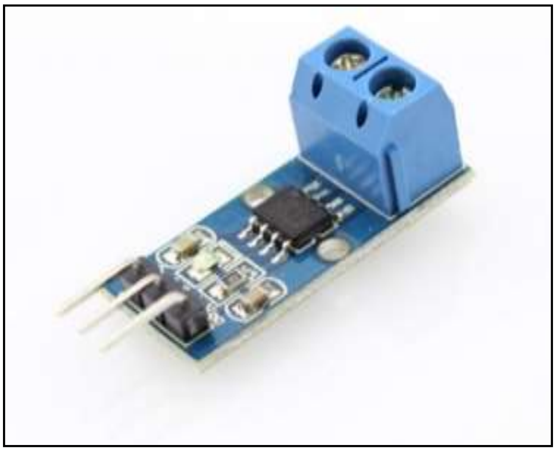

Fig 3: Current Sensor

This basic piezo sensor from Measurement Specialties is often used for flex, touch, vibration and shock measurements. A small AC and large voltage (up to +/-90V) is created when the film moves back and forth. A simple resistor should get the voltage down to ADC levels. Can also be used for impact sensing or a flexible switch, comes with solderable crimp pins.

Fig 4: Vibration Sensor

LM35 is a precision IC temperature sensor with its output corresponding to the temperature (in degree Celsius). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, the temperature can be resolute more accurately than with a thermistor. It also possesses low self-heating and does not cause more than 0.1-degree Celsius temperature rise in still air.

The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every degree Celsius rise/fall in ambient temperature, *i.e.,* its scale spect is 0.01V/ degree Celsius.

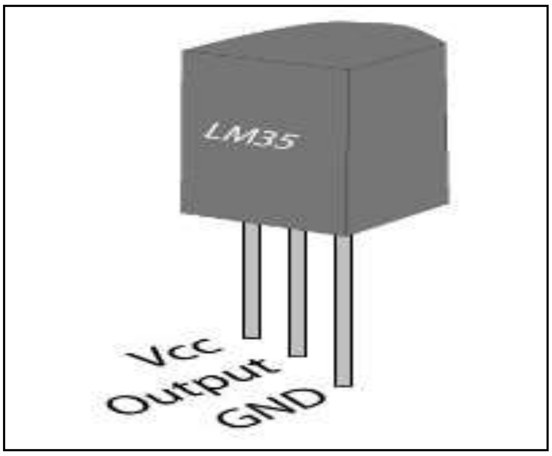

Fig 5: Temperature Sensor

A Hall effect sensor is a transducer that alters its output voltage in retort to a magnetic field. Hall effect sensors are used for proximity switching, positioning, speed identification, and current sensing applications.

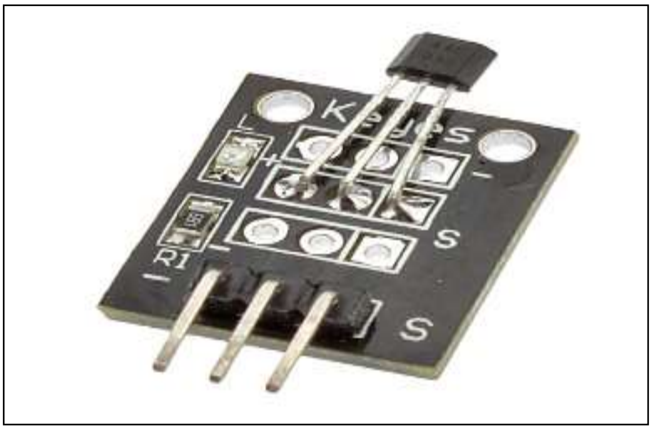

Fig 6: Hall Effect Magnetic Sensor

B. Control unit

The block diagram for control unit or pumping unit is shown below.

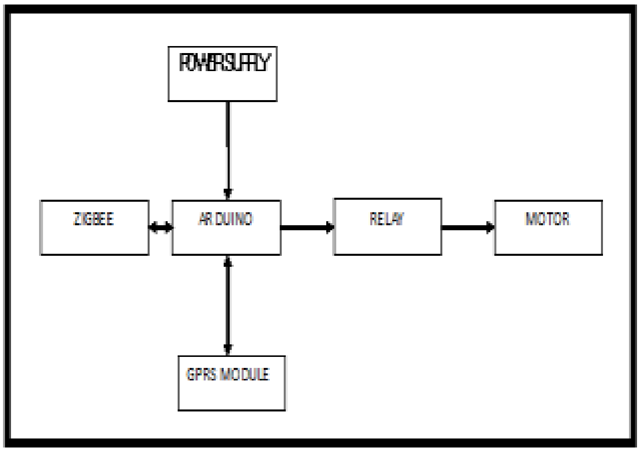

Fig. 7: Block diagram of control/Switching unit

Control unit comprises of a microcontroller which switches the motor ON/OFF with the help of relays, depending on the values received by the sensors whether they are normal or not.

C. Arduino

Arduino is an open-source electronics prototyping platform. It is based on flexible and easy-to-use hardware and software. The microcontroller on the board can be programmed using the Arduino programming language and the Arduino development environment. It is a tool for making computers that can sense and control more of the physical world than a desktop computer. It's an open-source computing platform based on a simple microcontroller board and a development environment for writing software for the board.

Fig. 8: Arduino Board

Arduino can be used to develop interactive systems, taking inputs from a variety of switches or sensors, and controlling a variety of actuators such as lights, motors, relays etc. Arduino projects can be stand-alone, or they can be communicated with software running on a computer. The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

D. Zigbee

Zigbee is a wireless communication technology. Zigbee is preferred over other wireless technologies because of its low power consumption and its ability to connect a large number of devices into a single network. Zigbee technology uses the globally available, license-free2.4GHz frequency band.

Zigbee uses a standardized set of high-level communication protocols sitting atop cost-effective, low-power digital radios based on the IEEE 802.15.4standard for wireless personal area networks. Zigbee technology is widely deployed in wireless control and monitoring applications because of its low cost. It has a longer life with small batteries due to its low power consumption. The mesh networking provides high reliability and larger range.

E. GSM module

GSM stands for global system for mobile communication. GSM is a mobile communication modem. GSM is an open and digital cellular technology used for transmitting mobile voice and data services. It operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. A GSM modem is devices which can be used to make a computer or any other microprocessor communicate over a network. A SIM card is required in GSM module to operate it over a network range subscribed by the network operator. It can be connected to a microcontroller through serial, USB or Bluetooth connection.

IV. SYSTEM OPERATION

The voltage, current, rpm, temperature and vibration sensor sense various values of the motor under healthy working conditions. These standard values are set and are used as a reference value for the protection system. When the values go beyond a safer limit the control unit gives a signal to the relay and switches OFF the circuit. Hence, the equipment is saved from getting burned.

Control unit is the heart of the whole system; it controls the overall protection system. It takes the input from the voltage, current, rpm, temperature and vibration sensor sense through ZigBee and according to the written program it turns ON or OFF the motor depending upon the instantaneous conditions. It also indicates the condition of the motor. Also, it uploads the data on the internet via GSM module. When the system is abnormal the motor supply is cut and when the conditions become normal the motor is again switched ON. Thus, the control unit controls the operation of the motor. Zigbee module is a wireless communication technology same as Bluetooth but different in a way that it is a full duplex mode of communication. It is used here to have a wireless link between sensing unit and the control unit. AC or DC motor or any type of electrical equipment can be protected using this system. On the basis of abrupt value detection, motor ON/OFF working will be done.

CONCLUSION

This paper gives a brief idea about a protection scheme that may prove to be very useful in predicting the future faults that may occur and may damage the electrical equipment. Furthermore, it saves time and money and helps in avoiding black-outs and sudden shut-down of the power system.

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