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Remote Condition Monitoring and Fault Alert System of the Induction Motor

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Abstract: Electric Machines play a very important role in industries and electric vehicles, etc. Continuous work of Induction Motors (IM) is an exigency for the recent industries which without a doubt influences the reliability and stability of the production process. If any one of the motor faults occurs, the particular system stops its work. It leads to an increase in the loss in the particular production unit due to the unscheduled downtime. This problem can be addressed by using **Condition Monitoring** based on IoT and Sensor Technology.
ESP32 send the signals to the Piezoelectric Buzzer to alarm and also the information can be sent to the server Node-Red. In these, we create a dashboard to display the sensing parameters and also have a voice intimation when the fault occurs.

Keyword:. ESP32 Module, ZMPT101B AC Single Phase Voltage Sensor, ACS712 Hall Effect Sensor, NTC Thermistor Sensor.

INTRODUCTION

In the evolution of electrical technology, DC motors were widely used different industrial applications. After the invention of ac motors especially induction motors the view of industry become changed due to the wide advantage of induction motors. An induction motor has two parts such as a stationary part and a rotating part. Two parts are interlinked by mutual induction that is the transformer principle. The performance of the induction motor depends upon the above electrical and mechanical parameters.

I.A Objectives:

The Objectives of this project are,
1. To monitor and control an induction motor based on the Internet of Things (IoT) for safe and economic data communication in industrial fields.
2. To start or stop the induction machine to avoid system failures by Automatic and manual control methods.

II. METHODOLOGY

II.A Components:

The basic components involved in this hardware project are,

- Single Phase Induction Motor
- ESP32 Module
- ZMPT101B AC Single-Phase Voltage Sensor
- ACS712 Hall Effect Sensor
- NTC Thermistor Sensor
- Infrared Sensor
- ADXL335 Accelerometer Module
- Piezo-electric Buzzer

II.B. Single Phase Induction Motor

Capacitor Start Capacitor Run Induction Motor:

The capacitor-start capacitor-run motor is a type of single-phase induction motor. The capacitor-start capacitor-run induction motor is also known as **Two Valve Capacitor Motor.**

The capacitor-start capacitor-run induction motor consists of a squirrel cage rotor and its stator has two windings, viz. the **starting** or **auxiliary winding** and the **main** or **running winding**. The two windings are displaced by an angle of 90° in the space. This motor uses two capacitors – the **starting capacitor** *(C_S)* and the **running capacitor** *(C_R)*. The two capacitors are connected in parallel at the instant of starting. In order to obtain a high starting torque, a large starting current is required. For this, the capacitive reactance in the starting winding should be low. Hence, for X_S to be small, the value of starting capacitor *(C_S)* should be large. The starting capacitor C_S is a short-time rated electrolytic capacitor. During the normal operation of the motor, the rated line current should be smaller than the starting current.

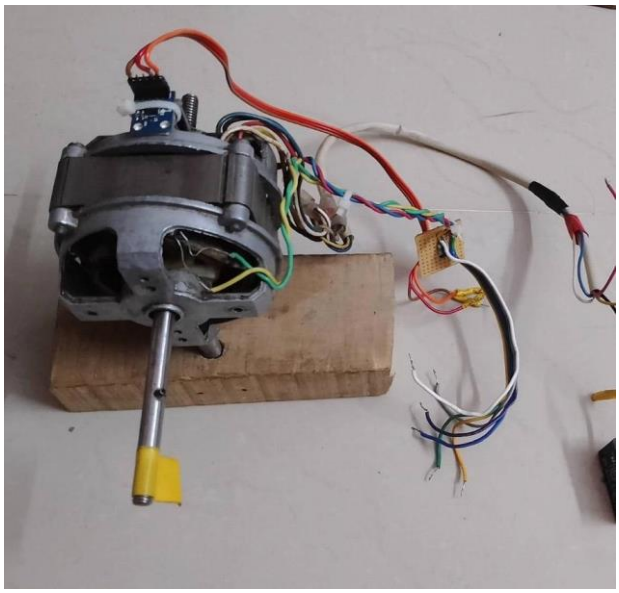

fig 2.B. Induction motor

II.C ESP32 Module

ESP32 is the name of the chip that was developed by Espressif Systems. This provides Wi-Fi (and in some models) dual-mode Bluetooth connectivity to embedded devices. While ESP32 is technically just the chip, modules and development boards that contain this chip are often also referred to as "ESP32" by the manufacturer.The ESP32 chip has a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, with a clock rate of over 240 MHz.

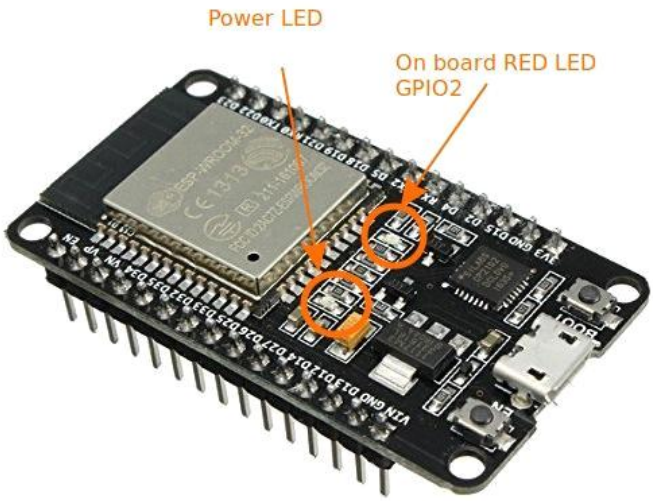

fig 2. C ESP32 Module

II.D ZMPT101B AC Single Phase Voltage Sensor

ZMPT101B AC Voltage Sensor is the best for the purpose of the DIY project, where we need to measure the accurate AC voltage with a voltage transformer. This is an ideal choice to measure the AC voltage using Arduino/ESP8266/Raspberry Pi like an open-source platform. In many electrical projects, an engineer directly deals with measurements with a few basic requirements like High galvanic isolation, Wide Range, High accuracy, and Good Consistency. Onboard precision miniature voltage transformer, The active phase AC output voltage transformer module. Onboard precision op-amp circuit, signal sampling and appropriate compensation for precise functions. Modules can be measured within 250V AC voltage, and the corresponding analog output can be adjusted. It is brand new, good quality high performance.

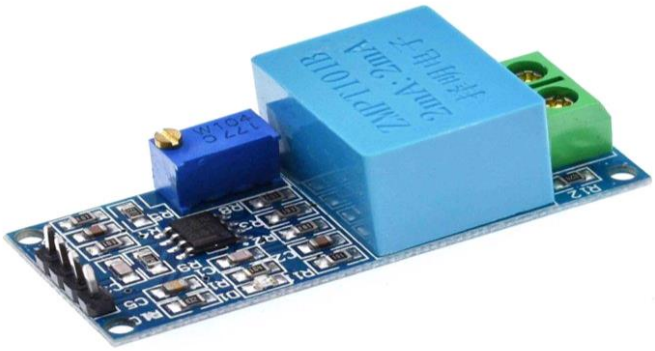

fig 2. D ZMPT101B AC Single Phase Voltage Sensor

II.E ACS712 Hall Effect Sensors:

Hall Effect Sensors consist basically of a thin piece of a rectangular p-type semiconductor material such as gallium arsenide (GaAs), indium antimonide (InSb) or indium arsenide (InAs) passing a continuous current through itself. When the device is placed within a magnetic field, the magnetic flux lines exert a force on the semiconductor material which deflects the charge carriers, electrons and holes, to either side of the semiconductor slab. This movement of charge carriers is a result of the magnetic force they experience passing through the semiconductor material. As these electrons and holes move sidewards a potential difference is produced between the two sides of the semiconductor material by the build-up of these charge carriers. Then the movement of electrons through the semiconductor material is affected by the presence of an external magnetic field which is at right angles to it and this effect is greater in a flat rectangular-shaped material.

Fig 1.F ACS712 Hall Effect Sensor

II.F Negative Temperature Coefficient Thermistor

NTC stands for "Negative Temperature Coefficient". NTC thermistors are resistors with a negative temperature coefficient, which means that the resistance decreases with increasing temperature. They are primarily used as resistive temperature sensors and current-limiting devices. The temperature sensitivity coefficient is about five times greater than that of silicon temperature sensors (silistors) and about ten times greater than that of resistance temperature detectors (RTDs). NTC sensors are typically used in a range from −55 to +200 °C. The non-linearity of the

relationship between resistance and temperature exhibited by NTC resistors posed a great challenge when using analog circuits to accurately measure temperature. However, rapid development of digital circuits solved that problem through enabling computation of precise values by interpolating lookup tables or by solving equations which approximate a typical NTC curve.

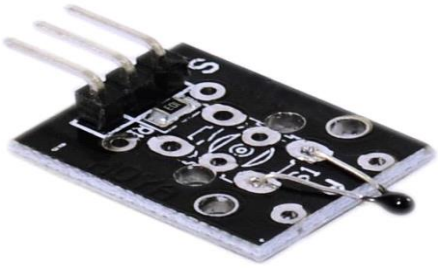

fig 1.G. Negative Temperature Coefficient Thermistor

II.G. Infrared Sensor:

IR Sensor module has the great adaptive capability of the ambient light, having a pair of infrared transmitters and the receiver tube, the infrared emitting tube emits a certain frequency, encounters an obstacle detection direction (reflecting surface), and infrared is reflected back to the receiver tube receiving, after a comparator circuit processing, the green LED lights up, while the signal output will output digital signal (a low-level signal), through the potentiometer knob to adjust the detection distance, the effective distance range 2 ~ 10cm working voltage of 3.3V-5V. The detection range of the sensor can be adjusted by the potentiometer, with little interference, easy to assemble, easy to use features, and can be widely used for robot obstacle avoidance, obstacle avoidance car assembly line count and black-and-white line tracking and many other occasions.

Fig 1.H Infrared Sensor

II.F. ADXL335 Accelerometer Module

An accelerometer is an electromechanical device that will measure acceleration forces. It shows acceleration, only due to the cause of gravity i.e. g force. It measures acceleration in g units. On the earth, 1g means an acceleration of 9.8 m/s2 is present. On the moon, it is 1/6th of the earth and on mars, it is 1/3rd of the earth. Accelerometer can be used for tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

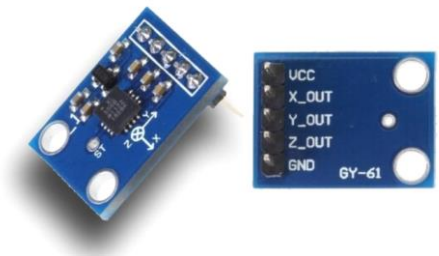

Fig 1. F. ADXL335 Accelerometer Module

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II.G. Piezoelectric Buzzer:

A piezo buzzer is a sound-producing device. The main working principle is based on the theory that, whenever an electric potential is applied across a piezoelectric material, a pressure variation is generated. A piezo buzzer consists of piezo crystals in between two conductors. When a potential difference is applied across these crystals, they push one conductor and pull the other conductor by their internal property. The continuous pull and push action generates a sharp sound wave. Piezo buzzers generate a loud & sharp sound. So, they are typically used as alarm circuits. Also, they are used to make an alert of an event, signal or sensor input. A special-characteristics of piezo-buzzer is, the sound pitch or level is not dependent on the voltage level that is, it works only in a specific voltage range. Typically, a piezo buzzer produce can generate a sound in the range of 2 to 4 kHz

- **Experimental Procedure**

III.A. HARDWARE IMPLEMENTATION: The supply is given to the Indutcion motor and the sensors, the sensors sense from the IM with continuous monitoring their parameters and then ESP32 receives the data information of parameters like Voltage, Temperature, Current, Vibration, etc.

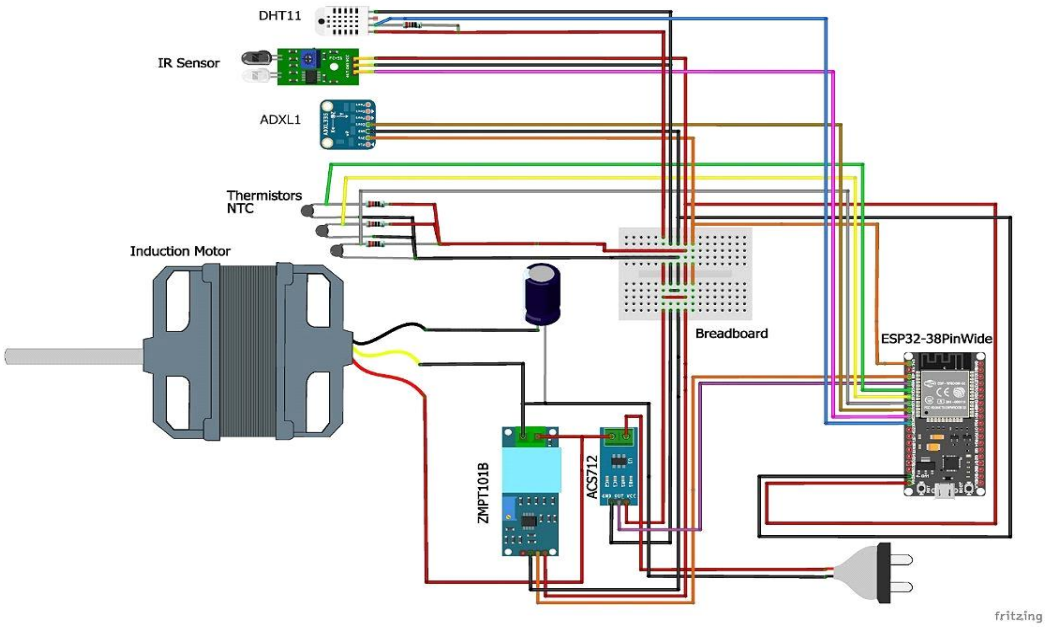

fig:3.A Circuit diagram of hardware implementation

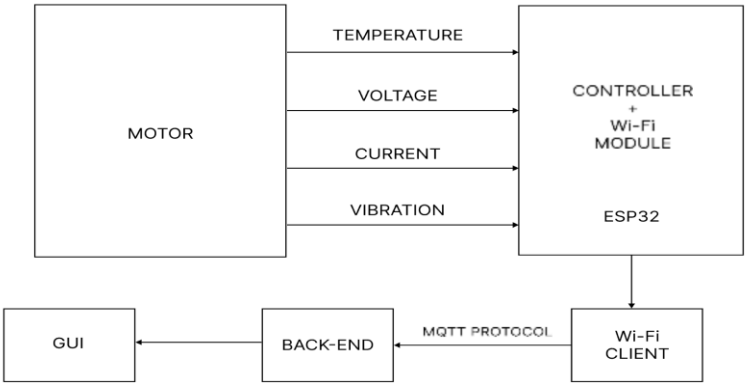

fig 3.Block Diagram of Hardware Implementation

The data goes to the Wi-Fi client that which is the server can build with backend programming to create a dashboard for monitoring the real time monitoring parameters to the interface through the server NodeRed.

WORKING

The 230 v AC supply can be given to the Induction motor. The motor is tied up with the vibration ADXL335 accelerating sensor and then in the stator the NTC thermistor can be soldered. The power and data pins are coming from the motor then it connected with the ZMPT1018 PT Sensor and ACS712 Hall effect current sensors and Infrared Sensor those are connected in the pins of the ESP32. The supply to the ESP32 is 5V DC supply and the program for it can be loaded to this module. The ESP32 is connected with the Server Node-Red by the IOT and Wi-Fi connectivity and the server can also be programmised. On the server we create the dashboard using the software programs coding. They are shown in the Software Program. The ESP32 is also connected with the Piezo Electric Buzzer . Now the motor can be switched ON the continuous supply is going to The IM and also the Sensors and modules. The sensors sense the parameters continuously by the condition monitoring system and the data can be send the information (parameters like voltage , current, temperature, vibration) to the ESP32. Then the real time data can be analysed and related to the previous analaysis real time data information from the database. Those collected Data's can be also stored in the server of the particular event for the future use. If the value are increased from the previous value the built backend software can confirmed the fault. Then the intimation is going to the HMI which is connected with GUI from the server NodeRed sends the information to the control room Authorized person (by the created Dashboard) to do the necessity work and also the sudden intimation can be alarmed by the using of Peizo electric Buzzer and also in voice command

```
#include <WiFi.h>
#include <PubSubClient.h>
// Update these with values suitable for your network.
const char* ssid = "spydy";
const char* password = "bfr12345";
constchar*mqtt_server= "test.mosquitto.org";
WiFiClient espClient;
PubSubClient client(espClient);
unsigned long lastMsg = 0;
#defineMSG_BUFFER_SIZE (100)
#define r pin 5
//crest_fact, form_fact, sd_acc, rms_acc,
mean_acc,max_acc,min_acc
char msg[MSG_BUFFER_SIZE];
char temp1[MSG_BUFFER_SIZE];
char temp2[MSG_BUFFER_SIZE];
char temp3[MSG_BUFFER_SIZE];
char crest[MSG_BUFFER_SIZE];
char form[MSG_BUFFER_SIZE];
char sd[MSG_BUFFER_SIZE];
double mean_acc = 0;
double sum_for_mean = 0;
double mean_count = 0;
char rms[MSG_BUFFER_SIZE];
char mean_[MSG_BUFFER_SIZE];
char max_[MSG_BUFFER_SIZE];
char min_[MSG_BUFFER_SIZE];
char volt_[MSG_BUFFER_SIZE];
=0char amp_[MSG_BUFFER_SIZE];
char watt_[MSG_BUFFER_SIZE];
char data_[MSG_BUFFER_SIZE];
int value = 0;
//temp variables
const int temp1Pin = 34;
const int temp2Pin = 35;
const int temp3Pin = 32;
int tempSensor1 = 0;
int tempSensor2 = 0;
int tempSensor3 = 0;
const int z_out = 33;
int  z_adc_value;
double z_g_value;
double max_acc = 0;
double min_acc = 0;
  WiFi.begin(ssid, password);
while(WiFi.status()!= WL_CONNECTED) {
```

```
double sum_for_rms = 0;
double rms_acc = 0;
double sum_for_sd = 0;



double sensorValue1 = 0;
double sensorValue2 = 0;
int crosscount = 0;
int climb_flag = 0;
int val[100];
int max_v = 0;
double VmaxD = 0;
double VeffD = 0;
double Veff = 0;
const int voltPin = 36;

const int sensorIn = 39;      // pin where the OUT pin from sensor is connected on Arduino
int mVperAmp = 66;            // this the 5A version of the ACS712 -use 100 for 20A Module and 66 for 30A Module
int Watt = 0;
double Voltage = 0;
double VRMS = 0;

double AmpsRMS = 0;

const float power_fac = 0.8;
double power;

void setup_wifi() {
  pinMode(voltPin,INPUT);
  pinMode(temp1Pin,INPUT);
  pinMode(temp2Pin,INPUT);
  pinMode(temp3Pin,INPUT);
  pinMode(z_out,INPUT);
  pinMode(r_pin,OUTPUT);
  delay(10);
  // We start by connecting to a WiFi network
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);

  WiFi.mode(WIFI_STA);
client.publish("outTopic", "hello world");
      // ... and resubscribe
//      client.subscribe("aruvii/in");
    } else {
      Serial.print("failed, rc=");
    delay(500);
    Serial.print(".");
  }
  randomSeed(micros());
    Serial.println(WiFi.localIP());
}
void callback(char* topic, byte* payload, unsigned int length) {
  Serial.print("Message arrived [");
  Serial.print(topic);
  Serial.print("] ");
  for (int i = 0; i <length; i++) {
    Serial.print((char)payload[i]);
  }
  Serial.println();
  // Switch on the LED if an 1 was received as first character
  if ((char)payload[0] == '1') {
    digitalWrite(r_pin, LOW);   // Turn the LED on (Note that LOW is the voltage level
    // but actually the LED is on; this is because
    // it is active low on the ESP-01)
  } else {
    digitalWrite(r_pin, HIGH);   // Turn the LED off by making the voltage HIGH
  }
}
void reconnect() {
  // Loop until we're reconnected
  while (!client.connected()) {
    Serial.print("AttemptingMQTT connection...");
    // Create a random client ID
    String clientId = "ESP8266Client-";
    clientId += String(random(0xffff), HEX);
    // Attempt to connect
    if (client.connect(clientId.c_str())) {
      Serial.println("connected");
      // Once connected, publish an announcement...
```

IV CONCLUSION

Condition Monitoring System tested on the basis of the ESP32 microcontroller, Sensors, Modules IoT and Software technologies. When the program was loaded into the ESP32 it receives the data from the sensors and then the created NodeRed server analysed the values and shows the values in the Control room Dashboard.

From the analysis, If The faults are detected from the continuous monitoring in real-time of the IM and those faults information is received and processed in the ESP32 module and it sends the signals to the Piezoelectric Buzzer to alarm and also the information can sent to the server Node-Red from this the values are shown in the dashboard to display status of the sensing parameter of the Induction motor to the Authority. After that from the information the Authorizer solves the problem and then the system can restart its process and again it gets their routine work of Condition Monitoring.

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