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PROTECTION OF THE SINGLE PHASE INDUCTION MOTOR BY USING SENSORS AND MICROCONTROLLER

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ABSTRACT

The main motive of this innovation research paper is to detection the fault and protection of single phase induction motor from over voltage, under voltage, over temperature, under current, overloading etc.

To identify and remove these faults we use following sensors and elements:

- *Current Sensor*
- *Thermal Sensor*
- *Potentiometer*
- *Relay*
- *Voltage Regulator*
- *Advanced Microcontroller*
- *LCD Display and Buzzer*
- *Cooling Fan and Heater*

Here the single phase induction motor is protected using advanced microcontroller. Current sensor is used for detecting the value of current, for detecting over and under, thermal sensor will detect low and high temperature values. The potentiometer is connected across the circuit by which we can vary the voltage of the motor. If the motor goes vary from certain temperature the motor may be automatically turned off using temperature sensor, thermal sensor etc.

Such that purpose of this project is to protected the single phase induction motor from unwanted factors.

Keywords :Induction Motor, AVR ATMega16, Mi0crocontroller, Potentiometer, Current Sensor, LCD Display, Buzzer, Relay, Power Supply, Thermal Sensor, Cooling Fan and Heater.

I.INTRODUCTION

Induction motor is very useful to perform the no. of operation in the domestic and industrial purpose. Induction motors are used for automation, appliances, induction control; because they are robust, reliable and durable but due to the subjected in undesirable stress, the efficiency of induction motor is lower or failure. Single phase induction motor are manufactured in fractional kilowatt range to be operated on single-phase supply and for use in numerous applications like ceiling fans, refrigerators, food mixers, hair driers, portable drills, vacuum cleaner, washing machine, sewing machine, electric shavers, office machinery etc. Single phase motor is manufactured in different types to meet the requirement of various applications [1].

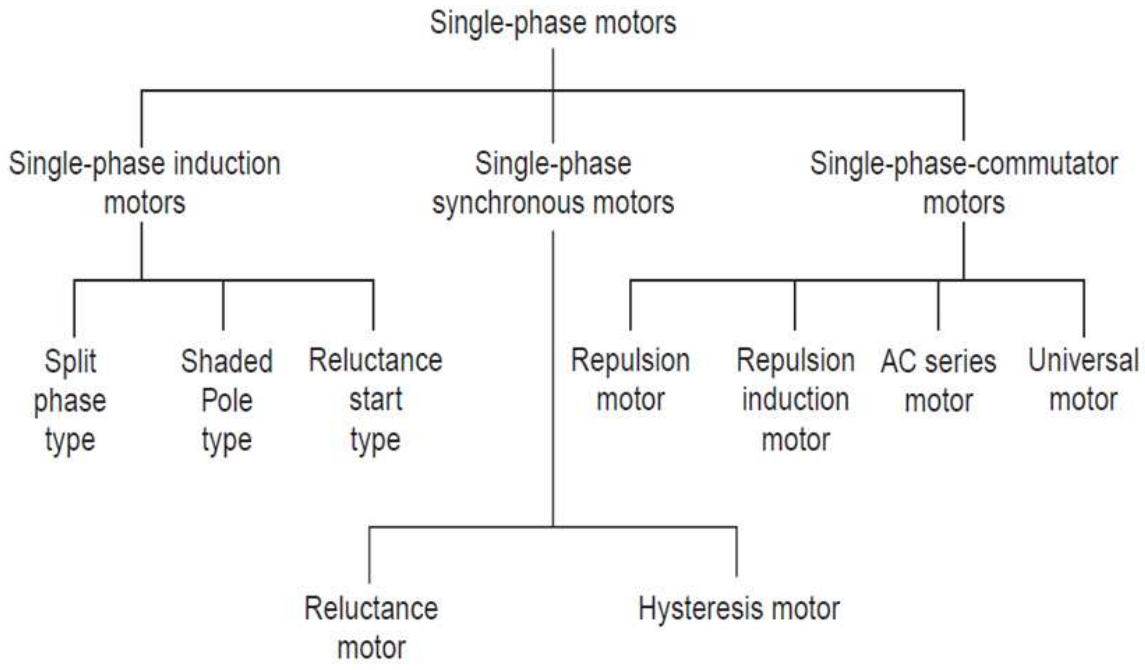

Figure 1. Type of Induction Motor

II.MOTOR FAULTS

Abnormal operating conditions are much more frequent than internal faults in case of induction motors.

- Short circuit faults:

Since power systems up to 6kV are generally operated with "isolated neutral", 'If', which is determined by the capacitance of the power circuit, is small in case of phase to earth fault. In many cases 'If' up to 10A is allowed to flow. Above 6kV, 'If' will depend on the impedance in neutral earthing link and can be more than "starting" current also. Inter-turn short circuiting result in increased phase currents [2].

- Overloads:

If the motor is heavily loaded beyond its capacity than it will be overload condition of motor in which case motor draws heavy current from the supply and there will be simultaneous rise in temperature of winding and deterioration of the insulation resulting in damage of winding. Hence the motor must be protected against this mechanical overloading with overload protection circuits. Normally thermal overload relays, over current relays or miniature circuit breaker with built in trip coils may be used [3].

- Heavy current:

It might be possible that the rotor is locked or starting lasts for longer duration or rotor does not move because of excessive load at start. In all these cases motor draws heavy current from the supply and results in damage to the winding due to overheating as started above [3].

CIRCUIT ELEMENTS

a) Microcontroller:

Figure 2. Micro-controller

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing, Know more about RISC and CISC Architecture) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. Atmega16 can work on a maximum frequency of 16MHz.

ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.

ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.

Each I/O pin has an alternative task related to inbuilt peripherals. The following table shows the pin description of ATmega16.

Pin Diagram:

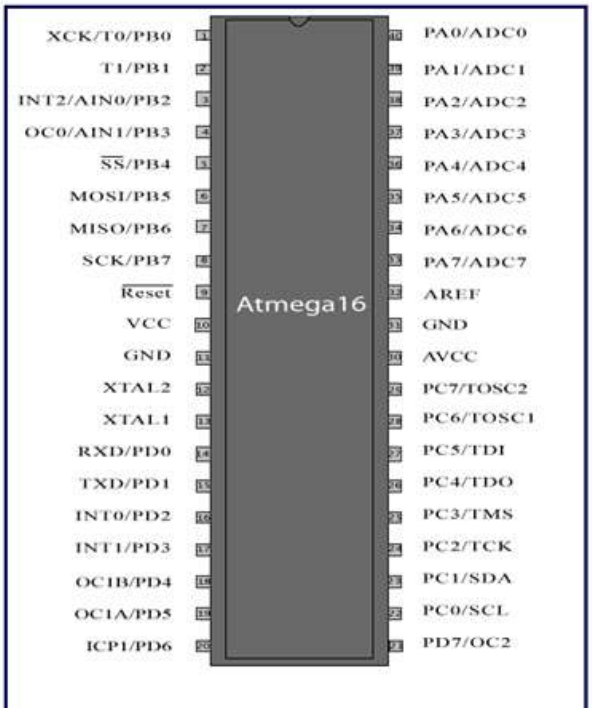

Figure 3. Pin diagram of MC [4].

b) Thermal sensor (LM 35):

Temperature is one of the most commonly measured parameter in the world. They are used in your daily household devices from Microwave, ridges, Air Conditioner to all fields of engineering. Temperature sensor basically measures the heat/cold generated by an object to which it is connected. It then provides a proportional resistance, current or voltage output which is then measured or processed as per our application.

Temperature sensor are basically classified into two types

- Non Contact Temperature Sensors: These temperature sensors use convection & radiation to monitor temperature
- Contact Temperature Sensors: Contact temperature sensors are then further sub divided into three type

1. Electro-Mechanical (Thermocouples).

2. Resistive Resistance Temperature

Detectors (RTD).

3. Semiconductor based. (LM35, DS1820 etc).

LM35 Temperature Sensor which is a semiconductor based sensor. LM35 is an integrated analog temperature sensor whose electrical output is proportional to Degree Centigrade. LM35 Sensor does not require any external calibration or trimming to provide typical accuracies. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

Features of LM35 Temperature Sensor

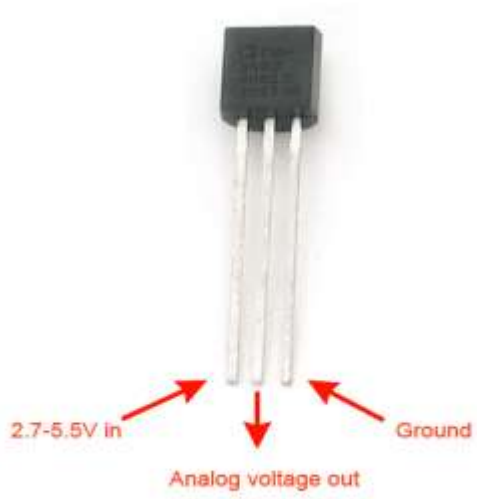

Figure 4. Temperature sensor

- Calibrated directly in Degree Celsius (Centigrade)
- Linear at 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee-able (at a25°C)
- Rated for full -55°C to a 150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 mA current drain
- Low self-heating, 0.08°C instill air
- Non-linearity only 0.25°C typical
- Low impedance output, 0.1Ωfor 1 mA load

LM35 is a very low cost and easily available Sensor. Main advantage of LM35 is that it is linear i.e. 10mv/°C which means for every degree rise in temperature the output of LM35 will rise by 10mv. So if the output of LM35 is 220mv/0.22V the temperature will be 22°C. So if room temperature is 32°C then the output of LM35 will be 320mv i.e. 0.32V.

- LM35 Interfacing Circuit

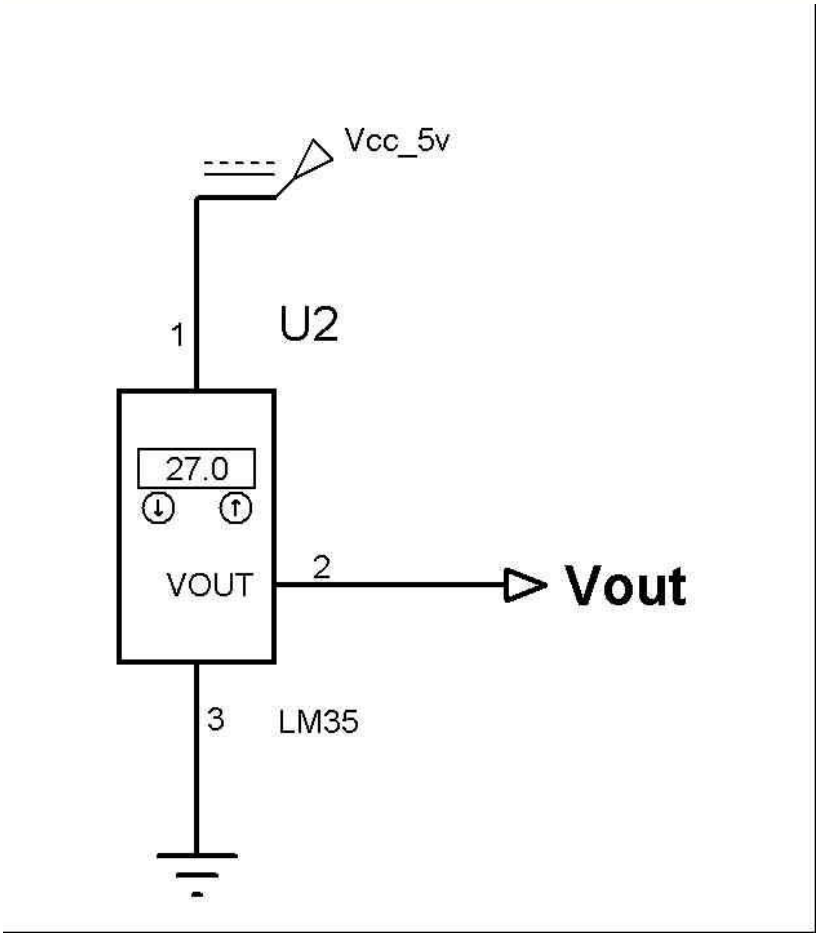

Figure 5. Connection diagram of temperature sensor

As such no extra components required to interface LM35 to ADC as the output of LM35 is linear with 10mv/degree scale. It can be directly interfaced to any 10 or 12 bit ADC. But if you are using an 8-bit ADC like **ADC0808** or **ADC0804** an amplifier section will be needed if you require to measure 1°C change.

LM35 can also be directly connected to Arduino. The output of LM35 temperature can also be given to comparator circuit and can be used for over temperature indication or by using a simple relay can be used as a temperature controller.

Alternative to LM35 Temperature Sensor

If you are interested in getting reading in degree Fahrenheit you can use **LM34 Temperature sensor**. It is same as LM35 except its electrical output is proportional to Degree Fahrenheit. It has same pin configuration and same voltage range as LM35.

You can also check out MCP9700 Temperature Sensor from microchip. MCP9700 can accurately measure temperature from -40C to +150C. The output of the MCP9700 is calibrated to a slope of 10mV/°C and has a DC offset of 500mV. The offset allows reading negative temperatures without the need for a negative supply. Basically the code for LM35 will not work for MCP9700.

If you are using an 8 bit ADC and want to measure 1°C change in temperature then you can also use MCP9701 Temperature Sensor from Microchip. The MCP9701 can accurately measure temperature from -10°C to +125°C. The output of the MCP9701 is calibrated to a slope of 19.53 mV/°C and has a DC offset of 400 mV. The offset allows reading negative temperatures without the need for a negative supply.

Projects Based ON LM35 Temperature Sensor

- **Temperature Controlled LED**: A non micro-controller based circuit for indicating if temperature is above or below set limit.
- **Arduino Thermometer**: Thermometer made using LCD, Arduino & LM35 Temperature sensor
- **PIC based Temperature Controlled Fan**: A project done using Microchip'sPIC16f877a microcontroller which measures the room temperature and as the temperature increases the Fan speed increases [5].

c) Transformer:

Figure 6. Transformer

This is a general purpose transformer. Transformer has 230 V primary winding and centre tapped secondary winding. The Transformer act as step down or step up transformer reducing AC - 230V to 9V. This Transformer gives two outputs of 230V to 9V and 5V to 230V. Drain 5 Amp current.

Features:

- Soft Iron Core
- 5 Amp Current Drain [6].

d) Relay:

A relay is an electrically operated or electromechanical switch composed of an electromagnet, an armature, a spring and a set of electrical contacts. The electromagnetic switch is operated by a small electric current that turns a larger current on or off by either releasing or retracting the armature contact, thereby cutting or completing the circuit. Relays are necessary when there must be electrical isolation between controlled and control circuits, or when multiple circuits need to be controlled by a single signal.

e) Potentiometer:

If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. The measuring instrument called a **potentiometer** is essentially a voltage divider used for measuring electric potential (voltage).

- Potentiometer Applications:

There are two principal circuits built using pots.

- Variable Resistor:

If we put the pot in our circuit with only the wiper and one end connected, it functions as a variable resistor. The overall resistance is directly related to the position of the wiper. There are a couple of different schematic symbols used to represent variable resistors, shown below.

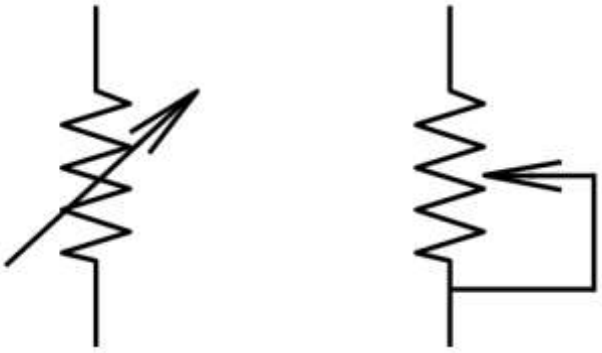

Figure 7. Variable resistor

If you're building a circuit that uses a variable resistor, consider what might happen in the circuit if the wiper loses contact with the resistor element, for instance, if a speck of dirt falls into the pot. Some circuits will misbehave if the resistor suddenly disappears like that. You'll notice that the second symbol above ties the wiper to one terminal – should the wiper lose contact, the circuit jumps to the overall value of the pot, rather than an open circuit.

Voltage Divider

Another common circuit built with potentiometers is the voltage divider.

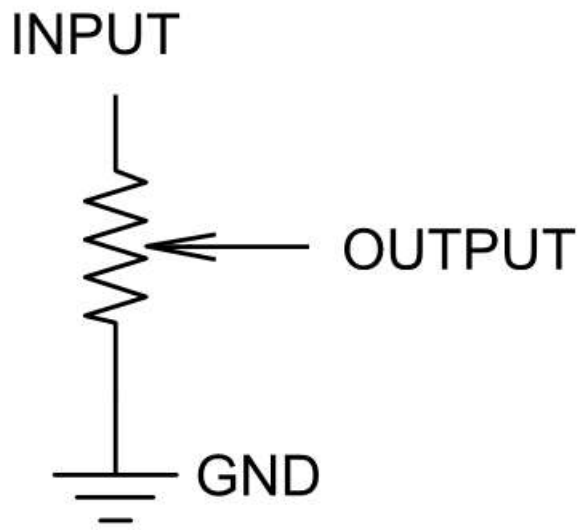

Figure 8. Voltage Divider

Voltage dividers are useful for reducing the voltage of a signal – as the name implies, they divide the input by a constant value. If you use a divider in the feedback loop of an opamp, you can turn the division into multiplication, building a variable gain amplifier [7].

f) Current Sensor:

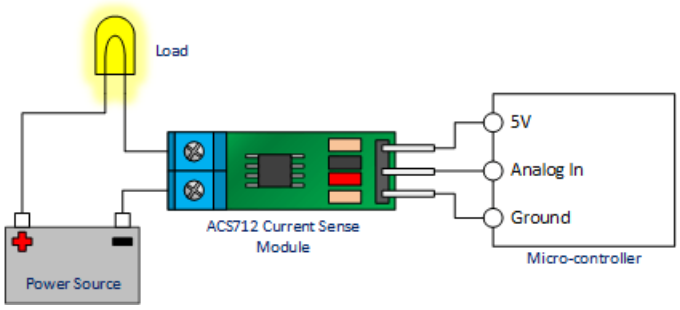

Figure 9. Current Sensor

A **current sensor** is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control. The sensed current and the output signal can be:

- Alternating current input,
- analog output, which duplicates the wave shape of the sensed current.
- bipolar output, which duplicates the wave shape of the sensed current.
- unipolar output, which is proportional to the average or RMS value of the sensed current.
- Direct current input,
- unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
- digital output, which switches when the sensed current exceeds a certain threshold

g) LCD and BUZZER:

Liquid Cristal Display (LCD) is an electronic display module, which is interfaced with AVR ATmega16. LCD will used to display different value of voltage, current and temperature.

Here we used the BUZZER which has low current consumption but high sound pressure level, which is triggered by microcontroller.

h) Use Of Cooling Fan And Heater:

We use the cooling fan for cooling purpose when the temperature of environment is increase and heater is used for heating purpose when the temperature of environment is decrease.

For example: at the -55*C or 110*C the motor will not perform action properly or become failure. In this case we use cooling fan or heater.

There are many factors that cause motor:

1. MOTOR IS TOO SMALL FOR THE APPLICATION

It is important to make sure the motor you are using has been properly sized for the application. A motor that is too small will not be able to dissipate heat quickly enough, and the motor will overheat.

2. HIGH AMBIENT TEMPERATURES

If a motor is running in a much warmer environment than it was designed for, it can overheat because the ambient temperatures will make it more difficult for the motor to cool down properly.

3. RUNNING AN INTERMITTENT DUTY MOTOR CONTINUOUSLY

It is important to run motors that are rated for intermittent duty applications at or below their duty cycle. In order for the motor to run at its rated performance specs, it needs to have time to cool-down completely between cycles. If the motor is run more frequently than it is supposed to, the motor will still be warm and will become increasingly hotter with each cycle, eventually overheating the motor.

4. HIGH OR LOW VOLTAGE SUPPLY

Power supply may be insufficient due to amp draw. In order to overcome load or inertia at a stand-still, the motor's running current will be much too high under load. Incorrect voltage supply will make the motor work harder and could cause it to overheat.

5. HIGH ALTITUDE

Motors cool less efficiently at higher elevations due to the thinner air. If you are at a higher elevation—1000 meters (3300 ft.) above sea level, talk to the manufacturer and make sure your motor is rated accordingly.

6. BLOCKED VENTILATION HOLES

This may seem obvious, but the ventilation holes on your motor must be open to allow heat to escape. Check and make sure nothing is blocking them [10].

Effect of Temperature:

Experts agree that excessive heat causes rapid deterioration of motor winding insulation. The common rule states that insulation life is cut in half for every 10 C of additional heat to the windings. As an example, if a motor that would normally last 20 years in regular service is running 40 C above rated temperature, the motor would have a life of about 1 year.

Leading standardization organizations have concluded that 30 percent of motor failures are attributed to insulation failure and 60 percent of these are caused by overheating. Articles have been published stating that a significant cause of bearing deterioration is overheating.

There are typically five main reasons for overheating—overload, poor power condition, high effective service factor, frequent stops and starts, and environmental reasons [11].

POWER CIRCUIT DIAGRAM TO CONVERT 220AC TO 5VOLT DC:

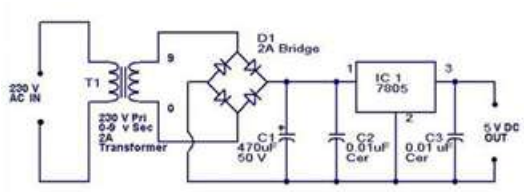

Figure 10. Circuit diagram

Description.

7805 is a 5V fixed three terminal positive voltage regulator IC. The IC has features such as safe operating area protection, thermal shut down, internal current limiting which makes the IC very rugged. Output currents up to 1A can be drawn from the IC provided that there is a proper heat sink. A 9V transformer steps down the main voltage, 1A bridge rectifies it and capacitor C1 filters it and 7805 regulates it to produce a steady 5Volt DC. The circuit schematic is given below[9].

REVIEW

- When the temperature of induction motor isvary from our required temperature condition then LCD will shows the result. In this case we use the heater or cooling fan to overcome the problem.

- When the supply voltage of the inductionmotor vary from range that is less then 200Volt and more than 240Volt, then fault will detect and motor stop working.

- When the supply current of the inductionmotor vary from required condition.
- For normal operation of motor, all parametersare within recommended range.

III.CONCLUSION

We have studied and conclude that we can detect and control the fault and protection of single phase induction motor from over voltage, under voltage, over temperature, under current, overloading etc.

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