Automatic Shynchronization of Synchronous Motor With Thermal Protection

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Abstract- *synchronous motors generally used in the industries are of synchronous motors with damper windings. These motors require continuous monitoring and attention for proper synchronization and maintaining constant speeds.*

This above-mentioned problem is very common and difficult to eliminate with minimum cost and man power. It also affects the overall performance and efficiency of the industry. Which further affects the cost effectiveness of the industry.

In our project we tried to eliminate this problem,we used Arduino and speed sensors to measure and maintaining the speed of motor in synchronism by some relay arrangements. Also, to maintain the thermal stability of the motor we used the LM35 temperature sensor with Arduino to monitor the temperature of the motor and also implemented the protection of motor from high temperature rise to avoid insulation failure and damage to motor due to overloading and internal faults of motor

Keywords- Arduino, IR Sensor, Thermal Sensor, Synchronization, Relay

I. INTRODUCTION

Within industry the most important power-hungry device is motor. Almost every process involves motor as one of its major or minor part except lightening and heating system. In industries most of the loads needs constant motions for that reason synchronous motor is well suited. Generally synchronous machine is not self-starting so to make it self-starting various practices are done. Damper winding is used to make it self-starting but damper winding suffers from many disadvantages and lots of manual intervention along with costly tachometers.

In another method DC motor coupled with synchronous motor is used. But in this method continuous human intervention is required. Also, the synchronism provided by this method is not permanent because if during running condition motor losses its synchronism then system totally shuts off this causes heavy production losses and may lead to damage to the motor.

To overcome this problem, we are done a simple solution using some components like Arduino, relays, speed sensors etc. these components acts in a closed loop system to continuously monitor and maintain the motor in synchronism. The primary objective of this circuit is to pull the motor in synchronism and during running condition maintain the motor in synchronism.

Most of the failures in motor causes thermal rise and damage to insulation and other parts of the motor, almost all the faults take some time to appear with their full strength and affect the motor performance. Hence, during this period motor rises its own temperature gradually above normal operating temperature. Hence to protect motor we used LM35 sensor for sensing temperature and feeding it to Arduino and measuring it for showing on LCD display and monitoring for faults. Arduino compares this temperature with some reference value and if the actual temperature is less than reference value then condition is considered as normal and if actual temperature is more then condition is considered as abnormal.

During this abnormal condition Arduino sends the trip signal to relays placed on both of the supply i.e. dc as well as ac supply. This relay trips and turn of the motor ensuring that motor is facing some issues.

II. COMPONENTS

2.1 Arduino:

The Arduino Nano is the latest version after the Duemilanove with an improved USB interface chip. Like the Duemilanove, it not only has an expanded shield header with a 3.3V reference and a RESET pin (which solves the problem of how to get to the RESET pin in a shield) AND a 500mA fuse to protect your computer's USB port, but ALSO an automatic circuit to select USB or DC power without a jumper! The Uno is pin and code-compatible with the Duemilanove, Diecimilla and older Arduino so all your shields, libraries, code will still

work. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, Max/MSP).

2.2 Relay:

The electromechanical relay is an output device which comes in whole host of shapes size and design and has many uses and application in electronic circuits. In this project the relay switch has a coil which is driven by the npn transistor. The coil of the relay switch gets energized due to the collector current of the transistor according to that switch gets on and off to control the water sprinkler. We can control High Voltage electronic devices using relays. A Relay is actually a switch which is electrically operated by an electromagnet. The electromagnet is activated with a low voltage, for example 5 volts from a microcontroller and it pulls a contact to make or break a high voltage circuit.

2.3 LM 35 Thermal Sensor:

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in oC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possesses low self-heating and does not cause more than 0.1 oC 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 oC rise/fall in ambient temperature, i.e., its scale factor is 0.01V/ oC.

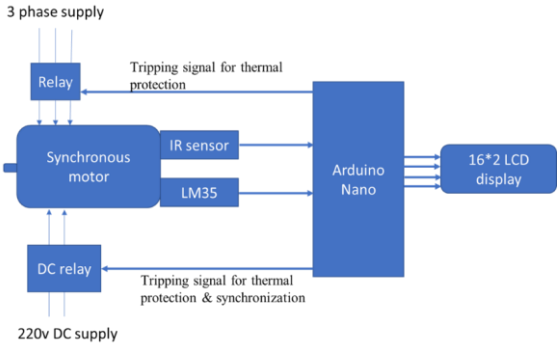
2.4 IR sensor (Transmitter Receiver):

Infrared Distance Sensor is also known as sharp distance sensor which is used to detect the presence of nearby objects. This sensor takes a continuous distance reading and reports the distance as an analog voltage that can be used to determine how close the nearest object is.These sensors are good for short-range detection i.e., from 10cm (~4") to 80cm (~32"). These sensors are used in TVs, Cars and Personal computers.

2.5 16*2 LCD Display:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD

III. CONSTRUCTION



Three phase supply is given to the synchronous motor through relay NC terminal, and DC supply is given through NO terminal of the Relay. Due to three phase supply, stator of synchronous motor will produce the magnetic field which is rotating in nature at the synchronous speed. The excitation circuits of the relays are feeded with DC supply and this excitation circuit is control by Arduino. IR speed sensor is placed in front of motor shaft for sensing speed in terms of voltage, this signal is feeded to Arduino using pilot wires. Temperature sensor LM35 is mounted on inner periphery of motor to sense the temperature in terms of voltage and sends it to Arduino to pilot wires. Separate power supply is used for Arduino and relay excitation. BC547 transistors are used as a relay driver circuit control by Arduino.16*2 LCD display is also interfaced with Arduino to show instantaneous speed and temperature of machine.

IV. WORKING

Initially three phase supply is given to stator winding of the synchronous motor.It produces Rotating Magnetic Field.So now the motor starts as an induction motor due to damper winding.The digital Tachometer is placed in front of the shaft so that it could measure the speed of Synchronous Motor in the form of the voltage pulses.This voltage pulses are given to the Arduino through the jumper wires.These pulses are given to the digital terminal (D2) of the Arduino Nano.Arduino converts these pulses in the Revolution Per Minute(rpm) by means of some calculation processes.Further this speed is continuously compared with reference synchronous speed of the motor.When speed of synchronous motor reaches synchronous speed (Ns), it sends a trip signal to the relay.Relay changes its position from NC to NO. This change will provide DC supply to the Synchronous Motor and its rotating winding produces permanent magnetic field of constant nature.This field has a tendency to lock with the rotating magnetic field of the stator. After this magnetic locking synchronous speeds holds the rotor with it and motor will run as a synchronous motor.To maintain the thermal stability of the motor LM35 temperature sensor is used, it senses the temperature and converts it in the voltage proportional to the input temperature to it.This voltage is further feeded to the Arduino which converts this voltage in the temperature using the same proportionality system.Now this temperature is continuously monitored by the Arduino and compares it with the reference temperature value.Arduino also shows this temperature value on the 16*2 LCD display and hence it is also monitored by user as per requirement.If the actual temperature value is more than pre-set reference value then system is considered to be abnormal then, Arduino generates the tripping signal for the relays connected in both AC and DC supply.This signal trips the relay and turns off the system to the scratch, it also could sound the alarm and make a visual indication on the LCD display about thermal rise in motor.

V. ADVANTAGES

- No continuous monitoring is required.
- No need of equipment's like small induction motor, pony motor, prime mover for starting purpose.
- Sensing devices used are of contactless type, so no interface is required and related losses also does not take place.
- Cost of the sensing and processing system is very less as compare to previous techniques.
- It is the most cost-effective solution for starting of synchronous motor.
- Speed and temperature can be visualized and stored for analysis purpose for user.
- It completely eliminates the human intervention in the power circuit.
- Remote operation of synchronous motor is possible.
- Cost required for modifications are recovered.
- Therma protection is also implemented using the same devices and some modification.
- Slowly rising faults could be detected and solved before they affect the motor performance.

VI. DISADVANTAGES

- Different values of dc supply are required for the operation of circuit.
- Circuit design is complicated to construct and maintain
- Components used are very delicate in nature.
- Programming of the Arduino is also difficult and complex to understand.
- Interfacing of controller circuit with power circuit is difficult and requires various driver arrangements.

VII. APPLICATIONS

- It can be used in industries for operation of various loads.
- It can used in remote places to start and synchronize motor automatically.
- In paper and flour mills where continuous operation with constant speed is required.

VIII. FUTURE SCOPE

- By making some changes in the existing system this project could be used for many machines by using same circuit configuration. Generally, the Arduino is very flexibly used in industries for making its full utilization. By using the same concept, we could control many motors using the same Arduino circuit by some program and hardware changes. This will again increase the cost effectiveness of the operation. By implementing some wireless techniques like GSM and PLCC we can remotely operate these industrial loads from the central location.
- For the large-scale industries, we could replace the Arduino by PLC and SCADA for more flexible and wide operation of the system the PLC have many advantages like it has many input and output ports, have large memory space and it also allows remote control of the devices. From the centralized location and also data storing on its server.

- By using more sensor and large display we could implement the current and the voltage measurement on the same circuit. Also, power factor measurement could be done using the same sensors like CT and PT. further these will help in calculating active power and reactive power taken by the machine for the user analyses purpose. Hence, it could be used in the power quality management of motor and power factor improvement for efficiency improvement. This system can be used in signature analysis of motor
- By sensing and measuring above parameters we could impellent their protection also, it will protect the motor from overcurrent and over voltages. Designing this scheme is very easy and requires very small changes in the existing system.
- For automatic compensation same circuit can be used by using power bank in the motor input terminal and connecting it through thyristor circuit. And by connecting the firing circuit to the Arduino for control of reactive power management.

IX. CONCLUSION

- By using this circuit arrangements, we can pull the motor in synchronism easily and also, maintain its synchronism for large span of loading values.
- When motor losses its synchronism circuit could automatically pull it again in synchronism after specified delay.
- Thermal protection is also implemented to avoid most of the internal faults occurring on motor.
- Analysis of speed and thermal loading is possible by recording the values displayed on LCD display.

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