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IOT based Smart Industrial panel for controlling Three-phase Induction motor

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***Abstract*-Technology has been developing throughout the world as system moved from manual to auto. This paper is on the smart control panel for controlling the appliances. Appliances are Inductive, resistive and capacitive in nature. Inductive type are mostly motors. Three-phase Induction motor is one of the most common types of electrical machines with vast amount of applications in the entire power system all over the world due to its various advantages such as low starting power, lower maintenance cost etc. For the sake of economy and their longer life, it is very much necessary to provide them with feasible conditions to perform optimal operation with best possible smart protection techniques, this paper is all about the analysis of faults in induction motor on MATLAB/SIMULINK, the provision of optimal protection combining traditional and IOT for both automatic as well as manual method to make it fully controllable based on the requirements of protection engineer for various loads. Control elements used here are vibration as well temperature sensation with IOT based remote data acquisition technique for automatic protection as well as a manual control using a selector switch for automatic as well as manual operation and a molded case circuit breaker for protection purpose.**

Index Terms – Motor Faults, MATLAB/SIMULINK, Monitoring, controlling, Internet of things.

I. INTRODUCTION

There are so many loads as Inductive, capacitive and resistive. Of all the Loads Inductive loads AC and DC motors, preferably are extensively used for various industrial applications. In both types of machine, Industries mostly use Induction machines i.e. three-phase IMs and Domestic use single-phase induction motor due to desirable features like robust in construction, low maintenance and operation cost, high starting torque, highly efficient and reliable [1-2-3].

Moreover, motors are also subjected to many faults include stator faults, Rotor faults, bearing faults, winding faults, lubrication, cooling, temperature rise and vibrations [4-5]. A small fault may lead to a big loss of motor and economical loss of industry, so for this condition monitoring is necessary to avoid any loss [6].

So many techniques have been used to control and monitor the operation of motors. Operations, electrical and mechanical faults but IOT has been revolutionized throughout the world in so many applications. Internet of things keeps vital role due to communication between machines.

The current considerations are being highlighted Machine-type related issues as M2M (Machine-to-Machine) communication requirements [4]. IOT basically is basically linkage between multiple equipment with a back support of intelligence to make operation smart and allowing them to communicate each other without any independent configuration.

Internet of things (IOT) refers to the inter-connection of multiple devices and providing them with the intelligence so as to make them smart. It allows the real-world devices to communicate with each other and configure themselves independently [8]. The word IOT or "Internet of Things" was first being used in 1999 by Kevin Ashton for describing network globally [9].

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The "IOT" Internet of Things has become used to in our daily life to be sensed, traced, addressed and measured objects through Internet, or either through RFID [10], wireless network [11], WAN etc. [12]. The objects which are not only food, material, non-electrical appliances but also other electrical appliances [9, 13-16].

The purpose of this paper is to operate the loads in both ways manually and through IOT. The automatic controlling system is very efficient and more comfortable which we can use from anywhere through Wi-Fi. Its operation is easily and quickly where there is no need of physical work to operate the system. If the automatic system does not work due to any problem, then we can easily operate the system by the manually. Also, our focus is on the Abnormalities of temperature and vibration in three-phase induction motor. The flow chart of whole work is given in figure-01.

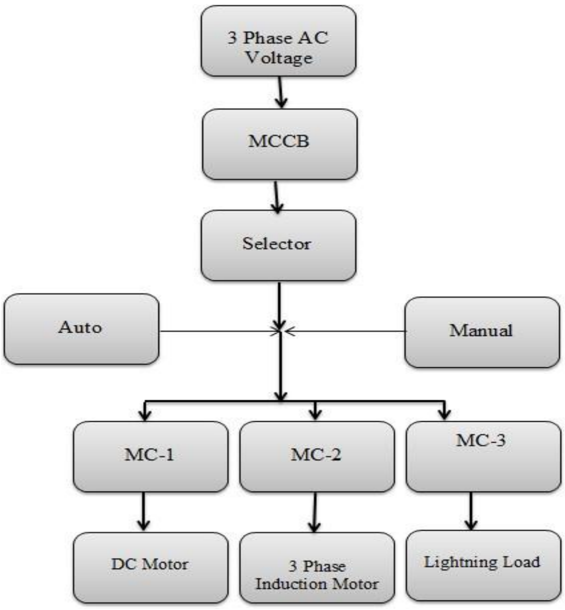


Figure-01: Flow Chart

Section-II describes the proposed sensors and equipment, Section-III describes methodology of whole system, Section-IV explains results and In Section-V conclusion is described by considering and analyzing all the factors and figures in the paper.

II. PROPOSED SENSORS AND EQUIPMENTS

In this paper lighting load named as Linear Fluorescent lamp (LFL), inductive loads are utilized manually and through IOT. We have just worked on the inductive loads and their operation during normal and abnormal conditions. Following equipment are used for the operation and control and protection of both motors.

1. MCCB (Molded case circuit Breaker)
2. Magnetic contactor
3. Selector Switch
4. Toggle switch
5. Pilot Devices
6. Current transformer (CT)
7. Single-Phase Transformer
8. Diode Bridge
9. VA Hz Meter
10. NodeMCU
11. Relay Bunch
12. Temperature sensor
13. Vibration Sensor
14. AC motor (Three-phase Induction Motor)
15. DC motor
16. Linear Fluorescent Lamp (LFL) The enlisted equipment is shown in figure-02.

Figure-2. Proposed Sensors and Components

III. METHODOLGY

Methodology comprises of two major parts; software and hardware. In software part we have simulated different faults and observed their results. Whereas hardware part we have made control panel to control the motor operation.

A. Software Part

There are different types of fault in the motor mainly under voltage, unbalanced supply, single phasing, overloading, earth faults and inter-turn faults. This part elaborates few faults as under voltage and overload on Induction motor.

The main reason to consider these faults is that these faults produce heat in the motor and in that case, it is very important to protect it from abnormalities. Two models for under voltage and overloading have been simulated in MATLAB as shown in Figure-03(a) and Figure-03(b).

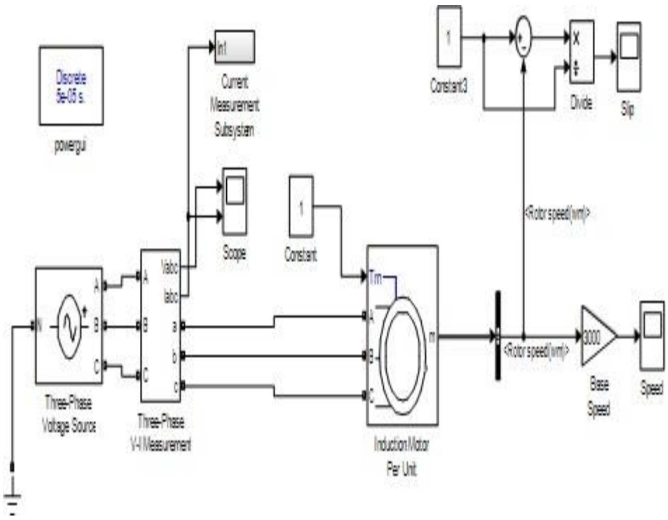


Figure-03(a): Simulink model for under voltage

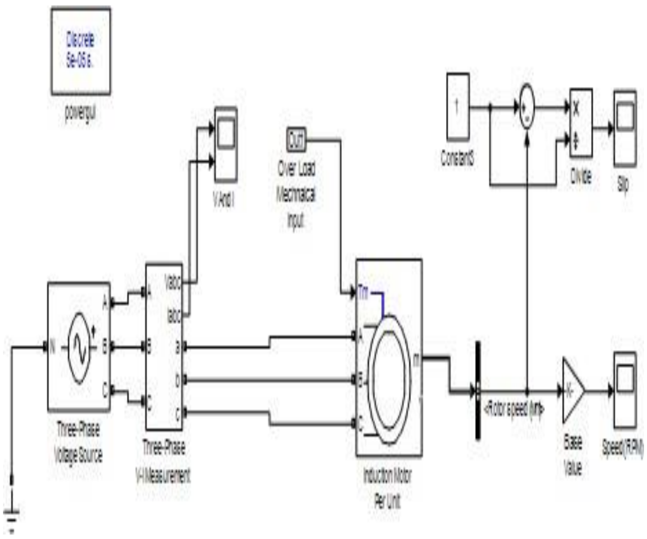


Figure-03(b): Simulink model for Overloading

B. Hardware part

Methodology describes the interconnection of proposed equipment with each other. The need of interconnections among equipment's is to monitor and control the operation of Three-phase induction motor and DC motor manually and through Internet of Things. Two types of wiring diagrams are used first power wiring for operation of loads (IM, DC motor and LFL) and second for their control. A selector is used to select the type of operation of loads which is through manually and via IOT. The circuit diagram shown in figure- 04 is used with the help of Multisim software, which clearly shows all the loads and equipment. In this controlling panel, we have used molded case circuit breaker (MCCB) for protection purpose which operates during short circuit faults in the motor. There are many other types of circuit breakers used but MCCB is specifically used on the secondary distribution or load side. For the controlling of motors, magnetic contactors keep vital role to be introduced in the controlling panel, so three magnetic contactors are used which are parallel looped. Magnetic contactors are used for both methods. First, we operate the contactors through auto system in which we are used NodeMCU and the NodeMCU is operating through Wi-Fi signals. When we give command to the NodeMCU through mobile app then the NodeMCU energize the relay and the relay operates the contactors. The load is connected with three-phase supply through contactors. If we give command through our mobile, we can individually connect the loads according to our requirements because we have separately installed the contactors and can individually operate the contactor through NodeMCU.

The second we connect the load with the three-phase supply manually in which we have set the manual switches to operate the magnetic contactors. The manual switching method is also used for back-up, if our auto system will not work due to any technical fault, then we can easily operate the contactor and connect the load with supply manually. For the operation of motor, we have used three-phase supply but for controlling purpose we need dc supply. For this we have also used a rectifier to convert the AC voltage to DC voltage with the usage of the Single-phase step-down transformer where the rectifier can easily convert the voltage. The pilot devices are used as three indicators Red, Yellow, and blue to be operated under normal and abnormal conditions. The meters are used for measuring the voltage current and frequency as these parameters are important for motor operation.

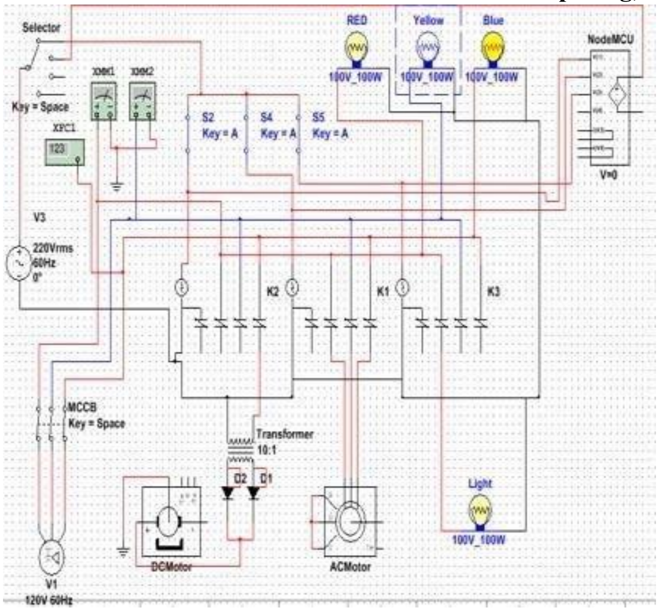


Figure-04: Circuit diagram

Our main requirement for making the whole panel is to control the motor by focusing on temperature and vibration during operation.so vibration sensor and temperature sensor are also used to check the condition of motor. The whole methodology for the smart control panel can be easily understood by the following block diagram in figure-05.

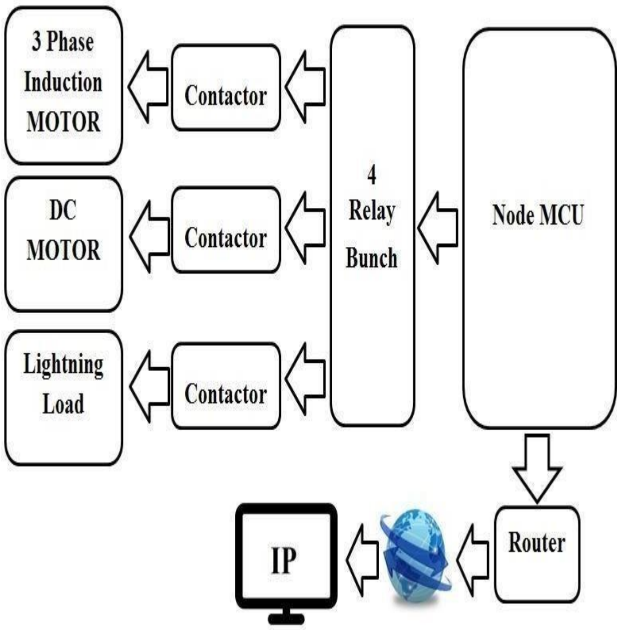


Figure-05: Block diagram

IV. RESULTS

As we have worked on software and hardware. The first part describes the results of MATLAB software and second part for hardware.

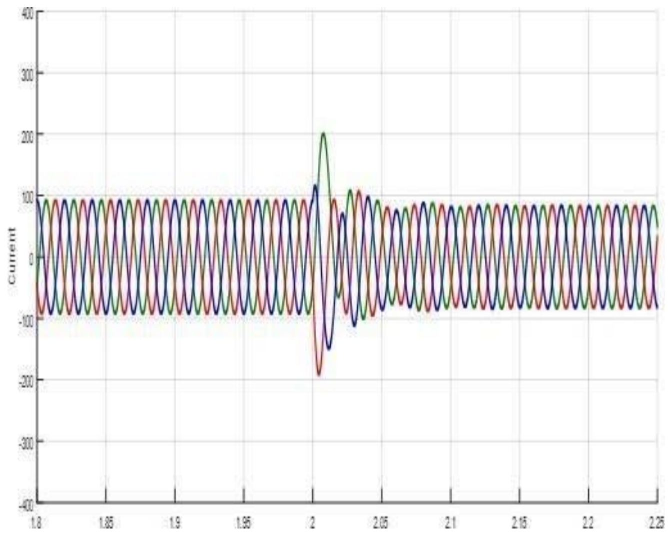
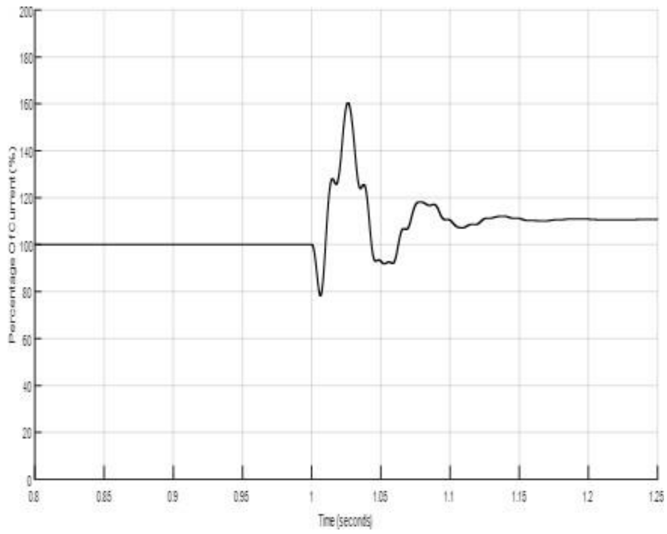


Figure-06(b): Current Measurement



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A. Software Results

Firstly, the results on under-voltage fault condition in three- phase induction motor have been taken from simulation Figure-06(c): Current during under voltage (1sec/sag 15%) shown in Figure-06 (a) to Figure-06(d).

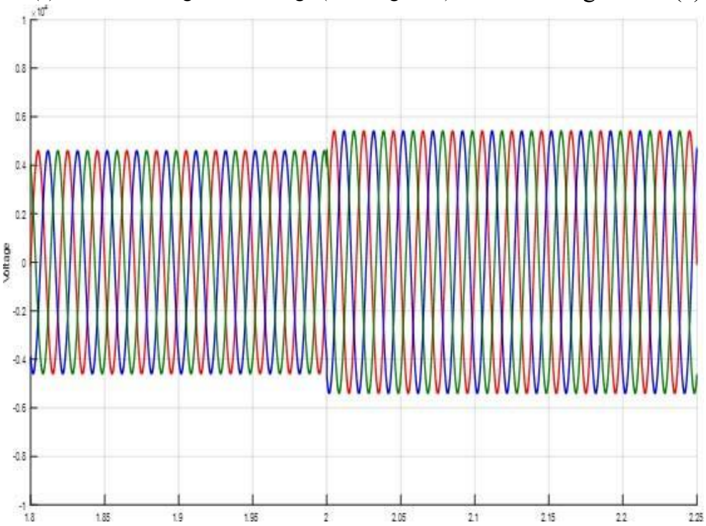

Figure-06(a): Voltage Measurement

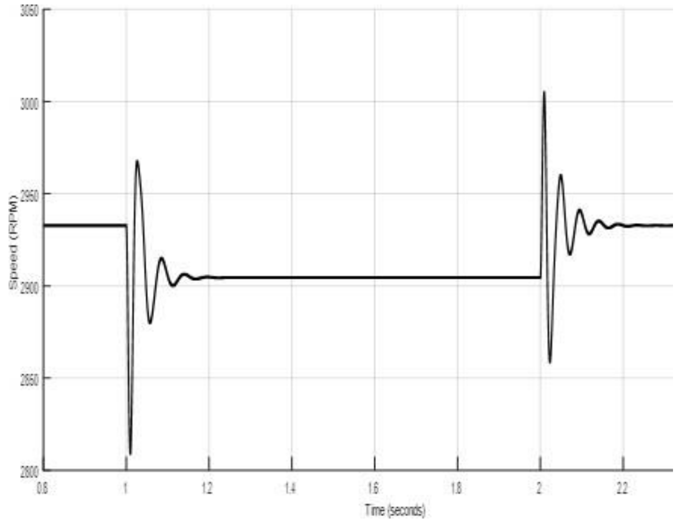

Figure-06(d): speed variation graph

From the above results it is clearly shown that when the voltage suddenly decreases, the main parameters of motor changed. These parameters are motor speed and motor current during under voltage condition. The changing of these parameters may cause the heating in motor. Heating is an alarming abnormal condition for the motor which may cause motor to burn. It is very important to protect motor from these types of abnormalities.

Secondly, the results also have been taken after simulation on Overloading condition which is very common in the motors. The following results represents the variations in the parameters of motor. These parameters include motor speed in RPM, voltage in volts and current in ampere profile. The results in the form of graph are shown in figure-06(e) to Figure-06(g).

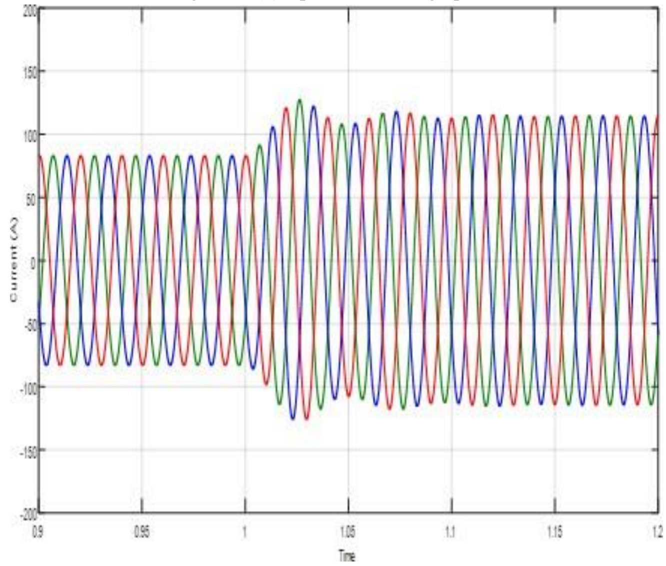

Figure-06(f): Three-phase current drawn by Induction motor in overloading condition

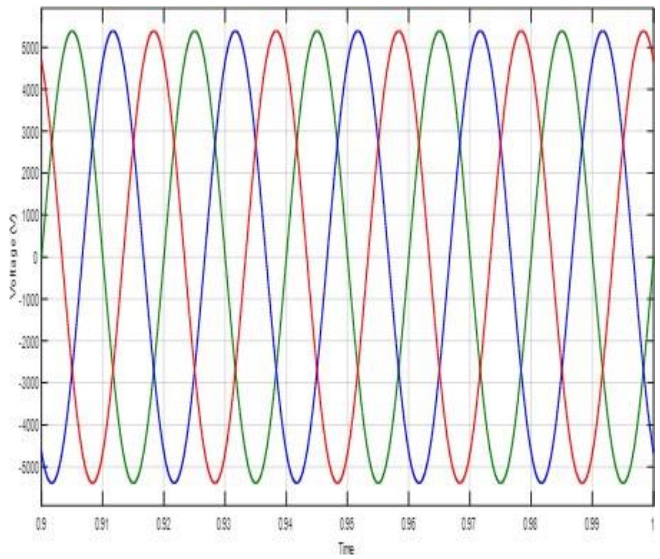

Figure-06(e): Three phase voltage input to induction motor

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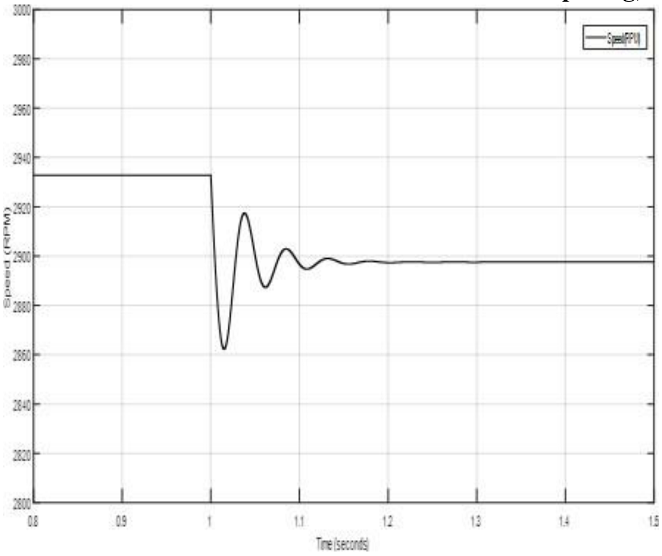

Figure-06(g): Motor speed subjected to overload (1sec)

From the above results it is clearly shown and observed that there is changing in speed of motor when suddenly load increases. This causes increase of mechanical load above the induction motor rating. The effects on Induction motor due to overload are shortening of insulation life, phase currents increment, overheating in machines, high rotor and stator losses and short circuiting of winding.
Analyzing the above results, we cannot ignore the faults in both cases.

B. Hardware Results

After installing all the equipment's, we have finally ended our work. Wiring connections and equipment's inside the panel are shown in figure-07(a) and (b). Mainly components are inside the panels as we cannot set outside the panel for safety purpose.

Figure-07(a): Inside the panel

Figure-07(b): Inside the panel

The pilot devices (three Indicators Red, Yellow and Blue), measuring equipment for voltage (Volts), current (Ampere) and frequency (Hz) are installed outside the controlling panel to check the parameters continuously. The results of voltage and currents are seen from all the three phases, to check the balancing and misbalancing of the loads at each phase. The selector is used outside the panel to operate control panel either manually or through IOT and toggle switches are used to operate the different loads as per requirement. Figure-07(c) clearly depicts the control panel which is in operation for all the loads.

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Figure-07(c): Outside the panel with loads

After completion of circuit and control panel, the main part of our paper is to check and analyze the operation of motors. As per title smart control panel is named because of Internet of things technology.

Motor may face mainly two faults; first electrical side and second mechanical side. Electrical side fault may occur due to short circuit current and overload on motors etc. whereas mechanical fault may occur due to friction, bearing and vibration etc. The electrical faults result in heating effects in motor. Heating is an alarming condition of motor fault on electrical side whereas vibration is also alarming condition of motor fault on mechanical side. For both the abnormalities an alarming device are used in control panel named as temperature sensor and vibration sensor. If any of fault occurs in the motor, we can check it and control it with the help of IOT. The results from both the sensors are shown in figure- 08.

Figure-08: IOT results

V. CONCLUSION

Inductive loads are extensively used in industries due to so many applications. It is very important to make some smart system. For this a smart panel is set which aims to operate the loads both manually and through IOT. The IOT controlling system is very efficient and more comfortable which we can use from anywhere through Wi-Fi. It is more easily and quickly operating system whereas compared to manual system because there will be no need of anybody to be available physically. This will not only save the cost of labors bit also make the system smart. However, for back-up support manually operation system is also used. If the automatic system does not work due to any technical problem, then we can easily operate the system by the manual controlling. Except these features, this smart panel is also beneficial from protection and controlling point of view. If any fault occurs in electrical side or mechanical side, then we can control it through IOT from anywhere. The electrical faults as under voltage and Overloading in three-phase induction motor are also considered in MATLAB/SIMULINK. The molded case circuit breaker is used for working on the control panel in case of maintenance purpose and protection purpose. This system is very much helpful to industries for controlling purpose and may be extended in future to work on all the types of faults in the motor and their reverse and forward operation through IOT.

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