Visvesvaraya Technological University
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A Project Report
On

"SMART CONTROLLER FOR MOTOR PROTECTION"

Submitted for partial fulfillment of the requirement for theaward of the degree

Of

Bachelor of Engineering
in
Electrical and Electronics Engineering

Submitted by

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CERTIFICATE

This is to certify that the project report entitled **"SMART CONTROLLER FOR MOTOR PROTECTION"** is a bonafide work carried out by **AISHWARYA S : 4AD13EE003,ARCHANA N L:4AD13EE006,PREETHAM L P :4AD13EE024 ,SHUBAEL SHANE S : 4AD13EE034**,in partial fulfillment for the award of Bachelor of **Engineering** in **Electrical and Electronics Engineering**,of the **Visvesvaraya Technological University,Belagavi -590 018** during the year 2016-2017.It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the report deposited in the departmental library.The Project report has been approved as it satisfies the academic requirements in respect of work prescribed for the said Degree.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Three-phase induction motors are industry's workhorses and widely used as electromechanical energy conversion devices. Although induction machines are considered relatively reliable and robust due to their simple design and well-developed manufacturing technologies, failures do occur and may severely disrupt industrial processes and even lead to disastrous accidents. To prevent these failure happen, many techniques have been developed for early condition monitoring. The old classical methods are complex. Hence to protect an Induction motor easily, a microcontroller based fault detection and protection of Induction motor is proposed.

Our project 'SMART CONTROLLER FOR MOTOR PROTECTION ' may be a sign of things to come in 'smart' as we incorporate efficient components mainly like microcontroller, GSM with which monitoring becomes easy for the farmers and let them know exactly about the motor condition under abnormal condition.

1.2 PROBLEM DEFINITION

PROBLEM 1

An induction motor would be in a very dangerous state if it operates through the fault condition of phase failure and this occurs mainly due to overcurrent, overheating of the motor winding. The causes of motor overheating are motor overloading, distortion in the supply voltage, impaired cooling capability, unbalanced supply voltages etc. Because of overheating, we can face the problems such as Electrical fire, Insulation failure, Decrease in life time. Such phase failure faults cannot be identified by the user.

PROBLEM 2

If water is not available in the tank and motor is operated then many components such as windings will get heated up and there will be chances of wear and tear and deformation of windings and other parts of motor due to heat. If motor is running dry ,then due to heat factor ,parts can be damaged and this will result in motor failure.Such dry run faults cannot be identified by the user.

1.3 PROBLEM SOLUTION

SOLUTION FOR PROBLEM 1

For the mentioned problem that is during the failure of any of the phases of the three phase induction motor, Microcontroller will sense the abnormality in the voltage values coming from the SMPS after getting stepped down and in case of phase failure, the signal will be sent from microcontroller to the relay module to stop the motor automatically and send the message to the user about the phase failure through GSM so that user gets to know about the fault taking place in the operation.

SOLUTION FOR PROBLEM 2

In our project we use Hall Effect Sensor as an excellent solution for the described problem. Hall Effect Sensor is a sensor used to indicate the flow of water from the sump to the tank through centrifugal pumps. If there is no water flow through the hall effect sensor that is if the motor is running dry ,it gives signal from the microcontroller to the relay module to stop the motor automatically and send the message to the user about the fault condition through GSM.

1.4 PROJECT OBJECTIVE

- To make a reliable protection system for induction motor using ATMEGA328 microcontroller and GSM.Protection of motor is done by connecting a simple circuit to it which consists of the following equipments :
    - Converter.
    - Voltage regulator
    - Relay
    - ARDUINO

- GSM(Global System for Mobile Communication)
- Hall effect sensor

➢ The circuit also informs the user about the working condition of the motor to the user's mobile using GSM.

➢ Information that can be passed through GSM which inturn can be sent as SMS to the user's mobile are as follows :-

- Phase failure condition
- Dry condition (unavailability of underground water that has to be pumped)

1.5 CHAPTER OUTLINE

The problem definition, project objective ,software &hardware description of the project have been compiled into several chapters as discussed here under.

CHAPTER 1 is an introduction chapter with general introduction, problem definition, objectives of work carried out during the project.

CHAPTER 2 involves the Literature survey of the project for the practical implementation.

CHAPTER 3 involves the description of the hardware design and the software used. The chapter comprises of general operation and the use of components in the circuit.

CHAPTER 4 involves the circuit diagram and working principle of the project, applications, pros and cons of the project.

CHAPTER 5 involves the Results and discussion of the project.

CHAPTER 6 concludes the report with suggestions for future improvements.The list of references are provided in the report

CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL INTRODUCTION

In this section we deal with various research papers of our project from which we got enormous information on the faults occurring on an induction motor and its respective protective schemes. Our project is completely based on motor protection for two fault conditions that is Phase failure condition and Dry run condition. In spite of this, the papers we had referred throughout the process of project was on all the possible fault conditions such as over-voltage, over-current, under voltage, under-current, over-temperature through the control of microcontroller which gave us more knowledge and also a scope of improvement for our project in all aspects.

2.2 LITERATURE REVIEW

This paper provides the distinguish issues of three phase Induction Motor (IM)and to control its faults using a microcontroller protection based scheme[1]. The most essential parameters are Voltage and Current. The control of motor is done using a 40 pin 8 bit microcontroller **AT89C52**.There are two separate types of fault with electric motors: faults in the motor itself and faults with external causes [1].

• Faults in the motor - Phase to ground short circuit, - Phase to phase short circuit, - Internal winding short circuit, - overheating of windings, - Broken bar in squirrel cage motors, - Problems in windings,

• Faults with external causes their sources are located outside the electric motor but their effects can damage it. Hence following table of electrical fault shows its causes and effects.

CAUSES	EFFECTS	POSSIBLE DAMAGE
Thermal overload: Extreme condition Locked rotor High overload Under-voltage Intermittent operation	over-current and thus unacceptable heating-up of windings	soldered joint damage rotor cage burnt windings stator windings
Cooling problems: Restricted cooling Ambient temperature too high	unacceptable heating-up	burnt windings stator windings
Electrical causes: Single phase condition Unbalanced voltage Earth fault Shorted turns Winding short circuit	unbalance over-current of winding sheeting-up depending on motor size and bearing damage load	individual windings parts burnt

Table 2.2: Breakdown causes, effects and possible motor damage

This paper tends to develop for protection of three phase induction motor from over voltage and under voltage, over current, over speed, temperature, Line frequency and phase failure with their sensing circuits using microcontroller**[2]**.The protection using solid state relay by designing sensing and control unit for the agriculture purpose using motor current signature analysis [MCSA] with wavelet transformer methods,Artificial intelligent fault monitoring approach ,Fourier spectral analysis using FFT and MATLAB programming for fault frequency methods and Zig Bee based methods are proposed.The above said methods are simulation based methods. Recently the PLC based protection systems including all variable parameters of three phase induction motor have been proposed **[2]**. This method is based on computer and programmable integrated circuit (PIC). This eliminates most of the mechanical components. But they are highly complex system and costlier. In order to overcome these problems, the microcontroller based fault detection and protection of induction motor is proposed.

A low cost and reliable protection scheme has been designed for a three phase induction motor against unbalance voltages, under voltage, over voltage, short circuit and overheating protection[3]. Taking the cost factor into consideration the design has been proposed using microcontroller Atmega32, MOSFETs, relays, small CTs and PTs. The heat produced by the motor under single phasing condition needs to be taken care of in adequate time[3]. When phase opens at distribution transformer or at feeder end, the stator and rotor losses increases to ten times and the shaft output power decreases to negligible. But if the single phasing occurs at motor terminals the losses increases twice and the shaft power reduces to nearly 70%. Motor life shortens as the temperature increases[3]. To protect the motor all the terminals should be open [3]. On distribution feeders, majority of faults are single phase. On an averagesingle phase fault occurs 70%, double phase fault 20% and symmetrical fault 10%[3].

This paper tends to develop for protection of three phase induction motor from single phasing, phase reversal, over voltage and under voltage[4]. Due to this electrical fault the winding of motor get heated which lead to insulation failure and thus reduce the life time of motor. This fault is generated in induction motor due to variation in induction motor parameters. When three phase induction motor runs continuously, it is necessary to protect the motor from these anticipated faults. Three phase induction motor generally directly connected through the supply, if the supply voltage has sag and swell due to fault the performance of motor is affected and in some cases winding is burned out. When phase sequence (RYB) is reversed due to wrong connection then motor start rotating in another direction, if supply system has only one phase and other phase is disconnected then it is single phasing problem[4].

The project design process is implemented referring all the above papers and optimal solution for the failure of motors due to the faults (mentioned in the project objective) is found out.The impact of motor protection using microcontroller describes how our design can be made accurate yet economical. The report concludes with future improvement suggestions for the circuit.

CHAPTER 3

COMPONENTS WITH HARDWARE AND SOFTWARE DESCRIPTION

3.1 GENERAL INTRODUCTION:

SL.NO	COMPONENTS	QUANTITY
1	ARDUINOBOARD WITH ATMEGA328	1
2	GSM(GLOBAL SYSTEM FOR COMMUNICATION)	1
3	CONVERTER	4
4	VOLTAGE REGULATOR	1
5	RELAY MODULE	1
6	CONTACTOR	1
7	INDUCTION MOTOR	1

Table 3.1: Components and their quantity

The above listed components are mainly used for the hardware design of our project. The chapter also includes the specifications and working of all the components required in the project.

3.2 SOFTWARE DESCRIPTION

3.2.1 General Introduction

The circuit is fully controlled by the microcontroller. According to the program written into the microcontroller the circuit will automatically on/off the motor.The prime use of the microcontroller is to protect the motor and is used for programming function ofmotor

3.2.2 Programming Logic

The following points will give a brief idea about the main program of our project explained in the form of a flowchart.The program is written for two fault conditions that is

- ✓ **Phase Failure Condition.**
- ✓ **Dry Run of Motor Condition.**

- First and foremost is to start the process by switching on the supply.
- now the phases are checked for abnormality conditions that is phase failure condition.
- Phases are checked one by one by checking the port A0,A1 and A2 for R, Y and B phases respectively to be high.
- If any of the port (R,Y,B/A0,A1,A2) is OFF/LOW state,the main output of ARDUINO board digital pin(13) becomes LOW ,which will stop the motor automatically , indicating in the form of message to the user through GSM as "PHASE FAILURE,MOTOR OFF"
- If all the phases (R,Y,B/A0,A1,A2 respectively) is in ON /HIGH state, it will check for hall effect sensor input(A3),where it indicates the flow of water through which it generates voltage of 5V. To check for the flow of water and generation of 5V through sensor as input to analog pin (A3) , a delay of 5 seconds has been given .
- Further if the inputs of all the three phases and hall effect sensor(A0,A1,A2,A3) are in HIGH state , the main output of arduino board digital pin (13) becomes HIGH which will lead to the working of motor successfully without any fault, indicating in the form of message to the user through GSM as " NO PHASE FAILURE,NO DRY RUN, MOTOR ON".
- In case ,even if all the three phases of supply(A0,A1,A2) are high and when hall effect sensor is unable to pump the water (when water is not available),leading to the failure of generation of 5V indicates analog pin (A3) as LOW, further the main output digital pin (13) becomes LOW. This will stop the motor operation automatically indicating in the form of message to the user through GSM as "NO PHASE FAILURE , DRY RUN ,MOTOR OFF"

3.3 FLOWCHART

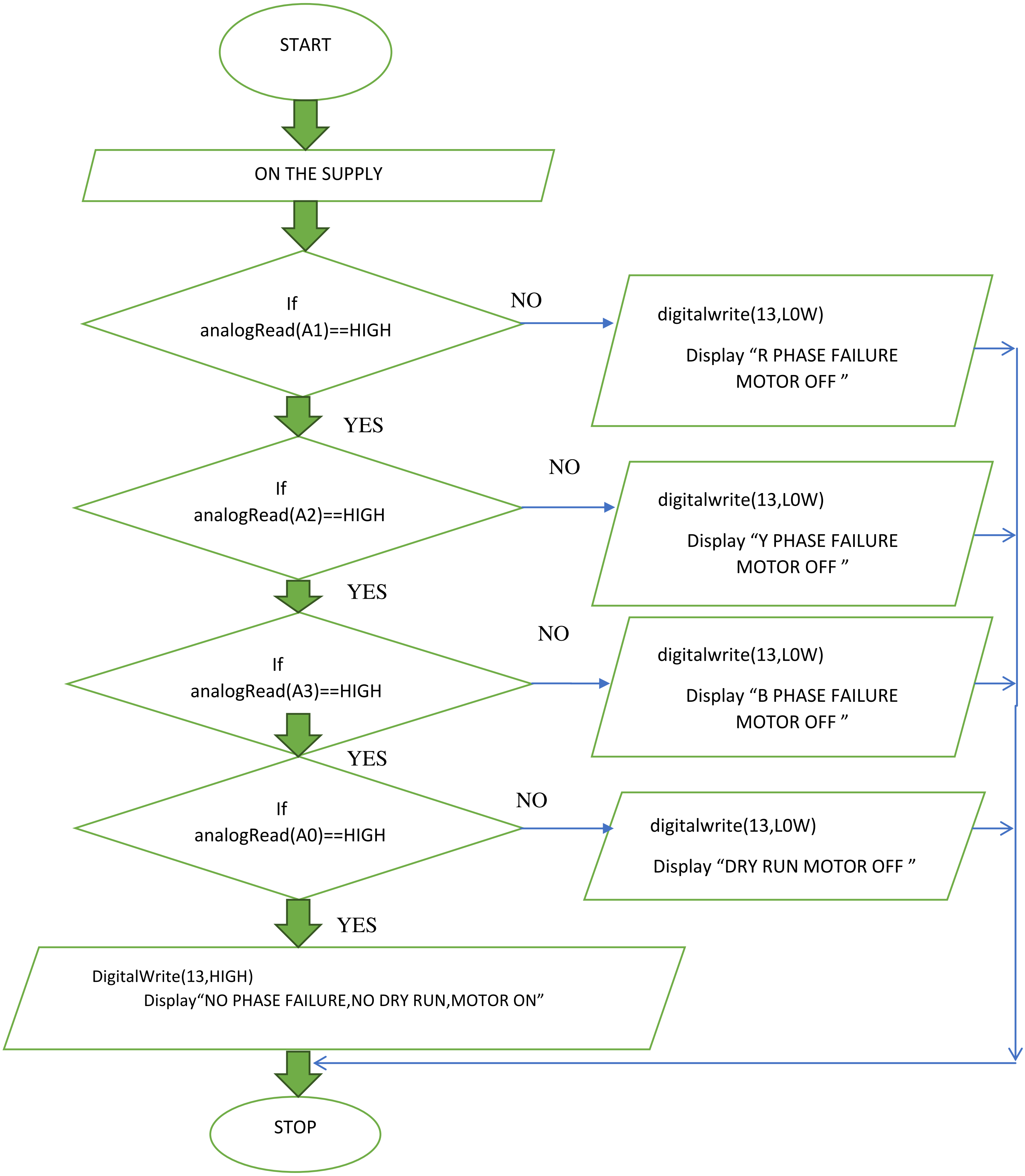


Fig 3.3 : Flowchart

3.4 COMPONENT DESCRIPTION FOR SOFTWARE ANALYSIS

3.4.1 ARDUINO UNO BOARD

The ARDUINO Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

FEATURES

Microcontroller ATmega328

Operating Voltage 5V

Input Voltage (recommended) 7-12V

Input Voltage (limits) 6-20V

Digital I/O Pins 14 (of which 6 provide PWM output)

Analog Input Pins 6

DC Current per I/O Pin 40 mA

DC Current for 3.3V Pin 50 mA

Flash Memory 32 KB of which 0.5 KB used by boot loader

SRAM 2 KB

EEPROM 1 KB

Clock Speed 16 MHz

The ARDUINO Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

• VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

• 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

• 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

• GND. Ground pins.

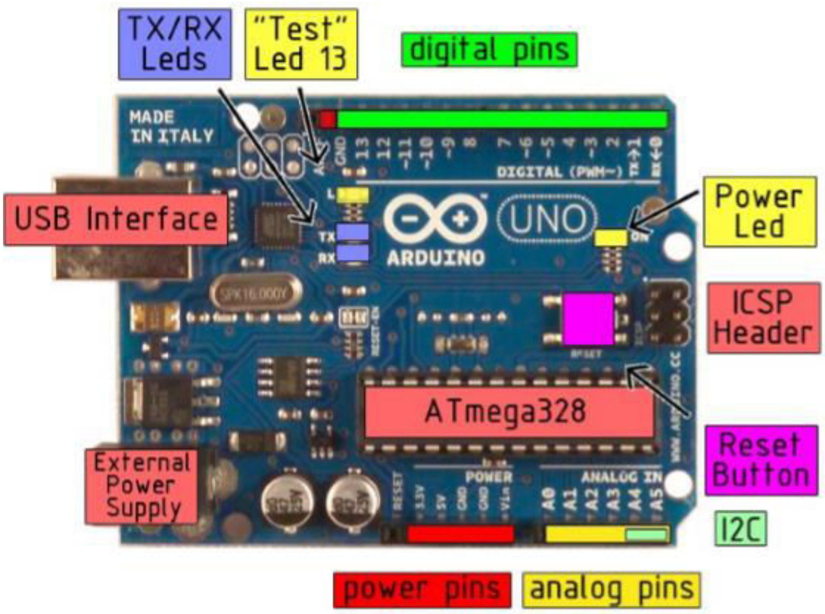


Fig 3.4.1 : ARDUINO board

3.4.2 ARDUINO SOFTWARE

The origin of the Arduino project started at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. At that time, the students used a BASIC Stamp microcontroller at a cost of $100, a considerable expense for many students.

In 2003 Hernando Barragán created the development platform *Wiring* as a Master's thesis project at IDII, under the supervision of Massimo Banzi and Casey Reas, who are known for work on the Processing language.

The project goal was to create simple, low cost tools for creating digital projects by non-engineers. The Wiring platform consisted of a printed circuit board (PCB) with an Atmega328 microcontroller, an IDE based on Processing and library functions to easily program the microcontroller.

A minimal ARDUINO C/C++ sketch, as seen by the ARDUINO IDE programmer, consist of only two functions:

- *setup()*: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- *loop()*: After *setup()* has been called, function *loop()* is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.[

Most ARDUINO boards contain a light-emitting diode (LED) and a load resistor connected between pin 13 and ground, which is a convenient feature for many tests and program functions.A typical program for a beginning ARDUINO programmer blinks an LED repeatedly.

FEATURES

- Xoscillo, an open-source oscilloscope
- Arduinome, a MIDI controller device that mimics the Monome
- OBDuino, a trip computer that uses the on-board diagnostics interface found in most modern cars
- Ardupilot, drone software and hardware

- Gameduino, an Arduino shield to create retro 2D video game.
- ArduinoPhone, a do-it-yourself cellphone.
- Water quality testing platform
- Automatic titration system based on Arduino and stepper motor
- Low cost data glove for virtual reality applications
- Impedance sensor system to detect bovine milk adulteration
- Homemade CNC using Arduino and DC motors with close loop control by Homofaciens
- DC motor control using Arduino and H-BridgeC-STEM Studio, a platform for hands-on integrated learning of computing, science, technology, engineering, and mathematics (C-STEM) with robotics.

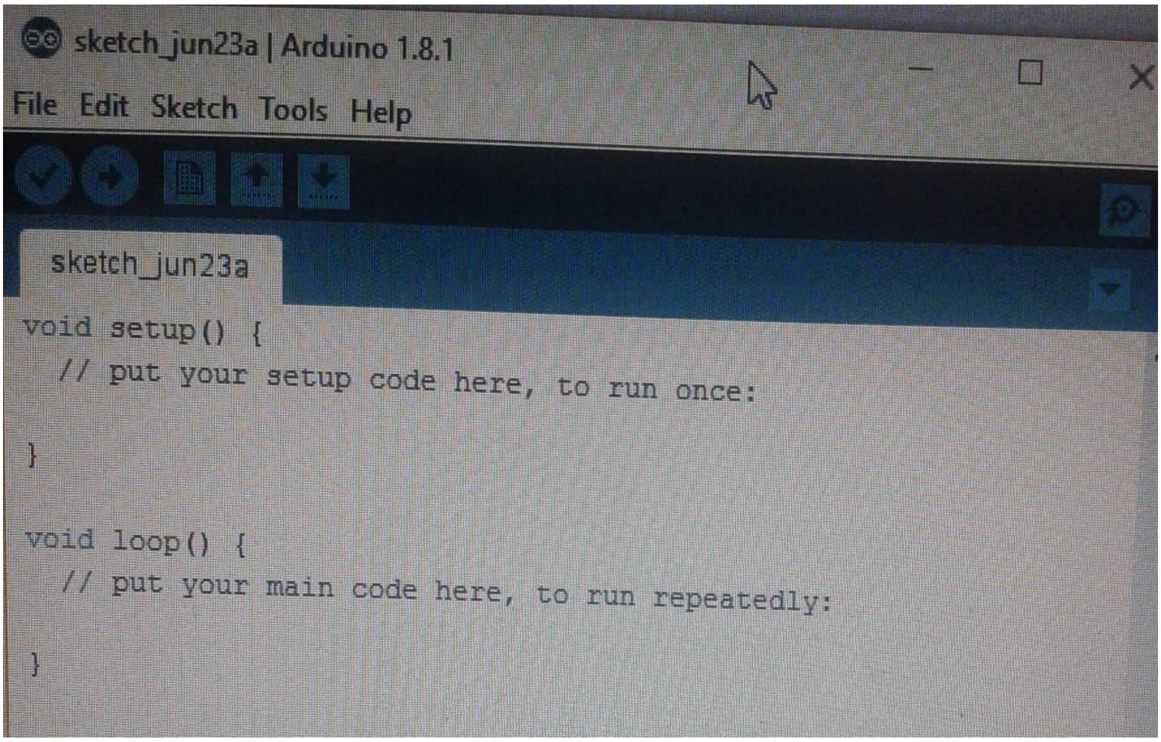


Fig 3.4.2 : Snap shot of ARDUINO software where program will be written

3.5 COMPONENTS WITH HARDWARE DESCRIPTION

3.5.1 BLOCK DIAGRAM

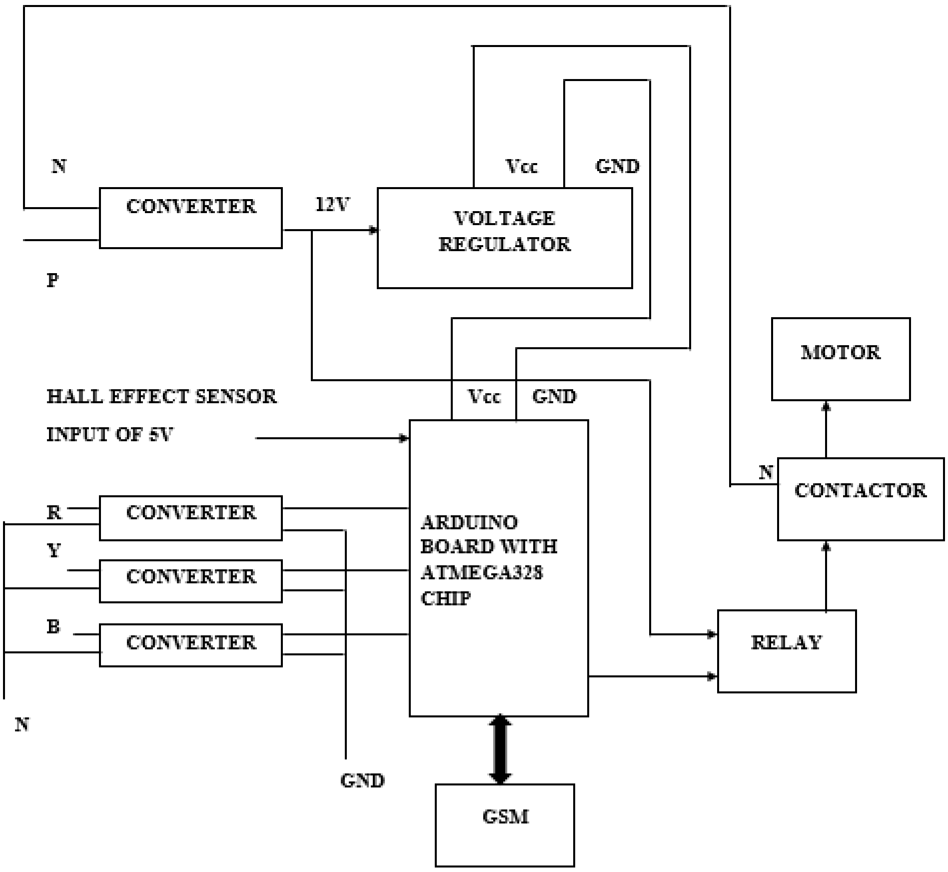


Fig 3.5.1 : Block Diagram

3.5.2 ATMEGA328 MICROCONTROLLER CHIP

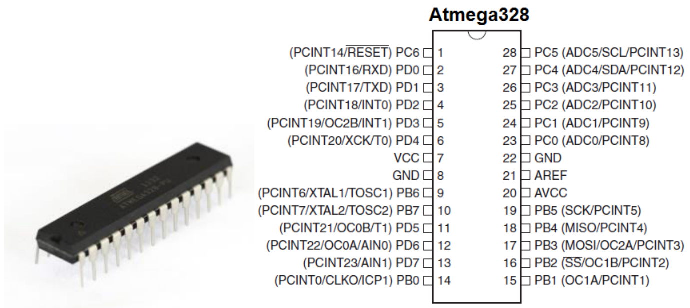


Fig 3.5.2 : ATMEGA328 microcontroller chip with pin description

Pin Descriptions

VCC

Digital supply voltage.

GND

Ground.

Port B (PB[7:0]) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clock source, PB[7:6] is used as TOSC[2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC[5:0])

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC[5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset. The various special features of Port C are elaborated in the Alternate Functions of Port C section.

Port D (PD[7:0])

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

AVCC

AVCC is the supply voltage pin for the A/D Converter, PC[3:0], and PE[3:2]. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC[6:4] use digital supply voltage, VCC.

AREF

AREF is the analog reference pin for the A/D Converter.

ADC[7:6] (TQFP and VFQFN Package Only)

In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

Input and Output

Each of the 14 digital pins on the Uno can be used as input or output, using pin Mode,

digital Write, and digital Read functions. They operate at 5 volts. Each pin can provide or

receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 KΩ. In addition, some pins have specialized functions.

- **Serial:**

Pin numbers 0 (RX) and 1 (TX) are used to receive (RX) and transmit (TX) TTL

serial data. These are connected to the corresponding pins of the ATmega8U2 USB-toTTL

Serial chip.

- **External Interrupts**:

Pin numbers 2 and 3 are configured to trigger an interrupt on a low

value, a rising or falling edge, or a change in value.

- **PWM:**

Pin numbers 3, 5, 6,9,10, and 11 provide 8-bit PWM output with the analog Write

function.

- **SPI:**

Pin numbers 10(SS), 11(MOSI), 12(MISO), 13(SCK) support SPI communication

using the SPI library.

Serial peripheral interface (SPI) is a synchronous serial data protocol used by

microcontrollers for communicating with one or more peripheral devices quickly over short

distances. It can be used for communication between two microcontrollers.

With an SPI connection there is always one master device (usually a microcontroller)

which controls the peripheral devices.

- **LED**:

In pin number 13 there is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it is off.

3.5.3 GSM (Global System for Mobile Communication)

GSM (Global System for Mobile Communications, originally ***Group Special Mobile***) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in December 1991.

- As of 2014, it has become the de-facto global standard for mobile communications – with over 90% market share.

- 2G networks developed as a replacement for first generation (1G) analog cellular networks, and the GSM standard originally described as a digital, circuit-switched network optimized for full duplex voice telephony.
- This expanded over time to include data communications, first by circuit-switched transport, then by packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution, or EGPRS).
- Subsequently, the 3GPP developed third-generation (3G) UMTS standards, followed by fourth-generation (4G) LTE Advanced standards, which do not form part of the ETSI GSM standard.
- "GSM" is a trademark owned by the GSM Association. It may also refer to the (initially) most common voice codec used, Full Rate.

Fig 3.5.3 : GSM module

Features-

- Quad-band 850/900/1800/1900MHz
- Dual-band 900/1900MH
- GPRS multi-slot class 10/8 GPRS mobile station class B
- Low power consumption:1.5ma
- Operation temperature- -40deg to +85deg
- Class 1(1w@1800/1900MHz)

3.5.4 CONTACTOR

- A **contactor** is an electrically controlled switch **used** for switching an electrical power circuit, similar to a relay except with higher current ratings and a few other differences.
- A **contactor** is controlled by a circuit which has a much lower power level than the switched circuit.

FEATURES

- A contactor is a relay that is used ***for switching power***.
- They usually ***handle very heavy loads*** like an electric motor, lighting and heating equipments and so on.
- Though their output is used for switching very high loads, they are controlled by a circuit with very less power.
- Though they are used for switching purposes, they ***do not interrupt*** a ***short-circuit current*** like a circuit breaker.
  - When current is passed through the contactor, the electromagnet starts to build up, producing a magnetic field. Thus the core of the contactor starts to wind up. This process helps in energizing the moving contact.
  - Thus the moving and fixed contacts make a short circuit. Thus the current is passed through them to the next circuit. The armature coil brings in high current in the initial position.. When the current is stopped, the coil gets de-energized and thus the contacts get open circuited.

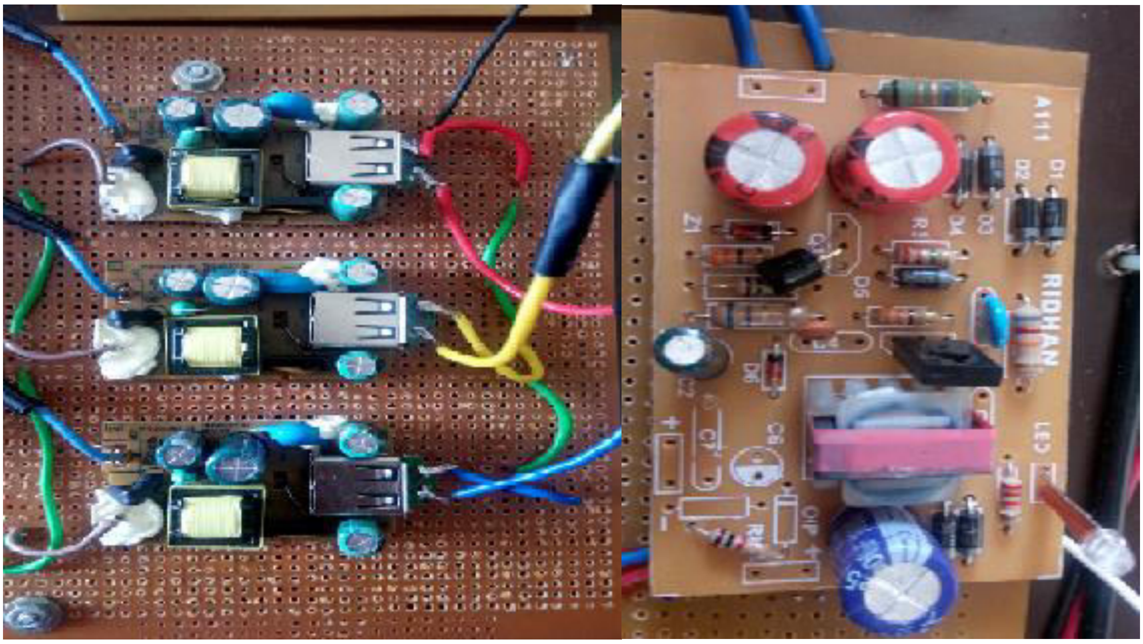
Fig 3.5.4 : Contactor

3.5.5 CONVERTER

In converter, the input AC is first rectified and filtered to produce relevant magnitude of DC. The above DC is applied to an oscillator configuration comprising a high voltage transistor or a MOSFET , rigged to a well dimensioned small ferrite transformer primary winding. The circuit becomes a self oscillating type of configuration which starts oscillating at some predetermined frequency set by other passive components like capacitors and resistors. The frequency is usually above 50 KHz.

This frequency induces an equivalent voltage and current at the secondary winding of the transformer, determined by the number of turns and the SWG of the wire.Due the involvement of high frequencies, eddy current losses become negligibly small and high current DC output becomes derivable through smaller ferrite cored transformers and relatively thinner wire winding.

However the secondary voltage will also be at the primary frequency, therefore it is once again rectified and filtered using a fast recovery diode and a high value capacitor. The result at the output is a perfectly filtered low DC, which can be used effectively for operating any electronic circuit.



5V Converter **12V Converter**

Fig 3.5.5 : Converter

3.5.6 VOLTAGE REGULATOR

Features

- Output Current up to 1A.
- Output Voltages of 5V.
- Thermal Overload Protection.
- Short Circuit Protection.
- Output Transistor Safe Operating Area Protection.

- The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a Wide range of applications.
- Each type employs internal current limiting, thermal shutdown and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output Current.
- Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

PIN DIAGRAM

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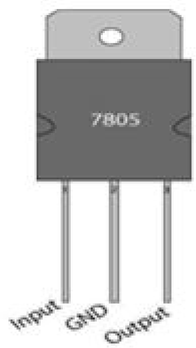


Fig 3.5.6 : VOLTAGE REGULATOR

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

Table 3.5.6 : Specifications of voltage regulator

3.5.7 INDUCTION MOTOR

- One of the most common electrical motor used in most applications which is known as **induction motor**. This motor is also called as asynchronous motor because it runs at a speed less than its synchronous speed.

- An **induction motor** is an AC electric motor in which the electric current in the rotor, needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding.

- Synchronous speed is the speed of rotation of the magnetic field in a rotary machine and it depends upon the frequency and number poles of the machine.

- An **induction motor** always runs at a speed less than synchronous speed because the rotating magnetic field which is produced in the stator will generate flux in the rotor which will make the rotor to rotate, but due to the lagging of flux current in the rotor with flux current in the stator, the rotor will never reach to its rotating magnetic field speed i.e. the synchronous speed.

Fig 3.5.7 : Induction motor

Features

HP – 0.5

Voltage-220V

Insulation –class B

Speed-2800 RPM

Current-2.8 A

3.5.8 HALL EFFECT SENSOR

Fig 3.5.8 : YF-S201 Hall Effect Water Flow Meter / Sensor

This sensor sits in line with water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution. The hall effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry.

The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output). By counting the pulses from the output of the sensor, we can easily calculate water flow. Each pulse is approximately 2.25 milliliters. Note this isn't a precision sensor, and the pulse rate does vary a bit depending on the flow rate, fluid pressure and sensor orientation. It will need careful calibration if better than 10% precision is required. However, its great for basic measurement tasks.

The pulse signal is a simple square wave so its quite easy to log and convert into liters per minute using the following formula.

Pulse frequency (Hz) / 7.5 = flow rate in L/min.

Features

- Model: YF-S201
- Sensor Type: Hall effect
- Working Voltage: 5 to 18V DC (min tested working voltage 4.5V)
- Max current draw: 15mA @ 5V
- Output Type: 5V TTL
- Working Flow Rate: 1 to 30 Liters/Minute
- Working Temperature range: -25 to +80℃
- Working Humidity Range: 35%-80% RH
- Accuracy: ±10%
- Maximum water pressure: 2.0 MPa
- Output duty cycle: 50% +-10%
- Output rise time: 0.04us
- Output fall time: 0.18us
- Flow rate pulse characteristics: Frequency (Hz) = 7.5 * Flow rate (L/min)

- Durability: minimum 300,000 cycles
- Cable length: 15cm
- 1/2" nominal pipe connections, 0.78" outer diameter, 1/2" of thread
- Size: 2.5" x 1.4" x 1.4"

Connection details:

- Red wire : +5V
- Black wire : GND
- Yellow wire : PWM output

3.5.9 RELAY

The Single Pole Double Throw SPDT relay is quite useful in certain applications because of its internal configuration. It has one common terminal and 2 contacts in 2 different configurations:one can be Normally Closed andthe other one is opened or it can be Normally Open and the other one closed. So basically you can see the SPDT relay as a way of switching between 2 circuits: when there is no voltage applied to the coil one circuit "receives" current, the other one doesn't and when the coil gets energised the opposite is happening. Relay is mainly used to activate the contactor in the project.

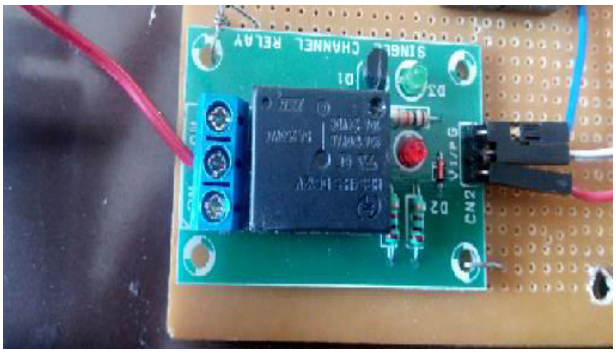


Fig 3.5.9 : Relay

CHAPTER 4

CIRCUIT DIAGRAM AND WORKING OPERATION

4.1 Circuit diagram

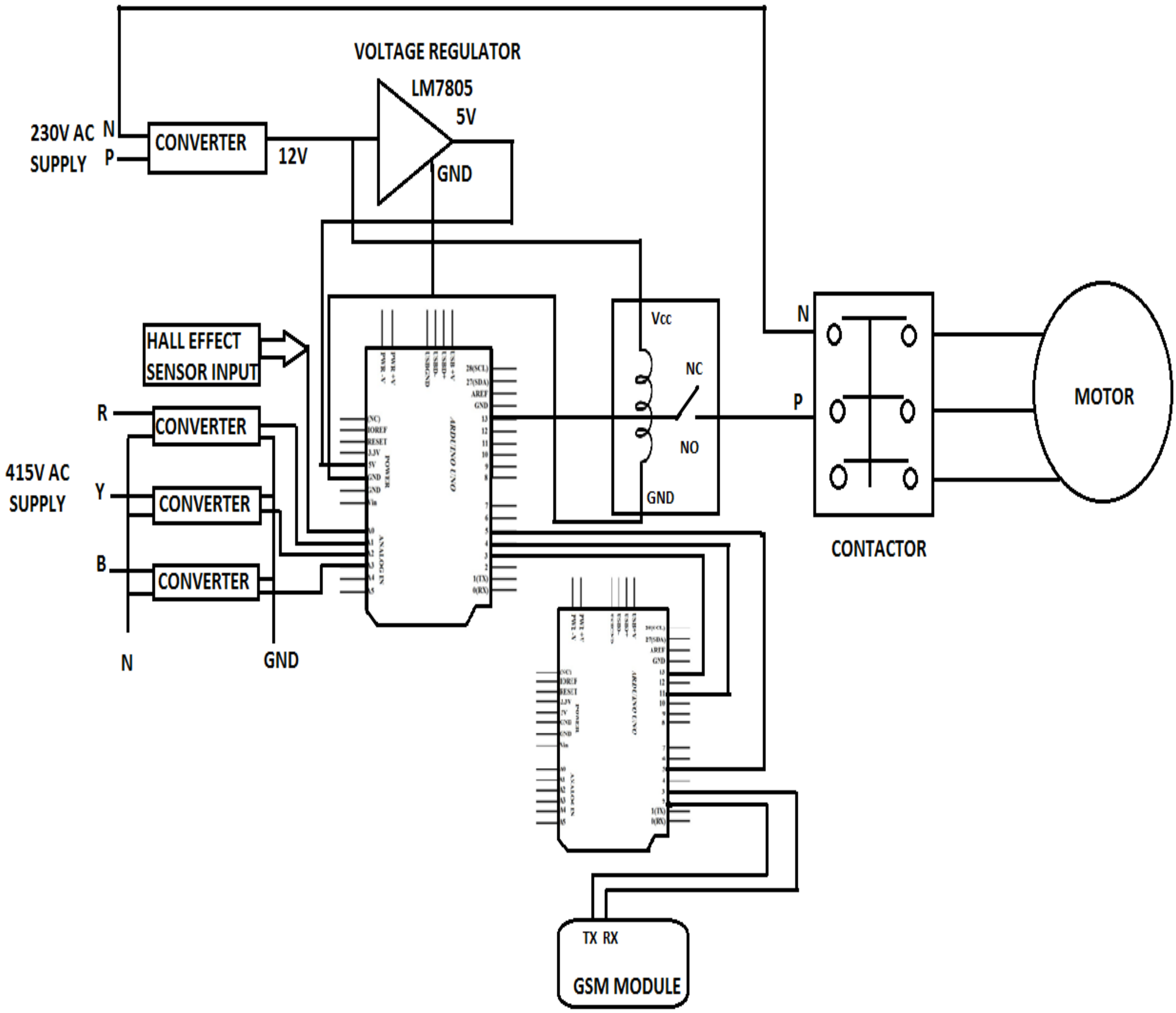


Fig 4.1 : Circuit diagram

4.2 Working Operation

- The circuit is fully controlled by the microcontroller.According to the program written into the microcontroller the circuit will automatically on/off the motor. The prime use of the microcontroller is to protect the motor and is used for programming function of motor.

- Three phase ac supply of 230V is given to the three converters where the voltage output from converter is 5V dc each. This 5V is given as primary input to the microcontroller.
- If the voltages are normal(there is no phase failure), then the microcontroller will be ON and the output of microcontroller will be HIGH and message is displayed as “NO PHASE FAILURE, MOTOR ON.”
- This HIGH output of microcontroller is used to actuate the relay.
- Relay is used to actuate the contactors.
- Though the contactor’s output is used for switching very high loads, they are controlled by a circuit with very less power.When current is passed through the contactor, the electromagnet starts to build up, producing a magnetic field. Thus the core of the contactor starts to wind up. This process helps in energizing the moving contact. Thus the moving and fixed contacts make a short circuit. Thus the current is passed through them to the next circuit.
- Thus the motor will be turned ON and water will be pumped from one tank to another tank. Thus water flowing through the pipes flow through the hall effect sensor placed inside the pipes connecting the two tanks. Due to the hall effect, a voltage of 5V will be produced which is given as the secondary input to the microcontroller.
- When microcontroller senses this 5V input, the output of the microcontroller continues to be in HIGH state and thus water pumping continues displaying message as “NO PHASE FAILURE, NO DRY RUN, MOTOR ON.”
- If there is no water in the first tank where the water is getting pumped from, then no 5V will be generated because there will be no water flow through the hall effect sensor and hence the output of the microcontroller will become LOW and LED does not glow indicating that motor should get off when there is no water. This tends the motor to get OFF automatically. Also a message will be sent to the user mobile regarding this condition as “NO PHASE FAILURE,BUTDRY RUN,MOTOR OFF.”

- In case there is a failure in any one of the phase (ports of R , Y or B is low), then there will be no input to the microcontroller and hence the microcontroller will not be turned ON. Hence we cannot get any message regarding the "PHASE FAILURE" condition. To overcome this limitation a battery of 9-5V is used that turns on the microcontroller in order to sense the phase failure and get the message regarding the failure condition in the form of a message "PHASE FAILURE, MOTOR OFF."

- GSM is interfaced with ATMEGA328 Microcontroller which sends message to the user regarding motor operations such as.

    1. Motor ON.
    2. Motor OFF.
    3. Dry condition (unavailability of underground water that has to be pumped)
    4. Phase failure condition (the failure may be in R, Y or B-phase)

- The GSM program is written in such a way that any variations takes place in circuit operation that is indicated by the ARDUINO BOARD is transmitted to the GSM module by interconnection of ports for the purpose of knowing the working or fault conditions of the circuit and motor.
- Through the transmitting and receiving operation the user will messages regarding all the operating and faulty conditions of the circuit.

CHAPTER 5

RESULTS AND DISCUSSIONS

RESULTS

5.1 HARDWARE DESIGN

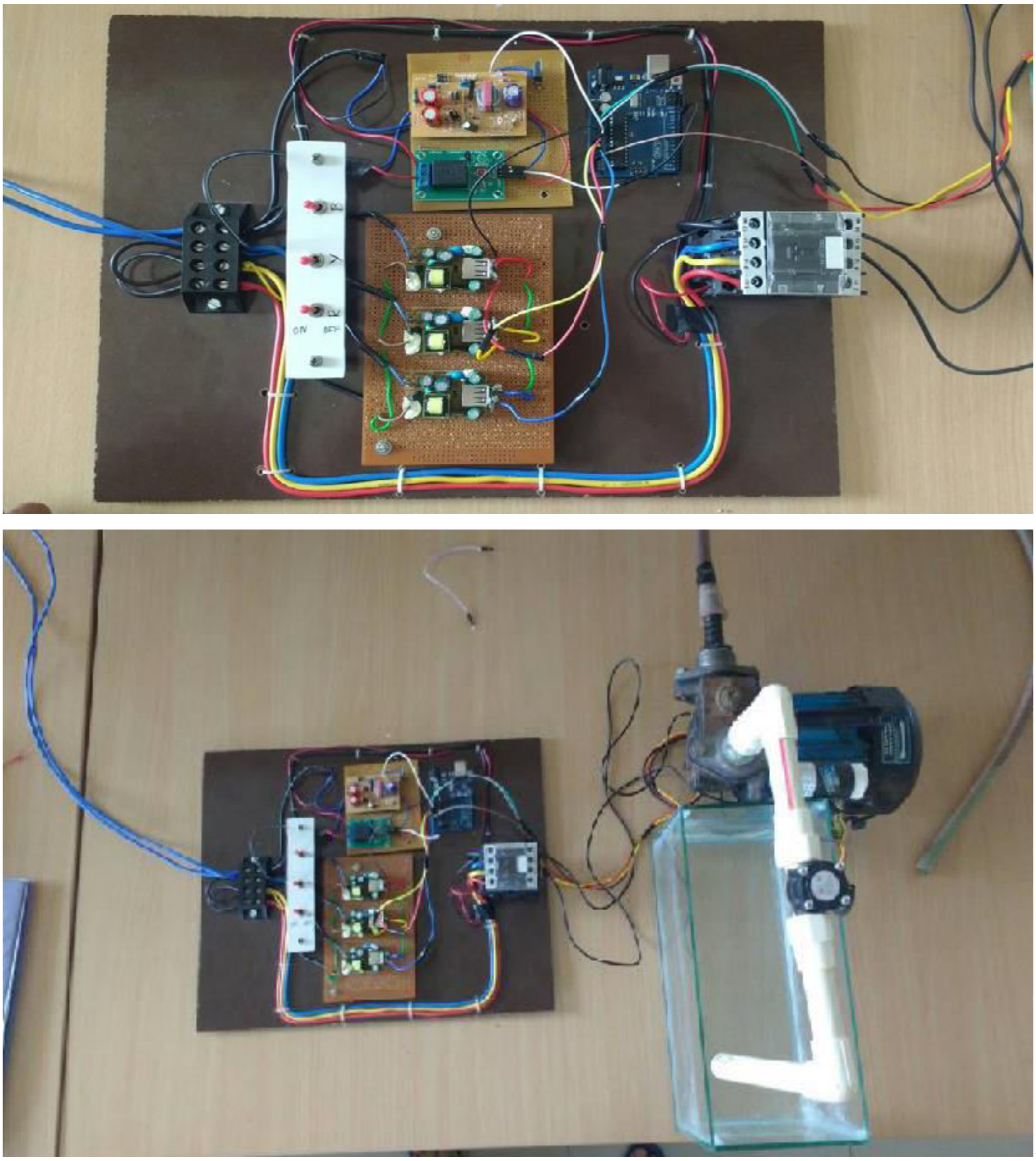


Fig 5.1 : Hardware design of the project

The above figure shows the hardware design of our project.

- The circuit is fully controlled by the microcontroller. According to the program written into the microcontroller the circuit will automatically on/off the motor.
- Three phase supply is given to the three converters which inturn produces 5V. this 5V is to activate microcontroller.
- If the voltages are normal(there is no phase failure), then the microcontroller will be ON and the output of microcontroller will be high which is used to actuate the relay
- relay actuates the contactors after getting HIGH signal from ARDUINO.
- Contactor acts as a bridge in passing the current through them to the next circuit that is the motor.
- Thus the motor will be turned ON and water will be pumped. Thus water flowing through the pipes flow through the hall effect sensor placed inside the pipes connecting the two tanks. Due to the hall effect, a voltage of 5V will be produced which is given as the secondary input to the microcontroller.
- Output of the microcontroller continues to be in high state and thus water pumping continues. If there is no water in the first tank where the water is getting pumped from, the motor to get OFF automatically. Also a message will be sent to the user mobile regarding this condition as "DRY RUN."
- In case there is a failure in any one of the phase (ports of R , Y or B is low), then also the motor gets OFF automatically.
- GSM is interfaced with ATMEGA328 Microcontroller which sends message to the user regarding motor operations

This hardware design is integrated with the software through the ARDUINO board which has the inbuilt ARDUINO program that controls the whole operation of the circuit.

5.2 SOFTWARE DESIGN

- According to the flowchart, the program is written and uploaded to the ARDUINO BOARD through USB cable.
- As soon as the supply was given, the ARDUINO BOARD LED turned ON or turned OFF depending upon the program written.

- This turn ON and turn OFF signal indicates further operation of the circuit.
- If LED was on then it indicates HIGH state where further operation will be carried out.
- If LED was OFF then it indicates LOW state where further operation will not be carried out and the motor turns OFF automatically.
- When all the phases were normal then LED was turning ON and motor was pumping water and message was sent to the user “NO PHASE FAILURE, MOTOR ON.”. But when the phases are not normal(phase failure), then LED will not glow and message will be sent as “PHASE FAILURE, MOTOR OFF.”
- After turn ON of LED signal the ARDUINO is given a delay of 5 seconds to check whether there is water flow. When there was water flow through the pipe where hall effect sensor is placed, 5V will be produced and thus motor is in operation sending a message to the user “NO PHASE FAILURE, NO DRY RUN, MOTOR ON”.
- But when there is no water flow then no 5V will be produced and thus it indicates “DRY RUN” condition and thus motor stops automatically and the LED will not blink anymore and message will be sent to the user as “NO PHASE FAILURE, BUT DRY RUN, MOTOR OFF”.

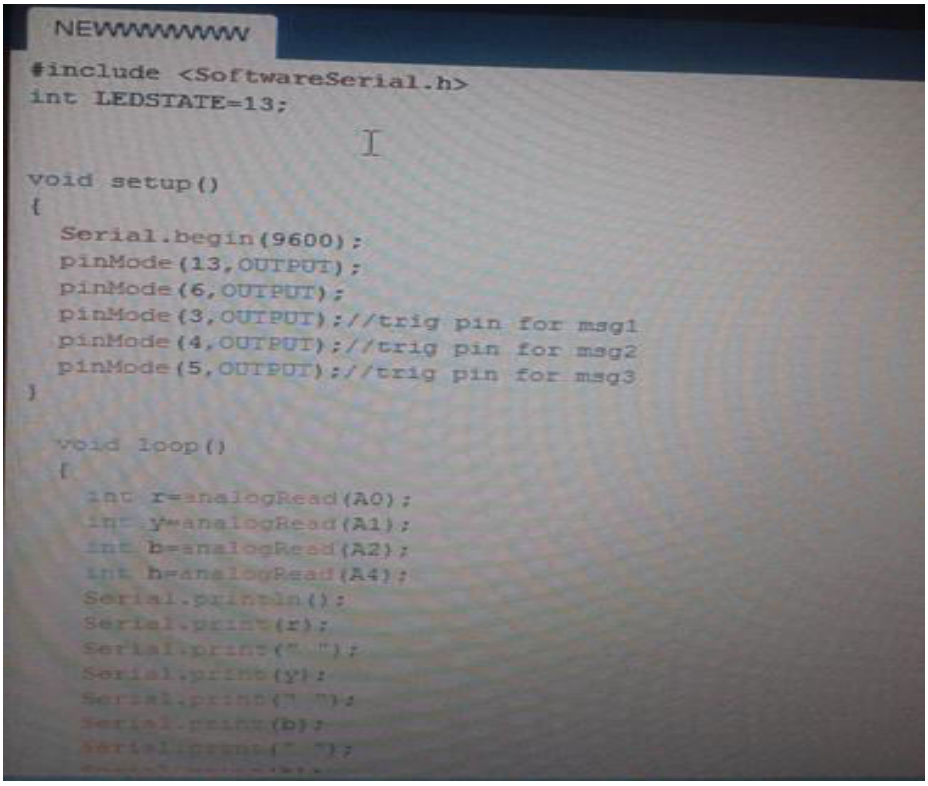


Fig 5.2.1 : ARDUINO program written in ARDUINO 1.8.1 software.

- The results are correspondingly checked with the help of LED light in the ARDUINO as well as in the "SERIAL MONITOR PORT" in the ARDUINO software and the results are shown in the figure below

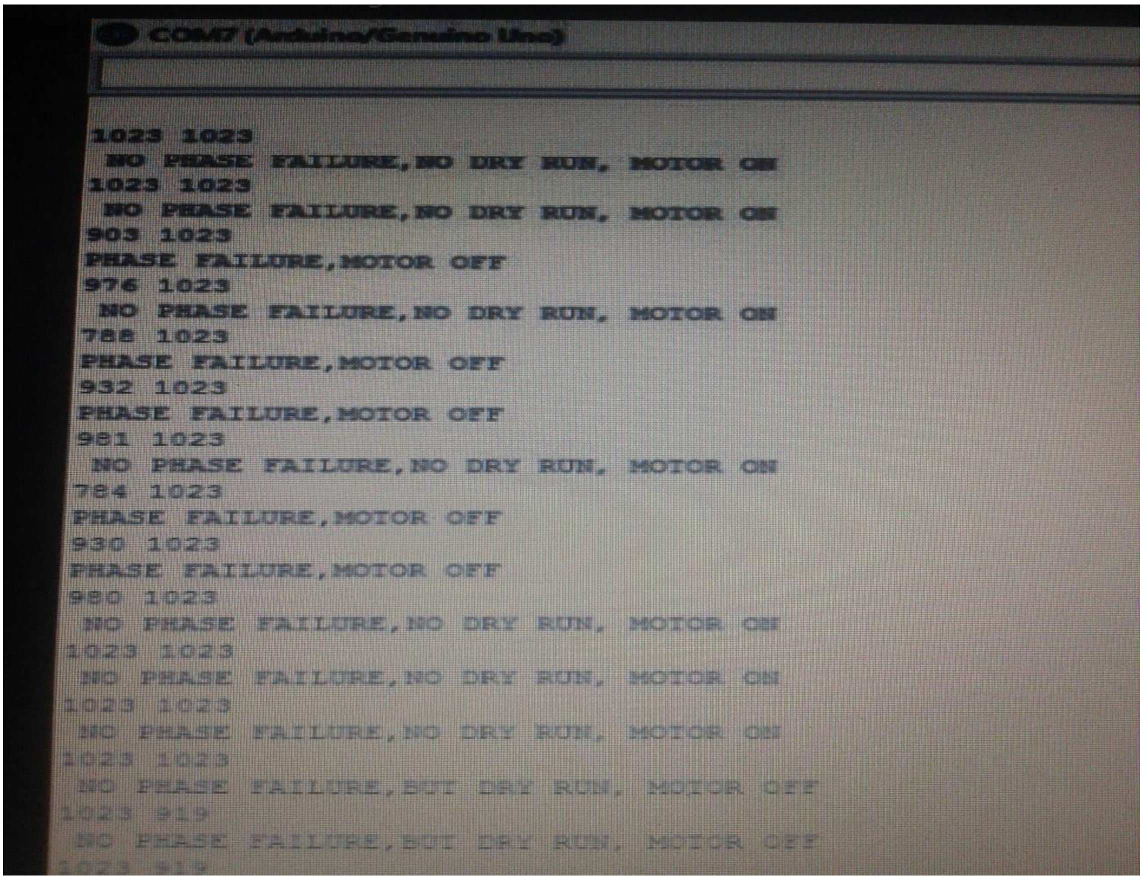


Fig 5.2.2 :- software output of the circuit

DISCUSSIONS

5.3 PHASE FAILURE PROTECTION

Objective of the project for overcoming the phase failure condition is achieved by writing the program in such a way that each phase is checked for its normality one by one. If any one of the three phases go abnormal, then the ARDUINO board will not glow and displays message as "PHASE FAILURE, MOTOR OFF." If there is no failure in any of the three phases then the ARDUINO board will glow indicating that there is no phase failure in a message form "NO PHASE FAILURE, MOTOR ON."

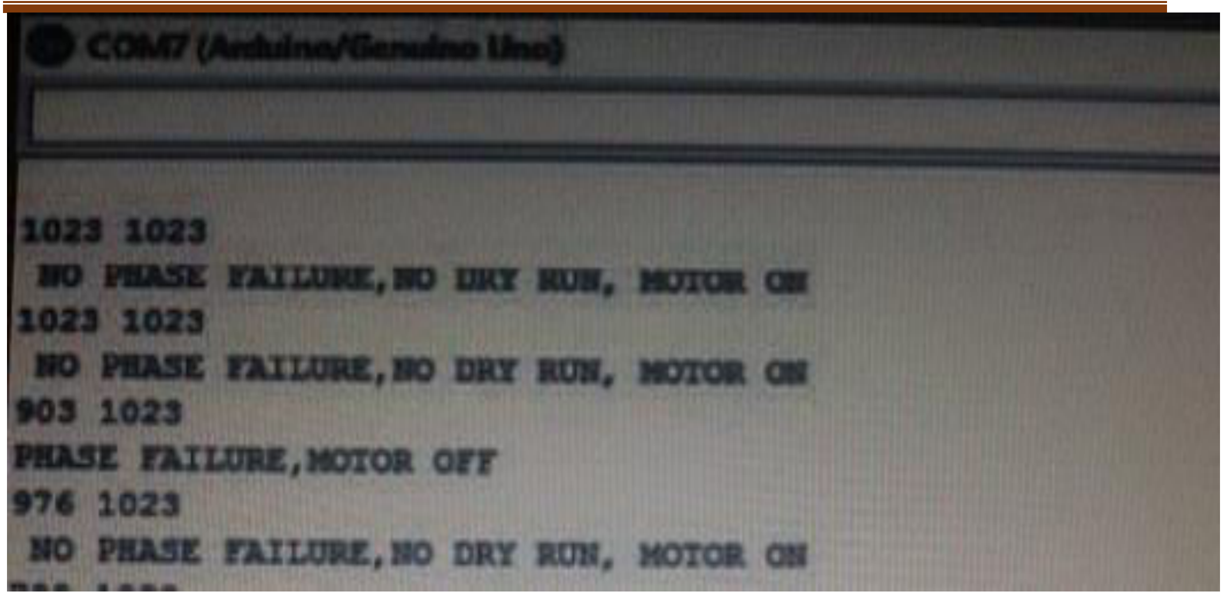


Fig 5.3 Phase failure

- Supply is ON and there is no phase failure and hence the motor is turned ON and this is displayed in the first two messages of the above figure .
- When there is failure of phase during the running operation, the motor automatically gets OFF indicating a message as shown in the third message of above figure as "PHASE FAILURE, MOTOR OFF."
- Again when the phase goes normal after its abnormality during the operation, the motor again turns ON and gives a message as shown in the final message in the above figure.

5.4 DRY RUN PROTECTION

Objective of the project for overcoming the dry run condition is achieved by writing the program in such a way that after each phase is checked for its normality one by one andif there is no failure in any of the three phases then the ARDUINO board will glow indicating that there is no phase failure in a message form "NO PHASE FAILURE, MOTOR ON."

Then a delay of 5seconds is given to check flow of water. If there is a water flow then a hall voltage of 5 volts is induced and this makes the LED on ARDUINO to continue glowing. If there is no water flow then no voltage is induced and this makes the LED OFF thus indicating that there is a dry run condition so even if there is a presence of supply voltage the motor is not performing its operation due to unavailability of water.

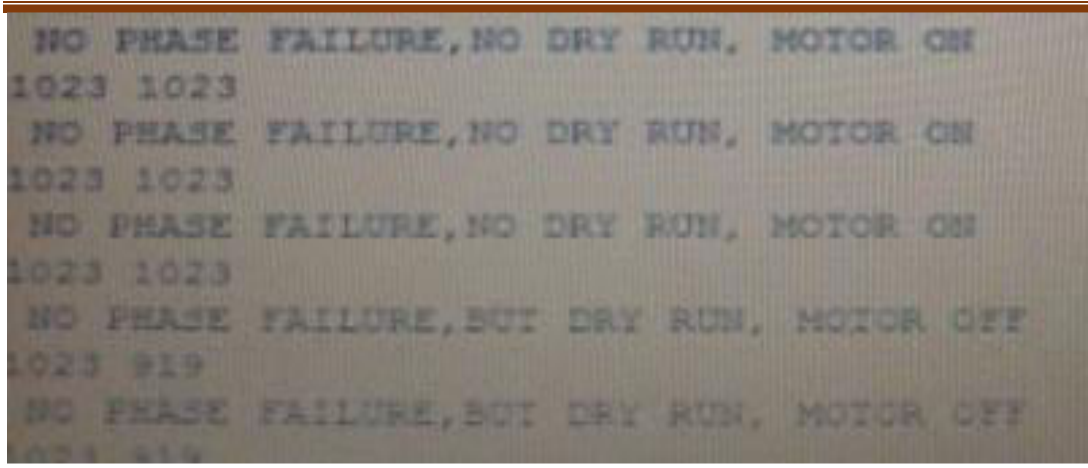


Fig 5.4 Dry run protection

- When supply is given, motor pumps water (LED is glowing) and waits for 5 seconds to sense the flow of water through hall effect sensor.
- When there is flow of water then LED continues to glow indicating message as shown in the first three messages as “NO PHASE FAILURE, NO DRY RUN, MOTOR ON.”
- During pumping of water if the water level decreases and there is no more water available to pump, then the LED does not glow indicating there is no water flow hence motor has been OFF in the form of a message as shown in the last two messages of above figure.

5.5 OVERALL VIEW OF PHASE FAILURE AND DRY RUN PROTECTION

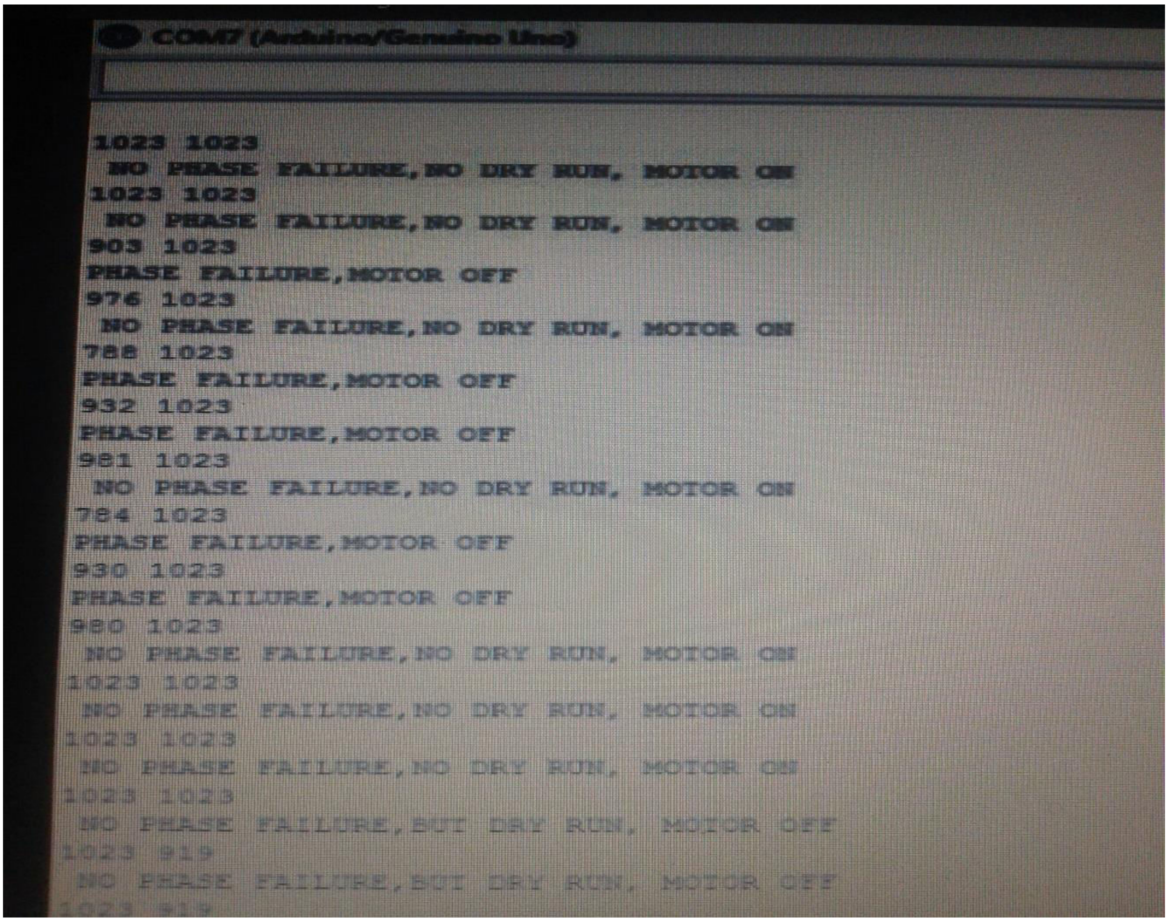


Fig 5.5.1 : overall output of phase failure and dry run protection

Checks for all the possibilities are follows:-

- NO PHASE FAILURE , NO DRY RUN

  Supply is ON and there is no phase failure and hence the motor is turned ON and water is pumped. This is indicated by the first two messages as “NO PHASE FAILURE,NO DRY RUN MOTOR ON.”
- PHASE FAILURE AT START

  If there is a failure in any of the phase then the LED will not glow and hence indicate there is a phase failure hence motor is no turned ON.
- PHASE FAILURE DURING RUNNING OPERATION

  When there is failure of phase during the running operation, the motor automatically gets OFF indicating a message as shown in the third message of above figure as “PHASE FAILURE, MOTOR OFF.”

Again when the phase goes normal after its abnormality during the operation, the motor again turns ON and gives a message as shown in the fourth message as "NO PHASE FAILURE, NO DRY RUN MOTOR ON."

- NO PHASE FAILURE , BUT DRY RUN
  During pumping of water if there is no more water available to pump, then the LED does not glow indicating there is no water flow hence motor has been OFF. It is displayed in the form of a message as shown in the last two messages of above figure.
- After the motor gets OFF due to the unavailability of water, there are no chances of motor getting ON even if the water is recollected in the sump after some time. This condition is explained below with the help of block diagram.

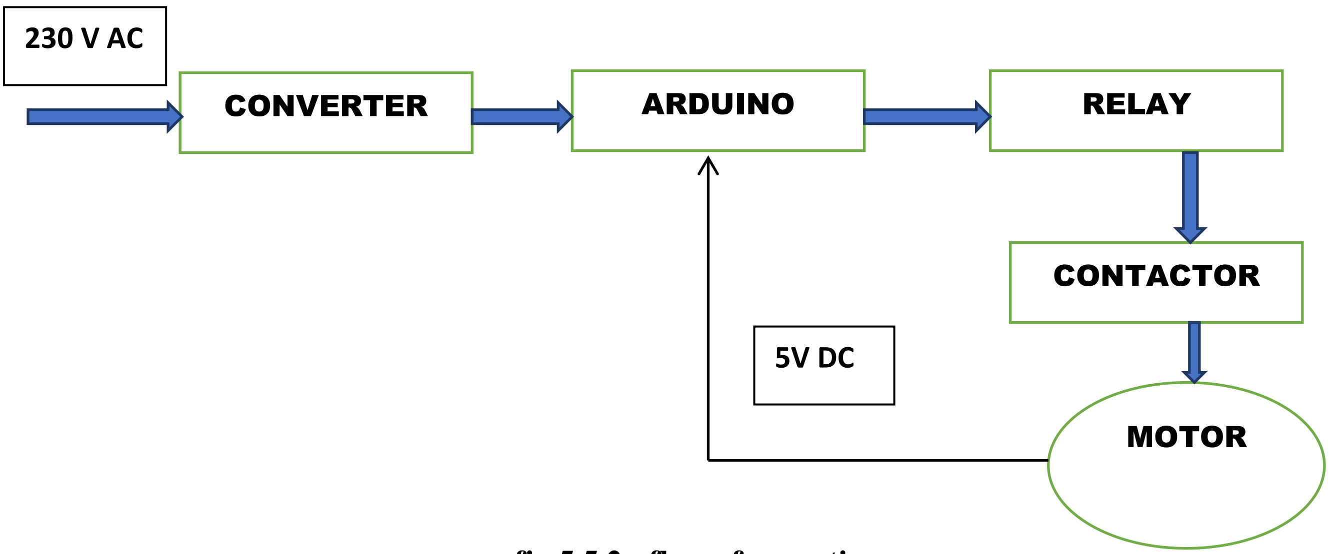


fig 5.5.2 : flow of operation

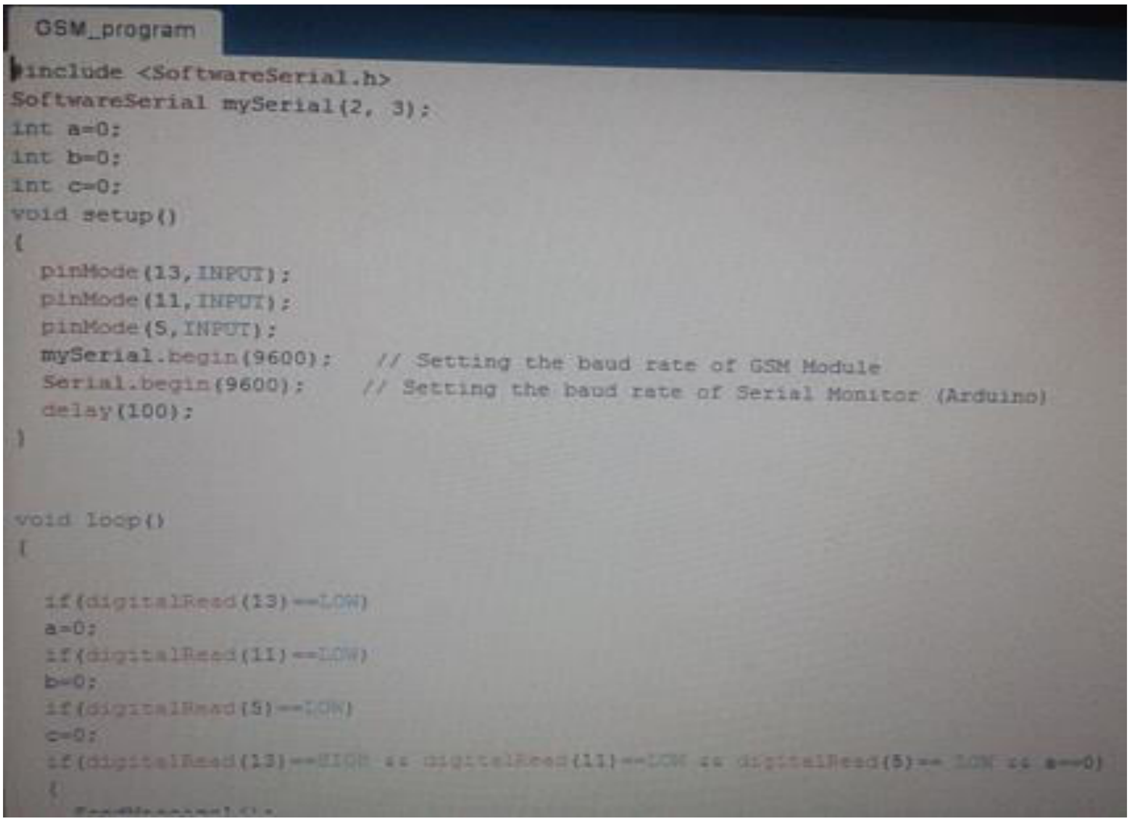
Once the converter is getting supply, it activates ARDUINO which in turn gives high signal to the relay and relay actuates contactor which is used to switch heavy load that is motor. Thus motor pumps water and 5V is generated hence ARDUINO continues to be in HIGH state and the loop repeats.

Once there is a sudden unavailability of water the motor stops pumping water. That is without water no 5V is generated and hence ARDUINO, relay and contactors get OFF and hence motor is also OFF.

Here the circuit is designed such that after some time if water gets recollected in the sump or tank, the motor does not get ON. This is due to the unavailability of signal from contactor. Since the contactor gets OFF after dry run, even if the water gets recollected it cannot be pumped because the main supply to the motor (contactor) will be OFF.

The circuit is designed in such a way to prevent fluctuating water flow out the pipe. If the motor was made to pump whenever there is a flow or recollection of water after dry run, the motor would normally pump water but in case again the water becomes unavailable then the motor has to get OFF automatically and again it should get ON if water is available after some time. This leads is discontinuous water flow at the output. To avoid this, the circuit is designed to OFF the motor once dry run condition occurs.

5.6 GSM MODULE INTERFACE



```
GSM_program
#include <SoftwareSerial.h>
SoftwareSerial mySerial(2, 3);
int a=0;
int b=0;
int c=0;
void setup()
{
  pinMode(13,INPUT);
  pinMode(11,INPUT);
  pinMode(5,INPUT);
  mySerial.begin(9600);   // Setting the baud rate of GSM Module
  Serial.begin(9600);    // Setting the baud rate of Serial Monitor (Arduino)
  delay(100);
}


void loop()
{

  if(digitalRead(13)==LOW)
  a=0;
  if(digitalRead(11)==LOW)
  b=0;
  if(digitalRead(5)==LOW)
  c=0;
  if(digitalRead(13)==HIGH && digitalRead(11)==LOW && digitalRead(5)== LOW && a==0)
  {
```

Fig 5.6 : Program written in ARDUINO for transmitting SMS to the user

The GSM program is written in such a way that any variations takes place in circuit operation that is indicated by the ARDUINO BOARD is transmitted to the GSM module by interconnection of ports for the purpose of knowing the working or fault conditions of the circuit and motor.

Through the transmitting and receiving operation the user will messages regarding all the operating and faulty conditions of the circuit.

5.7 OBSTACLES FACED DURING PROJECT PREPARATION AND ITS SOLUTIONS

There are many obstacles faced during the preparation of the project.

Mainly problems were emerging in the software part that is coding for ARDUINO.

- Firstly motor is made ON to pump water and a delay of 5 seconds was coded in the program to check whether water flow is there to avoid dry run when there is no water flow. There was a problem in giving a delay function in the ARDUINO software. It is totally different from the delay functions used in TURBO C and many other software.
- The solution to this problem of giving delay is to give delay in order of thousands so that the software analyses it in the form of milli seconds. 1000 (in program) is analyzed as 1 (by ARDUINO).

Problems were also faced with operation of ARDUINO board.

- When there was a phase failure then no supply was activating the ARDUINO and hence the ARDUINO would stop its operation. Hence the user would not get message regarding the fault since the ARDUINO was going to a LOW state.
- The solution to this problem is to give a 9-5V battery connection to the ARDUINO board so that even during phase failures the ARDUINO would get activated just for the messaging purpose. This 9-5V will not contribute to the HIGH signal to the relay for further operations. Hence message will be sent to the user regarding phase failure even when there is no supply from the mains.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSIONS

- Our objective to make a reliable protection system for induction motor using ATMEGA 328 microcontroller is achieved.
- The circuit also informs the user about the working condition of the motor to the user's mobile using GSM.
- It gives information regarding motor on, motor off, phase failure and dry run which may occur in number of possibilities.
- All the possibilities are checked for proper detection of HIGH and LOW signals and the circuit is controlled and the same is sent to the user's mobile using GSM.

6.2 SCOPE FOR FUTURE WORK

This project can be modified such that it should satisfy the under voltage protection condition so that the upcoming faults due to under voltage can also be prevented resulting in a more reliable operation of the circuit with more number of fault detections and it's preventions.

Further it can be modified such that the user can not only get the information regarding the operation and faults, but also can control the circuit by remote actions for ON and OFF the supply for motor pumping and stopping its operation.

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[4]Devesh Kumar ,Piyush Kumar Verma,Brijesh Kumar Singh "Single Phasing,Phase Reversal,Over voltage,Under voltage and Over heating ".Volume :1,Issue 1,pp no.7-10,International Journal of Scientific Research and Management Studies(IJSRMS).