Documentation on

AUTOMATION OF SPEED CONTROL OF DC MOTOR USING PLC AND ONLINE ENERGY AUDITING

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LIST OF CONTENTS

WORKING MODELS:

1. PLC TRAINER KIT

1.1 INTRODUCTION

PLC Trainer Kit is a setup of Crouzet Millenium PLC and power circuit interfacing unit consisting of various components. PLC trainer kit provides an advanced real time hardware implementation of various programmable switching schemes, logical and process control. On this PLC trainer kit we can also perform application oriented experiment by making use of in-built applications of FBD programming. This trainer kit facilitates to perform various experiments and project work for research and development of existing schemes for the students to wide spread their opportunities in core and industrial sector.

PLC Trainer Kit consists of following blocks:

1. SMPS (SWITCHED MODE POWER SUPPLY)
2. XD 26 Crouzet Millenium PLC
3. Relay Unit and Contactor
4. Manual Control Panel Block
5. Output Testing Unit
6. Protective Devices

Block Diagram of PLC Trainer Kit:

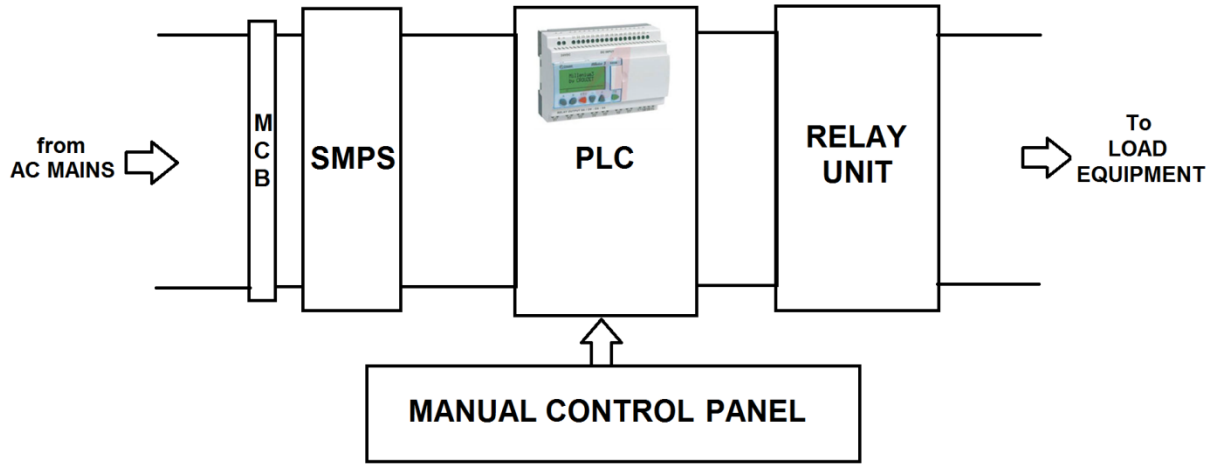
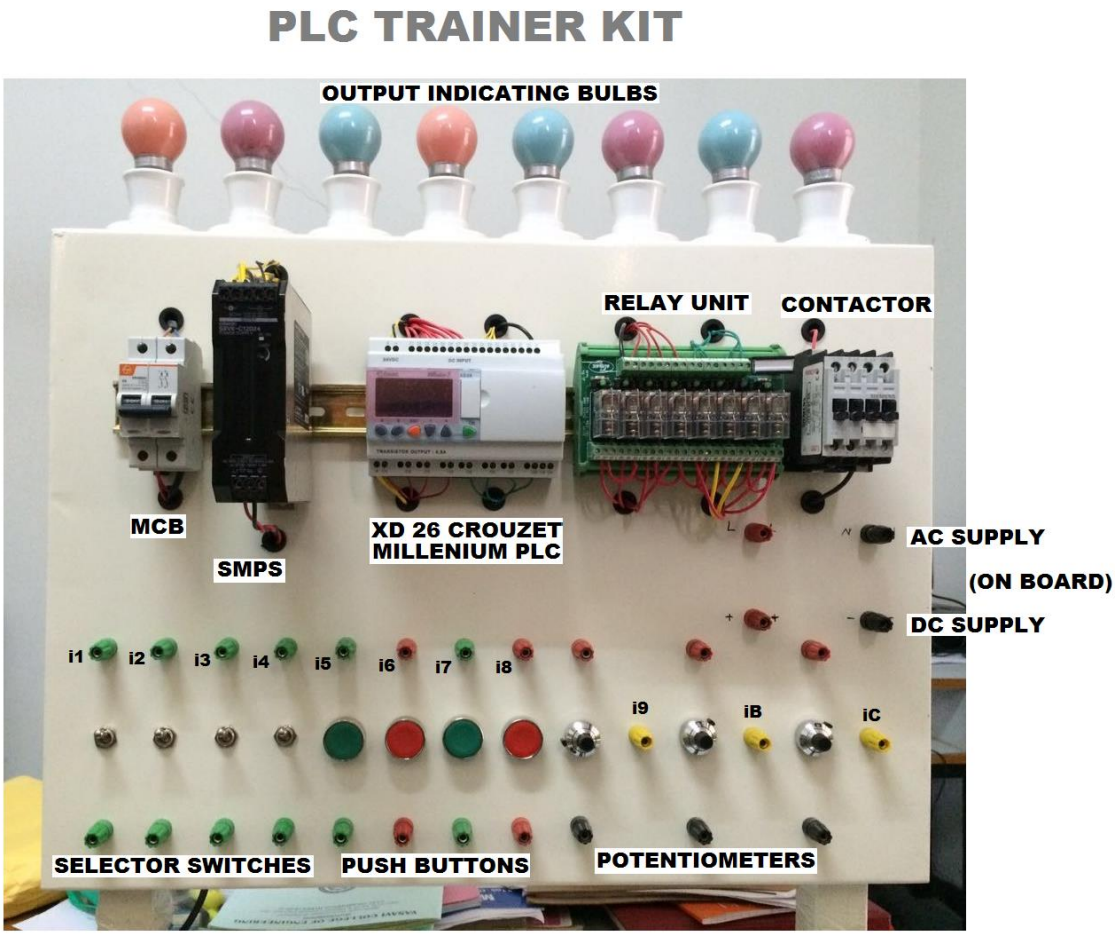


Fig Block diagram of PLC trainer kit

PLC Trainer Kit can be sectionalized for better understand of the kit to use it safely and logically as shown below:



PLC Trainer Kit blocks are discussed in briefly as follows:

1.2 SMPS (SWITCHED MODE POWER SUPPLY):

SMPS (Switched Mode Power Supply) is a power electronic device which converts variable input ac (230 V) to fixed dc (24 V as per requirement) to energize PLC.

Terminals:

Input: ac 230v, 1-phase (L+) and neutral (N-)

Output: dc 24v, 2 + terminals and 1 - terminal

SMPS assembled in our trainer kit is as shown in figure below:

Fig SMPS

1.3 XD 26 Crouzet Millenium PLC:

XD 26 Crouzet Millenium PLC is a user friendly, application oriented and inbuilt functions powered PLC. The numbering for the XD 26 PLC implies it contains 16 Digital (10 discrete and 6 analog) inputs and 10 discrete static relay outputs. And the total number of these inputs and outputs account to 26. The Software used for the PLC is Crouzet Millenium 3 Programming Language. The controller offers two programming languages

1. Ladder Programming (LD)
2. Function Block Diagram (FBD)

Terminals:

Input: dc 24v, 1 + terminals, 1 – terminal, I1-IG (16 input terminals)

Output: dc 24v, O1-OA (10 output terminals)

PLC powered and programmed in our trainer kit is as shown in figure below:

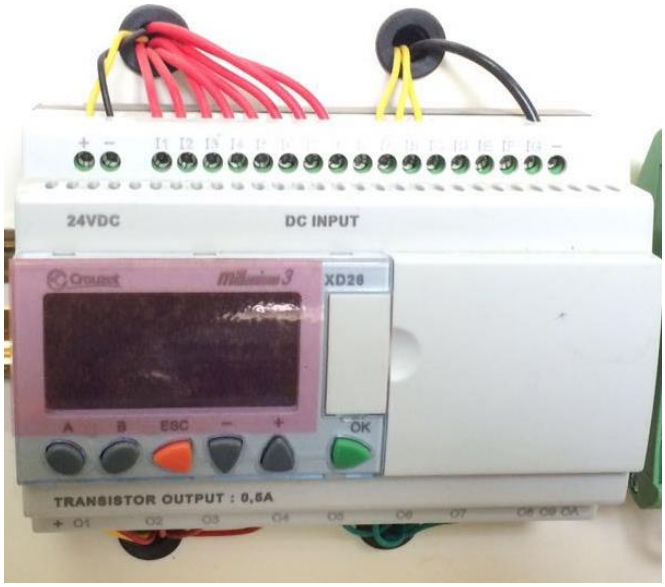


Fig XD 26 Crouzet Millenium PLC

1.4 Relay Unit and Contactor:

Relay unit:

It consist of a set of relays which are controlled and actuated by PLC, upon an actuating signal generated by the programmer through PLC programming to control load equipment. A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch.

Terminals:

Input: dc 24v, 1 + terminals, 1 – terminal, I1-IG (16 input terminals)

Output: dc 24v, O1-OA (10 output terminals)

Relay Unit assembled in our trainer kit is as shown in figure below:

Fig Relay Unit.

Contactor:

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Contactor gets activated by PLC through relay to drive heavy load equipments.

Terminals:

Input: Control terminals are ac 230v, A1 and A2

Power terminals are ac 440 v, L1, L2, L3 and NC

Output: Power terminals are ac 440v, T1, T2, T3 and NC

Contactor assembled in our trainer kit is as shown in figure below:

Fig Contactor.

1.5 Manual Control Panel Block

Manual Control Panel Block facilitates the option of controlling the output of PLC manually by operating it correctly. This block contains 3 types of input parameter switching devices. They are as follows

a) Selector switches
b) Push Buttons
c) Potentiometers

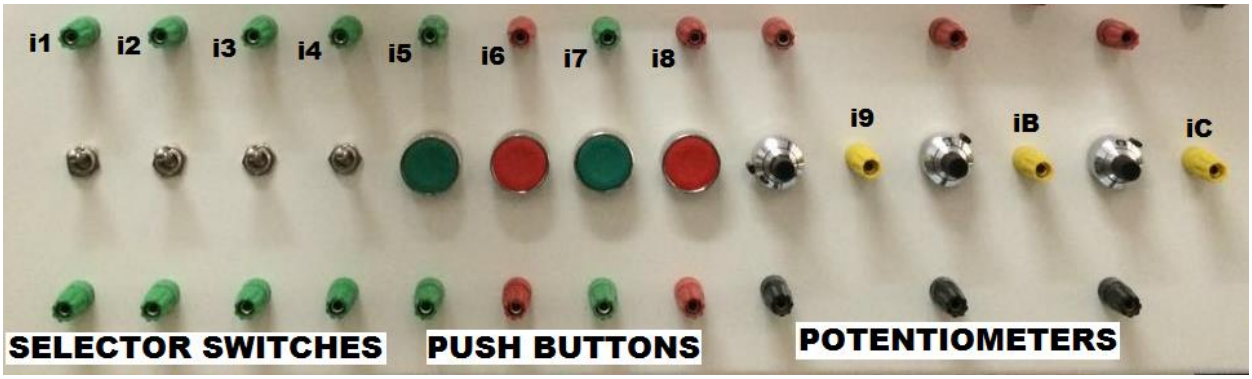


Fig Manual Control Panel Block

The differnt types of input switching devices are discussed briefly.

a) Selector switches:

Selector switch: A manually operated multi-position switch, which is usually adjusted by a knob or handle, and may have detents to hold in a given position. Used for instance, in devices or instruments with multiple functions, ranges, or modes of operation. Such a switch is usually rotary also called selector. There are 2 positions NC and NO. When selected in NC the device is in OFF mode whereas when selected in NO position the device gets connected and it is in ON mode.

Terminals:

In this trainer kit there are 4 selector switches dedicated for controlling input of PLC i1-i4 (4 inputs). The upper terminals are connected to input of PLC and the lower are connected to positive (+) terminal.

b) Push Buttons

Push Button: A push-button or simply button is a simple switch mechanism for controlling some aspects of machine or a process. A push button is a momentary or non-latching switch which causes a temporary change in the state of an electrical circuit only while the switch is physically actuated. An automatic mechanism (i.e. a spring) returns the switch to its default position immediately afterwards, restoring the initial circuit condition.

Terminals:

In this trainer kit there are 4 Push Button (2NC and 2NO) dedicated for controlling input of PLC i5-i8 (4 inputs). The upper terminals are connected to input of PLC and the lower are connected to positive (+) terminal.

c) Potentiometers

A potentiometer or a pot is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. 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)

Terminals:

In this trainer kit there are 3 Potentiometers dedicated for controlling input of PLC i9-iA (3 inputs). The middle terminals are connected to input of PLC, the lower are connected to positive (+) terminal and the upper terminals are connected to negative (-) terminal.

1.6 Output Testing Unit

Prior to connection of all the hardware input output devices, the output can be tested on a set of bulbs as a precautionary measurement for safe through monitoring of PLC and output devices. There are 8 bulbs of ac 10W, 230v. These all are connected to output of relay unit powered by 1-phase supply. Figure shows a set of 8 bulb for output indication.

1.7 Protective Devices

The main important device in all electrical equipment is the protective device. In this kit before giving the supply to SMPS, it's passed through a MCB which isolate the whole equipment from power supply and shut down the system during fault condition, by isolating healthy part from the faulty one

Fig MCB

For avoiding lengthy and complex power circuit connection, both the ac and dc power terminals are dropped at one corner of the kit for ease of connections.

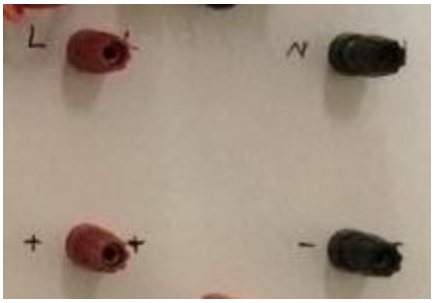
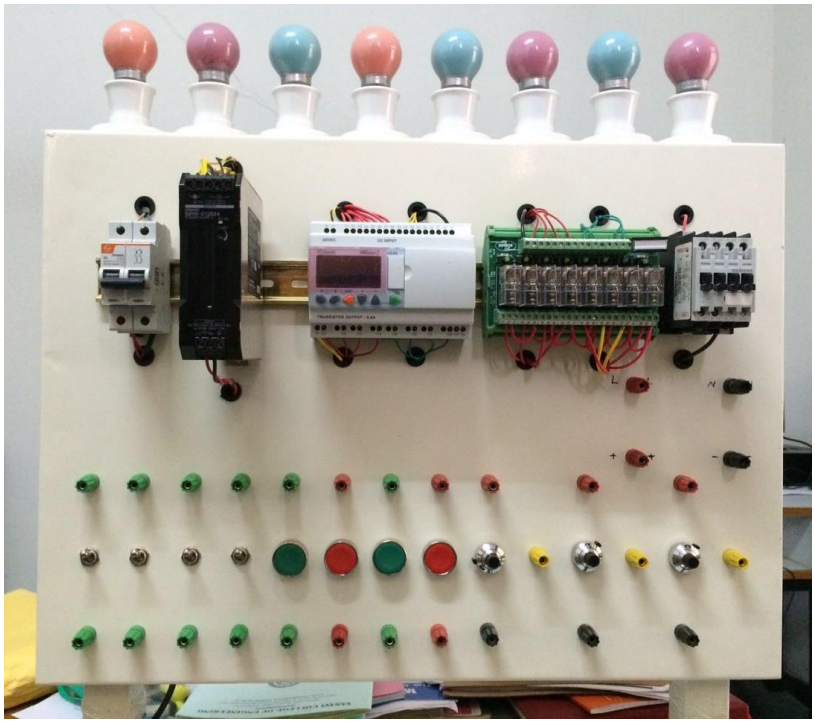


Fig ac and dc power terminals

1.8 PLC Trainer Kit:



Photograph of PLC TRAINER KIT

2. AUTOMATIC DRIP IRRIGATION SYSTEM

2.1 INTRODUCTION

Now a days there is heavy scarcity of water for irrigation purposes. It is known that in the conventional irrigation systems water is distributed through canals, during this process water that goes wasted is much more than the water that is really utilized by the crop or plants. To minimize this wastage of water, drip irrigation has been started in which water is distributed throughout the field through pipes which has small perforations. In this process the perforations are so designed that the water is delivered directly to the plant and very little water is lost through evaporation, etc.

From this it may be seen that one has to have facilities to pump water through tubes when needed. It is common practice that the farmers manually control the valves connected to the tubes from the overhead tank, further the time for which the water to be pumped is generally based on the farmers experience. This process is rather tedious and time consuming. In view of this it is felt that there is a need to develop an automatic or semi automatic system in which the water can be supplied at any time for any duration and also monitor the moisture content in the field by regulating the motor automatically.

This type of system involves two parts

- Distribution of network of perforated pipes over the entire field.
- The mechanism by which the moisture content is monitored and the water delivery system to be regulated by sensing the moisture at different points in the field.

2.2 CONTROL SYSTEM

In this chapter the details of the various components used in the realization of control system are described below.

Block diagram of transmitter and receiving unit

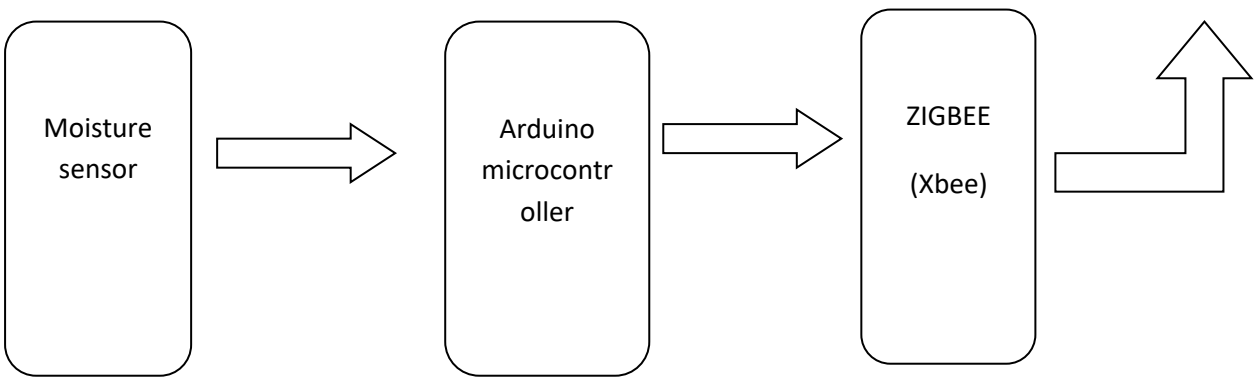


Fig 5.1: block diagram of transmitter

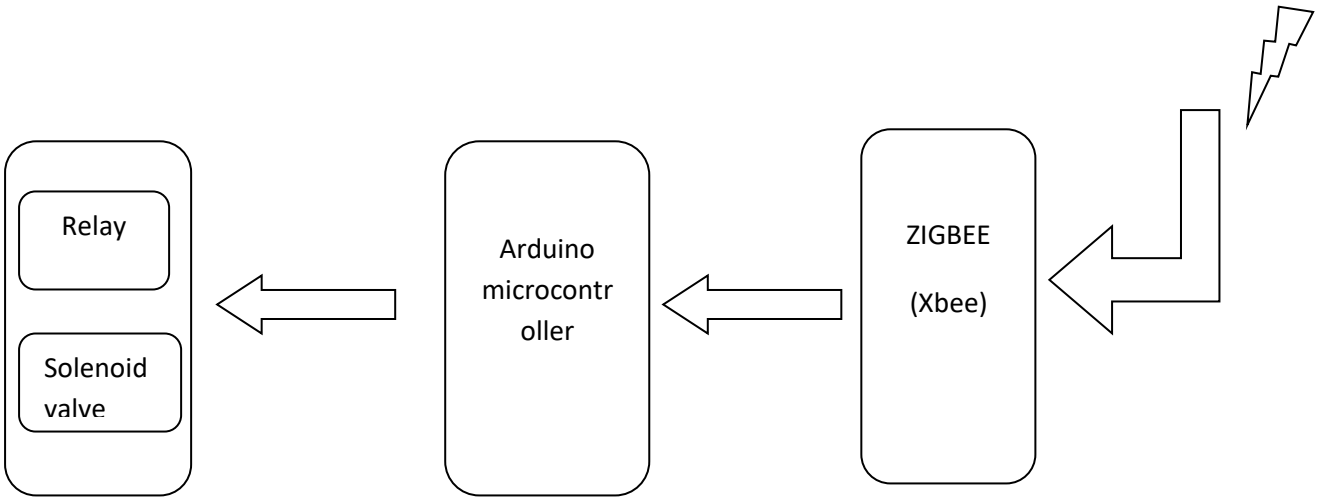


Fig 5.2: Block diagram of receiver

The block diagram of the control system is given. It mainly consists of

1. Moisture sensor
2. Arduino microcontroller
3. Xbee transceiver
4. Relay board
5. Solenoid valve

2.3 Moisture Sensor

Introduction

The main purpose of moisture sensor is to measure the water content in the soil**.** The sensor used in this project is resistive type moist sensor. The fundamental theory behind this sensor is to use voltage divider circuit to measure the moist content in the soil. This sensor consist of two probes, those are connected in series with resistor as show in figure below. The two probes inserted into the soil to measure the conductivity of the soil. The output voltage value depends upon the resistance in between the two probes. When the soil is dry, the resistance in between the probes is infinity. At that time the output voltage is maximum (applied voltage). When the moisture content increases, the resistance between the probes decreases, this decreases the output voltage.

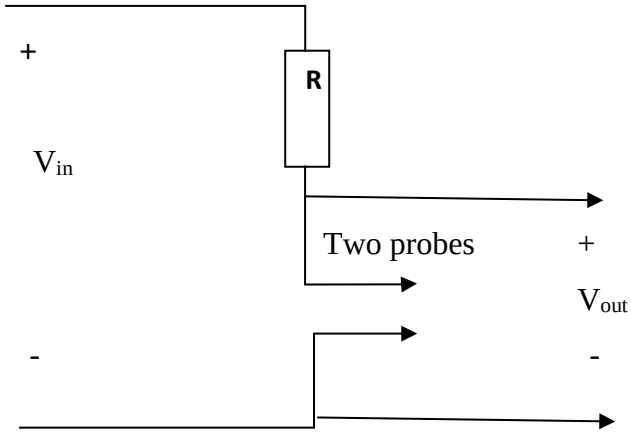


Fig: Moisture Sensor Circuit

Description of Moisture Sensor

This moisture sensor is made up of Electroless Nickel Immersion Gold. The immersion gold protects nickel from oxidation. It has high conductivity, low power consumption and high sensitivity.

s : Output Signal

\+ : Input Power Supply

_ : Ground\

2.4 Arduino Uno Microcontroller

In this project Arduino microcontroller plays a vital role. The moisture sensor is connected to Arduino board. Moisture sensor gives analog value. The Arduino board has internal ADC circuit which converts the analog data of moisture sensor to digital data. This digital data is transmitted to receiving unit with the help of x-bee wirelessly.

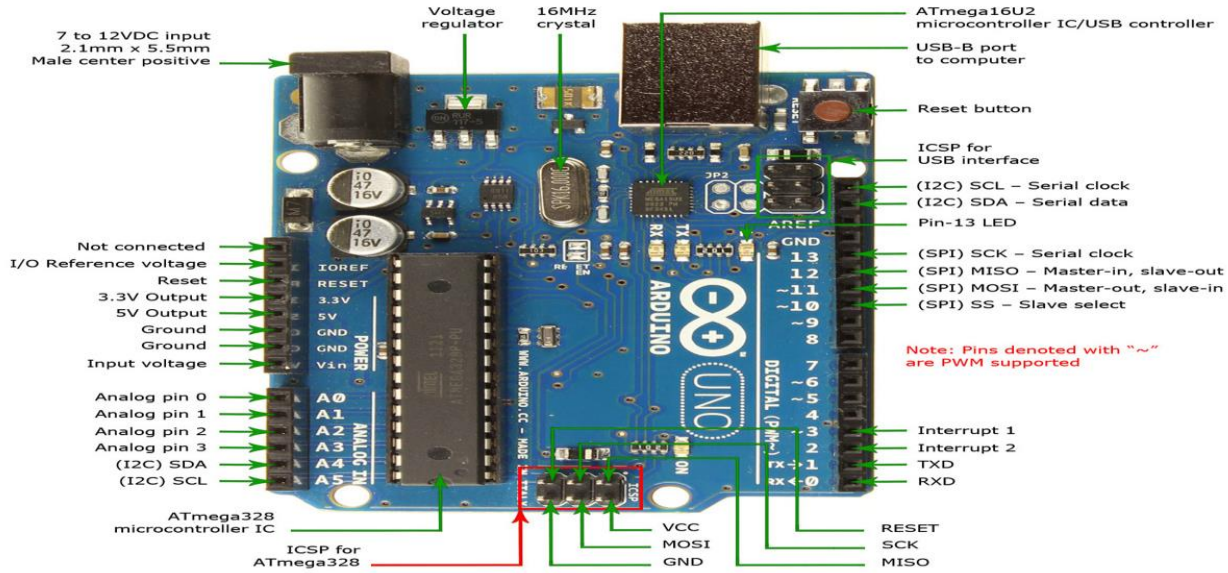
Overview

The Arduino Uno is a microcontroller board based on the ATmega328. 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."Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

Arduino Uno Board

The labeled Arduino Uno board is shown below



Programming

The Arduino Uno can be programmed with the Arduino software. Select "Arduino Uno w/ ATmega328" from the Tools > Board menu (according to the microcontroller on your board). The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer.

2.5 Xbee

Xbee is the brand name of a family of form factor compatible radio modules from Digi International. One Xbee radio acts as both transmitter and receiver depending on the configuration. In this project Xbee takes the data from the Arduino at sensor and transmits it wirelessly to the central unit

Overview

The Xbee is a 20 pin microcontroller made by DIGI to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other. Xbee send and receive data over a serial port, which means they're compatible with both computers and microcontrollers (like Arduino).

Pin Diagram

Pin Assignments for the XBee and XBee-PRO Modules
(Low-asserted signals are distinguished with a horizontal line above signal name.)

Pin #	Name	Direction	Description
1	VCC	-	Power supply
2	DOUT	Output	UART Data Out
3	DIN / CONFIG	Input	UART Data In
4	DIO8*	Output	Digital Output 8
5	RESET	Input	Module Reset (reset pulse must be at least 200 ns)
6	PWM0 / RSSI	Output	PWM Output 0 / RX Signal Strength Indicator
7	PWM1	Output	PWM Output 1
8	[reserved]	-	Do not connect
9	DTR / SLEEP_RQ / DI8	Input	Pin Sleep Control Line or Digital Input 8
10	GND	-	Ground
11	AD4 / DIO4	Either	Analog Input 4 or Digital I/O 4
12	CTS / DIO7	Either	Clear-to-Send Flow Control or Digital I/O 7
13	ON / SLEEP	Output	Module Status Indicator
14	VREF	Input	Voltage Reference for A/D Inputs
15	Associate / AD5 / DIO5	Either	Associated Indicator, Analog Input 5 or Digital I/O 5
16	RTS / AD6 / DIO6	Either	Request-to-Send Flow Control, Analog Input 6 or Digital I/O 6
17	AD3 / DIO3	Either	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Either	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Either	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0	Either	Analog Input 0 or Digital I/O 0

Fig 5.4: pin diagram and pin definitions

2.6 Relay Module

From the x-bee the signals flew to Arduino which process them and take decision over water control system having a relay and solenoid valve. The input voltage required to control the solenoid valve is 230v ac but the maximum output voltage comes from the Arduino is 5 v. so we need relay module to control the solenoid valve.

The diagram shown below is the relay module.

Fig Relay module

2.7 Solenoid valve Working Principle

The coil consists of capillary copper wire wound on a support reel. When electric current is fed into the coil, magnetic flow lines are generated, which are strongest in the centre of the coil. This magnetic flow raises the moveable plunger in the coil until it brings it into contact with the pole piece. The valve body has an orifice through which the liquid or gas flows when the valve is open. The moveable plunger has an integral seat which, when the solenoid coil is energized, moves off the position of the plunger to open the valve. When the coil is de-energized, a return spring repositions the plunger in the original closing position on the valve to cut off the flow of the fluid.

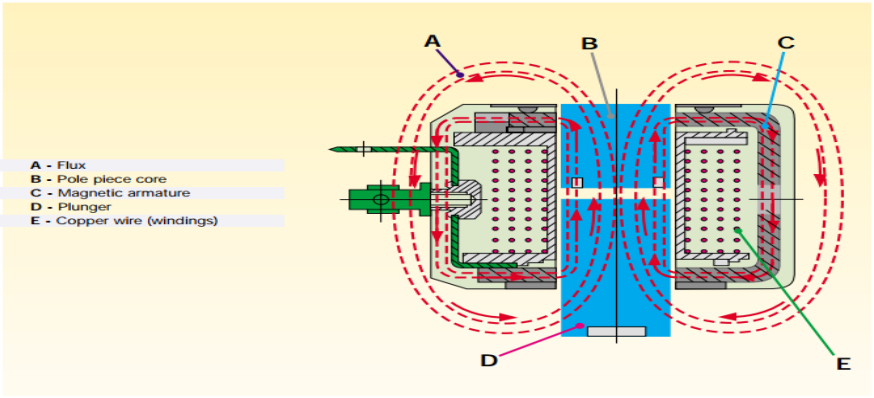


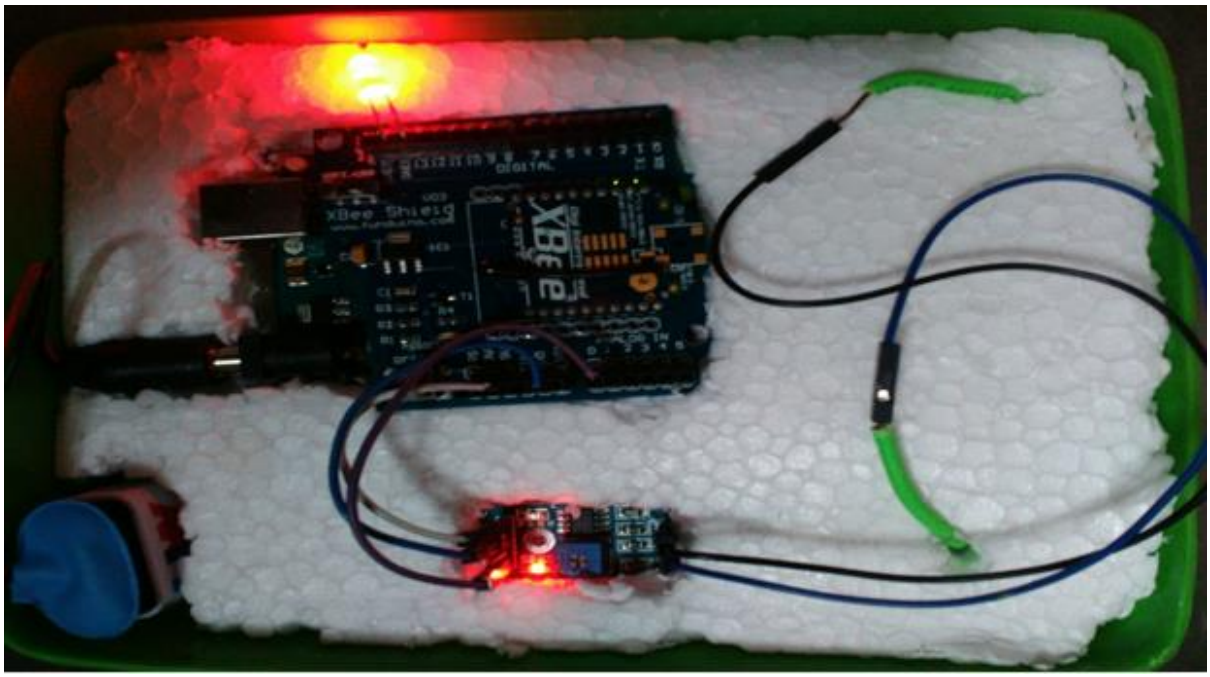
Fig Working principle of solenoid valve

2.8 Working of the project

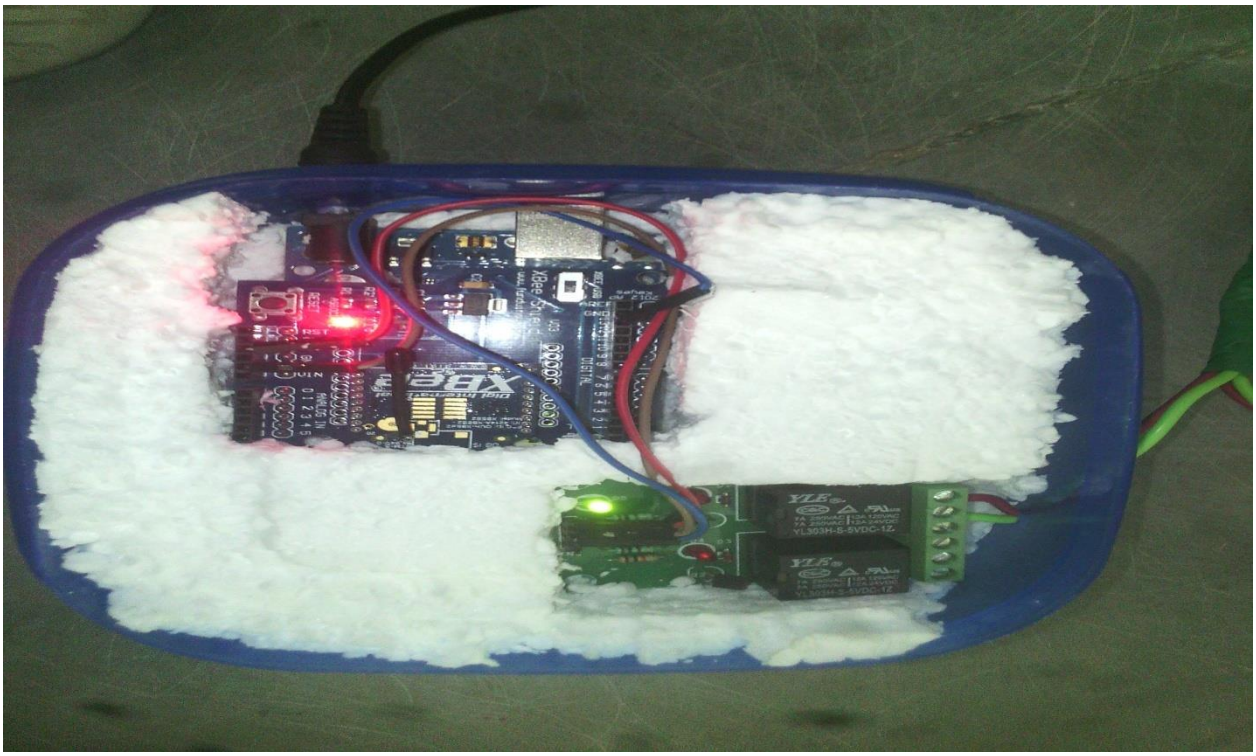
This project helps in understanding the procedures to be followed in designing autonomous drip irrigation system. This has been achieved through the design of a small drip irrigation system consisting of a single moisture sensor, single perforated tube, a solenoid valve, zigbee communication system and Arduino processing unit.

It has been shown that the sensor block with zigbee transceiver could communicate over a distance of 100 feet. The functioning of the zigbee receiver at the controlling unit along with Arduino processor has been successfully demonstrating by controlling the solenoid valve. Also it has been possible to fabricate a sensor module which is powered by a battery which perhaps can be replaced by the energy harvesting system in future. The moisture sensor can be easily placed anywhere in the field with in the distance that can be covered by Xbee system.

The picture below shows the transmitter which has a moisture sensor, xbee and Arduino. Moisture sensor measures the moisture level in the soil. This moisture level sends to the receiver through xbee wireless communication.



The picture shown below is receiver unit which has xbee, Arduino, relay and solenoid valve. The xbee acts as receiver here. The transmitter unit sends the moisture levels to the receiver unit. If the moisture level is below the lower threshold voltage, the controller at the receiver unit turns on the solenoid valve with the help of relay. When the moisture level is above the upper threshold level, at that time controller turns off the solenoid valve. The solenoid valve is in off condition only until the moisture level goes below the lower threshold voltage.



During the period of this project there were several investigations that were carried out, some of them are calibration of sensors which included investigations on the moisture saturation point, depth of the sensor and dimensions of the sensor. Further the interfacing of sensor with zigbee transmitter and interfacing of zigbee receiver with Arduino processing unit and interfacing of Arduino processing unit and solenoid valve required many iterations with varying parameters.

3. AUTOMATION OF SPEED CONTROL OF DC MOTOR USING PROGRAMMABLE LOGIC CONTROLLER

3.1 ABSTRACT

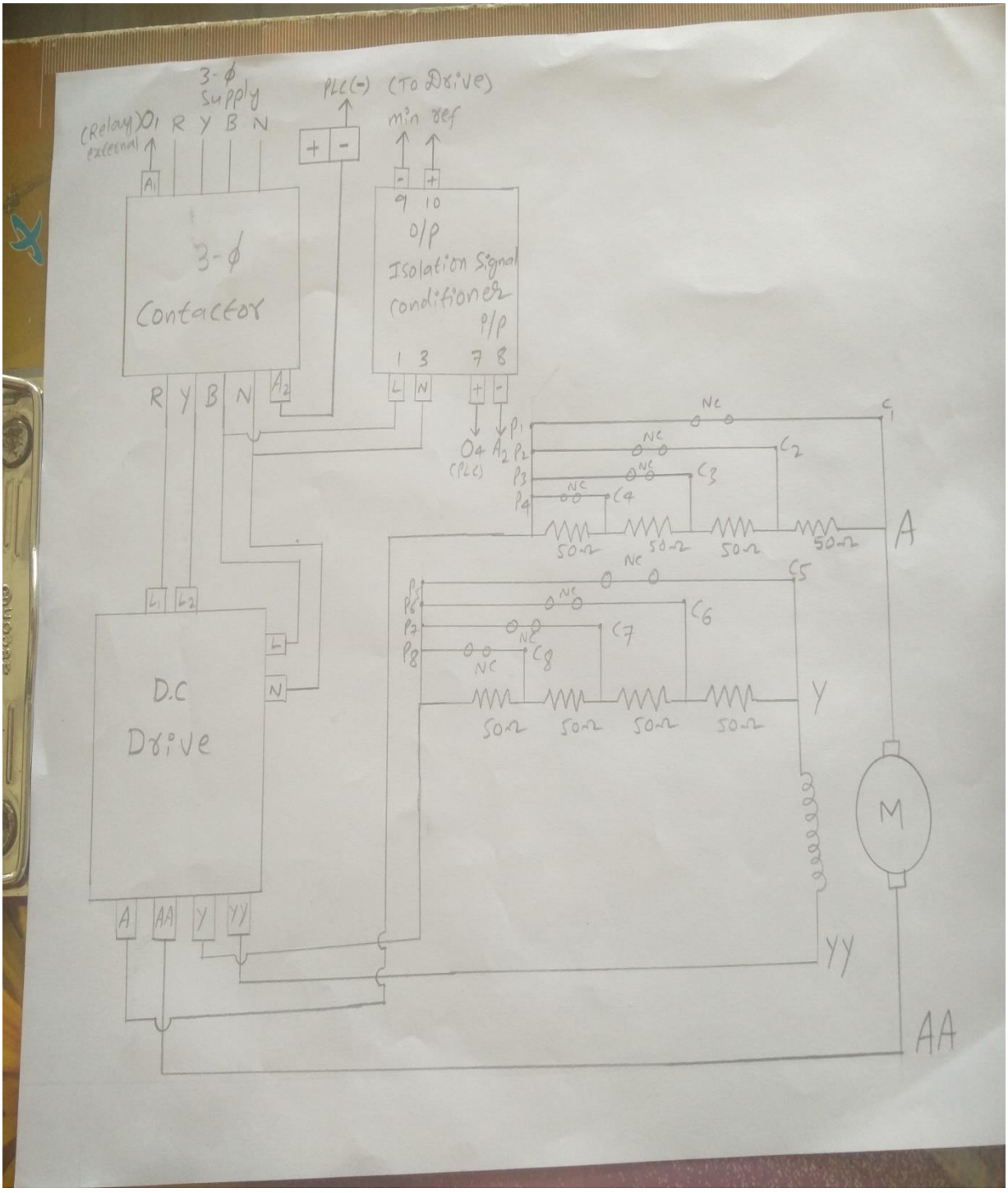
Due to the fast performance of DC motors, these motors are regulated in a wide range of speeds and can be used in many applications. The main advantage of using DC motors in today's world is the ability to easily control the speed and angle of the motor. This project is about controlling the speed of DC motor by using Programmable Logic Controller. The controller has more advantages than conventional control circuits. The benefits can be noted such as reducing the size of the control panel, very low energy consumption, Durable Equipment, Proper operation in the worst cases. Using PLC for controlling industrial systems is initiated in 1968 and, its development has been greatly accelerated in recent years.

A simplified approach for speed control of a DC motor using programmable logic controller (PLC) is presented. This approach is based on providing a variable dc voltage to armature circuit of dc motor from a fixed dc supply voltage via a PLC for supply voltage control method. Relay based PLC control method is used for switching on or off the resistors which are connected in series with armature and field circuits of dc motor depending on the reference (command) speed for armature and field control methods. It is easy, fast and effective by this method of control to vary motor speed. The proposed system is suitable for different industrial applications such as subway cars, trolley buses, or battery-operated vehicles.

In this project we made an attempt to convert the conventional Dc motor into computer controlled Dc motor which is an automatic and programmed using a M3 soft software to control from computer using a programmable logic controller(PLC)**.**

PROJECT DESCRIPTION:

3.2 Circuit diagram



3.3 CIRCUIT CONNECTIONS:

3.3.1 Contactor connections

Connect 3-phase supply to 3-phase contactor, then connect contactor output R, Y, B, N to L1, L2, L, N of dc drive respectively.A1 of contactor connected to O1 of external relay and A2 is connected to negative(-ve) of PLC.

3.3.2 Isolation signal conditioner connections

Connect R, N, A2 of contactor to L, N, 8^{th} pin of signal conditioner respectively, connect 7^{th} pin to O4 of PLC and 9^{th}, 10^{th} pins to min, ref pins of dc drive.

3.3.3 dc drive connections

Connect A, Y to armature and field circuit before the resistance and AA, YY to AA, YY terminals of

3.3.4 Relay connections

Connect C1,C2,C3,C4,C5,C6,C7,C8,P1,P2,P3,P4,P5,P6,P7 and P8 to resistors of armature and field circuit as shown in circuit diagram. Connect 1+,2+,3+,4+,5+,6+,7+ and 8+ to O2,O3,O5,O6,O7,O8,O9 and OA of PLC respectively and connect 1- to negative terminal of PLC.

Components used are as follows:

1. Dc Contactor
2. Isolation signal conditioner
3. Relays
4. Fixed resistors
5. Dc Drive

Description

Open M3 Soft software, click on file then click on open file and select speed control program. Then follow the execution steps.

1) To turn on dc drive

Click on the I1 input of PLC to turn on the dc drive. when we turn on the I1 it closes the contactor switch using the external relay to give the supply to the dc drive.

2) Armature supply voltage control

Click on I2 input of PLC to provide variable dc output. By using AND gate, NOT gate, Timer(1second delay) and Counter. The output of PLC O4 is given to input 7^{th} pin of isolation signal conditioner. Output of signal conditioner is connected to dc drive so we get variable dc output voltage. There by we are getting armature supply voltage control. As the armature voltage increases speed of the dc motor increases. Because speed is directly proportional to armature voltage.

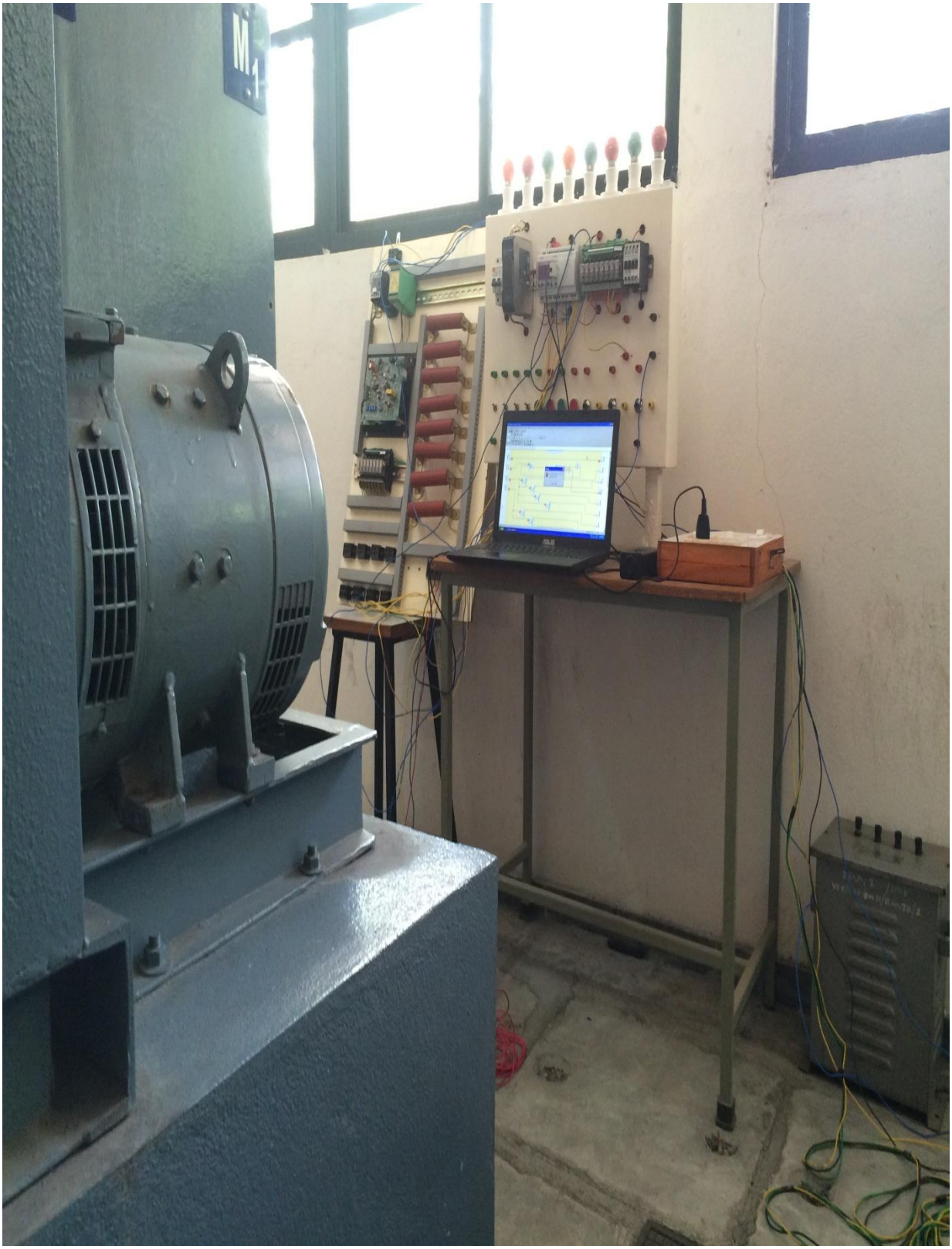
3) Armature Resistance Control

Click on I3 input of PLC to add resistances in series with armature circuit. This done by using four timers with delay time of 10s, 15s, 20s and 25s respectively. It add resistances 50ohms, 100ohms, 150ohms and 200ohms respectively to the armature circuit. Armature resistance is inversely proportional to the speed of the dc motor so as the resistance increases speed deceases. In this method we get below base speed.

4) Field Resistance Control

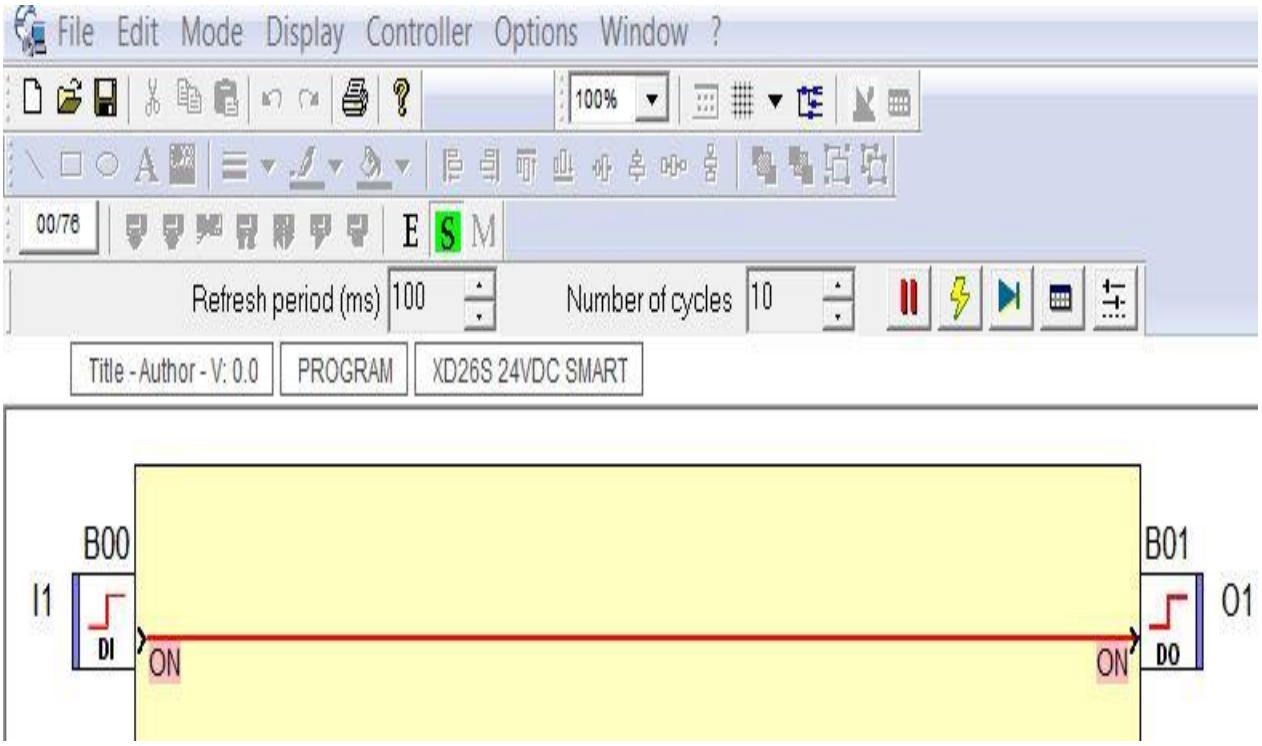
Click on I4 input of PLC to add resistances in series with field circuit. This done by using two timers with delay time of 10s and 15s respectively. It add resistances 50ohms and 100ohms respectively to the field circuit. Field resistance is directly proportional to the speed of the dc motor so as the resistance increases speed also increases. In this method we get above base speed.

3.4 HARDWARE SETUP

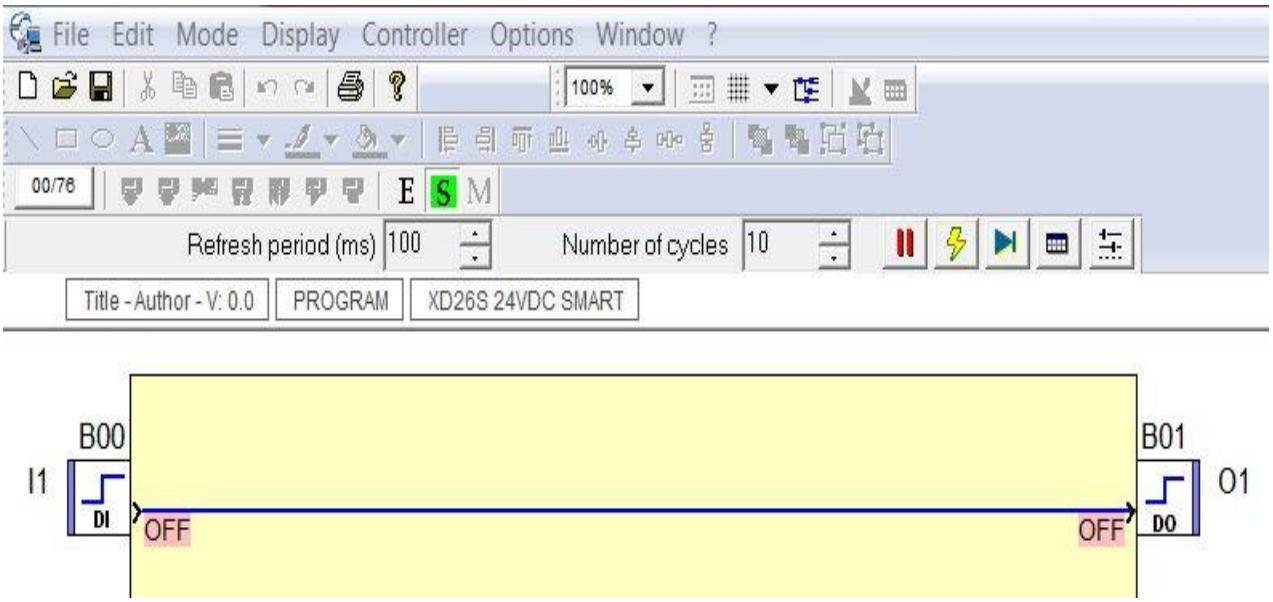


3.5 PROGRAM

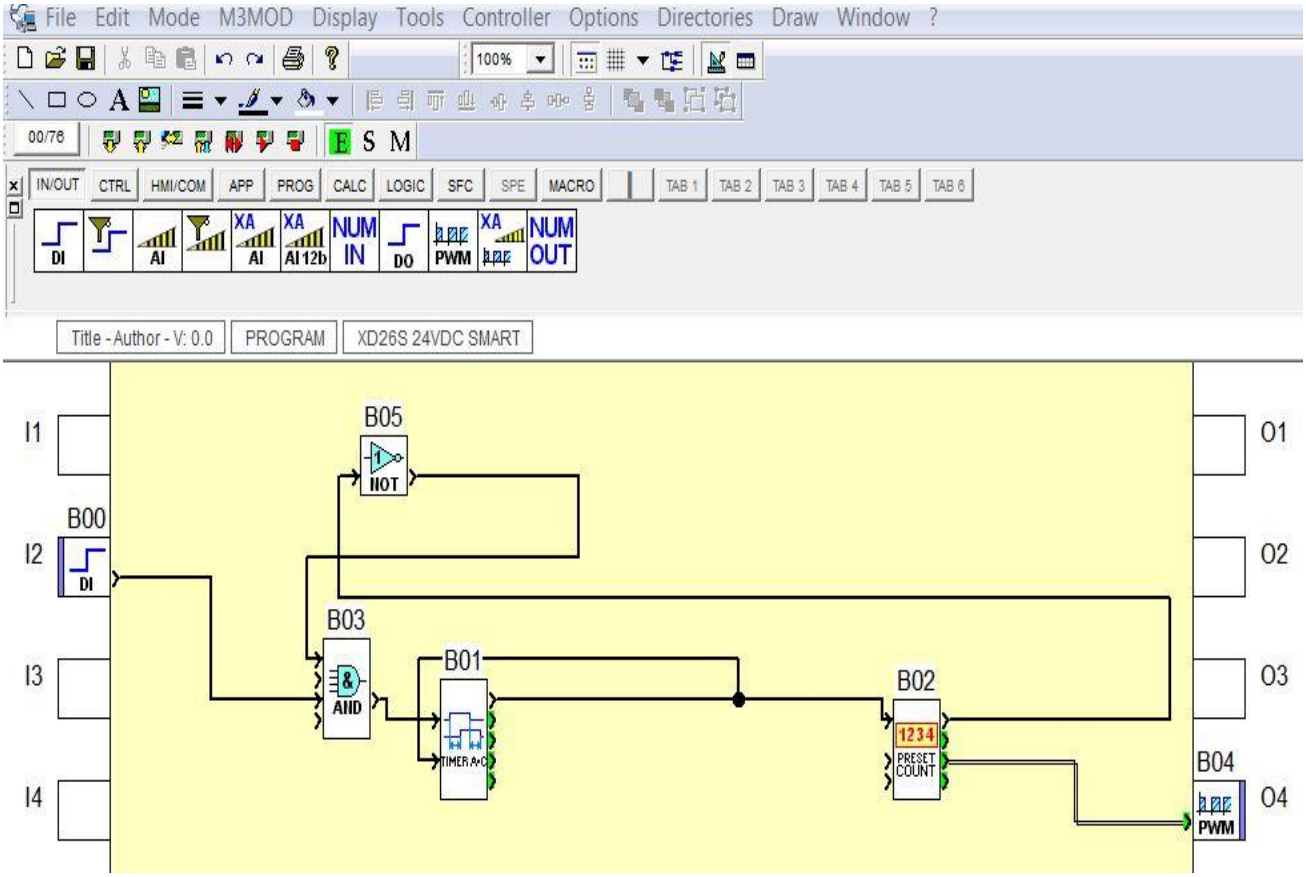
1) To turn ON dc drive:



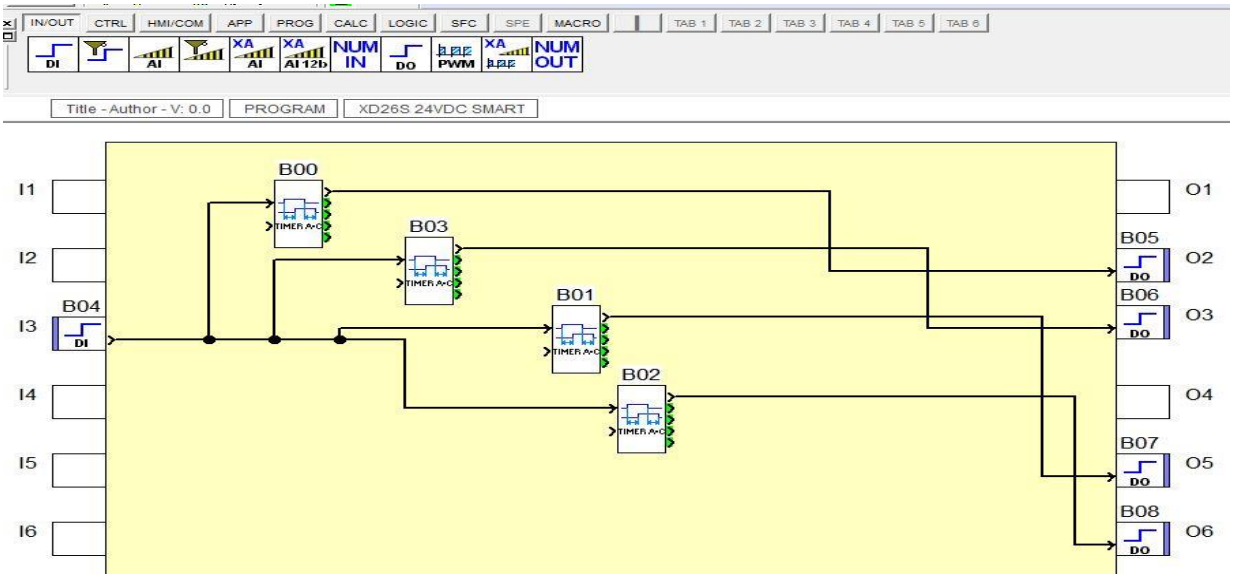
2) To turn OFF Dc Drive



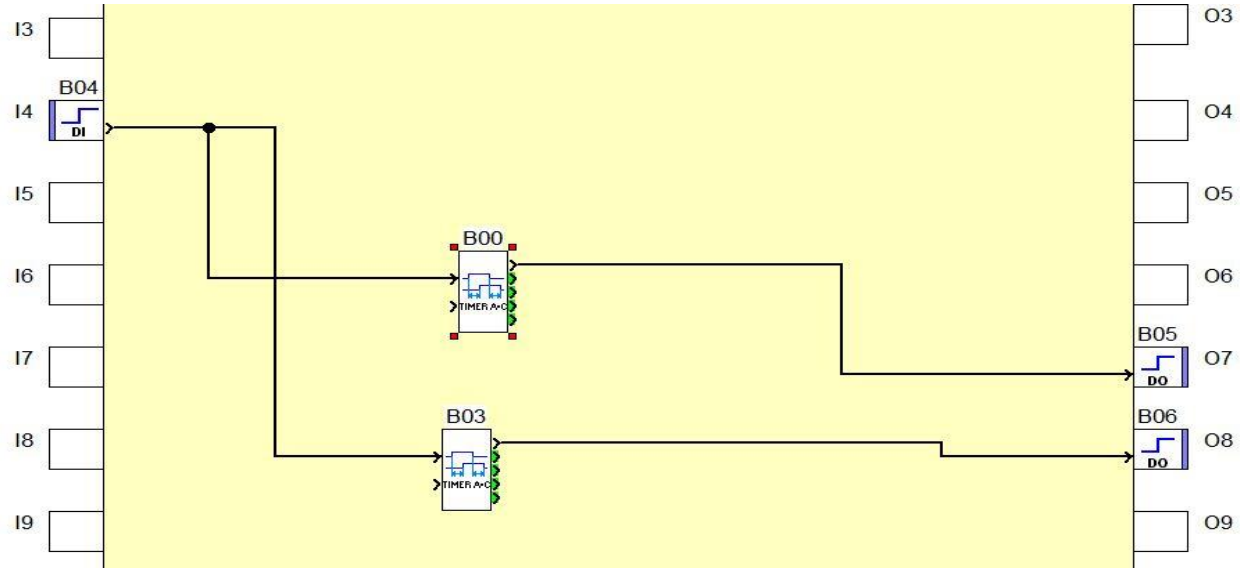
3) Armature Supply Voltage Control



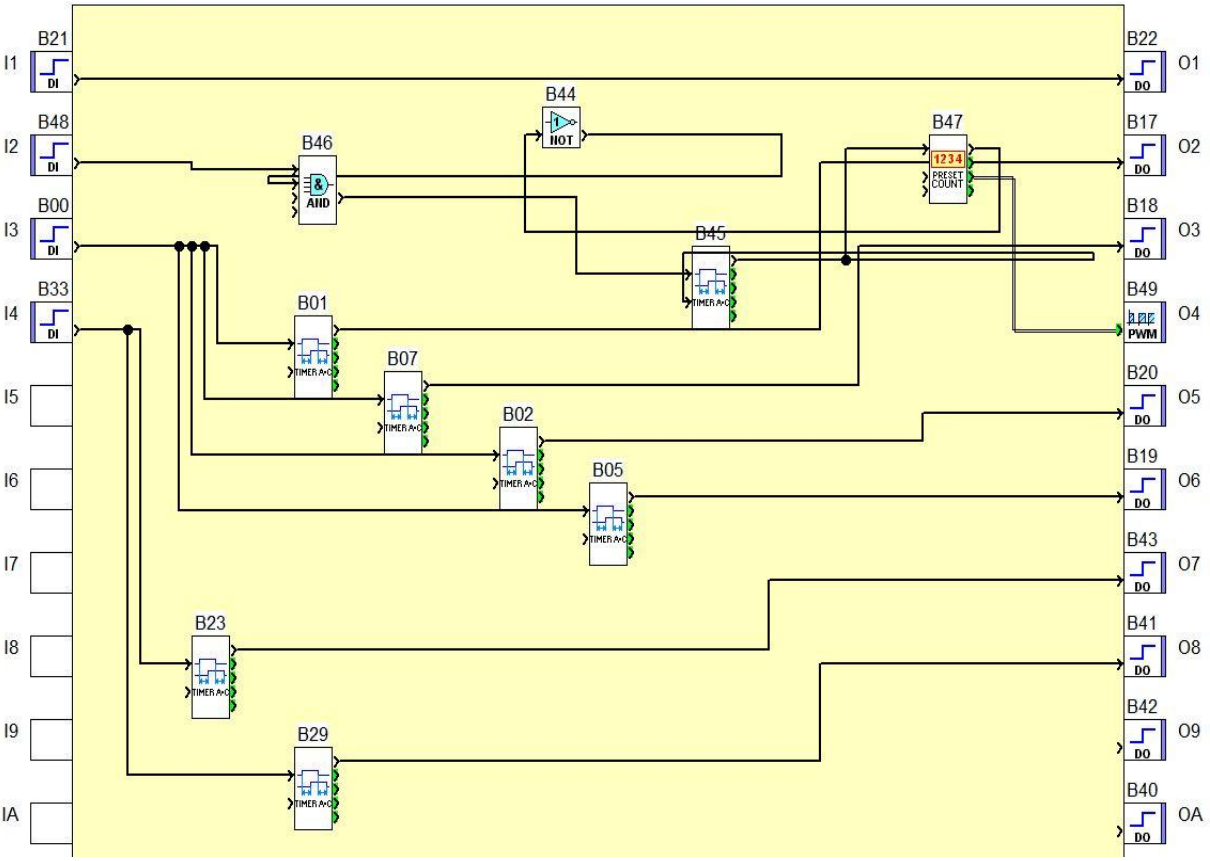
4) Armature Resistance control



5) Field Resistance Control



6) Speed Control of Dc Motor



3.6 OBSERVATIONS:

1) Armature supply voltage control:

Field voltage=205V

S.No	PWM value	Va(V)	N(rpm)
1	34	145	938
2	36	162	1020
3	38	183	1176
4	40	208	1330

2) Armature resistance control:

Field voltage=205V

S.No	Ra(ohm)	Va(V)	N(rpm)
1	50	176	1220
2	100	97	794
3	150	63	599
4	200	18	440

3) Field resistance control:

Armature voltage=209V

S.No	Rf(ohm)	Vf(V)	N(rpm)
1	50	167	1408
2	100	130	1572

RESULTS:

In this project an attempt is successfully made to convert a conventional dc motor control into an automated speed controlled dc motor using programmable logic controller by which an improvement in process is obtained and speed control is accurate when compared to conventional method with greater flexibility and ease. We obtained three types of speed control.

3.7 CONCLUSION:

Speed control of dc motor using programmable logic controller was carried out and following conclusions were made

1. Speed varies directly with armature voltage by keeping field voltage constant.

2. Speed varies inversely with increasing armature resistance by keeping field voltage constant.

3. Speed varies directly with increasing field resistance by keeping armature voltage constant.

4. Armature voltage control gives the speed below the base speed whereas field control gives the speed control above the base speed.

5. For a given field current in a shunt motor, the speed drop from no-load to full load is invariably less than 6% to 8%. In view of this, the shunt motor is termed as a constant speed motor. Therefore, for constant speed drives in industry DC shunt motors are employed.

6. When constant speed service at low speeds is required, DC shunt motors are preferred over synchronous motors.

7. When the driven load requires a wide range of speed control, both below and above the base speed, a DC shunt motor is employed.

8. DC shunt motor can be used as a separately excited motor, if the field winding is disconnected from armature and connected to a external voltage source.

4. ONLINE ENERGY AUDITING

4.1 ABSTRACT

This project deals with the measurement of power using Arduino and transferring the data through Zigbee. The demand for power has increased exponentially over the last century. One avenue through which today's energy problems can be addressed is through the reduction of energy usage in households. This has increased the emphasis on the need for accurate and economic methods of power measurement. The goal of providing such data is to optimize and reduce their power consumption. This project explains the process of a condensed design explaination and implementation of a laboratory and wireless reading transmission further eliminates the role of a Meter Reader. Power calculation through wireless smart meter using Zigbee is proposed for automatic meter data collection and energy auditing. This system operates with multiple channels and frequency hopping and coexists with potential interferers. This is the project to meet demand and to satisfy consumers. Power consumed by the consumer is monitored by arduino and zigbee through wireless. It aims to reduce the man power for billing. In this project, we discuss different hardware techniques for indicating the consumers and power monitoring, the Microcontroller based system continuously records the readings. Zigbee has major role in monitoring and for efficient power utilization. It covers enough area needed for communication and it works on low data rate with minimum power consumption.

4.2 INTRODUCTION

The struggle between global warming and human beings is well recognized by the international society. Scientists devoted their effort into the development of renewable energies while governors/administrators audit and control energy consumption based on regulation. In view of the compulsory energy consumption control in near future, researchers have developed energy aware technology such as ZigBee. ZigBee is a wireless sensor network for home and building automation. Recently, ZigBee has been widely adopted for both metering as well as energy management.

In the existing automatic meter reading technology, the meter reading process is done by the help of manpower. But this method is subjected to several disadvantages like errors during calculation, absence of consumer during billing time and extra expenses for the billing process. Automatic Energy Calculation Through Wireless Smart Meter Using Zigbee aims to minimize these difficulties by providing automatic energy calculation through wireless

medium. This method can eliminate the problems such as manpower requirement for billing and errors during calculation etc., and can provide necessary information such as tariff variation and due date for payment etc. to the consumer through the wireless medium. The wireless technology can be implemented by having a Zigbee enabled transceiver interfaced with the EB section server as well as in the consumer side.

Each Zigbee module is like a telecommunication station, and the modules can communicate with each other within the whole network. The communication distance between the nodes can range from the standard 75 meters to hundreds of meters and even several kilometers. The Zigbee network can also be connected to other networks.

Serial Communications in zigbee

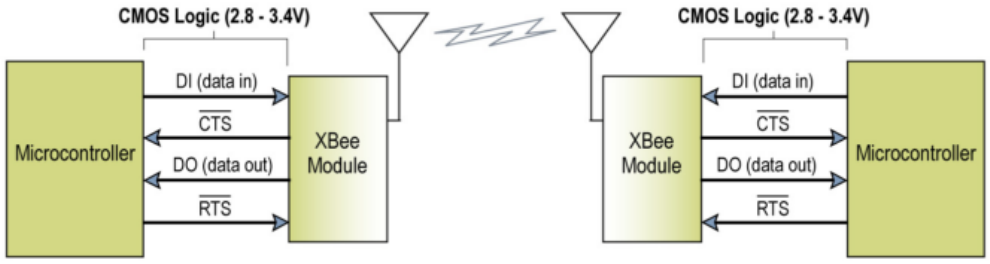
The XBee®/XBee-PRO® RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device (For example: Through a Digi proprietary RS-232 or USB interface board).

UART Data Flow

Devices that have a UART interface can connect directly to the pins of the RF module as shown in

the figure below.

System Data Flow Diagram in a UART-interfaced environment
(Low-asserted signals distinguished with horizontal line over signal name.)



Serial Data

Data enters the module UART through the DI pin (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted. Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

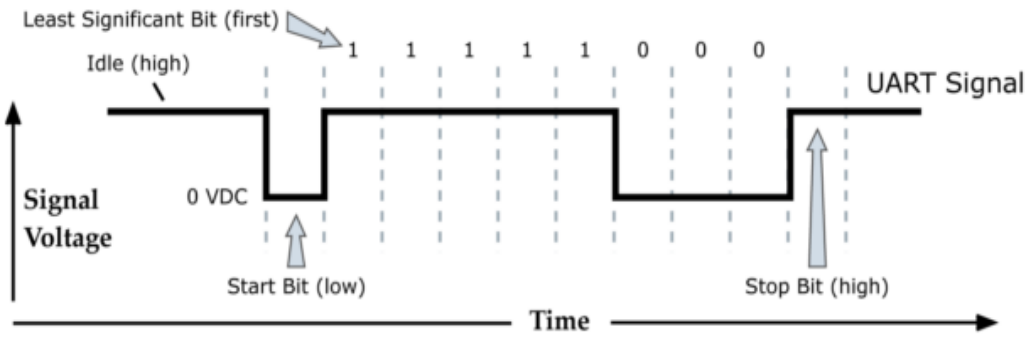


figure shows,

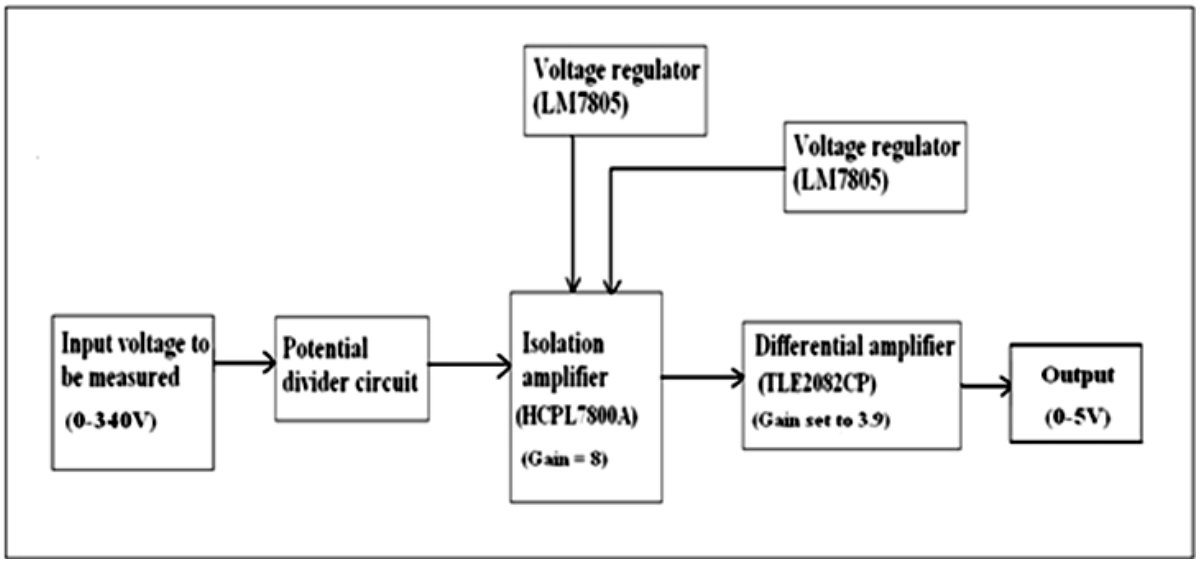
UART data packet 0x1F (decimal number ″31″) as transmitted through the RF module

Serial communications depend on the two UARTs (the microcontroller's and the RF module's) to be configured with compatible settings (baud rate, parity, start its, stop bits, data bits).The UART baud rate and parity settings on the XBee module can be configured with the BD and SB commands, respectively.

By default, XBee®/XBee-PRO® RF Modules operate in Transparent Mode. When operating in this mode, the modules act as a serial line replacement - all UART data received through the DI pin is queued up for RF transmission. When RF data is received, the data is sent out the DO pin.

SENSORS:

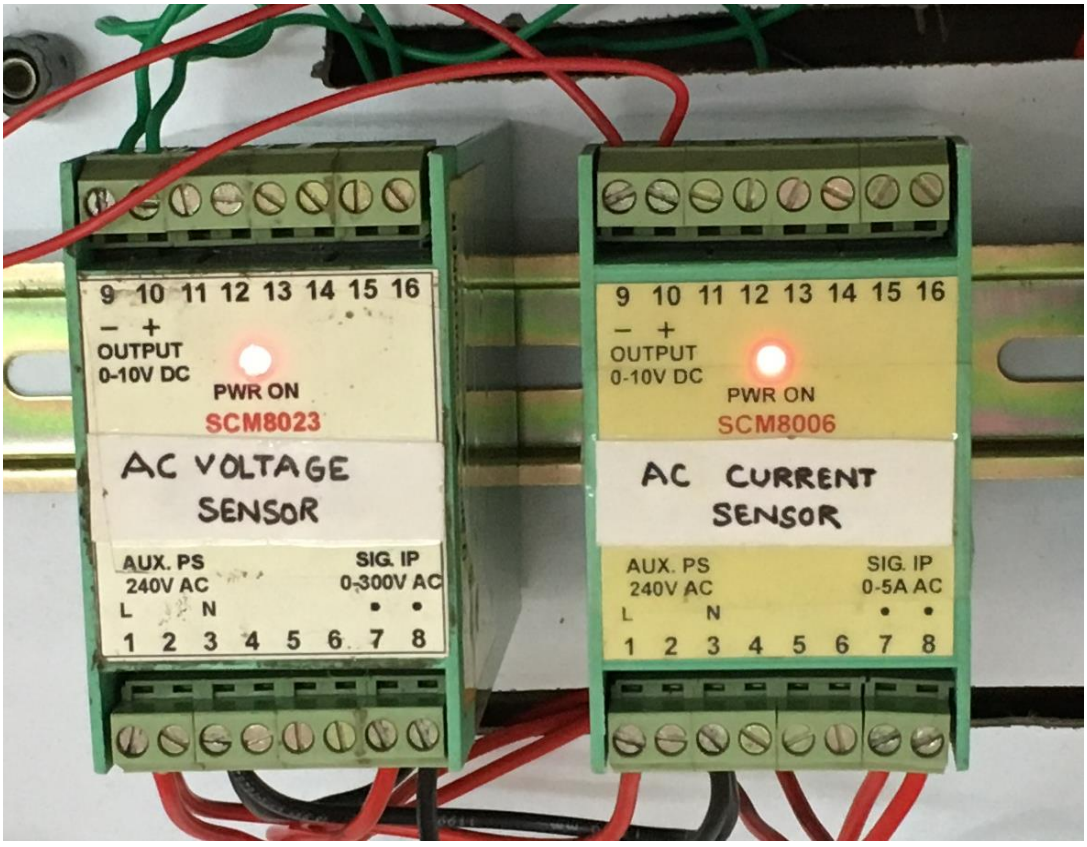
Block diagram of sensors



The input voltage to be measured lies in the range (0-340V_{Peak}, range can be modified). It is given to the potential divider circuit which brings down the voltage to be measured to the order of millivolts. The potential divider circuit consists of four 470kΩ resistors and a 1kΩ POT in series. The voltage across the 1kΩ POT setting gets applied between the input terminals of

HCPL-7800A. Since, the output voltage should lie in the range (0-5V), the POT setting is set to 0.9kΩ which is connected to pins 2 and 4 of HCPL-7800A.

The +5V power supply to the pins 1 and 8 are isolated. Therefore, they are represented by two +5V voltage regulators (LM7805) in the block diagram.The recommended operating range for the input voltage applied to HCPL-7800A lies in the range -200 mV to +200mV. The mean gain value of HCPL-7800A is 8. Hence, the output of HCPL-7800A lies between +1.6V to -1.6V. For the sensor under consideration, the maximum output of HCPL-7800A is $1.2992V_{Peak}$ which is the maximum value of input voltage to TLE2082CP. The gain of TLE2082CP is set to 3.9 by using 1kΩ resistor at its inverting input and 3.9kΩ as the feedback resistor. Hence, the maximum value of the output of TLE2082CP which is also the output of the sensor is 1.2992 * 3.9 = 5.06V.



4.3 HARDWARE DETAILS

4.3.1 VOLTAGE SENSOR:

The above circuit consists of the potential divider circuit by using which the voltage is stepped down and is given to the input terminals of the HCPL7800. The output of this isolation amplifier is given to the TLE2082 to get the required voltage.

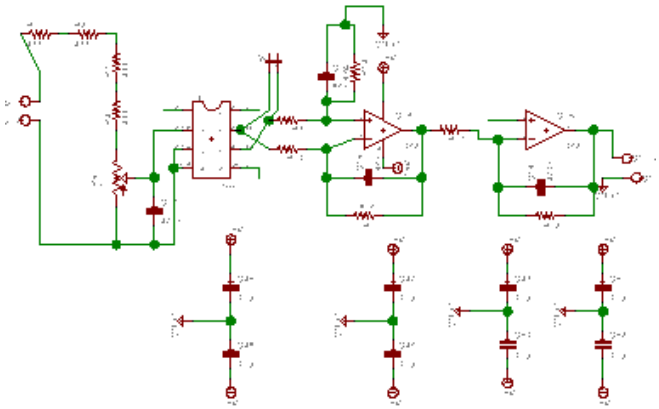


Fig Showing the internal connection of voltage sensor

4.3.2 CURRENT SENSOR

The current sensing circuit is same the voltage sensing circuit. But at the input terminals of the HCPL7800 voltage is given which is measured across the SHUNT resistor. His shunt resistor is connected in series with the load and the voltage measured across this SHUNT is in the order of milli volts which is given as input to the isolation amplifier.

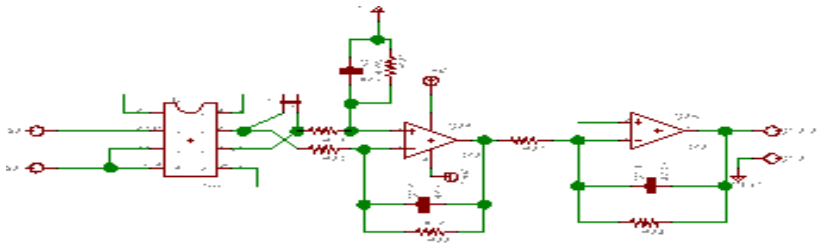


Fig Showing the internal connection of current sensor

4.3.3 ARDUINO

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based onWiring), and the Arduino Software (IDE), based on Processing.

All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Arduino is simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Windows. Teachers and students use it to build low cost scientific instruments, to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments.

Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive
- Cross-platform
- Simple, clear programming environment
- Open source and extensible software
- Open source and extensible hardware

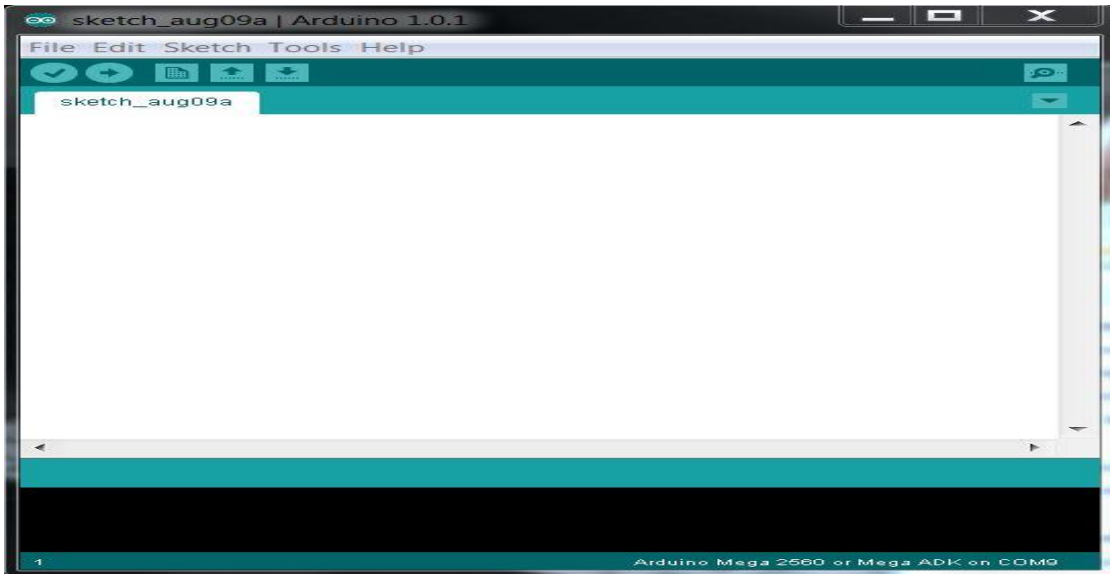


Figure showing the arduino software IDE

4.4 ZIGBEE TECHNOLOGY

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer.

Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

ZigBee is a low-cost, low-power, wireless mesh network standard targeted at the wide development of long battery life devices in wireless control and monitoring applications. Zigbee devices have low latency, which further reduces average current. ZigBee chips are typically integrated with radios and with microcontrollers that have between 60-256 KB flashes memory.

ZigBee is one of the global standards of communication protocol formulated by the significant task force under the IEEE 802.15 working group. The fourth in the series, WPAN Low Rate/ZigBee is the newest and provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. Other standards like Bluetooth and IrDA address high data rate applications such as voice, video and LAN communication.

4.4.1 SOFTWARE

XCTU is a multi-platform application that enables developers to interact with Digi radio frequency (RF) modules through a simple-to-use graphical interface. The application includes embedded tools that make it easy to set up, configure and test Digi RF modules.

XCTU now offers the following functionality:

- You can , even remotely (over-the-air) connectedmanage and configure multiple RF devices devices.
- The process restores your module settings, automatically handling firmware update seamlessly mode and baud rate changes.
- Two specific and , have been designed from scratch to communicate with your API AT consoles radio devices.
- You can now and load them in a different PC running XCTU.
- XCTU includes a set of embedded tools that can be executed without having any RF module be connected:
  - Frames generator
  - Frames interpreter
  - Recovery
  - Load console session
  - Range test
  - Firmware explorer
- An update process allows you to automatically update the application itself and the radio firmware library without needing to download any extra files.
- XCTU contains complete and comprehensive documentation which can be accessed at any time .

4.4.2 XBee RF modules

XBee is the brand name of a family of RF modules produced by Digi. They are modular products that make deploying wireless technology easy and cost-effective. Digi has made multiple protocols and RF features available in the popular XBee footprint, giving customers enormous flexibility to choose the best technology for their needs.

XBee RF modules are available in two form-factors, Through-Hole and Surface Mount, with different antenna options. One of the most popular features of these modules is that almost all of them are available in the Through-Hole form factor and share the same footprint.

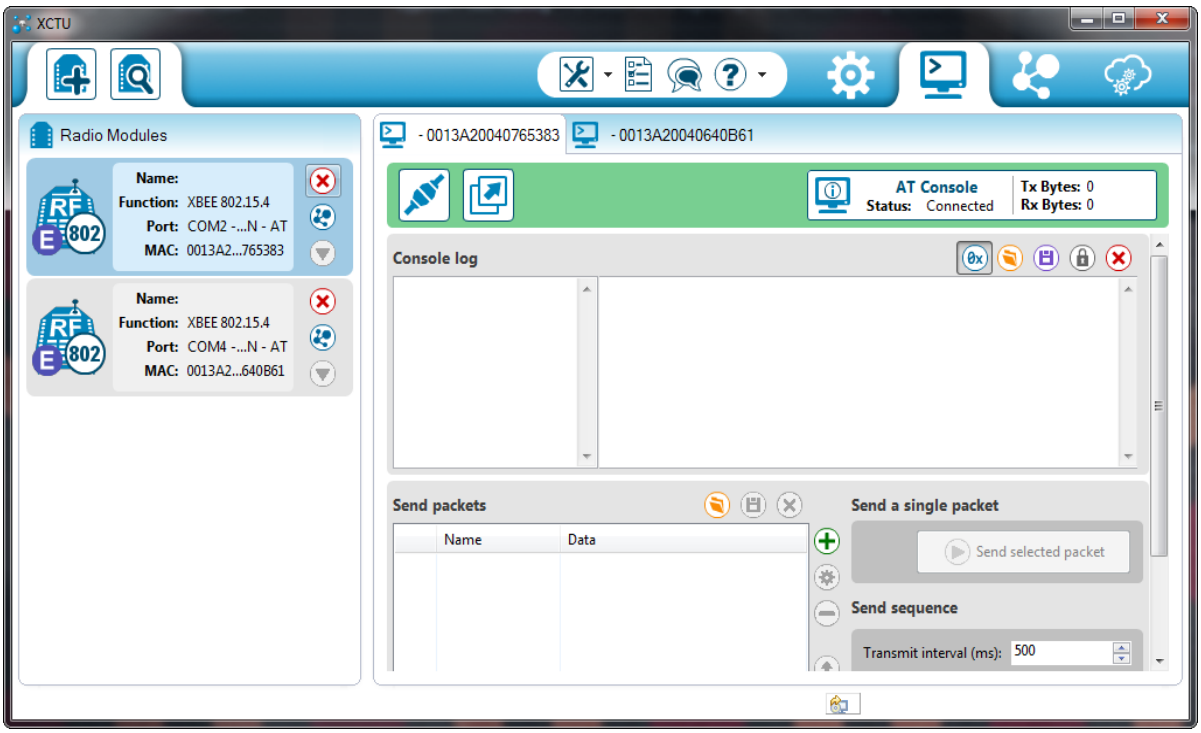


Fig Showing the XCTU software IDE

4.5 SPECIFICATION OF COMPONENTS

Hardware

- **Sensors**

  Voltage sensor – 0-230V AC to 0-10V DC

  Current sensor- 0-5A AC to 0-10V DC

  Bulbs - 100W 4 No.s

- **Xbee**

  Indoor/Urban: up to 100’ (30 m)

  Outdoor line-of-sight: up to 300’ (90 m)

  Transmit Power: 1 mW (0 dBm)

  Receiver Sensitivity: -92 dBm

Advanced Networking & Security

- Retries and Acknowledgements
- DSSS (Direct Sequence Spread Spectrum)
- Each direct sequence channels has over 65,000 unique network addresses available
- Source/Destination Addressing
- Unicast & Broadcast Communications
- Point-to-point, point-to-multipoint
- and peer-to-peer topologies supported

XBee-PRO

• TX Peak Current: 250mA (150mA for international variant)

• TX Peak Current (RPSMA module only): 340mA (180mA for international variant

• RX Current: 55 mA (@3.3 V)

• Power-down Current: < 10 µA

ADC and I/O line support

Analog-to-digital conversion, Digital I/O

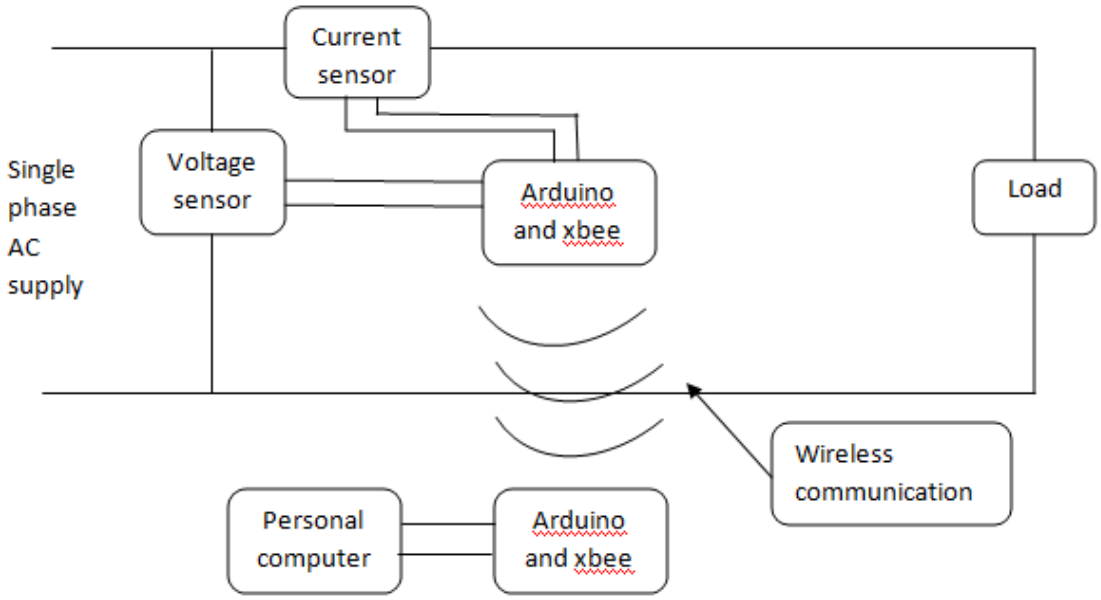
I/O Line Passing

4.6 OPERATION

Easy-to-Use

- No configuration necessary for out-of box
- RF communications
- Free X-CTU Software
- (Testing and configuration software)
- AT and API Command Modes for
- configuring module parameters
- Extensive command set
- Small form factor

METHODOLOGY USED FOR REALIZATION



As shown in the above figure the connections are made and arduino are configured according to our project specifications. Voltage sensor, current sensor, and load are given supply through Single phase ac supply. xbees are configured as transmitter and receiver and respective programmes are dumped into the arduino and setup is made to run and this sets appear wireless communication between the xbee modules and the data is transmitted from transmitter to receiver. We can see the data i.e. voltage, current and power is being displayed on the personal computer. Here the load s used are four 100W bulbs and they are switched

ON and OFF at regular intervals by this current and power drawn by the total load varies and this data can be seen on the computer wirelessly.

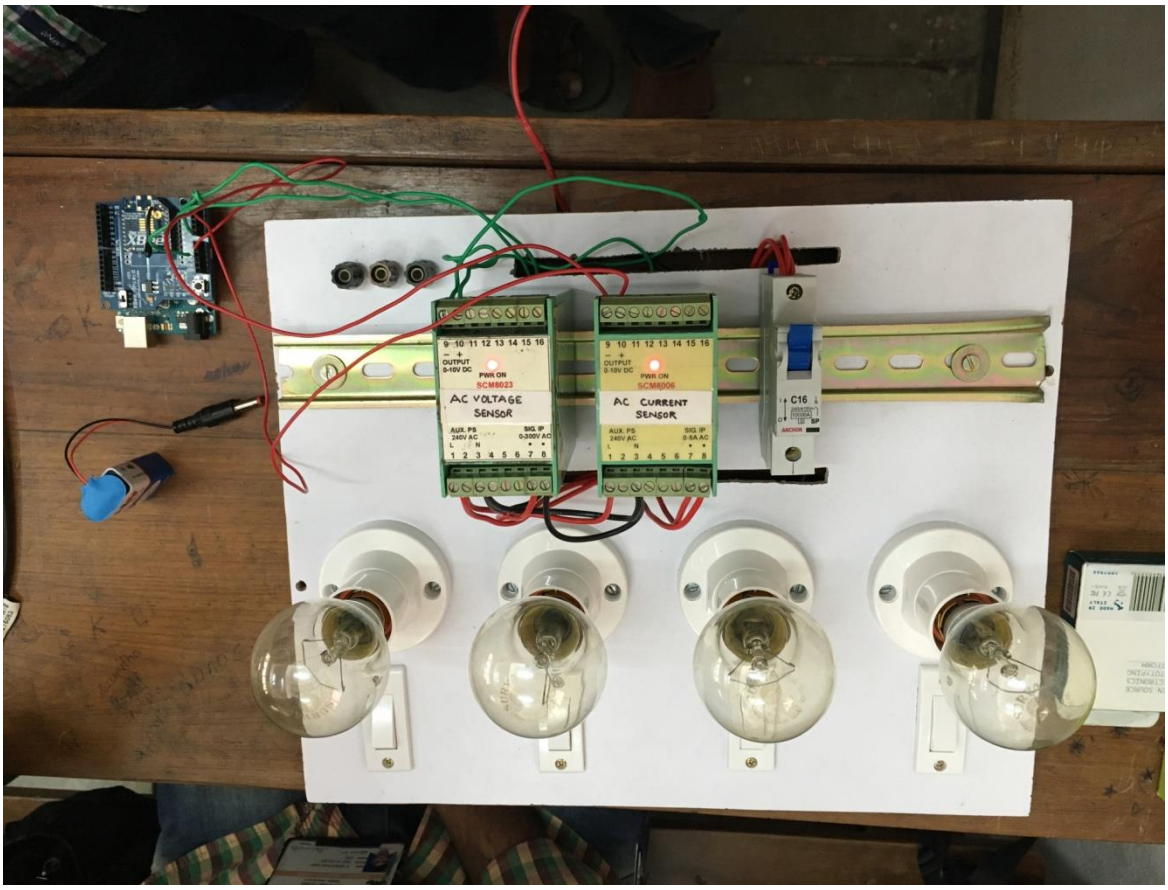


Fig Showing the actual setup

4.6.1 CODE EMPLOYED

A) Programme for receiver module

```
int sensorPin = A0;

char sensorValue;

void setup(){

Serial.begin(9600);

}

void loop()

{

  if(Serial.available())

  {

  sensorValue = Serial.read();

  Serial.print(sensorValue);

 }

 delay(10);

}
```

B) Programme for transmitter module

```
float energy=0;

int time1=0;

float total_energy=0;

void setup(){

Serial.begin(9600);

}
```

```
void loop() {
 int sensor_voltage1 = analogRead(A0);
  delay(10);
  int sensor_voltage2 = analogRead(A0);
  delay(10);
  int sensor_voltage3 = analogRead(A0);
  delay(10);
  int sensor_voltage4 = analogRead(A0);
  delay(10);
  int sensor_voltage5 = analogRead(A0);

  float sensor_voltage = (sensor_voltage1+sensor_voltage2+sensor_voltage3+sensor_voltage4+sensor_voltage5)/5.0;

  float actual_voltage = (sensor_voltage * (5.0/ 1023.0))*60;

  int sensor_current1 = analogRead(A4);
  delay(10);
  int sensor_current2 = analogRead(A4);
  delay(10);
  int sensor_current3 = analogRead(A4);
  delay(10);
  int sensor_current4 = analogRead(A4);
```

```
  delay(10);
  int sensor_current5 = analogRead(A4);
  float sensor_current = (sensor_current1+sensor_current2+sensor_current3+sensor_current4+sensor_current5)/5.0;

  float actual_current = (sensor_current * (4.95 / 1023.0))/2.0;

  float actual_power = actual_voltage*actual_current;

   if(actual_current>0.05)
   {
     energy=energy+actual_power*time1;
     time1++;
   }
   else
   {
     actual_current=0;
     time1=0;
     actual_power=0;
   }
   total_energy=energy;

   Serial.print("voltage is\t");
```

```
  Serial.println(actual_voltage);
  Serial.print("current is\t");
  Serial.println(actual_current);
  Serial.print("power is\t");
  Serial.println(actual_power);
  Serial.print("energy is\t");
  Serial.println(total_energy);
  Serial.println(time1);
  delay(1000);
}
```

4.7 TEST RESULTS:

Number of loads connected	Voltage(V)	Current(A)	Power(W)
1	230	0.44	100
2	230	0.88	200
3	230	1.22	300
4	230	1.66	400

4.8 CONCLUSION

An automatic power calculation through wireless smart meter using Zigbee communication has been designed and tested successfully. This reduces the work of the office person to a great extend. It also reduces the difficulty faced by the people when readings are taken manually. The project may be further extended by adding an additional feature of payment of the electricity bill from home itself using some pre paid banking cards or such techniques.

Power measurement is done for resistive loads up to a maximum load of 1500 watts using Arduino environment Arduino Power Measurement is an advanced method of determining power which uses a microcontroller and this method is more advantageous because the programming part is easier than C language. The advantages of Arduino over other software's are it simplifies the amount of hardware and software development needed inorder to get a system running .It is open source software and can be extended by experienced programmers. Arduino has simple and clear programming environment and also has a quicker writing code.

From the above discussion Arduino Power Measurement is an advanced method of measuring power and can also observe it graphically can be implemented for laboratory scale. The data is then transmitted through the wireless xbee and back to the base station xbee and is represented visually to the user. This method provides the domestic power consumption accurately, safely, and with a relatively fast update rate, thus helping the user optimize and reduce their power usage.

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