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Secure IOT Plotform For Industrial Control Systems

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Abstract
Supervisory control and data acquisition (SCADA) systems, are part of industrial control system (ICS), have been playing crucial roles in real-time industrial automation and controls. Through the evolution of 3rd generation, or networks based system, SCADA systems are connected to almost types of networks such as wired, wireless, and cellular and satellite communication, but security is still a big challenge for SCADA system while communicating within. Internet of things (IoT) is a ubiquitous platform, a new advance enhancement, for efficient SCADA system, where billions of network devices, with smart sensing capabilities, are networked over the Internet access. Deployment of smart IoT platform, SCADA system will significantly increase system efficiency, scalability, and reduce cost. Security is still a major issue for both-, as they were initially designed without any priority and requirements of security.

This study modeled IoT-SCADA system and deployed a security mechanism, employing of cryptography based algorithm, which provided a secure transmission channel while each time communication occurred, between the field devices in the SCADA system. Proposed security implementation, and computed measurements analyzed as potential security building block against authentication and confidentiality attacks.
Keywords:- SCADA, ICS, IOT, Microprocessor, ATmega

INTRODUCTION

With the recent developments in technology, all processes are being automated. Apart from industrial automation, automation is prevalent in the domestic domain making homes more smart and secure. It has also helped reduce human effort enabling the control of devices/appliances with great ease while being energy efficient. Various home automation models have been implemented incorporating Android platforms, Global System for Mobile communications (GSM) modules, Wi-Fi-based systems etc., into the fundamental microprocessor, sensor and actuator network. The wide application of microprocessors is not confined to domestic/home automation applications but can also be further extended into the industrial environment.

In the industrial domain, a fundamental automation system model is a basic control system, which includes an input/sensor, a controller and an output/actuator. This model can help implement any industrial application with appropriate hardware and software selection. The application discussed in this paper is level and temperature control during a continuous sequential switching operation.

A repetitive sequential switching operation replicates a traditional production line. Sequential operations are widely used in industries for packaging, production and similar activities. A simple example of such an operation would be the production of a

batch of screws in a factory. The sequence of the process flow for the mentioned activity would be cutting, heading, lathing, threading, heat treatment, electroplating, and packaging. This repetitive sequential nature of activities is widely observed in all industries and can be easily replicated on a small scale for small factories.

Level determination and monitoring systems are used in wastewater treatment plants, oil and gas industries, chemical and food processing industries, etc., for several applications including liquid storage, monitoring and control. These systems use sensors based on different working principles namely magnetic, ultrasonic, and Radiofrequency technology. The controllers used are mostly PLC's or conventional Proportional-Integral (PI)/Proportional-Integral-Derivative (PID) controllers, which communicate between the sensor and the output device (usually a pump) to assist the inflow or outflow of fluid as required.

Temperature control and monitoring systems find its application in a wide range of process control industries. The input is derived from contact temperature sensors like thermistors, thermocouples or resistance temperature detectors or non-contact sensors based on infrared or similar technologies. These devices provide the required input to the system and trigger output as determined by the controller. Depending on the entire system either conventional controllers like the PI/PID controller or an ON/OFF controller is used. The latter is used if the temperature is not a very critical parameter in the system.

Microprocessors like the ATmega 328P (present on the Arduino), can make a number of logical control decisions by mere programming in C/C++ languages. Arduino UNO is compatible with a number of software's like Matrix Laboratory (MATLAB), Parallax Data Acquisition (PLX-DAQ) tool apart from its main software, which is the Arduino IDE. The applications of this board can be extended even further by using compatible shields and external modules like GSM, Bluetooth, etc. With its affordable price, it thus, becomes a feasible option for a wide range of applications like Access Control, Data Logging and Automation.

LITERATURE SURVEY

Industrial automation using CAN protocol describe project is implemented to control the industrial loads that are run by DC motor based on the temperature variations of the process. Various process control systems are depends on the temperature. So this project achieves this with the use of CAN protocol which is highly efficient and reliable low-cost communication. Two microcontrollers are used in this project, one for acquiring temperature data and the other for controlling the DC motor. CAN Controller MCP2515 and CAN transceiver MCP2551 are connected to both microcontrollers to implement CAN communication for exchanging the data but disadvantage practically it is limited to 110 nodes due to the hardware transceivers. It supports cabling up to 250 meters.

Industrial automation using ZigBee describe the transmitter section, the Zigbee module is configured in such a way that it receives the data collected from the microcontroller and sends it to the remote receiver. In this system, the microcontroller is programmed to collect the data from an analog to digital converter that continuously monitors temperature, voltage and current parameters. At the receiver side, the Zigbee module receives all the sent data from a Zigbee transmitter within the range of communication. This data is further transferred to the microcontroller using an

embedded circuitry wherein the microcontroller program compares all these data parameters with predefined set limits. If any parameter exceeds its limit, then the microcontroller sends command signals to a relay driver IC, which is responsible to operate different loads such as motors, relays, circuit breakers, etc. All these parameters' information is also displayed on LCD display as a Human machine interface. In this way, industrial parameters can be easily monitored and controlled through the short range low cost and low powered Zigbee communication technology. It supports two ways communication between transmitting devices and controllers at 10-100 meters distance.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air.

The **MQ-2** is a flammable gas and smoke sensor detects the concentrations of combustible gas in the air and outputs its reading as an analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm. The MQ-2 gas sensor is sensitive to LPG, i-butane, propane, methane, alcohol, Hydrogen and smoke. They are used in gas leakage detecting equipments in family and industry and in portable gas detector.

Humidity Sensor is one of the most important devices that has been widely in consumer, industrial, biomedical, and environmental etc. applications for measuring and monitoring Humidity.Humidity is defined as the amount of water present in the surrounding air. This water content in the air is a key factor in the wellness of mankind. For example, we will feel comfortable even if the temperature is 00C with less humidity i.e. the air is dry.

Humidity is also a major factor for operating sensitive equipment like electronics, industrial equipment, electrostatic sensitive devices and high voltage devices etc.

HR201 is a new kind of humidity-sensitive resistor made from organic macro molecule materials, it can be used in occasions like: hospitals, storage, workshop, textile industry, tobaccos, pharmaceutical field, meteorology, etc.
LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.

The piezo buzzer produces sound based on reverse of the piezoelectric effect. The generation of pressure variation or strain by the application of electric potential across a piezoelectric material is the underlying principle. These buzzers can be used alert a user of an event corresponding to a switching action, counter signal or sensor input. They are also used in alarm circuits.

INTRODUCTION TO EMBEDDED SYSTEMS

APPLICATION AREAS

Nearly 99 per cent of the processors manufactured end up in embedded systems. The embedded system market is one of the highest growth areas as these systems are used in very market segment- consumer electronics, office automation, industrial automation, biomedical engineering, wireless communication, data communication, telecommunications, transportation, military and so on.

Consumer appliances At home we use a number of embedded systems which include digital camera, digital diary, DVD player, electronic toys, microwave oven, remote controls for TV and air-conditioner, VCO player, video game consoles, video recorders etc. Today's high-tech car has about 20 embedded systems for transmission control, engine spark control, air-conditioning, navigation etc. Even wristwatches are now becoming embedded systems. The palmtops are powerful embedded systems using which we can carry out many general-purpose tasks such as playing games and word processing.

Office automation: The office automation products using em embedded systems are copying machine, fax machine, modem, printer, scanner etc.

Industrial automation: Today a lot of industries use embedded systems for process control. These include pharmaceutical, cement, sugar, oil exploration, nuclear energy, electricity generation and transmission. The embedded systems for industrial use are designed to carry out specific tasks such as monitoring the temperature, pressure, humidity, voltage, current etc., and then take appropriate action based on the monitored levels to control other devices or to send information to a centralized monitoring station. In hazardous industrial environment, where human presence has to be avoided, robots are used, which are programmed to do specific jobs. The robots are now becoming very powerful and carry out many interesting and complicated tasks such as hardware assembly.

Medical electronics: Almost every medical equipment in the hospital is an embedded system. These equipments include diagnostic aids such as ECG, EEG, blood pressure measuring devices, X-ray scanners; equipment used in blood analysis, radiation, colonoscopy, endoscopy etc. Developments in medical electronics have paved way for more accurate diagnosis of diseases.

Computer networking: Computer networking products such as bridges, routers, Integrated Services Digital Networks (ISDN), Asynchronous Transfer Mode (ATM), X.25 and frame relay switches are embedded systems which implement the necessary data communication protocols. For example, a router interconnects two networks. The two networks may be running different protocol stacks. The router's function is to obtain the data packets from incoming pores, analyze the packets and send them towards the destination after doing necessary protocol conversion. Most networking equipments, other than the end systems (desktop computers) we use to access the networks, are embedded systems

Telecommunications: In the field of telecommunications, the embedded systems can be categorized as subscriber terminals and network equipment. The subscriber terminals such as key telephones, ISDN phones, terminal adapters, web cameras are embedded systems. The network equipment includes multiplexers, multiple access systems, Packet Assemblers Dissemblers (PADs), satel1ite modems etc. IP phone, IP gateway, IP gatekeeper etc. are the latest

embedded systems that provide very low-cost voice communication over the Internet.

Wireless technologies: Advances in mobile communications are paving way for many interesting applications using embedded systems. The mobile phone is one of the marvels of the last decade of the 20th century. It is a very powerful embedded system that provides voice communication while we are on the move. The Personal Digital Assistants and the palmtops can now be used to access multimedia services over the Internet. Mobile communication infrastructure such as base station controllers, mobile switching centers are also powerful embedded systems. Insemination: Testing and measurement are the fundamental requirements in all scientific and engineering activities. The measuring equipment we use in laboratories to measure parameters such as weight, temperature, pressure, humidity, voltage, current etc. are all embedded systems. Test equipment such as oscilloscope, spectrum analyzer, logic analyzer, protocol analyzer, radio communication test set etc. are embedded systems built around powerful processors. Thank to miniaturization, the test and measuring equipment are now becoming portable facilitating easy testing and measurement in the field by field-personnel.

Security: Security of persons and information has always been a major issue. We need to protect our homes and offices; and also the information we transmit and store. Developing embedded systems for security applications is one of the most lucrative businesses nowadays. Security devices at homes, offices, airports etc. for authentication and verification are embedded systems. Encryption devices are nearly 99 per cent of the processors that are manufactured end up in~ embedded systems. Embedded systems find applications in every industrial segment-consumer electronics, transportation, avionics, biomedical engineering, manufacturing, process control and industrial automation, data communication, telecommunication, defense, security etc. These are used to encrypt the data/voice being transmitted on communication links such as telephone lines. Biometric systems using fingerprint and face recognition are now being extensively used for user authentication in banking applications as well as for access control in high security buildings. Finance: Financial dealing through cash and cheques are now slowly paving way for transactions using smart cards and ATM (Automatic Teller Machine, also expanded as Any Time Money) machines. Smart card, of the size of a credit card, has a small micro-controller and memory; and it interacts with the smart card reader! ATM machine and acts as an electronic wallet. Well, the list goes on.

EXISTING SYSTEM

Industrial control system controls the devices whenever any of the sensed parameters exceed their respective set points. Controlling was automated but monitoring of the parameters was accomplished using the indoor panels within the same industrial place. Most of industrial based systems, employing sensors, actuator, PLCs, and other controlling and monitoring facilities, are limited and not connected to the Internet.

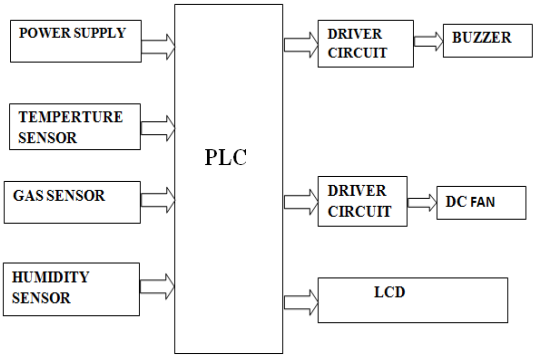
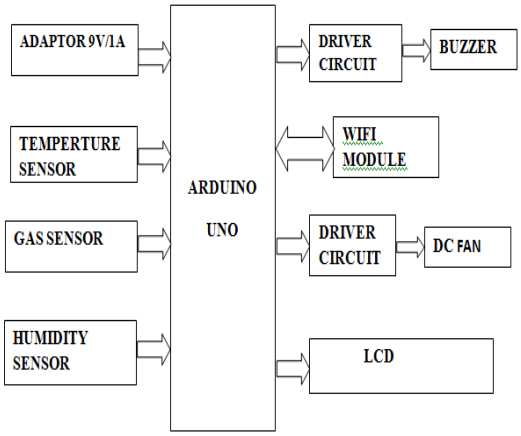


Fig: 4.1 Block Diagram Of Existing system

PROPOSED SYSTEM

This IOT based industrial control system allows the user to monitor the parameters from anywhere in the world. The sensors values will be updated on the web page continuously and the user can view these values on the web page. And also, not only a single industry plant values, but several plants can be put together and collectively the sensor data values can be viewed online.



Fig;5.1 Block Diagram Of Proposed system

5.2 ARDUINO UNO

Arduino is used for building different types of electronic circuits easily using of both a physical programmable circuit board usually microcontroller and piece of code running on computer with USB connection between the computer and Arduino. Programming language used in Arduino is just a simplified version of C++ that can easily replace thousands of wires with words.

Fig :5.2 ARDUINO UNO

FIG: ARDUINO UNO

5.2.1 ARDUINO UNO-R3 PHYSICAL COMPONENTS

ATMEGA328P-PU microcontroller

The most important element in Arduino Uno R3 is ATMEGA328P-PU is an 8-bit Microcontroller with flash memory reach to 32k bytes.

Features

1. High Performance, Low Power Atmel®AVR® 8-Bit Microcontroller Family

- Advanced RISC Architecture

– 131 Powerful Instructions

– Most Single Clock Cycle Execution
– 32 x 8 General Purpose Working Registers
– Fully Static Operation
– Up to 20 MIPS Throughput at 20MHz
– On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory Segments
– 32KBytes of In-System Self-Programmable Flash program
2. Memory
– 1KBytes EEPROM
– 2KBytes Internal SRAM
– Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
– Data Retention: 20 years at 85°C/100 years at 25°C(1)
– Optional Boot Code Section with Independent Lock Bits
• In-System Programming by On-chip Boot Program
• True Read-While-Write Operation
– Programming Lock for Software Security
• Atmel® QTouch® Library Support
– Capacitive Touch Buttons, Sliders and Wheels
– QTouch and QMatrix® Acquisition
– Up to 64 sense channels
3. Atmel-42735B-ATmega328/P_Datasheet_Complete-11/2016
• Peripheral Features
– Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
– Real Time Counter with Separate Oscillator
– Six PWM Channels
– 8-channel 10-bit ADC in TQFP and QFN/MLF package
• Temperature Measurement
– 6-channel 10-bit ADC in PDIP Package
• Temperature Measurement
– Two Master/Slave SPI Serial Interface
– One Programmable Serial USART
– One Byte-oriented 2-wire Serial Interface (Philips I2C compatible)
– Programmable Watchdog Timer with Separate On-chip Oscillator
– One On-chip Analog Comparator
– Interrupt and Wake-up on Pin Change
• Special Microcontroller Features
– Power-on Reset and Programmable Brown-out Detection
– Internal Calibrated Oscillator
– External and Internal Interrupt Sources
– Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and
4. Extended Standby
• I/O and Packages
– 23 Programmable I/O Lines
– 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
• Operating Voltage:
– 1.8 - 5.5V
• Temperature Range:
– -40°C to 105°C
• Speed Grade:
– 0 - 4MHz @ 1.8 - 5.5V
– 0 - 10MHz @ 2.7 - 5.5V
– 0 - 20MHz @ 4.5 - 5.5V
• Power Consumption at 1MHz, 1.8V, 25°C
– Active Mode: 0.2mA
– Power-down Mode: 0.1µA
– Power-save Mode: 0.75µA (Including 32kHz RTC)

PRECESION CENTIGRADE TEMPERATURE SENSOR

LM35 converts temperature value into electrical signals. LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration since it is internally calibrated. . The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C

over a full −55 to +150°C temperature range.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air.

Features

1. Calibrated directly in ° Celsius (Centigrade)
2. Linear + 10.0 mV/°C scale factor
3. 0.5°C accuracy guaranteed (at +25°C)
4. Rated for full −55° to +150°C range
5. Suitable for remote applications
6. Low cost due to wafer-level trimming
7. Operates from 4 to 30 volts
8. Less than 60 µA current drain
9. Low self-heating, 0.08°C in still air
10. Nonlinearity only ±1⁄4°C typical

Low impedance output, 0.1 W for 1 mA lo

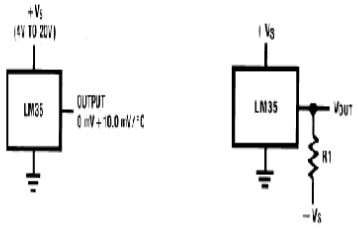


Fig:5.3 LM 35 Circuit Diagrams

The characteristic of this LM35 sensor is:

For each degree of centigrade temperature it outputs 10milli volts.

In addition to thermistors, several other types of temperature sensors are used. The most common are Resistance Temperature Detectors (RTD) and integrated circuits (IC), such as the LM335 and AD590 types. Which sensor works best for a particular use is based on many factors. The table below gives a brief comparison of the benefits and drawbacks of each.

Table : 5.3 Different Types Temperatures

PARAMETERS	THERMISTOR	RTD	LM35	AD592
Temp Range	With in-50*c of a given center temperature	-200*c to+850*c	-40*c to +100*c	-20*c to +105*c
Relative Cost	Very inexpensive	Most expensive	Moderately expensive	Moderately expensive
Time Constant	6 to 14 seconds	1 to 7 seconds	1 to 3 seconds	2 to 60 seconds
Stability	Very stable 0.00009*c	-0.05*c	-0.01*c	-0.01*c
Sensitivity	High	Low	Low	Low
Advantages	Durable Long lasting Highly sensitive Small size Lowest cost Best for measuring single point of temperature	Best response time Linear output Widest operating temperature range Best for measuring range of temperature	Moderately expensive Linear output	Moderately expensive Linear output
Disadvantages	Non linear output Limited temperature range Slow response time	Expensive Low sensitivity	Limited temperature range Low sensitivity Large size	Slow response time Limited temperature range

5.4 GAS SENSOR

The **MQ-2** is a flammable gas and smoke sensor detects the concentrations of combustible gas in the air and outputs its reading as an analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm. The MQ-2 gas sensor is sensitive to LPG, i-butane, propane, methane, alcohol, Hydrogen and smoke. They are used in gas leakage detecting equipments in family and industry and in portable gas detector.

Fig :5.4 Gas Sensor

Specifications

- Supply Voltage:5V
- Sensitive to H2, LPG, CH4, CO, Alcohol, Smoke or Propane
- Analog and Digital Output
- Digital Out is High or Low based on a adjustable preset threshold.

Table: 5.4 Pin Diagram

Pin No	Pin Name	Description
For Module		
1	Vcc	This pin powers the module, typically the operating voltage +5v
2	Ground	Used to connect the module to system ground
3	Digital Out	You can also use this sensor to get digital output from this pin, by setting a threshold value using the potentiometer
4	Analog Out	This pin outputs 0-5v analog voltage based on the intensity of gas
For sensor		
1	H-pins	Out of these two H pins. One in connected to supply and other to ground
2	A-pins	The A pins and B pins are interchangeable. these pins will be tied to the supply voltage
3	B-pins	The A pins and B pins are interchangeable. one pin will set as output while the other will be parallel to ground

1.1.1. Features:

- Operating Voltage is +5V
- Can be used to Measure or detect LPG, Alcohol, Propane, Hydrogen, CO and even methane
- Analog output voltage: 0V to 5V
- Digital Output Voltage: 0V or 5V (TTL Logic)
- Preheat duration 20 seconds
- Can be used as a Digital or analog sensor
- The Sensitivity of Digital pin can be varied using the potentiometer

Selecting between Sensor type and module type:

When it comes to measuring or detecting a particular Gas the **MQ series Gas sensors** are the most commonly used ones. These sensors can either be purchased as a module or as just the sensor alone. If you are trying to only detect (not measuring ppm) the presence of a gas then you can buy it as a module since it comes with an op-amp comparator and a digital out pin.

Where to use MQ-2 Gas sensor:

The **MQ-2 Gas sensor** can detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane. The module version of this sensor comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

So if you are looking for a sensor to detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane with or without a microcontroller then this sensor might be the right choice for you.

How to use MQ-2 Sensors to detect gas:

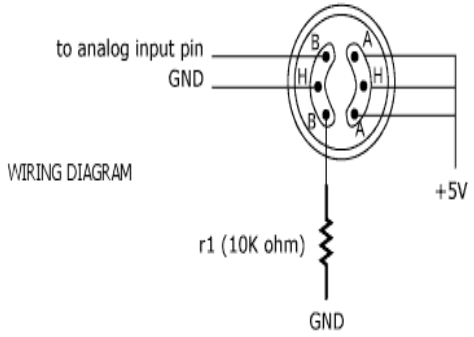
Using an MQ sensor it detects a gas is very easy. You can either use the digital pin or the analog pin to accomplish this. Simply power the module with 5V and you should notice the power LED on the module to glow and when no gas it detected, the output LED will remain turned off meaning the digital output pin will be 0V. Remember that these sensors have to be kept on for pre-heating time (mentioned in features above) before you can actually work with it. Now, introduce the sensor to the gas you want to detect and you should see the output LED to go high along with the digital pin, if not use the potentiometer until the output gets high. Now every time your sensor gets introduced to this gas at this particular concentration the digital pin will go high (5V) else will remain low (0V).

You can also use the analog pin to achieve the same thing. Read the analog values (0-5V) using a microcontroller, this value will be directly proportional to the concentration of the gas to which the sensor detects. You can experiment with this values and check how the sensor reacts to different concentration of gas and develop your program accordingly.

How to use the MQ-2 sensor to measure PPM

If you are looking for some accuracy with your readings then measuring the PPM would be the best way to go with it. It can

also help you to distinguish one gas from another. So to measure PPM you can directly use a module. A basic wiring for the sensor from datasheet is shown below.



1.1.2. Fig:5.4.1 Gas Sensor wiring Diagram

Applications

- Detects or measure Gases like LPG, Alcohol, Propane, Hydrogen, CO and even methane.
- Air quality monitor.
- Gas leak alarm.
- Safety standard maintenance.
- Maintaining environment standards in hospitals.

HUMIDITY SENSOR

Humidity Sensor is one of the most important devices that has been widely in consumer, industrial, biomedical, and environmental etc. applications for measuring and monitoring Humidity.

Humidity is defined as the amount of water present in the surrounding air. This water content in the air is a key factor in the wellness of mankind. For example, we will feel comfortable even if the temperature is 00C with less humidity i.e. the air is dry.

Humidity is also a major factor for operating sensitive equipment like electronics, industrial equipment, electrostatic sensitive devices and high voltage devices etc. Such sensitive equipment must be operated in a humidity environment that is suitable for the device. Hence, sensing, measuring, monitoring and controlling humidity is a very important task.

Some of the important areas of application for sensing, measuring and controlling Humidity are mentioned below.

Domestic: Sensing and controlling humidity in our homes and offices is important as higher humidity conditions will affect the blood flow. Other areas include cooking, indoor plantation etc.

Industrial: In industries like refineries, chemical, metal, or other industries where furnaces are used, high humidity will reduce the amount of oxygen in the air and hence reduces the firing rate. Other industries like food processing, textile, paper etc. also need control of humidity.

Agriculture: Irrigation techniques like drip irrigation need accurate moisture content for plants. Also, the moisture in the soil plays an important role in the proper growth of the plant. Other areas where humidity control is required is indoor vegetation.

Electronics and Semiconductor: Almost all electronic devices are rated with a range of humidity values in which they work as expected. Generally, this value will be something like 10% – 50% Humidity. Semiconductor Fabs (Fabrication Plants) should maintain very precise temperature and humidity values as even minute difference can show a huge impact in the production.

Medical: Medical equipment like ventilators, incubators, sterilizers etc. need humidity control. It is also used in pharmaceutical plants and biological processes.

1.1.1. Important Terms Related to Humidity

Moisture: Generally, the term Moisture means water content of any material or substance. But practically, the term

Moisture refers to the water content in solids and liquids. The term Humidity refers to the water content in gases (air).

Absolute Humidity: Absolute Humidity (AH) is the ratio of mass of the water vapour to the volume of the air. If m is the mass of the water vapour and V is the total volume i.e. volume of air and water vapour mixture, then Absolute Humidity AH is given by

$$AH = m/V$$

Absolute Humidity doesn't take temperature in to account but it changes with temperature and pressure.

Relative Humidity: Whenever we talk about measuring Humidity, it usually Relative Humidity that we are talking about (unless otherwise specified). Relative Humidity or RH is the ratio of the actual water vapour pressure present in the air at a temperature to the maximum water vapour pressure present in the air at the same temperature.

In weather reports and forecasts, the probability of precipitation or dew or fog is indicated using Relative Humidity and hence, it is considered an important metric.

Relative Humidity takes both temperature and pressure in to consideration. Hence, the Humidity Sensors which measure Relative Humidity, measure both the moisture content as well as the air temperature.
NOTE: For temperatures above 1000C, measuring Relative Humidity (RH) is of no use as it would deliver misleading values.

Specific Humidity: Specific Humidity (SH) is the ratio of mass of the water vapor to the total mass of the air.
Mixing Ratio or Humidity Ratio: Mixing Ratio is the ratio of mass of the water vapor to mass of the dry air

Dew Point Temperature: Dew Point Temperature is the temperature at with the water vapor content is saturated in the air. At Dew Point temperature, the Relative Humidity RH is 100%. In other words, for the air to hold maximum amount of water vapor (or moisture), it has to reach Dew Point Temperature.

Humidity Sensors – Classification and Working Principles
Humidity Sensors are very important devices that help in measuring the environmental humidity. Technically, the device used to measure the humidity of the atmosphere is called Hygrometer. Humidity Sensors or Hygrometers can be classified based on the type of humidity it is used for measuring i.e.

Absolute Humidity (AH) sensors or Relative Humidity (RH) sensors: Humidity Sensors can also be classified based on the parameter used for measuring Humidity i.e. Capacitive Humidity Sensors, Electrical Conductivity (or Resistive) Humidity Sensors and Thermal Conductivity Humidity Sensors.

Resistive Humidity sensor-HR201

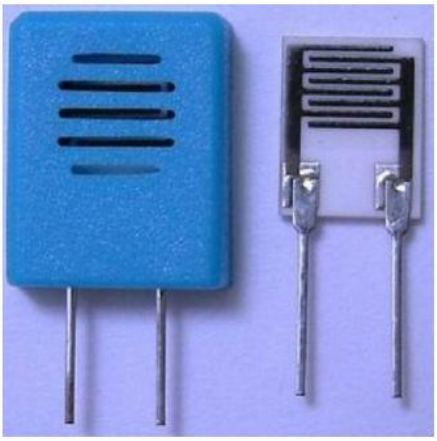


Fig: 5.5 resistive Humidity sensor

HR201 is a new kind of humidity-sensitive resistor made from organic macro molecule materials, it can be used in

occasions like: hospitals, storage, workshop, textile industry, tobaccos, pharmaceutical field, meteorology, etc.

Features

- Excellent linearity
- Low power consumption
- Wide measurement range
- Quick response
- Anti-pollution
- High stability
- High performance-price ratio

Technical Specifications:

- Operating range: humidity (20-95%RH), temperature(0-60Celsius)
- Power supply: 1.5V AC(Max sine)
- Operating frequency: 500Hz-2kHz
- Rated power: 0.2mW(Max sine)
- Central value: 23kΩ(at 25Celsius, 1kHz ,1V AC, 60%RH)
- Impedance range: 19.8-50.2kΩ(at 25Celsius, 1kHz ,1V AC, 60%RH)
- Accuracy: +-5%RH
- Hysteresis: +-1%RH
- Long-term stability: +-1%RH/year
- Response time: <10s
- Dimensions: with case 12*15*5mm, without case 8*10*0.7mm

5.6 LIQUID CRYSTAL DISPLAY

LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
4. Ease of programming for characters and graphics.

These components are “specialized” for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

HARDWARE IMPLEMENTATION OF THE PROJECT

This chapter briefly explains about the Hardware Implementation of the project. It discusses the design and working of the design with the help of block diagram and circuit diagram and explanation of circuit diagram in detail. It explains the features, timer programming, serial communication, interrupts of atmega328 microcontroller. It also explains the various modules used in this project.

Project Design

The implementation of the project design can be divided in two parts.

- Hardware implementation
- Firmware implementation

Hardware implementation deals in drawing the schematic on the plane paper according to the application, testing the schematic design over the breadboard using the various IC’s to find if the design meets the objective, carrying out the PCB layout of the schematic tested on breadboard, finally preparing the board and testing the designed hardware.

The project design and principle are explained in this chapter using the block diagram and circuit diagram. The block diagram discusses about the required components of the design and working condition is explained using circuit diagram and system wiring diagram.

INTRODUCTION TO MICROCONTROLLER

Based on the Processor side Embedded Systems is mainly divided into 3 types

1. Microprocessor: - are for general purpose eg: our personal computer

2. Microcontroller: - are for specific applications, because of cheaper cost we will go for these

3. DSP (Digital Signal Processor):- are for high and sensitive application purpose

MICROCONTROLLER VERSUS MICROPROCESSOR

A system designer using a general-purpose microprocessor such as the Pentium or the 68040 must add RAM, ROM, I/O ports, and timers externally to make them functional. Although the addition of external RAM, ROM, and I/O ports makes these systems bulkier and much more expensive, they have the advantage of versatility such that the designer can decide on the amount of RAM, ROM and I/O ports needed to fit the task at hand.

A Microcontroller has a CPU (a microprocessor) in addition to a fixed amount of RAM, ROM, I/O ports, and a timer all on a single chip. In other words, the processor, the RAM, ROM, I/O ports and the timer are all embedded together on one chip; therefore, the designer cannot add any external memory, I/O ports, or timer to it. The fixed amount of on-chip ROM, RAM, and number of I/O ports in Microcontrollers makes them ideal for many applications in which cost and space are critical.

Table: 6.1 microprocessor vs micro controller

Microprocessor	Microcontroller
CPU is a stand alone, RAM, ROM, I/O, timer are separate.	CPU, RAM, ROM, I/O and timer are all on a single chip
Designer can decide on the amount of ROM, RAM, and I/O ports	Fix amount of on chip ROM,RAM, I/O ports
Expensive, Versatility	For applications in which cost, power and space are critical
General purpose	Single purpose

OTHER ARDUINO UNO R3 PARTS

Input and Output

Each of the 14 digital pins on the Uno can be used as an 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 k Ohms.

In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analog Write() function.
- **SPI**: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- **LED: 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's off. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e.1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference()

function.

- Additionally, some pins have specialized functionality:
- **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library. There are a couple of other pins on the board:
- **AREF:** Reference voltage for the analog inputs. Used with analog Reference().
- **Reset:** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

MEMORY

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

COMMUNICATION

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

PROGRAMMING

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available.
ATmega16 U2/8U2 is loaded with a DFU boot loader, which can be activated by:
On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader).

DESCRIPTION

The Atmel AVR® core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

Atmel offers the Q Touch® library for embedding capacitive touch buttons, sliders and wheels functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offers robust sensing and includes fully debounced reporting of touch keys and includes Adjacent Key Suppression® (AKS™) technology for unambiguous detection of key events. The easy-to-use Q Touch Suite tool chain allows you to explore, develop and debug your own touch applications.
The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core.

The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328/P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications. The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits.

Table: 6.6 configuration summary

FEATURES	ATMega328/P
Pin Count	28/32
Flash	32K
SRAM	2K
EEPROM	1K
General Purpose I/O Lines	23
SPI	2
TWI (I2)	1
USART	1
ADC	10-Bit 15ksps
ADC Channel	8
8bit Timers/Counters	1
16Bit Timers/counters	1

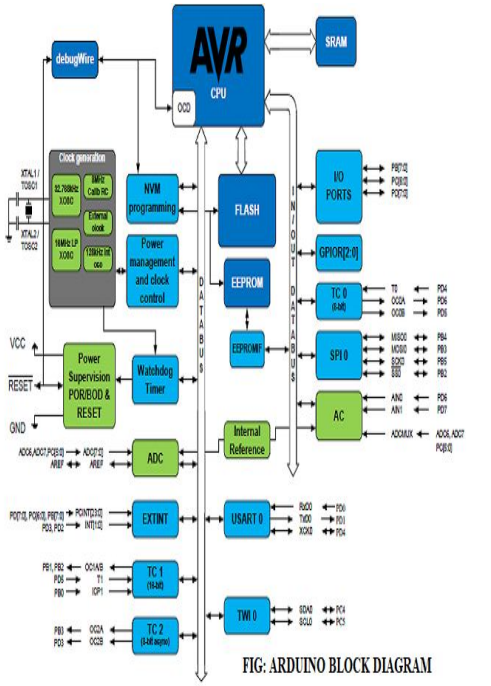


Fig 6.6: Arduino Block Diagram

Pin-out

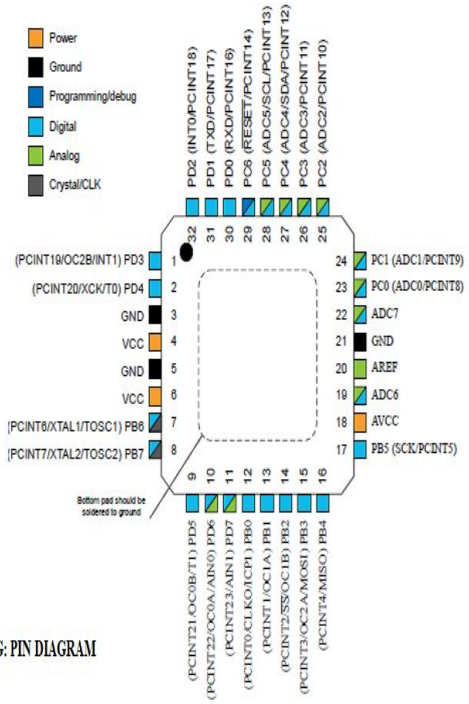


FIG: PIN DIAGRAM

Fig:6.6.1 Pin Diagram

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 un programmed, 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.

I/O Multiplexing

Each pin is by default controlled by the PORT as a general purpose I/O and alternatively it can be assigned to one of the peripheral functions. The following table describes the peripheral signals multiplexed to the PORT I/O pins.

TYPES OF ARDUINO BOARDS:-

- Arduino UNO.
- Arduino MEGA.
- Arduino MINI.
- Arduino NANO
- Arduino DUE.
- Arduino YUN.
- Arduino Lily pad.
- Arduino Duemilanova.

Apart from this there are many more boards that can be used. As it's open source instead of Arduino you can also find, Freeduino, Arkduino etc. available in the market. Selection of Board should be done according to the application.

Choosing the right controller

The table below compares the Arduino Uno, Leonardo, and our A-Star 32U4 Prime controllers. The A-Star Primes are based on the same ATmega32U4 AVR microcontroller as the Leonardo and ship with Arduino-compatible boot loaders. The Primes also offer many advantages, including superior power management that enables efficient operation from 2.7 V to 11.8 V (LV version) or 5 V to 36 V (SV version).

Table 6.8 Types of Arduino

		Arduino Uno R3	Arduino Leonardo	A-Star 32U4 Prime LV	A-Star 32U4 Prime SV
Microcontroller:		ATmega328P	ATmega32U4	ATmega32U4	
Clock:		16 MHz resonator	16 MHz crystal	16 MHz crystal	
User I/O lines:		20	23	26	
PWM outputs:		6	7	7	
Analog inputs:		6	12	12	
Ground access points:		4	4	43	
User LEDs:		3	3	3	
User pushbuttons:		—	—	3	
Reset button:					
Power switch:					
Buzzer option:					
microSD option:					
LCD option:					
Arduino-compatible bootloader:					
USB connector:		B	Micro-B	Micro-B	
USB/regulator power selection:		partial	partial	TPS2113A	
High-performance reverse-voltage protection:					
Recommended input voltage:		7 V to 12 V	7 V to 12 V	2 V to 16 V	5 V to 36 V
Regulator type (5 V):		linear	linear	switching step-up/step-down	switching step-down
Available 5 V output current:	at 3 V in	—	—	0.75 A	—
	at 5 V in	—	—	1.5 A	0.2 A
	at 7 V in	1.0 A	1.0 A	1.9 A[1]	1.0 A
	at 9 V in	0.5 A	0.5 A	1.9 A[1]	1.0 A
	at 11 V in	0.35 A	0.35 A	1.8 A	1.0 A
	at 24 V in	—	—	—	1.0 A
	via USB connector	0.5 A[2]	0.5 A[2]	1.9 A[3]	1.9 A[3]
Weight:		28 g	20 g	13 g to 33 g	

1 There is more available 5 V output current via VREG, see maximum regulator output current graph for details.
2 With sufficient USB power supply.
3 Nominal current available through power MUX with sufficient USB power supply.

FIRMWARE IMPLEMENTATION OF THE PROJECT DESIGN

FIRMWARE IMPLEMENTATION

This chapter briefly explains about the firmware implementation of the project. The required software tools are discussed in the following section.

Software Tool Required

Arduino 1.0.6 software tools used to program microcontroller. The working of software tool is explained below in detail.

PROGRAMMING MICROCONTROLLER

A compiler for a high level language helps to reduce production time. To program the Arduino UNO microcontroller the Arduino is used. The programming is done strictly in the embedded C language. Arduino is a suite of executable, open source software development tools for the microcontrollers hosted on the Windows platform.

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

One of the difficulties of programming microcontrollers is the limited amount of resources the programmer has to deal with. In personal computers resources such as RAM and processing speed are basically limitless when compared to microcontrollers. In contrast, the code on microcontrollers should be as low on resources as possible

ABOUT ARDUINO COMPILER

GET AN ARDUINO BOARD AND USB CABLE

You also need a standard USB cable (A plug to B plug): the kind you would connect to a USB printer, for example. (For the Arduino Nano, you'll need an A to Mini-B cable instead).

FIG: ARDUINO BOARD AND USB CABLE

FIG : 7.3 ARDUINO AND USB CABLE

CONNECT THE BOARD

The Arduino Uno, Mega, Duemilanove and Arduino Nano automatically draw power from either the USB connection to the computer or an external power supply. If you're using an Arduino Diecimila, you'll need to make sure that the board is configured to draw power from the USB connection. The power source is selected with a jumper, a small piece of plastic that fits onto two of the three pins between the USB and power jacks. Check that it's on the two pins closest to the USB port. Connect the Arduino board to your computer using the USB cable. The green power LED (labeled PWR) should go on.

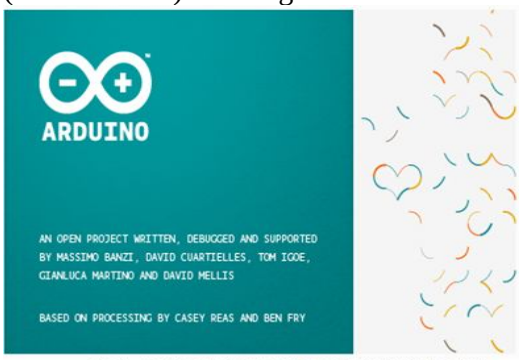


FIG: OPENING THE ARDUINO WINDOW

Fig :7.3.1 Arduino window

Open the blink example

Open the LED blink example sketch: File > Examples > 1.Basics > Blink**.**

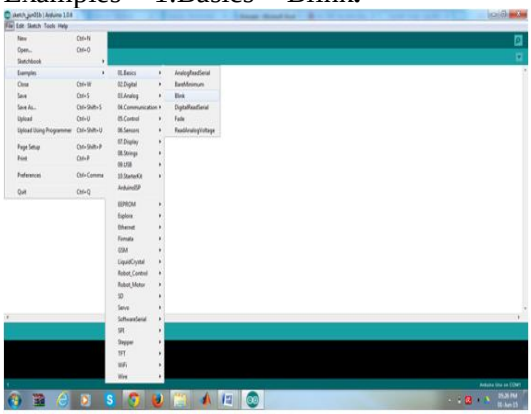


FIG: OPENING BLINK EXAMPLE

Fig:7.3.2 Opening Blink Example

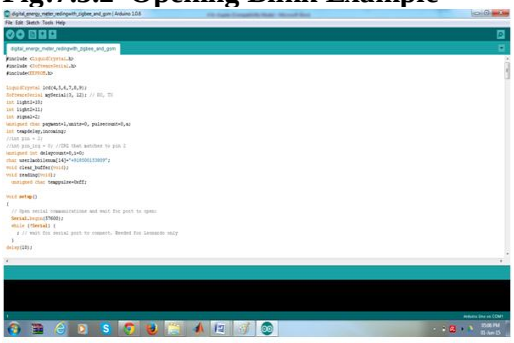


FIG: SOURCE CODE WRITTEN IN ARDUINO COMPILER

Fig: 7.3.3 Source Code Written In ARDUINO

Select your board

You'll need to select the entry in the Tools > Board menu that corresponds to your Arduino.

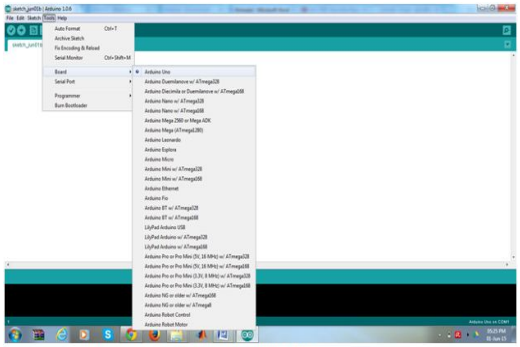


FIG: SELECTING AN ARDUINO UNO

Fig: 7.34 Selecting An ARDUINO UNO

7.4 WRITING SKETCHES

Software written using Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension .ino. It has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom right hand corner of the window displays the current board and serial port. The toolbar buttons allow you to verify and upload programs, create, open and save sketches and open the serial monitor. NB: Versions of the IDE prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

Table:7.4 writing sketches

Verify	Check your code for errors
Upload	Compiles your code and upload it to the Arduino I/O board. See uploading below for details
New	Create a new sketch
Open	Presents a menu of all sketches in your sketch box. Checking one will open it with in the current window. NOTE: due to bug in java, this menu does not scroll; if you open a sketch late in the list, use this File| sketch book menu instead
Save	Saves your sketch
Serial monitor	Opens in a serial monitor

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive which means only those items relevant to the work currently being carried out are available.

SELECT YOUR SERIAL PORT

Select the serial device of the Arduino board from the Tools | Serial Port menu. This is likely to be COM3 or higher (COM1and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu; the entry that disappears should be the Arduino board. Reconnect the board and select that serial port.

UPLOAD THE PROGRAM

Before uploading your sketch, you need to select the correct items from the **Tools > Board** and **Tools > Serial Port** menus. The boards are described below. On the Mac, the serial port is probably something like **/dev/tty.usbmodem241** On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be **/dev/ttyUSB0**,**/dev/ttyUSB1** or similar.

Once you've selected the correct serial port and board, press the upload button in the toolbar or select the **Upload** item from the **File** menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino environment will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino **boot loader**, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The boot loader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The boot loader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

Now, simply click the "Upload" button in the environment. Wait a few seconds - you should see the RX and TX leds on the board flashing. If the upload is successful, the message "Done uploading." will appear in the status bar. (*Note:* If you have an Arduino Mini, NG, or other board, you'll need to physically present the reset button on the board immediately before pressing the upload button.)

FIG: COMPILATION UNDER PROCESS

Fig:7.5 Compilation Under Process

A few seconds after the upload finishes, you should see the pin 13 (L) LED on the board start to blink (in orange). If it does, congratulations, You've gotten Arduino up-and-running.

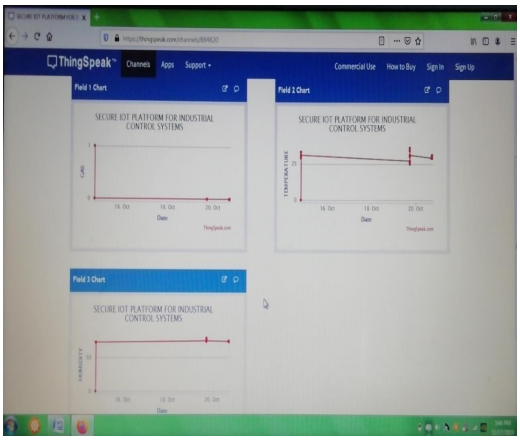
RESULTS AND DISCUSSIONS

WORKING PROCEDURE

Secured IOT platform for Industrial control system is a working model designed to monitor and control the industry parameters continuously. This model uses Arduino as the main controlling element to implement the tasks efficiently.

The microcontroller unit consists of three sensors-gas sensor, humidity and temperature sensor. The data from sensors are continuously processed by the microcontroller and uploaded to the webpage and also the buzzer is activated immediately if gas sensor or humidity sensor values exceed their set points. If the temperature sensor triggers, then the fan will be switched on.

The system will remain in deactivated mode initially. After the system activation, the system will work as follows. The temperature sensor LM35 will constantly send the room temperature values to ARDUINO. If temperature value is above a certain level, ARDUINO unit immediately switches on the fan. The gas sensor detects the emission of any gases in the industry and if it detects any gases, this value will be sensed by the ARDUINO and it triggers an alarm. The humidity sensor measures the humidity level and if this value changes, this value will be sensed by the ARDUINO and it triggers an alarm. LCD is used to display the introductory messages, Wi-Fi module establishes the communication between the ARDUINO and Internet and the sensor data will be continuously uploaded on the webpage.



FUTURESCOPE AND APPLICATIONS

FUTURE SCOPE

As a future enhancement to this working model, data can be analyzed in advance. For instance, the data is collected and has to be analyzed for a period of 1 year. This can be achieved using Artificial Intelligence. Integrating AI in this project, we can analyze and estimate the values for a certain period in advance.

APPLICATIONS

In Automation of Industries
In Railways
Home Automation with sensors

REFERENCE

Secured IoT platform for Industrial control system-references

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[4] B. Meena Kumari1, M. Satya Sailaja, "Industrial Automation and Process Control System Using Can Bus", International Journal of Science and Research (IJSR) (2014).