Micro Irrigation Engineering
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Lecture - 54
Automation of Micro Irrigation System (Part – 4)

Hello participants, I welcome you to the lecture 54 is on automation of micro irrigation system part 4. In previous 3 lectures we discussed about different components, we discussed about the networking system, we discussed about the different types of the topology, different types of sensor network and then different programs. Now, here in this particular lecture, we will be discussing about the prototype development and what are the different types of components which are involved in the prototype development of the wireless sensor network, when we are using with or without internet operated micro irrigation system automation.

So, as I told you that in the previous lecture, we discussed about why to automate micro irrigation system? What is the role of ICT and IoT in micro irrigation automation? Types of micro irrigation automation and then parameters which are considered for automation of micro irrigation system, which are the different components which deal with the automation of micro irrigation systems, sensors, controller, and actuators. And in the previous lecture 53, we discussed about the network wireless, wired or hybrid for data communication. We also discussed about the different types of programs with database graphical user interface and then associated software dealing with this.

Here we are talking about the prototype system development. So, why we should have the prototype, automate prototype system development, what is the main goal of the prototype development? So, our aim is for automation of irrigation system, if you see that it is for reducing the human involvement or minimizing the human or without human involvement, reducing the wastage of main thing because we are talking about micro irrigation.

So, our aim is to reduce loss or wastage of water and fertilizer and ultimately it should increase the crop yield. Our aim is to get real time data, then it should be of low cost that is the one of the challenge that should involve the low cost, there should be low power

consumption, there should be low maintenance, and it should be readily available to use. Then it can operate using internet or it can operate without having the internet facility.

Particularly such systems are required but when the area is inaccessible with net connectivity, so for that purpose wireless, without internet system can also work. To irrigate and fertigate the plant instead of soil that is the normal thing which we do, we do not give water to the soil but we give water for meeting the evapotranspiration requirement of the crops. Similarly, for the growth of the plant we supply fertilizer or nutrients. To bring more land area under cultivation, where water is limited so this is another priority of using micro irrigation system which we started in the beginning also and automation is also meant for doing the systems.

The prototype soft component involvements are internet, Arduino IDE and then web server, database, and graphical user interface. So, internet it said that it is used for communication or making connection or connectivity, that is the prerequisite for IoT based application and it is for the transmitting the data, it is used for receiving the data, and which is in as well as the command.

Arduino IDE that is Arduino Integrated Development Environment is a cross platform application. It is used to write or upload program to Arduino board. So, any instruction any data reading that can be uploaded in the Arduino board. Web server and database, so purpose of using the web server is to get or collect the data, stored the data, and also transmits data. So, it act as intermediate, it is the intermediate between logic and action. So, PHP web server or MySQL database this is the example that it can be these are the things and GUI that is the Graphical User Interface displays the objects and convey information and represent actions that can be taken by the user.

Now hardware components or prototype development when we think of or when we are developing, so the Arduino Uno mega, Arduino so this is Arduino Uno mega, this means Atmega2560, ATmega328P are the primary controller and the Arduino Uno R3 and mega are the open source microcontroller platform. It is used to collaborate, send instruction, and receive input from the DH22, motor and relay etcetera. So, practically it is receiving information or collaborating information and it is also sending instruction.

DHT 11 that is the humidity and temperature sensor, it is used for recording the atmospheric temperature data, relative humidity data, and the data are in the analog signal, the range of operation is 3.3 volt to 5.5 volt. So, this is what you see here, this is the data which is coming and then the information which is coming so this is the device which is the DHT sensor.

Capacitive soil moisture sensor, this is the device which is being shown so practically what it does it record the sensor value when probe is exposed to the air the value 1 and this is the boundary value of dry soil when 0% RH that this reflects the humidity. So, the temperatures as well as humidity these data are collected and this is humidity of the moisture content of the soil, humidity of the soil it is being used so it could be the value is given between 0 and 1 and in between these two.

So, record sensor value when the probe is exposed to the water as when we say the value is 2 mean humidity or moisture content of the soil is 100%. DS3231 this module this is the thing, so this module preserve the time even if the microcontroller power it has lost the power. It has an inbuilt battery system, so because it has inbuilt battery system, the microcontroller and it will collect the data and then it will give you at what time the data has been collected.

This is another hardware component which is LoRa Ra-02 SX1278 this is the device which you see here LoRa as this part is given. Now, this communication module transfer data from field module to remote module and command from the remote module to irrigation pump. So, this is the purpose of having this particular communication module and this is LoRa series Ra- 02 spread spectrum wireless module.

It is a wireless transmission module, based on this wireless trans-receiver, trans-receiver means it is transmitting as well as receiving data. It adopts advanced LoRa spread spectrum technology with the communication distance of 10,000 meter or 10 kilometre. So, this is the special feature as compared to other communication thing that it is able to capture the information from 10 kilometer distance.

The another node is, the Ai Thinker node MCU this is the specification, so this module acts as a Wi-Fi hotspot, web server for offline mode, when I was telling you that it can work on the online as well as offline. So, this is when no internet is there so this particular device is kept to work during when Wi-Fi connectivity is not there to be Wi-Fi connectivity be the hotspot this will make the connection. So, Wi-Fi connections interface for online mode. It includes firmware that runs on this, in this particular series Wi-Fi SoC and the hardware which is based on ESP 12 modules.

The other hardware component involves here is micro SD card module; this module is a simple solution for transferring data to and from a standard micro SD card. So, micro SD card reader module has an SPI interface that is a controller interface, which is compatible with any micro SD card it uses 5 or 3.3 volt power supply so, this is the feature. Practically, it stores the data when it is being collected and also it is working like it has an SPI interface unit.

So, another part here is 1.3 inch, OLED display module, this is 1.3 inch 12C OLED display is an OLED monochrome 128 by 64 dot matrix display module with I2C interface or controller interface. It is compatible with any 3.3 volt to 5 volt microcontroller such as Arduino. So, this is for OLED display unit where it will be displaying the value.

The other one is channel relay generic 5 volt 10A 1 channel relay, so this acts as an electromagnetic actuator. Relay act as a switch where output connection will be determined by input data line, so this is what we see here. Because Arduino board have a 5 volt DC output pin, it cannot handle irrigation pipe line of 240 volt AC line. So, this purpose, this particular channel relay is used.

This relay solves this problem by acting as electromagnetic switch and relay is used to operate the motor. So, this device is very important for interfacing with the 240 volt AC line with the particular Arduino board when it is fitted. Water pump it controls the flow of fluid or liquid and supplied water for micro irrigation and creates adequate pressure that is the job of the pump when we are giving water that all the points' water should reach and then deliver adequate pressure to operate different emission devices.

Now, the components which we are using in our system, when we are making it so there are a different component which has been used, there justification why we have used these components. So, ARDUINO UNO and mega is being used as a microcontroller board, because it is readily available, it is low in cost, it requires low energy consumption, and it has got a 256 kilobyte flash memory and 8 KB random access memory and then this is EEPROM of 4 KB.

And then it is open source, this is another advantage it is open source no permission is needed. And this particular board is with the integrated development environment, it is a free and easy to operate. Microcontroller program is easy to learn debug and large online community to help out. It is compatible with the sensors peripheral hardware and also cheap and available in large variety. Sensors and peripheral libraries are free open source and readily available so this is the features of ARDUINO UNO IDE.

And then another device which we are using for communication module is a LoRa Ra-02 SX1278 this is a long range about to 10 kilometre in perfect condition around 1 kilometre where there is no line of sight. This particular range is sufficient for our Indian condition to transmit and receive data from field to end user. It requires low power or low energy consumption that it is a low cost compared to other communication module and it operates in licensed free bandwidth that is from 865 to 867 megahertz this is the range available for our India and very basic encryption is available at software level programmer can assign a node address as well as an encryption that is a security feature for the nodes. And then it is compatible with the Arduino and corresponding libraries are also available.

The other component which we will be using in our prototype development, so this hardware is Ai Thinker Node MCU, this is also for communication. It act as an web server for offline mode, act as a Wi-Fi hotspot means for offline mode of operation and it connect to any Wi-Fi network be the internet connectivity, easy to program, it is open source library, very cheap and it requires low power, it is reliable, it has RAM of 128 kilobyte and 4 megabyte ROM and provided with the larger memory and very important while deploying web server to node MCU. The on-board USB to serial chip to easily program and upload code from the Arduino

IDE. Easy access to the general purpose input output GPIO pins for easy prototyping. So, these are the essentially useful features to select this particular communication module.

There are from electromagnetic actuator that is your channel relay and so we have selected generic 5V 10A 1 channel relay, it has got back EMF protection. The other features why we are selecting so, it works with the logic level signals from 3.3 volt to 5 volt devices. AC control voltage 250 volt, maximum 10 ampere, and DC control up to 30 volt, maximum 10 ampere. So, it is of low cost that there another advantage.

The real time clock module, so it maintains the clock even at the time of power failure. It will retain the time and it has inbuilt battery, Arduino has one internal clock, but it cannot retain the time in case of power failure so this is a feature of this particular. So, it is a compatible with Arduino, open source libraries are available low power requirement and it is of low cost.

Now, I am coming to the hardware which we are putting in the field. So, this is a field module and the field module here what you see here, this is the sensor means this is a capacitive soil moisture sensor, which is placed in the field means put up in the soil which will capture the data means soil moisture content. Then, there is a real time clock this already I have told why this particular clock it is using. And then there is a Arduino mega controller, so already this particular feature we have discussed about the Arduino 2560 which are connect means these sensors, as well as soil moisture sensor, temperature, and humidity sensor these are connected and then there is a communication module means the data which are being captured is being displayed by OLED display and then it will transmit the data to the other Arduino.

So, the description here that Arduino mega controller gets soil moisture data from the soil moisture sensor, it gets the atmospheric, there could be many other sensors it can be tagged with this device which are required in the automated irrigation system though here just I am showing you only the temperature and humidity there could be many other sensor that can be connected as per the requirement. It sanitize the incoming sensor data and display this via OLED. At predefined interval Arduino mega send this data to receiver module which is around 200 meter from the field for further processing via this LoRa Ra-02 module wirelessly. So, this is the advantage of having the LoRa.

Now this is a receiver module means data which has been captured from the field is being received and this model. So, this is your node MCU communication module which has come from the field so it is being received and then this is here the OLED display unit. So, these data are being once received, so in this Arduino IDE in this controller, these are being captured. It is being stored in the micro SD card and then it is displayed. So, let me just explain you in more detail about this particular arrangement of the different devices which are being received from the field Arduino mega microcontroller receive sensor data via LoRa Ra-02 module wirelessly. Now, Arduino mega stored the data, it store data at micro SD and display the relevant information in both OLED. So, this is the thing this being displayed after the data is being received.

Depending on the type of requirement, it can work online as well as offline mode. Online mode when the internet connectivity is there and offline mode when no internet connectivity exists. Online mode, the MCU connect to the internet via Wi-Fi network and send data to the web server and retrieve the user input data from the server. Then transfer this command to the Arduino mega.

So, based on the command Arduino send command to the field water pump via LoRa through again the LoRa is communication information to the actuator or relay. In offline mode, when data are not available means your network is not available then node MCU acts as a web server and Wi-Fi hotspot will be the other card which can have connection that is hotspot network created user has to connect this Wi-Fi network from their mobile devices.

So, a mobiles, cell phone can be used and this app will request the relevant information to the web server that is maintained by the node MCU and user can give command to start or stop the pump from the app, an app will be loaded and this will function for stopping or putting on the pump, opening the pump. So, this is a third part, third part means the data which has been received that has been processed and depending on the status of the field, then information is coming to here, the data are coming means it has come to the communication from the LoRa communication module and it is received here and then it is brought to the Arduino board then a program is written over here and then it will communicate information and then that will be switching on and switching off the pump.

So, Arduino mega microcontroller receives command by LoRa Ra-02 module wirelessly, Arduino mega sends signal to the relay depending on the command it has received. So, OLED screen display relevant information and the state of the water pump whether it has given how much volume of water to give, how much time it should be operated that can be taken care. So, relay in turn switch on or switch off the water pump according to the command.

Now command it can be timer based, it can be volume based, and it could be soil moisture based. So another sensor will be soil moisture sensor, which we are taking data that there can be a threshold value that this is the threshold value, the water, moisture content it has gone below a threshold value. So, it will switch on the pump then the soil moisture data which will be getting updated means it will be increasing the moisture content in the soil. So there will be again threshold value that is soil value which field capacity of the soil, then we will switch off the pump. So, this information it will be coming to the LoRa and then Arduino will be doing the relay part of this thing.

So, this has been explained by using this particular diagram so what we see this is farm land where our sensors are deployed, and these sensors are from the farm land there is a field module where the sensors are deployed the sensor could be a solar radiation or it could be a temperature sensor about the weather or it can be soil moisture sensor or combination of several sensors.

Then the field module sends information data to the remote receiver via LoRa and then it comes to that is a remote module this part is a remote module and then this remote module sent information field data to the server via the cloud. So, this is the cloud platform it goes to the server and what server does, the server store the data and wait for the user request and command. So, what happens? It is coming that user request for the information what I needed it there and then server sent information.

Then the user give instruction to start or stop the pump so this again, it comes to this place that your sent information then again, it is from the server it will come to the remote module

which will pulled the instruction and remote module send information, instruction to the field actuator. Accordingly, the field actuator will start or stop the pump as per the instructions. Same thing what I am telling, it can be volume based, it can be timer based, it can be soil moisture based, depending on the things which are there.

This is about the online things which already I have explained here in the particular field module consists of Arduino soil moisture and there could be many other things. Arduino collects soil moisture data and this is means this is also time history of the data at what time the data are being collected, there can be some error in the data due to malfunctioning of certain hardware so this should be rectified before it.

And then remote module consists of Arduino mega, micro SD card, Lora module, node MCU and this remote Lora module continuously looking for incoming sensor data. After receiving the data, it will sanitize it and from error as data can be corrupted while transmission. It will save the data with the timestamp in micro SD card and backup and at the same time send it to the node MCU, this node MCU connects to the internet and send this data to the server.

There are 2 servers working in tandem, web server and data base server, database server is store data, web server wait for the user request that is the what type of programming we are giving. When the request comes from the user web server first check and authorized request, user set the threshold limit depending upon the real time data command is given to start and stop the pump it is first saved and at the data base server at regular interval note the MCU connect to the server and looking for water pump status that is saved in the database.

This command is then sent back to the field module with relay and water pump. User request real time data using mobile app to the web server, so this thing is happen. Then another thing is offline mode means when internet connectivity that does not happen or it is not available things are same and there will be sensor data, field module, remote module then sent field data then what we say there is your node MCU act as webserver. Here, there is a Wi-Fi hotspot. So, Wi-Fi hotspot means from the mobile information is available this will be connected. So, this is connected using a mobile.

So, user request for information node MCU sent data and user give instruction to start or stop the pump, it comes from their node MCU it sends data and then a remote module sent information to actuator by using LoRa and then the pump will actuate say whether it is to put on the motor or it will de-actuate depending on the condition exist.

So, these are the set of things which you have seen there it is explained over here, the data means, the field module consists of Arduino same thing which the Arduino collects. So, whatever I have explained that these are the sensors that is soil moisture sensor, weather sensor data, these data should be error free, it is sent to the remote module for further processing. The remote module consists of Arduino mega, micro SD card and the LoRa module, node MCU OLED module.

And then the LoRa module, it looks for incoming sensor data after receiving data it will sanitize and this data will be made error free while transmitting to the next step. So, it will save the data, it will go to time is time in micro SD card and backup at the same time it sent to the node MCU.

Node MCU has inbuilt web server but it did not have any kind of a data server. So, database data are in micro SD card for future reference and those data can be used for other program. And then the node MCU has capability to act as a Wi-Fi hotspot with user defined Wi-Fi credentials. User can connect to this Wi-Fi network from their mobile device by providing credential. So, user requests real time data using mobile app to web server that is operated by MCU.

So, these are the steps which is same as what is there in the online mode except the Wi-Fi hotspot for making the internet connectivity that has been explained. Now these are the user interface, what we see here, how the user means there are things displayed to the graphical mode soil moisture sensor data, temperature data, humidity data, temperature humidity data, means time history on this particular day, at every interval 1 minute or 1 second depend upon the type of refinement we need, such data are can be stored and then these data can be used and based on this data, this particular user interface here what you see here, this particular switch is showing as the system is on.

Now if for the given particular time interval when it has passed, then you put it on that it is partly manually operated, but this can be programmed and then the system can be means pump can be switched on or switched off. So, these are the putting the off when we are doing it. So, to go deeper about this topic, refer the books as well as internet references.

So, in this particular lecture, we discussed about the different components of prototype development where hardware component and software component we discussed. Then how the hardware component they operate their working system in the online mode and in offline mode this has been discussed.

In the forthcoming lecture we will discuss about the economic analysis of micro irrigation system part 1. So, thank you very much.