Introduction to Industry 4.0 and Industrial Internet of Things
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Lecture – 31
Key Enablers of Industrial IoT: Connectivity – Part 4

In this lecture, we talked about the 4th episode of Connectivity. In this particular lecture, I am going to focus on two technologies; LoRa and SIGFOX. And then I am going to show you; I am going to first talk about some of these features of LoRa and SIGFOX. And then I am going to show you a real example, a real set up for sending data over LoRa.

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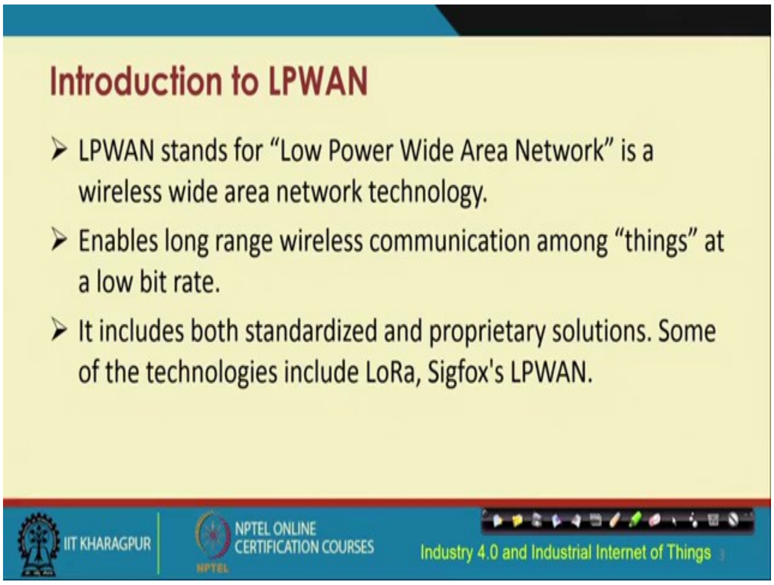

So, low power wide area network sorry double LPWAN; it is a wellness wide area network topology that enables long range wireless communication among different things. Technologies such as ZigBee, which we have briefly understood in the introduction section and also in the next lecture I am going to show you a demo of. So, technologies such as ZigBee do not have too much long range of communication particularly if the sender and the receiver are not too much close to each other.

So, basically they Zigbee is for mid range communication and particularly if they are not the sender and the receiver are not within the line of sight of each other then even this range reduces in Zigbee. So, for long range wireless communication between different things at a low bit rate; that means, low data rate, LPWAN techniques are useful. So, LoRa, SIGFOX these are two different technologies that could be used for long range communication.

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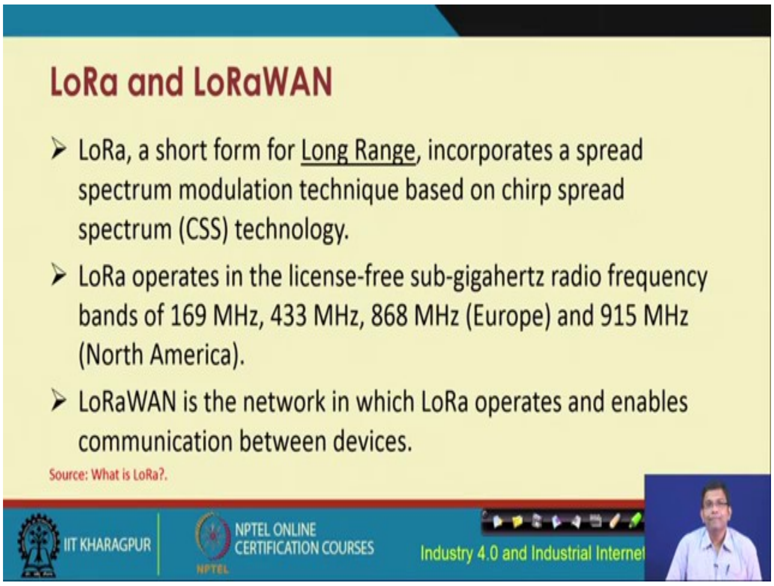

Lora is a short form of long range; long Lo, and range Ra so that is how this LoRa is has been acronymed. So, long range or communication for long range communication, LoRa incorporates a spread spectrum modulation technique, based on something known as the CSS, CSS spread spectrum technique the full form of which is chirp speed sorry Chip Spread Spectrum. C stands for chirp. So, LoRa operates in the license free sub gigahertz radio frequency band.

Sub giga hertz means that it is less than 1 gigahertz. So, all these different bands like 169 megahertz 433 megahertz 868 megahertz and 915 megahertz. These are the different bands of operation of LoRa depending on the territory where it is being used. And LoRa WAN is a network in which LoRa operates and enables communication between different devices.

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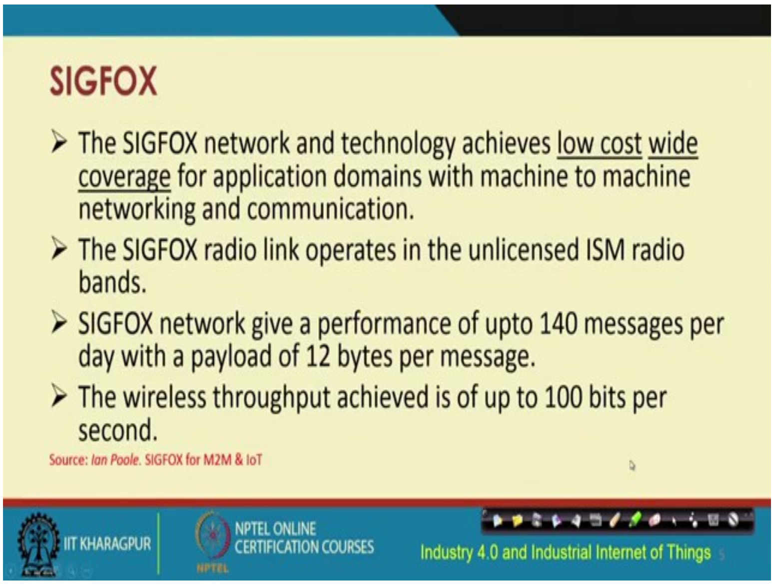

SIGFOX is another technology, which is compared to LoRa low cost, but has wider coverage for application domains with machine to machine networking and communication. SIGFOX radio link operates in the unlicensed ISM radio bands and the SIGFOX network gives a performance of up to 140 messages per day, with a payload of 12 bytes per message. And the throughput is achieved using SIGFOX is up to 100 bps.

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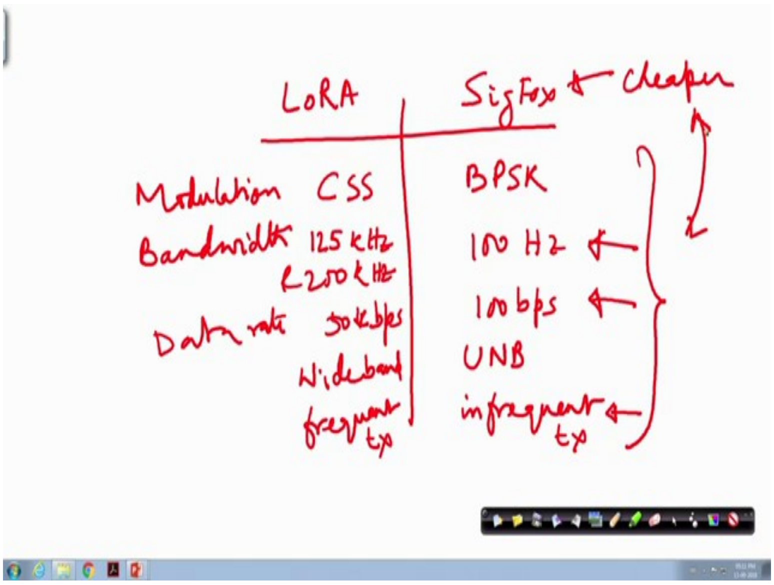

Let us now have a better understanding about how these two technologies for long range communication LoRa and SIGFOX compare with each other. So, basically in terms of modulation technique that is used LoRa as I said uses CSS chirp spread spectrum on the other hand SIGFOX uses BPSK. And in terms of bandwidth, LoRa uses 125 kilohertz and 250 kilohertz.

It offers bandwidth of 125 and 250 kilo hertz. And whereas, SIGFOX basically gives 100 hertz. So, as you can see over here the bandwidth in SIGFOX is much less compared to LoRa. So, basically in low bandwidth scenarios or applications SIGFOX will be more useful, because as I said earlier SIGFOX is overall cheaper compared to LoRa. In terms of the data rate in terms of the data rate for LoRa it is 50 kbps.

Whereas, for SIGFOX it is only 100 bps bits per second; for LoRa, LoRa operates in wide band whereas, SIGFOX in ultra narrow band. The frequency of transmission is frequent in LoRa whereas, in SIGFOX it is infrequent.

So, basically where your requirements are less, where the bandwidth requirement and data rate are less, where infrequent transmissions will suffice your purpose, then it might be better to go with cheaper SIGFOX technology.

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Now, let us talk about how this communication happens. So, I am going to now give you a demo of how communication happens with LoRa.

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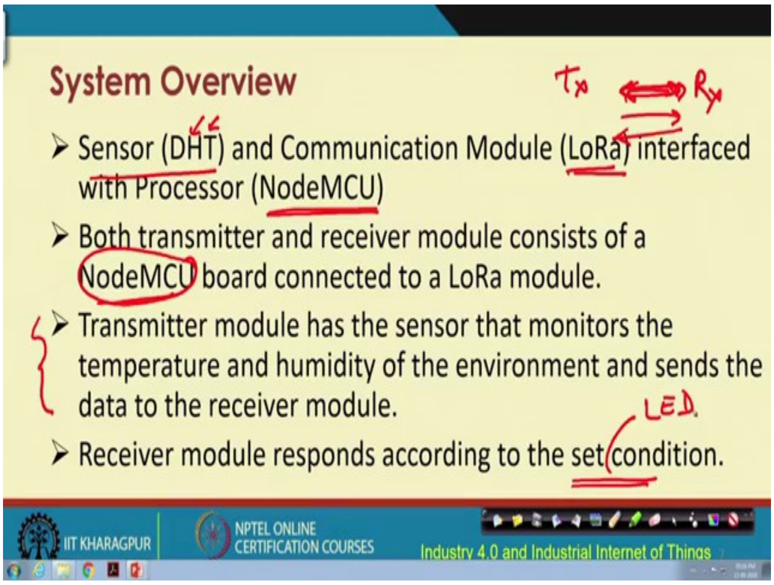

Over here let us look at.

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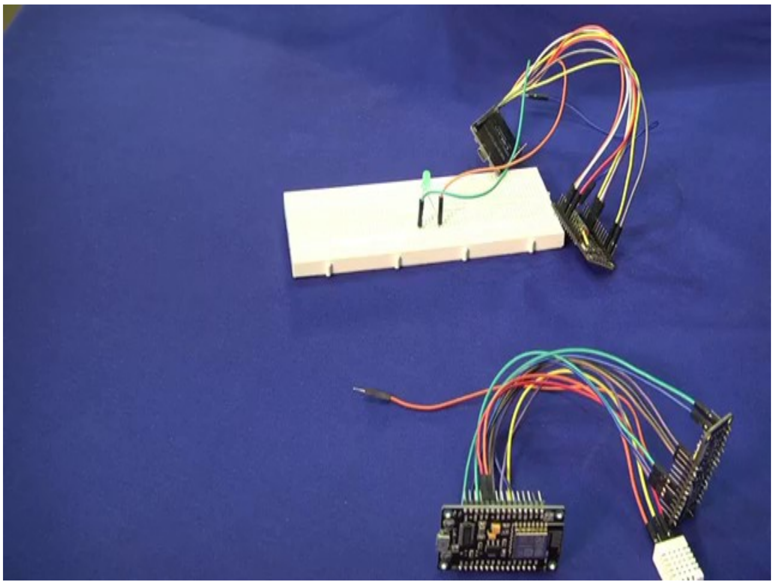

Let us look at this setup here; we have the LoRa module this one is the LoRa module this is this transmitter and there is a sensor the temperature sensor connected to this transmitter. This temperature data from the transmitter are going to be sent to the receiver module, this is this receiver. So, I have this transmitter I will keep it separately and this is my receiver.

The temperature data from this transmitter unit is going to be sent from through this LoRa transmitter to this LoRa receiver, which is this one. And if the temperature crosses a certain threshold, then, basically, this light is going to blink, this is how this setup is done. So, what we have? We have this temperature sensor this one this is the temperature sensor this is this LoRa transmitter module.

And we have something known as the Node MCU which I am going to talk about shortly this is this Node MCU, this is this Node MCU. And then we have this receiver unit with the receiver LoRa this one this is this receiver LoRa, I am pointing through this pen, this is this receiver LoRa. And this is this receiver Node MCU and this is this led, which is going to blink once you send the data, from this transmitter to the receiver.

So, we are going to show this in action and let us try to first get an overview about this system that we talked about. We are talking about a DHT sensor and a communication module, which is basically the LoRa communication model over here interfaced with the processor, which is the NodeMCU. So, we have the DHT digital Digital Humidity and Temperature sensor DHT sensor. We have this LoRa communication module and the Node MCU processor.

So, both the transmitter and the receiver modules consist of this Node MCU as we have seen. And this processor board is required at both the ends the transmitter end as well as the receiver end. So, for this one way of communication, this will be the transmitter this will be the receiver and this could be made the other way as well. So, that is why I have denoted using a double headed arrow like this.

The transmitter module has the sensor that monitors the temperature and humidity of the environment and sends the data to the receiver module and this is what I am going to give you a demo of. So, this receiver module will then respond, according to the set condition. And this I am going to show using the glowing of the led lamp, that I have shown you a while back.

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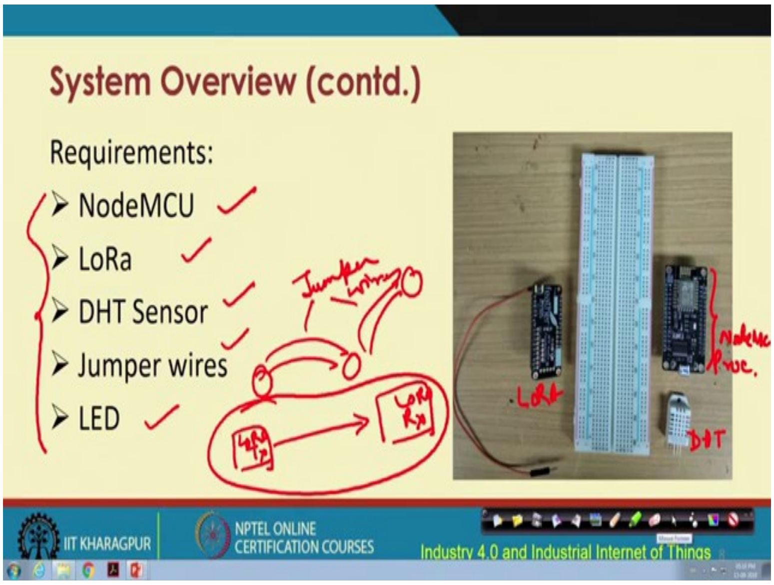

So, let us go further and try to get an understanding first about our setup. I have captured this entire setup in the form of pictures taken, so that it becomes very easier for you to have a glimpse of what how these devices look like and this is these pictures.

And after this basically I am going to show you I am going to switch back and show you the actual setup the demo, that I have for you over here. So, first let us go through these materials to understand, how this setup looks like from a much closer viewpoint. So, what we have over here this is this, I am going to show you this is this LoRa.

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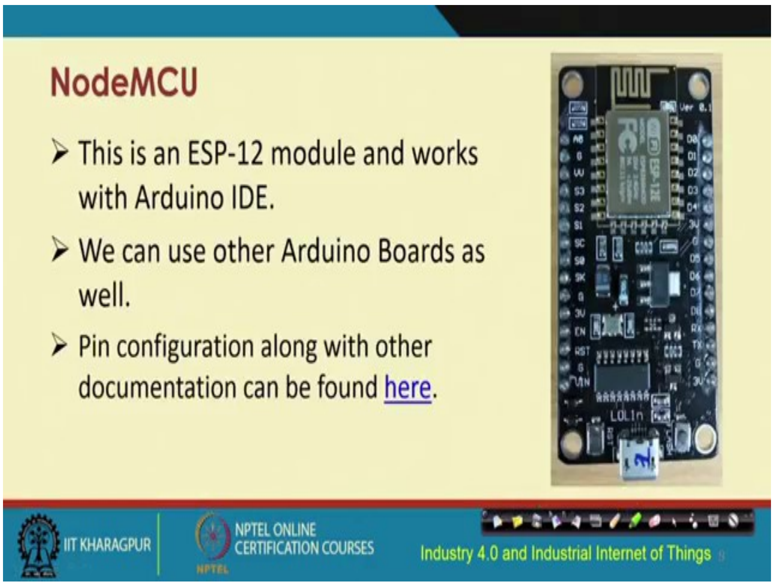

This is this LoRa module and this is your DHT sensor the digital humidity temperature sensor and this is your Node MCU; Node MCU which is nothing, but the processor, this is the processor. So, we need the Node MCU, LoRa, DHT sensor, and some jumper wires those wires, that I was showing you connecting different units like.

So, these were these different wires these are known as the jumper wires and the led. So, these are the components that are required in order to give you a demo of the system that I have just shown you. And here what we are going to show is that we have a LoRa transmitter sending the data to the LoRa receiver.

And so this is what basically is what I am going to show you I am going to show you the corresponding code as well. So, this Node MCU, I think this basically shows you from a very closer this gives you a closer view of how this Node MCU looks like.

So, this Node MCU is basically a cheap Arduino board you can think of that way it is a very cheaper module which does similar kind of function which has similar kind of functionalities like your Arduino and it is basically an ESP 12 module which is compliant with the Arduino IDE. So, basically instead of using Arduino which is a little bit more expensive you could use the Node MCU.

So, this Arduino IDE it is compliant with and we can use other Arduino boards along with this one. So, there is interoperability between the Node MCU and the Arduino IDE and the pin configurations are shown over here this is the pin configuration. And if you go to if I go to this link if I go to this particular link, I can show you how this pin configuration looks like for the Node MCU.

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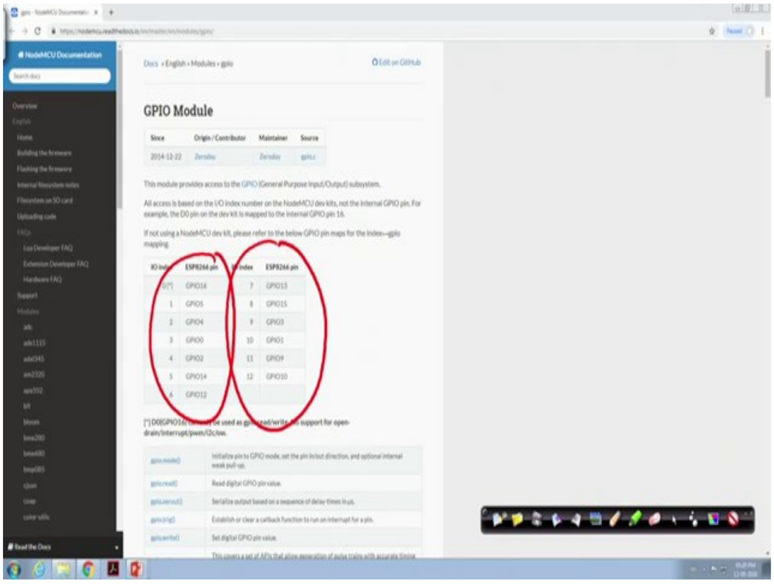

So, these are the different mapping between the IO pins and the GPIO pins. So, this is the basically the pin configuration and the mapping between the regular IO pins and the corresponding GPIO numbers. So, this basically will have to be taken this information will have to be taken into consideration while trying to map between the GPIO and the pin numbering in this Node MCU board. Let me now, close this and go back to where we were.

So, this is this Node MCU pin configuration and as you can see over here these different data pins D0 D1 D2 D3 D4. And this is where we are going to connect our other components of this setup, this is this pin corporate configuration overall. And what are these I am not going through in detail, but you could you could go through yourself through from this particular link, this will give you the complete picture of what each of these different mean.

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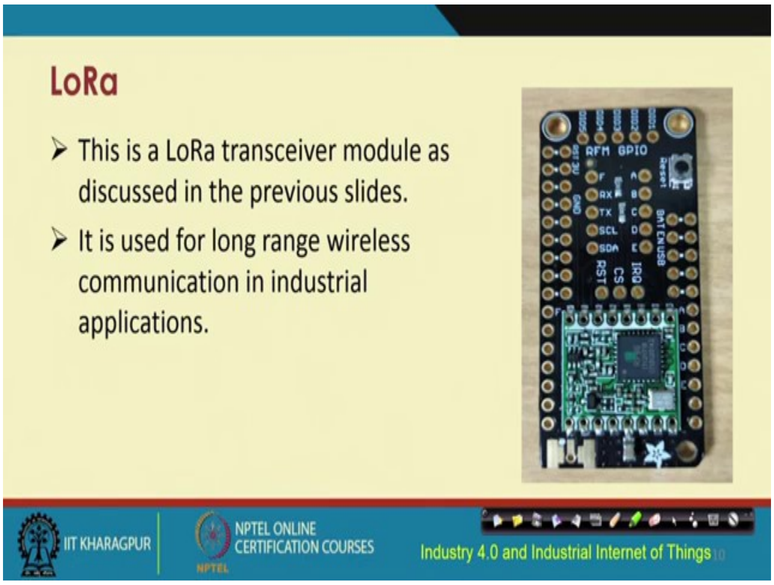

So, now this is basically how the LoRa transceiver module looks like. So, this is this LoRa transceiver and it has different pins like shown over here in this figure, this is the pin configuration. And it is used basically for long range wireless communication and that is very important particularly for Industrial IoT scenarios, LoRa basically is very useful.

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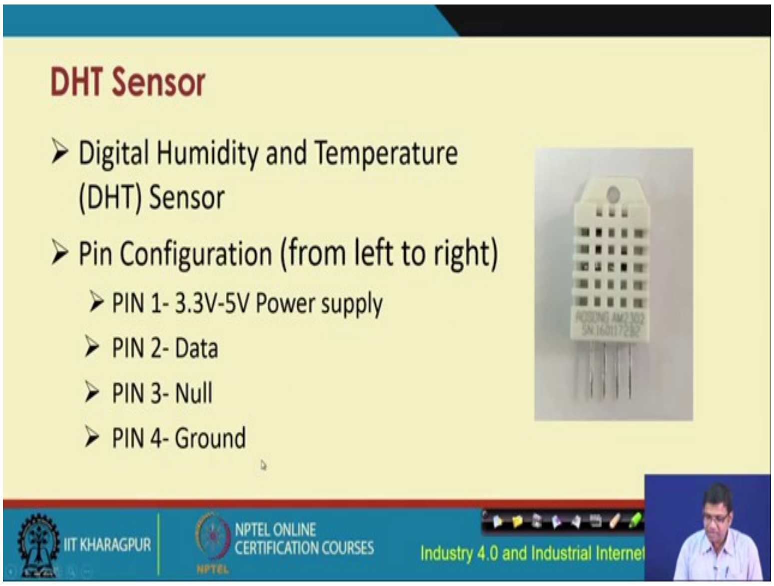

And this is the pin configuration of this DHT sensor. The other component that we are using in our setup so; PIN 1 basically is the 3.3 volt to 5 volt power supply. Then PIN 2 is the data, PIN 3 is the null, and PIN 4 is the ground. So, we have four different pins over here.

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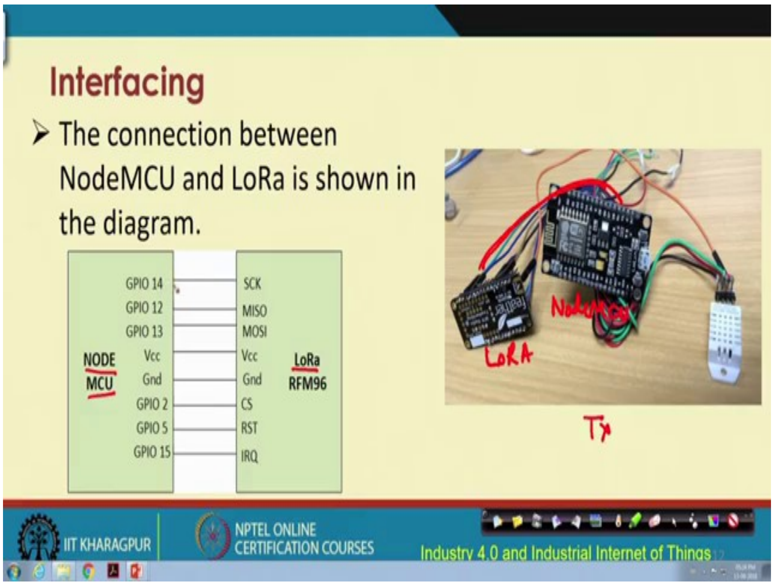

So, this is how this connectivity is going to happen between the Node MCU between the Node MCU and the LoRa. So, Node MCU and LoRa, this is how this connection is going to take place. So, we have this is this LoRa module, this is this LoRa and this is your Node MCU. And these jumper wires if you can see from the figure are connecting from one port of this LoRa to the corresponding port in the Node MCU.

So, we have different (different) wires jumper wires connecting different ports from this LoRa module to the Node MCU. And also you can see over here how these different jumper wires are connecting this temperature sensor, this temperature sensor, the different pins, there were four pins as we have seen in the previous slide. So, these four different PIN's 1 2 3 4 how they connect to this LoRa module is shown over here.

So, this is basically how your connection is going to happen because the temperature sensor will sense. And then it will through this LoRa module it is going to send the data, this will be the overall transmitter and it is going to send the data, and it will be received by the receiver. So, over here this mapping between the different pins of this Node MCU and the LoRa module are given for you, you can try it out yourselves.

So, as you can see over here the GPIO 14 pin in NodeMCU connects to the SCK for clocking. And then GPIO 12 to the MISO pin. So, this is basically multiple input single outputs and GPIO 13 connects to the MOSI. Then Vcc to Vcc ground to ground to GPIO 2 to CS and then GPIO 15 5 to RST which is the reset and 4 this is for the interrupt and so these, if you look, at if you look at this NodeMCU.

Let us look at this over here you do not find any GPIO written, so it is not mentioned over here. So, for that basically this mapping, that I had shown you through that particular link if you remember in that website that I had that linked to from that link you can get mapping between this GPIO to these numbers that are given over here. So, these are the numbers that are given over here.

So, with this mapping between this GPIO and that one will have to be derived. And however, for convenience over here we have shown you that what is this GPIO pin and where to which other pin of the LoRa module it connects.

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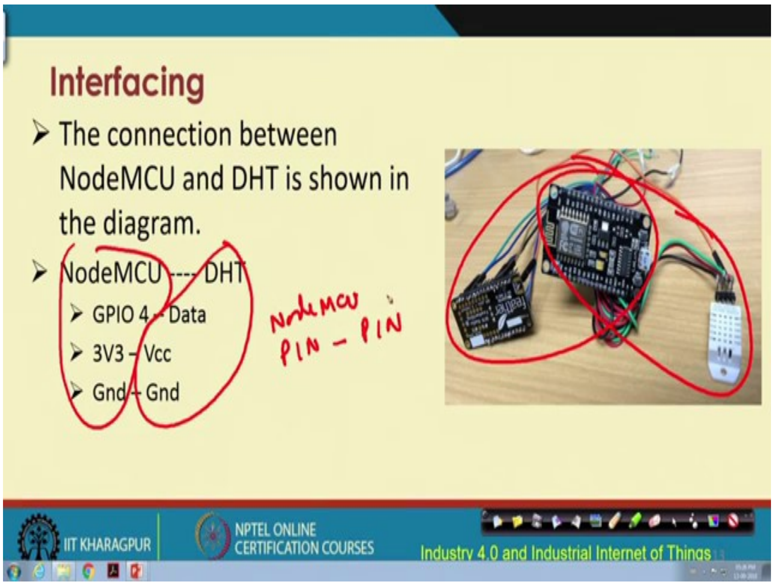

Then then for the connection between the Node MCU and the DHT; so, this part I have already shown you, this part I have shown you in the previous slide. Now, for this part for this part of connection between this GPIO 4 so, GPIO 4 of Node MCU connects to the DHT of data and sorry the data of the DHT.

So, 3V3 is 3.3 volts this one connects to the Vcc and ground to ground. So, this is this overall this is how this mapping between this Node MCU and DHT looks like in terms of the pin configurations in both. So, Node MCU pin configuration with the DHT sensor pin configuration.

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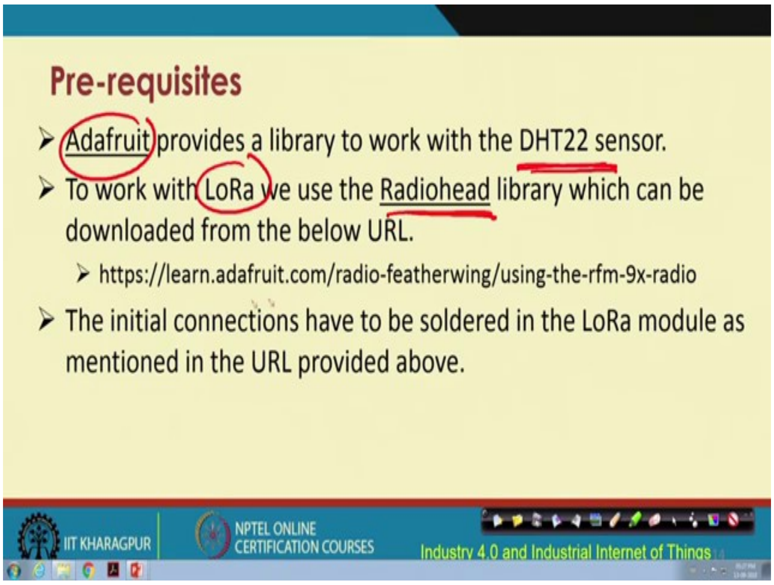

So, I am going to show you all of these in action, shortly. So, the there are some of these prerequisites that are required in order to make this setup run. So, one thing that you need is basically this adafruit library, which will work with which will make this DHT 22 sensor to work.

You also need this Radiohead library for this LoRa module to work and these can be downloaded from here. And the initial connections for convenience have been soldered in the LoRa module as mentioned in the URL over here.

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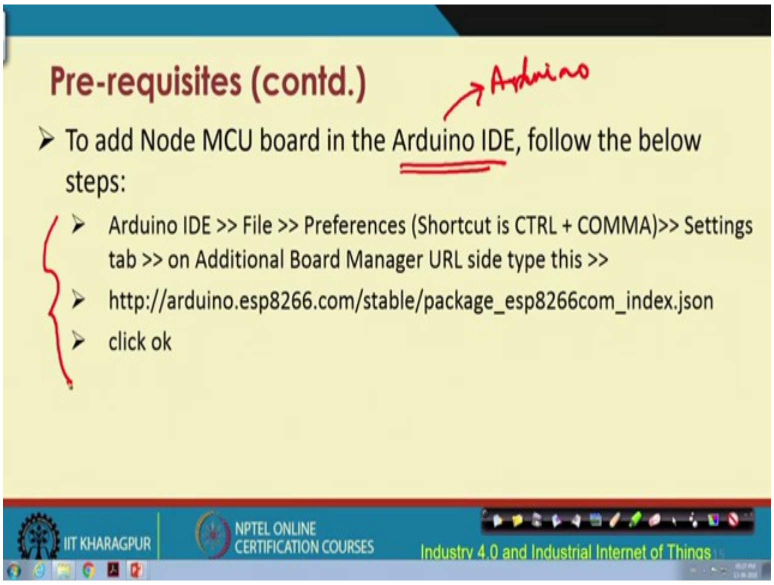

So, this is given here and to add the Node MCU board to the Arduino IDE, because I told you earlier at the outset if you recall that we would be using this Arduino IDE, which typically is compliant with only Arduino. But node Node MCU also works on the Arduino IDE platform. So, for doing that you have to follow these steps.

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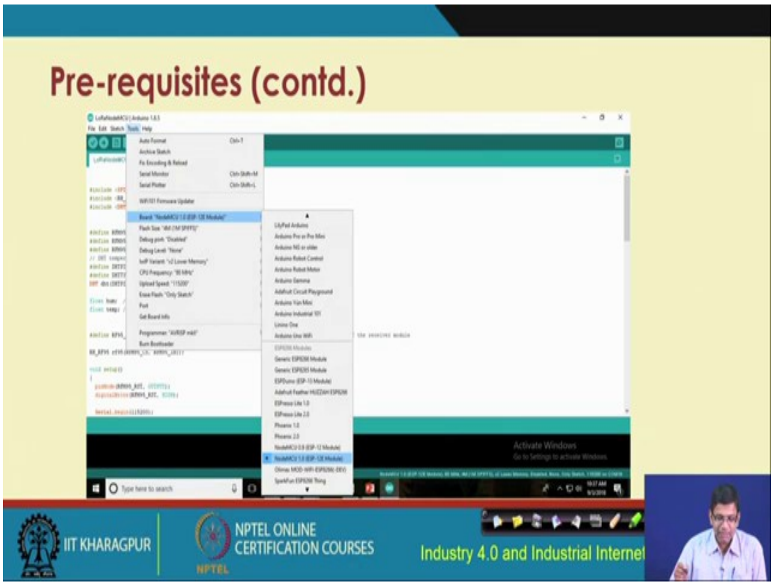

So, you follow these steps and then this is how this Arduino IDE looks like for LoRa Node MCU. And these are the steps that you will have to follow and for just brevity, I am skipping this thing.

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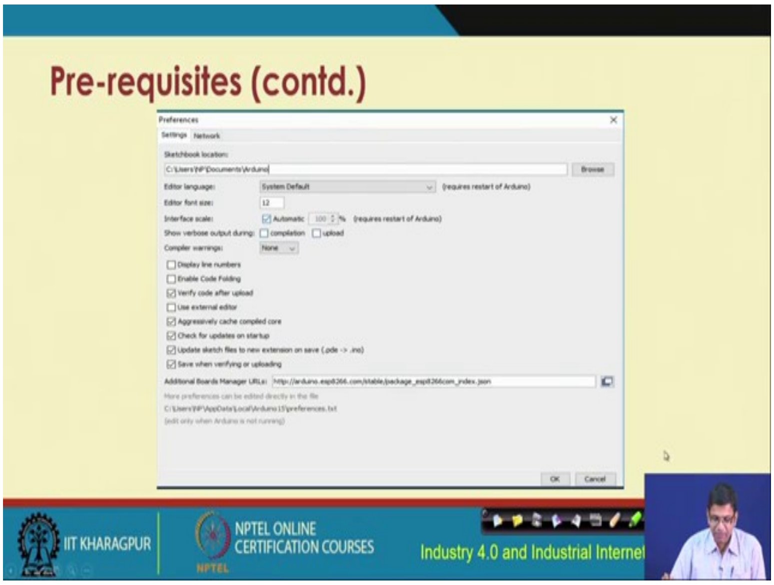

So, these are the steps that you will have to follow as given in the previous slide.

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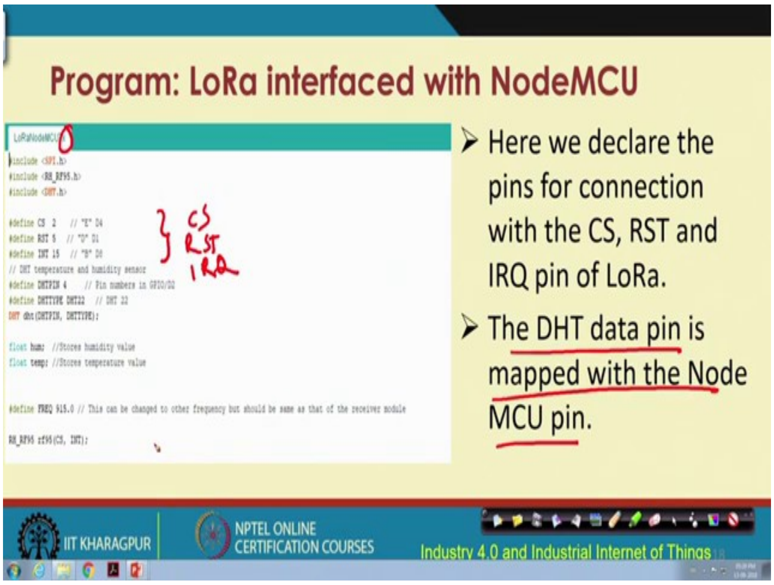

And so finally, you will have to open the programs, the corresponding programs for the LoRa. So, for LoRa interfacing with Node MCU, this is this transmitter program, this is how it is going to look, like this is for the transmitter end. So, as you can see over here we have these declarations for the different pins of LoRa CS RST and IRQ or interrupt.

So, these are the different pins and their definitions are given. So, these are this value the pset values. And this data pin this is also something that you will have to do the DHT data pin will be mapped with the Node MCU pin. And this is a long code and these snapshot basically shows only part of it, but this basically is something that will have to be done.

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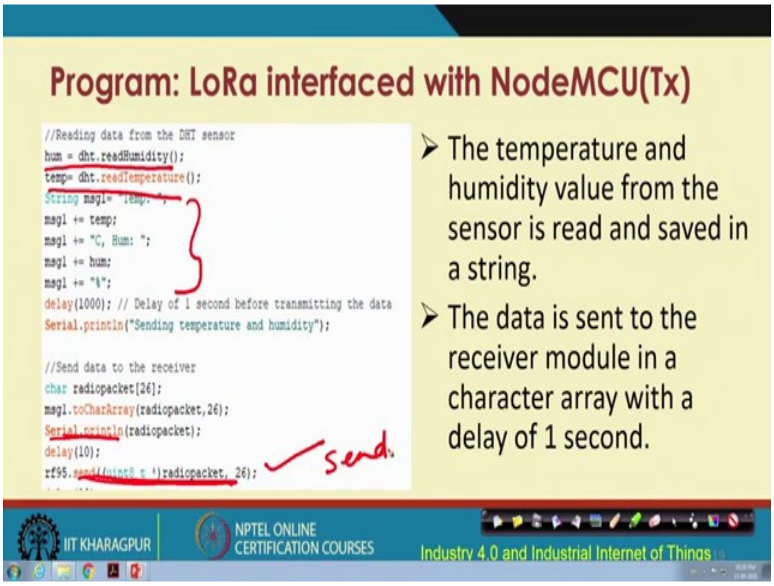

So, for the LoRa interfacing with the Node MCU this is this part of the code. So, as you can see over here the temperature and the humidity value from the sensor will be read and saved in the form of a string. So, as you can see this humidity value is being read, the temperature value is being read, and then through string concatenation in this code this long string msg 1 is being built, which will have the concatenated humidity and temperature values.

And then this will have to be sent through the port. So, this message one, which has been built earlier through this string concatenation, it will have to be converted to a character array and is printed in the serial port. Then it is sent, then it is sent using this part of the code, it is sent using this part. So, the sending will be done.

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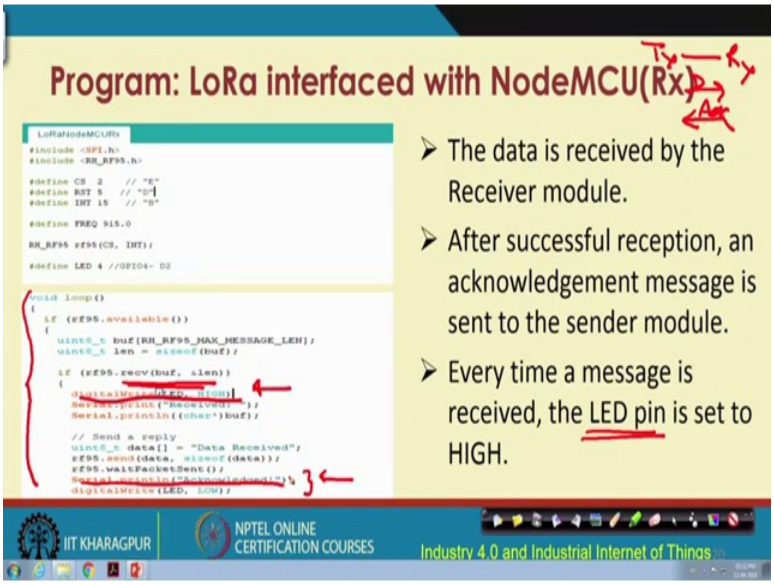

After that for the receiver side, the data will have to program in such a way that the data will have to be received. And after you receive the data, it has been programmed in such a manner that you the transmitter sends, receiver receives, and then it will send an acknowledgment. So, this is this data and the acknowledgment will be sent from the receiver to the transmitter. So, the transmitter knows that there has been a successful reception.

So, after successful reception and acknowledgement message is sent to the sender module. And every time a message is received, the led pin that I am going to show you is going to glow; that means, it is set to high and. So, this is where this led is set to high, through this comment. So, this loop as you can see this is a loop, which runs to receive the data, it is listening over the channel.

This receiver is listening continuously through a loop to see if there is any data being received. And this is this transmitter had sent the message packaged in this manner. So, it receives this message, and once it has received it is programmed in such a way that it is going to glow that led through this particular command high.

So, thereafter it is going to print that it has been received and what has been received is also going to be printed. Now corresponding to the data that is received the acknowledgement will have to be sent and that is done with the help of this code. So, it will acknowledge that it has been sent.

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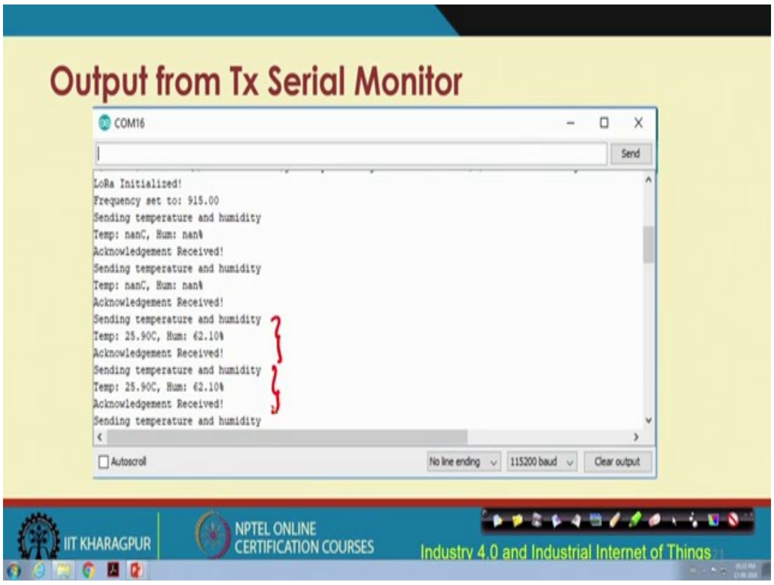

And this is the output from the transmitter serial monitor. So, as you can see over here LoRa is initialized first, frequency set up to 915, temperature sending temperature and humidity values temperature is given so because we are not showing the actual temperature of the humidity values. But this is how this code is going to look like. So, initially it is like that then it starts sensing the temperature and sensor temperature sensor senses the temperature and the humidity.

Then basically it sends it and the receiver basically will send it back, the acknowledgement will be received by the transmitter. And then the process is going to continue further. So, these are basically this part sending temperature humidity temperature equal to this humidity equal to this and acknowledgement received this basically keeps on repeating like this.

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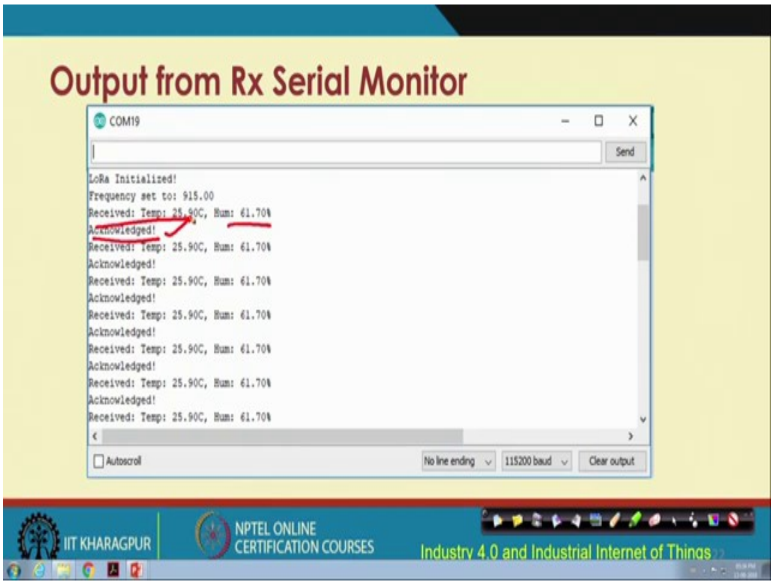

This is how it looks like at the receiver, in their Arduino IDE for the receiver end, basically, as you can see over here. This received temperature and the humidity value is shown. And then this acknowledgement is sent and this acknowledged message is printed.

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Now, I am going to show you the actual working of this particular setup. So, now, let us go back to our original setup. So, if you recall that this is what we have as our transmitter and this is our temperature sensor, the DHT sensor, and their corresponding pins, this temperature sensor is connected to this Node MCU.

And the corresponding pin configuration I had shown you in the slide, and from this Node MCU, there is a connection to this LoRa transmitter, and this connection also I have shown you in the slide, so you can try it out yourselves. So, these are the three different components that are connected at the transmitter site these three components. And so then from this LoRa transmitter this is the transmitter.

And it has this antenna also this is this antenna for from this LoRa transmitter we. So, the data are being sent. So, the data are being sent and the data are being sent to the; are being sent to the receiver and this is this LoRa receiver, this is this LoRa receiver. And this is the transmitter, this is the antenna of the LoRa receiver. And this is this transmitter and also this Node MCU at the receiver end.

So, we have this transmitter sending the data to this receiver. So, from this transmitter LoRa to the receiver LoRa, the data are being sent transmitter to the receiver LoRa, the data are being sent. And based on that and actuation of this led lamp, as you can see over here will be done.

So, the way it has been programmed is that the immediately after receiving the data from the transmitter it is once it is sent it is received and then it is basically whenever it is sent, whenever it is received this receiver, basically will make this lamp the led lamp glow and as you can see that it is glowing. So, this is this small setup that we have.

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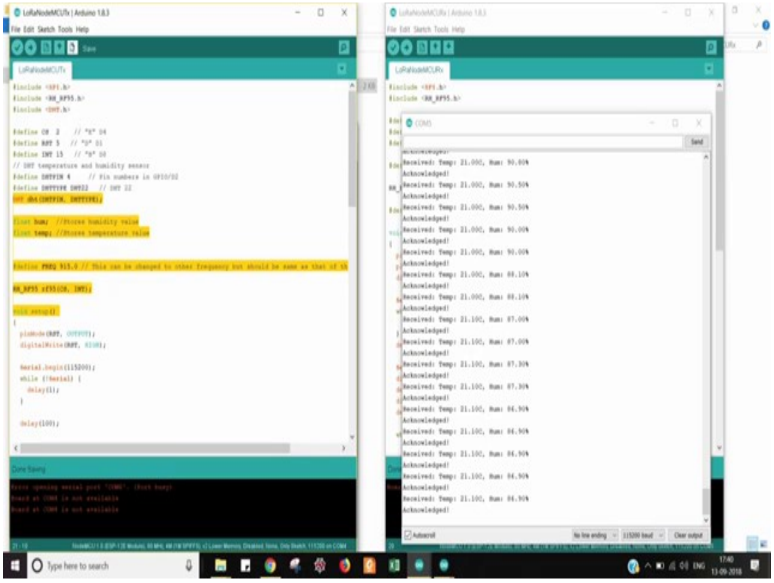
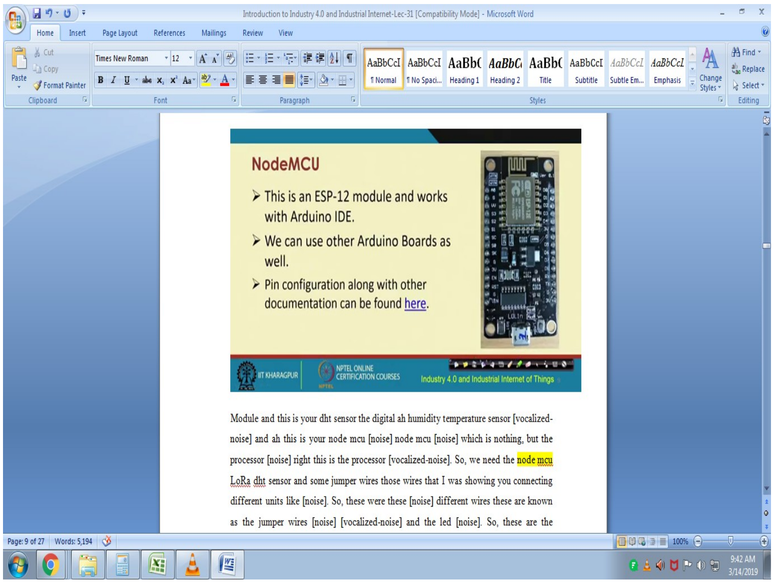


And so let us now go back and look at our screen. So, this is this IDE platform.



And if you recall that there is some configuration that you would have to make and so I earlier in the slide I talked about this configuration. So, let us say that this is your transmitter site in the Arduino IDE.

And this is your Node MCU, LoRa, Node MCU transmitter, and this is your LoRa Node MCU receiver. So, we will look at this code from the transmitter, but before that in the IDE this configuration will have to be made, few configurations will have to be made.

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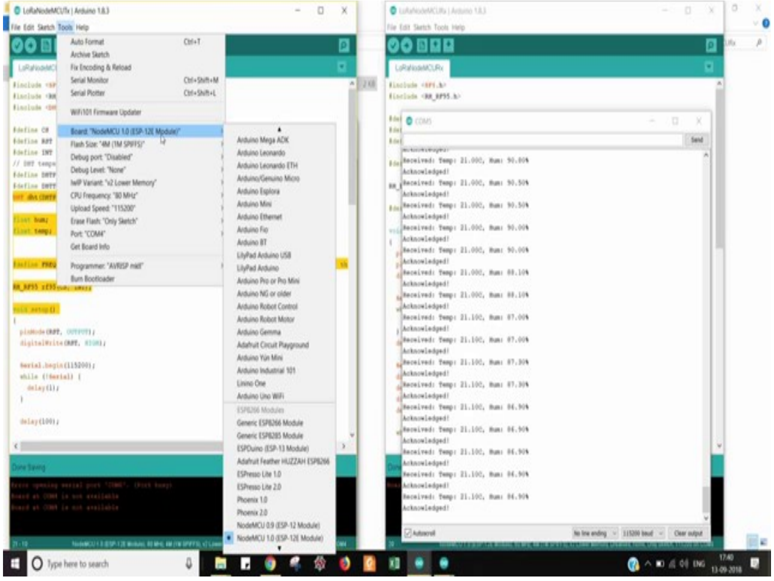

First of all the type of this board will have to be selected and we are using this Node MCU 0.0SP12E module. So, this was selected, we have pre-configured this way. And also for the transmitter, which communication port is going to be used so we have selected COM 4 for it so, this is done and thereafter. So let us go back.

And so so this is basically how this code looks like. And already I told you how you preset each of these different pins and their corresponding values. And basically there after this message is sent it is composed and it is sent through this serial port and is being received at the other end.

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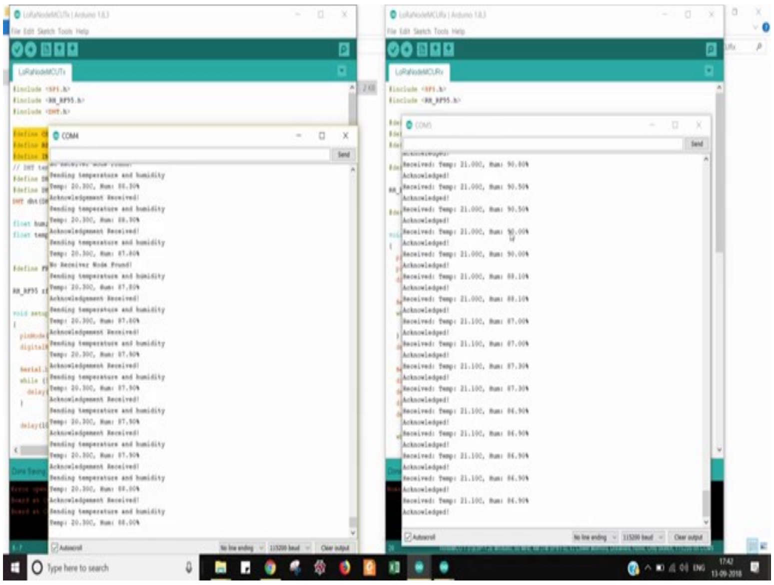

So, for the transmitter sending part, this is as you can see over here. The temperature value let us start from somewhere this temperature value, and the humidity, and the acknowledgment received continuously, it is showing the corresponding values, so this is basically how it looks like at the at the transmitter panel.

And at the receiver panel likewise these are basically what is being received and the corresponding code is also shown over here. So, this is how the receiver window looks like and this is the overall panel and. So, this is the way we have programmed that we have programmed, in such a way, that once the transmitter sends and it is received the data is received by the receiver it is going to show, it is going to blow that led.

And you could basically program the way you would like you do not have to glow an led you could actuate something maybe turn on the refrigerator or turn on the air cooler or something like that. So, these are this is the overall setup and you try out by doing this coding in the Arduino IDE platform yourselves, with this very small setup.

And then once you are confident you could try out with different other setups, where through the use of LoRa module you would be sending the data from 0.1 to another point. And that between that the spacing between the transmitter to the receiver could be more than even 100 meters in LoRa. And finally, we come to an end and these are the different references, if you are interested you could go through these references.

Thank you.