Design for Internet of Things
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Lecture - 25
Basics of RFID

This particular lecture is about RFID which essentially stands for Radio Frequency Identification. So, let us do one thing we will go into some basics of RFID. So, we will put down some basics which include some applications.

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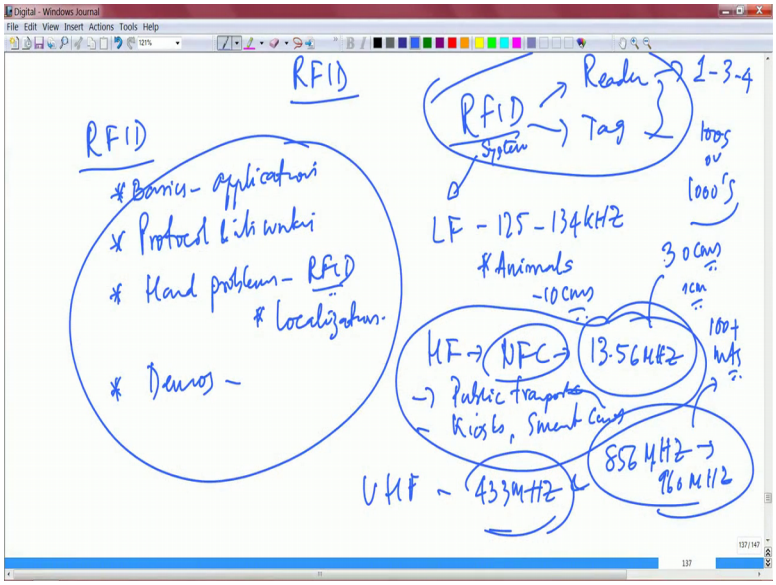

Some applications of RFID then we will understand the basic protocol working protocol and its working and then we will get into. So, what are the hard problems? For instance, hard exciting problems in RFID what are the hard and exciting problems in RFID here one exciting problem which has been increasing researchers and increasing many people which has very practical applications indeed is with respect to localization.

Localization, we do not have much time for localization, but we will see what we can understand from an overview of localization with respect to RFID. Then we will do some demos because ultimately you have to start designing your IoT system with a RFID tag let us say and a RFID solutions for your application and then you will have to which go across many different design choices under which you have to see that what is the type of

tag to use what is a type of reader to use what should be the polarization of the reader what should be the tag sensitivity what is its radiation pattern.

So, many related issues are there to make things into a very nice working solution for your IoT application. So, again you are back to the same question choice how do you choose between tag a and tag B what are the different types of choices what are the different types of readers which are available what kind of handles are available from the from these readers in a manner that you will be able to use it for your application. So, you have to get into demos to understand to see and get a feel of the whole problem. So, we just try and wind up with all these four.

And essentially see how we can configure RFID systems into this into our integrate them into our design for IoT applications course essentially if you talk about RFID it is not a new technology anyway this technology has existed as a low frequency when you say RF frequency you can bit talk of low frequency high frequency and ultra high frequency when low frequency RFID was operating in the 125 to the 134 kilo hertz. So, these tags where available and we have used them extensively in some of our previous applications.

Mainly, they were use for in applying them on tracking animals for typically you would get something like 10 centimeters as close as 10 centimeters then you have high frequency type of RFID systems see when I say RFID system you have to note that it includes what is known as a reader and what are and a tag we come in to the details of that, but just to understand a system. Basically comprise of a reader and a tag. In fact, why just one reader it can be multiple readers it can be anywhere from 1 2 3 or even 4 readers and 100s or even 1000s of tags together we will call them an RFID system.

So, when I say low frequency I just do not mean that it is about the reader frequency, but indeed the system frequency. So, when you say high frequency there was a high frequency system which is actually currently when used in many mobile phones and that manifests itself as NFC near field communication and essentially that is at 13.56 megahertz., and this will not give you too much of range. And you will see that recently I saw in the newspapers that most of the public transport systems are any other places where you want to go for kiosks.

And typically if you are looking at smart cards all these systems essentially public transport where smart cards are used kiosks and so on essentially will use this NFC

technology it is actually an extension of n f of RFID where functionality is a little more enhanced then just dump tags. So, that is the key thing here. In fact, that would be hard to say dump tags anymore because even the dump. So, called dump tags which where are you know which do not have battery in them, but just give information about their ID become very or can be made very very intelligent and if time permits will see how we can do that.

Just to tell you that NFC indeed is also a subset of the large understanding of RFID our systems and. So, you could use it in smart cards you could use it in different kiosk you could use it in ticketing applications and so on then you have you UHF UHFs are essentially means you are talking about 433 megahertz tags and you can also be talking of 856 megahertz running up to a 960 megahertz see when we talk about these frequency ranges in UHF you have to be careful, because every free every country will have its own range. And this is basically the complete range of UHF application. And here you could be talking of a larger range you could be talking of many meters even people talk about 100 plus meters, but I do not think this is we have not seen this kind of applications 12 to 15 meters easily doable with these kind of this 850 to 856 to 960 megahertz.

I am not seen too many or 433 megahertz UHF tags, but that is also possible I did not mention about the is the high frequency tags the NFC typically has a the standard defines 30 centimeters also, but we have not seen applications going more than even 1 centimeter almost contact based systems. So, it actually brings in security right because its wireless is un-tethered and you getting 1 centimeter gives you a lot of security. So, NFC has found popularity standard size 30 centimeters, but we have not seen that kind of rangers it is about 1 centimeter frequency available on RFID systems. So, let me go to the next page.

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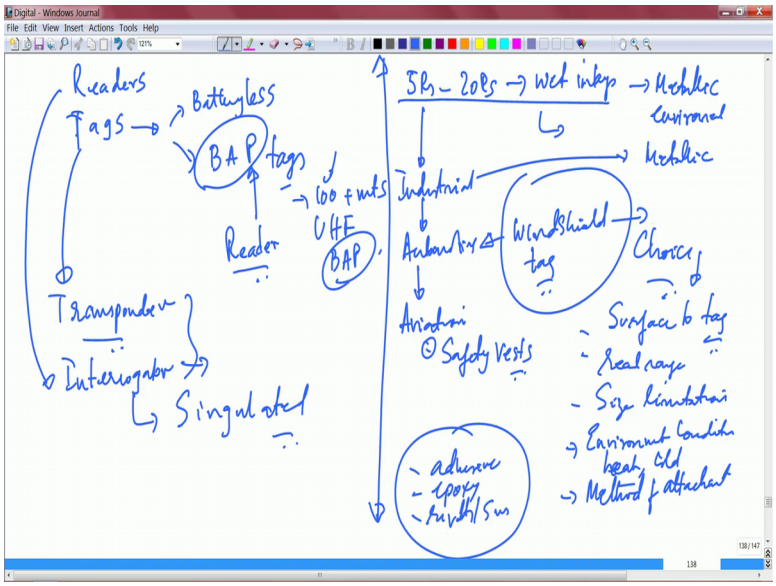

So, essentially when you talk about RFID systems you talk about readers and you talk about tags; tags are battery less battery less they can be battery assisted passive tags as well bap tags and battery less tags we will show some pictures of them and then you will understand that better because Zhuhai I have made. And Tejaswini are back here who work on RFID in my lap and they will show you a few things and that will be very useful for you why do you want to when if it is battery assisted why it should we call it passive they are still called passive, because without the reader they cannot give information back.

So, master continues to be the reader and that is important they can only give information back to the reader only thing is if you have battery assisted tags its very obvious right the range improves and this 100 plus meters which is promised by UHF is a possibility if you use these battery assisted passive tags. So, you have to keep that in mind.

Now, many many things have to be known if you want to really go ahead and understand RFID technology first thing is do not call them tags there is a technical name for tag and this is actually called transponder this is the technical name the reader is also called interrogator; interrogator this two names you will come across tags T, for tags T for transponder just replace tags with transponder readers are called interrogators. So, the name is very nice and intuitive when do you mean what do you mean by interrogation

when you say I am being interrogated somebody is asking you a question and you reply back to that question right this is the essence of RFID you have to note this.

This is the essence of RFID you cannot go on chatting you cannot go on transmitting data if you are not asked a question you are no way by which you are going to reply who is asking you the question the interrogator can ask you a question and who is the interrogator the reader is the interrogator. And another thing is the interrogator will tell you some rules under which you can respond. He will tell you: you have to meet you should talk to me only when I ask you.

In other words there can be many many tags lying around and the interrogator can say I have identified you as a as the person to talk and you will respond to me which means you can be cingulated the tag can be cingulated and the reply can come from a given tag which is being interrogated this. You have to keep in mind that is indeed if you understand this basic rule you will understand many things about the way RFID protocol actually works. So, keep that in mind.

Now, range I mentioned to you already about the fact that the range is a debatable topic hot topic, but if you have battery assisted tags you may reach this. So, called standard where people talk about 100s of meters of tag now tags are you know can cost anywhere from I will talk in terms of Indian rupees 5 rupees to about 20 rupees and you can have industrial tags for industrial applications you can have tags for automotive applications you can have tags for aviation applications aviation applications.

In fact, if you look at the aviation tags these tags are used for the safety vests which are below each and every seat of an aircraft. So, if you talk about safety vests there is a tag associated with every safety vest which is below the seat of an aircraft. In fact, if you look at automotive applications there is a windshield. Windshield tag currently windshield tags are become very popular all new cars being shift out have this windshield tags which are essentially used for keeping track of a vehicle and all lot of parameters associated with the vehicle actually is part of this is programmed into the tag.

So, you can have different types of tags industrial you can have what are known as wet inlays wet in lays wet inlays in lay tags I will show you some examples. And will show you samples of that industrial tags can be metallic tags they can be metallic tags and they can be enclose inside metallic surfaces and they can be interrogated in automotive tags

windshield I mentioned Maruti if you take any of the new cars or any company for that matter actually apply the RFID tag right at the windshield.

And therefore, windshield the special tags mend for being sensed from the tag is placed inside the windshield and that easily read I know across even the glass surface. So, you can have automotive tag you can have aviation tags. As I mentioned to you and all these possibilities exist. So, choice is a problem choice design for internet of things means choice; choice of what to choose. So, you see already you have different types of tags and how do you choose them. So, that is another important thing.

So, when you want to choose a tag you have to look at the surface you want to tag the surface you want to tag what is the read range. So, I will say choice right surface of tag read range size if any size limitations. Size limitations if any then environment conditions environment conditions how is it going to happen is it going to be excessive heat out there is it going to be cold environments.

And remember I mentioned to you about during the discussion on vibration energy harvesting the way by which you mount the harvester actually gives you the opportunity for harvesting quite like that method of attachment also is critical are you going to use an adhesive or are you going to use an epoxy; sorry, epoxy right or are you going to use rivets and screws and so on; so, all these things. So, again mounting becomes critical here the type of tag you choose means where are you going to fix it how are you going to fix it you will have to use this also as a another important parameter. So, cost becomes a critical here now this is about tags.

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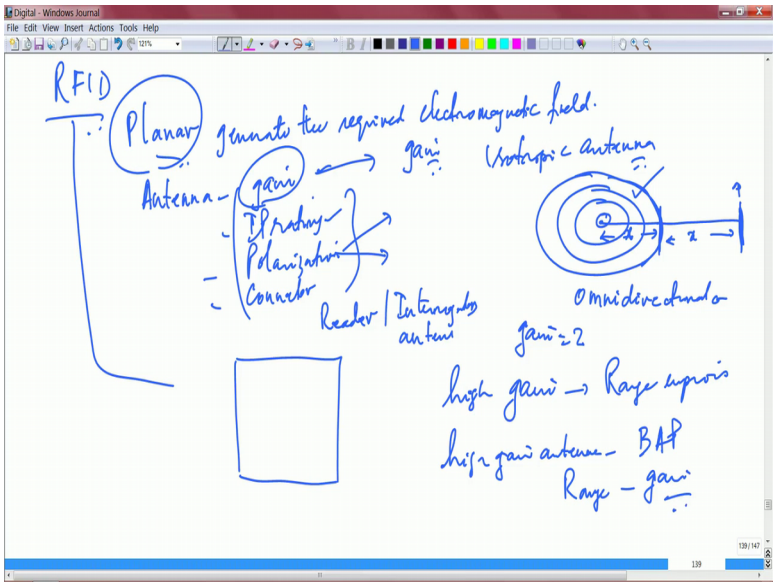

Now, let us look at and peep into how the antennas are the RFID; RFID antennas how what is their important requirements. So, you are essentially this is the radiating element right which you to have power. And then you essentially transmit power is actually radiated using these antennas you can have planar antennas, planar antenna and you would essentially talk about this basically a dump device essentially which I use the power as an input and they generate the net required generate the required electromagnetic field right that generate the required electromagnetic field.

So, you can have antennas of vary in sizes antenna of different sizes I mentioned to you planar antenna is one type of antenna and you can be talking about antenna gain enclosure itself you can be talking about I p rating of the antenna, because if it is used for external applications outdoor applications you must be talking about the I p rating you can be talking about polarization this is very very critical. And the type of connector that is being used all these parameters will start coming into picture when you want to choose the RFID antenna.

RFID antenna for the tag also has a few of these parameters, but by and large when you talk about RFID antenna you will be talking about a flat surface like this which is essentially part of the readers or nothing but the user right word interrogator interrogators antenna these are planar antennas and then have a gain associated with it polarization is also as I mentioned as an important thing when you talk about polarization you will be

talking about before we go into polarization let us talk about gain; gain essentially you have to understand gain. So, when you talk about a passive element like an antenna what is gain there right we understand voltage gain you understand gain of op amp for instance right and we understand gain in the in the electronic sense, but what is the gain of an antenna well even there it is a nice definition.

Assume that there is a isotropic sorry isotropic antenna isotropic antenna when you say isotropic antenna the electromagnetic energy which is radiated by the antenna is circular is completely circular it is in all directions nothing but omni directional this is one parameter then you can have an antenna which has a gain of two. Let us say if you want to have a gain equal to 2 you are saying if this is the omni directional antennas range from this point why is this I am getting a range right.

That means, I am able to reach to this; this is x let us say this is another x gain is 2 means it is 2 into x you are saying gain I want twice as compared to that of the omni directional antenna we need V in and V out if you want to 2 gain quite like that what is V in equalent in the antenna terms it is the gain of the omni directional antenna. And therefore, with respect to the omni directional antenna what is the additional gain what is the additional range you got improvement with respect to the omni directional antenna is what the again.

So, gain of 2 dB or actually when you talk about gain. In fact, anything can be expressed in dB right gain is normally expressed in dB and I just showed you a picture of gain actually relating to improvement in range right in data basically if you have a high gain when you say high gain high gain the range improves range improves you can come half the distance that tag can come half the distance. And again this 100 plus meters can be met what does it mean you put a high gain antenna you put a high gain antenna and you put a battery assisted passive tag.

So, he is coming half the distance you are going half the distance you meaning antenna the interrogator is going half the distance the tag is coming half the distance therefore, 100 plus may be possible. So, keep this in mind you want a good range think about a high gain antenna from the reader side think about a battery assisted passive tag from the a tag perspective and therefore, combination of high gain antenna with battery assisted passive tag can perhaps give you a good range this will keep bothering you because how

do I use this in different IoT applications gain range is a issue. Therefore, how do I manage that?

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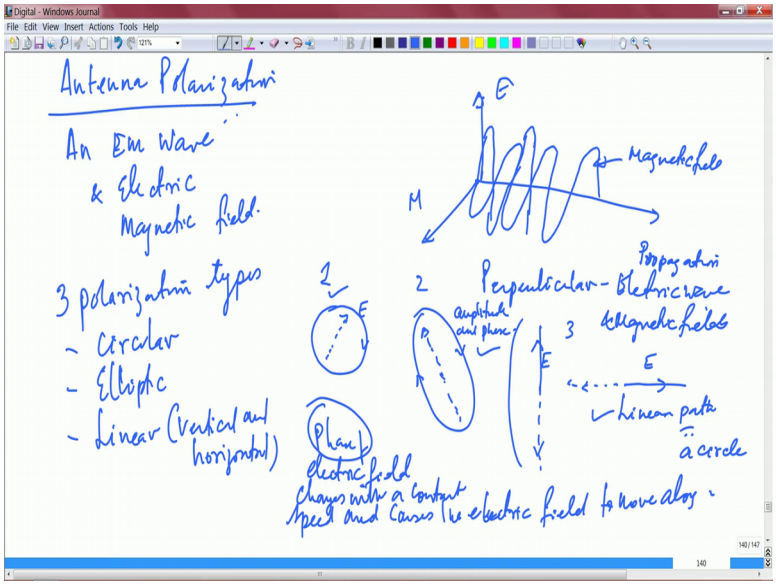

I will give you some basics antenna; antenna polarization; polarization is the topic of interest basically an electromagnetic wave emitted by the antenna consists of what when you say electromagnetic it has an electric and magnetic field electric field and magnetic field as simple as that traveling with the same speed this is E this is m magnetic field and this is the propagation path this is propagation lack of practice perhaps is creating a little bit of m s.

So, that is what would go and this is the magnetic field. So, this is the magnetic field now with respect to the electric field you must show it in this direction right. So, let us show this like this then going like this like this and going like this going like this cutting back here and so on. So, you can see one way going like this which is the E wave the electric field way and this is a magnetic field wave. So, the E m wave is essentially which consist of the perpendicular electric and magnetic fields.

There are 3 polarization types polarization types there are 3 polarization types one of them is called circular the other is called electric and the other one is called linear vertical it can when you say linear you can be vertical and horizontal. Now look at this picture look at this picture look at this picture or look at this picture I put one arrow here, I put an arrow here, I put one arrow here and I put here. So, you can see I am being

consistent this is circular right this is elliptic this is vertical this is horizontal all the 4 I have shown. In fact, there only 3 this is one this is 2 and this is 3 there only 3.

Now, this is horizontal polarization and here. So, let us go with this part here the electric field rotating is rotating with a constant amplitude the electric field is rotating with the constant amplitude essentially in circular polarization what should happen the phase the phase of electric field the phase of the electric field changes with the constant speed and causes the electric field the electric filed; causes the electric field to move along a circle to move along a circle. So, the magnetic field is what is shown in the dotted part.

So, I have been consistent now this becomes e; obviously, and this is this is also E right everything that is hard line is a E. So, you have E and m basically. So, what we are saying is that in the. So, let us look at elliptic. So, in elliptic polarization this is which is here both amplitude and phase it is not only this one in this case the amplitude as well as phase of the electric field change and causes the electric field to rotate in an elliptic form amplitude and phase amplitude and phase.

So, both aptitude and phase of the electric field change and cause the electric field to rotate in an elliptical form an E m wave has a linear when you say linear which is here if the electric field moves along a straight line instead of any type of rotation. So, 3 here are basically the electric field the dotted perhaps indicates the amplitude and what is rotating you see here is the phase there is phase and amplitude.

And essentially when we talk about phase and amplitude we talk about electric field rotating with constant amplitude. In this case you talk about electric field rotating electric field rotating with an elliptical pattern in this case and here you talk about electric field moving along linear path. So, this is essentially what you should know about the antenna polarization which is a very critical part of understand why is it important because when you talk about phase you actually use this as an important parameter for the purposes of localization.

So, you must know this; this term associated anyway we will have a phase and amplitude right. So, this is an electric wave and we had looking about talking about the relation of how the electric field is rotating whether its rotating in constant amplitude or its in an elliptic pattern or whether it is moving along a linear path very simple to say if it is moving along the linear path what should happen the range should automatically

improve right it should automatically improve highly directional antennas which I have which have a linear path essentially will improve the direction are the range of the antenna right. So, that is a very important thing.

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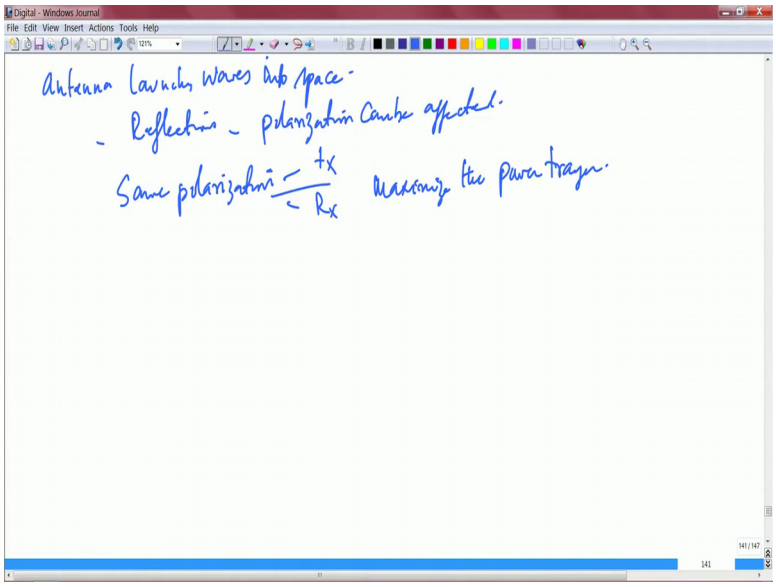

So, initial polarization of a radio wave is determined by the antenna basically how is this initial polarization come about the antenna launching. Launching the waves into space how the waves get launched into space launching of waves antenna launching waves into space that is what determines the initial polarization and of course, the environment and incidents once the wave is launched. You will have a lot of issues right you will have reflection you will have reflection from any surface and all that which will change the polarization. Polarization can be affected every time the wave hits some surface and gets reflected.

So, if you add an initial polarization it is hard to say what was the ultimate polarization when it reached the RFID tag that is the real difficulty which means if the antenna and tag. For instance in this particular case we are to be a bit more careful if the they are depolarized for some reason then you have problems of tag not being read at that is an issue. So, tag being read or not read could also mean that they seem to be depolarized for some reason.

So, antenna of the receiver and transmitter notes specially in line of set applications if they have the same polarization they have the same polarization on the transmit and

receive same polarization maximum maximized the power transfer right you have the maximum power transfer between the 2 antenna then if there is maximum power transfer range improves automatically, but if they are not you may even have a situation whether tag is not being read this is the big take away from the antenna polarization part gain will not get into the details, but basically you should know it is with respect to the isotropic gain isotropic range of the.

So basically isotropic gain is one when you talk about an isotropic and ideal isotropic antenna the gain is one any range improvement any wave which has travelled beyond the isotropic range essentially we can be called as the I can be known as the range. So, that is about what we have with respect to basically RFID.

Now, let us go into a few more details on the UHF tag let us concentrate on UHF tags RFID tags.

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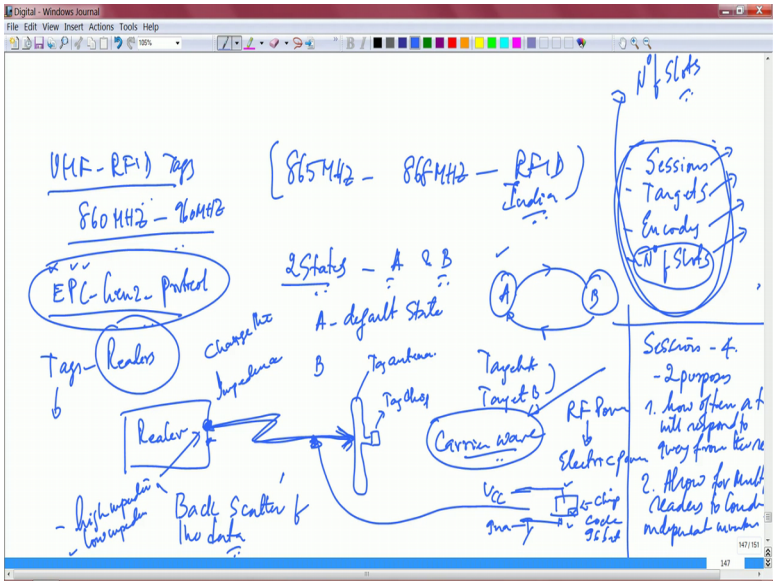

And let us spend a little better understanding of the system before we go into demonstrations and other things. So, when you talk about UHF let us concentrate mainly on the 860 megahertz I mentioned to you earlier to 960 megahertz. And you have to look at your country specific detail in order to understand what is the frequency allowed for RFID applications the understanding I have is that in India it is already defined by try 865 megahertz; 868 megahertz to 868 megahertz. This is the RFID range in India please

note in India at least here there is no ambiguity about what you should buy when you buying in Indian country.

Essentially RFID systems when you buy you will have to talk about a protocol called EPC generation 2 protocols. So, most of the tags as well as the antennas sorry tags as well as the readers have to follow what is known as the EPC generation 2 EPC stands for electronic product code generation 2 protocol here when we talk about EPC 2. There are a few things which you will have to therefore buy tags which are compliant to EPC gen 2 and you have to buy readers which are also complain to EP gen 2 when you talk about EPC gen 2 tags these tags come into states.

You now get into a little more detail on what these states are these states are called A and B sates. And essentially state a is the default state default state the A state is default state when the tag powers up and or after B state time that either it goes from A to B, and then comes back to A. So, it could be so default is you be when you have the tag powering up it comes to a state then it does a few things there goes to B state and comes back. So, essentially this is also called target A and target B target A and target B.

So, let us start with how the whole thing actually begins the reader actually uses you know transmits a certain amount of energy right to put sort an r f energy and tag is small like this the tag also has a tag antenna associated this is a tag chip and this is the tag antenna and there is no battery. Remember we are talking about battery less RFID systems to begin with battery assisted is also quite similar. It just applying the power supply filed to the electronics of the tag just for the improvement of range, but for better understanding.

Let us start with totally passive tags reader throws transmits energy puts out r f power that r f power reaches this tag I will just show a single wave like this which is this power carrier wave as it is called initial carrier wave is used for harvesting r f power to electric power I will not go into detail because we already discussed this.

So, you will generate a small V c c and ground and this V c c and ground generated from the r f power from the initial carrier wave is used to power the RFID chip which is here and what is the chip supposed to do chip has what is known as a EPC code this EPC code is 96 bits wide and first initial carrier wave is used to power this tag after this tag chip gets powered after that chip is powered the chip basically has to give this data back to the

reader see this arrow this arrow clearly indicates that this chip is using this forward arrow to give the data back to the reader on the same arrow which is a clear indicator that it is trying to use the forward transmitted wave and put its data back on this forward transmitted wave which means it is doing a back scatter of the data it is doing the backscatter of the data now.

So, this is very important what it is doing is it is changing the impedance here it is changing the impedance change the reader antenna transmute antenna when it is transmitted the wave that goes out that impedance is changed for every time there is a digital data the if it is one let us say it goes into high impedance and if it is digital 0 bit 0 put it into low impedance that is caused by the received chain of the reader antenna and that essentially decodes it into the bit stream that is given by the RFID chip now this is insufficient the reason is the reader will always tell the tag to provide data in a particular format for example, encoding is an important thing right.

So, what are the parameters it will have to provide back it will have to tell the sessions will come into that we I will talked about.

That in a moment then targets then encoding then number of slots then that is it. So, mainly these setup parameters have to be fed to the tag and the tag will have to first. So, what it will have to do it will have to power the carrier wave will have to power carrier wave powers the chip this power V c c will come then reader will continuously be transmitting this information which it will decode and say reader is has ask me to configure sessions targets the encoding of data to be sent back and the number of slots.

Now, let us go one by one to understand these 4 parameters and after which we can get into the demonstration part EPC gen 2 complain tag means there is essentially or you can have in EPC gen 2 up to 4 sessions. So, well let us take this sessions first sessions they can be up to 4 sessions and sessions start actually what sessions visit or serves 2 purposes and what are the 2 purposes one it determines how often how often how often a tag how often a tag will respond will respond to a query to a query from the reader that is one of the purposes second is it allows multiple readers to conduct independent inventories allow for multiple readers to conduct independent inventories.

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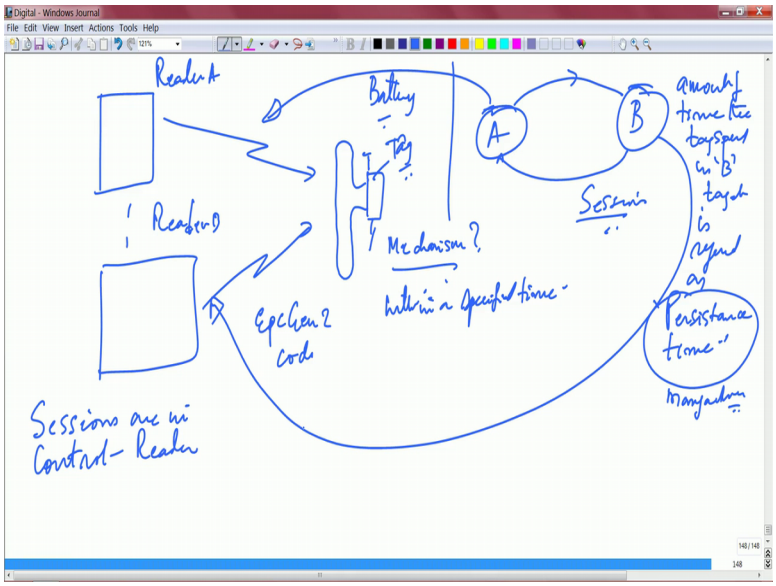

What a beautiful way it can do things it simply means it simply means that if there is a reader a if there is a reader A and reader B; reader B there is a single tag I will show it like this there is a single tag and reader A is querying and reader B is also querying the same tag.

You want to situation where remember the challenge here is there is no battery right in RFID passive tags there are no battery somehow you and because reader a has already powered let us say a did the transmission first and powered that tag and. So, there is the rain feed the voltage is available on the tag is powered. And as I mentioned the default state of the power on state of the tag indeed is target a correct. Now that it is there and it has finished reading B also wants to find out the EPC gen 2 code wants to read it these are 2 place in 2 different places and that querying the same tag you must have a mechanism key what is the key you need a mechanism whereby multiple readers should be able to read within a specified time and how do you do that you simply tell the tag you configure something on the on the tag which says look you respond to me when you are in state a reader a can say that and B can say please respond to me when you are in B state B target that is one thing. So, what essentially it means is quickly it reads whenever is in state a to reader a and then it goes to B and reader B simply picks it up from when it is in state B and at that instant a will not be reading this particular tag which is the nice thing right.

That is why you have sessions and targets. So, let us put down what are the sessions? Sessions are before we go into sessions let me spend a little more time on persistence time persistent time simply means while the default state is target a connecting back to this picture here you want reader a to read when it is in target a beautiful and you want a to be read by reader a then the tag decides to go into target B and in target B reader B reads you do not want this state B to come back to state a quickly or if you are in state a you want to read and go to state B and remain. Therefore some time that state the amount of time amount of time that tag spends in B target in B target is referred to as persistence time what a beauty again why do you need it we said this right and you are multiple readers therefore. And this is not in your control this is a control of the manufacturer decide what is the persistent time.

What you have in control is definitely the sessions; sessions are in control of whom of the reader and sessions can be provisioned by the reader after the tag powers up. So, that is what we wanted to say about the sessions. So, how often a tag will respond to a query from the reader is one of the requirements for to one purpose the second purpose is to allow multiple readers to conduct independent inventories.

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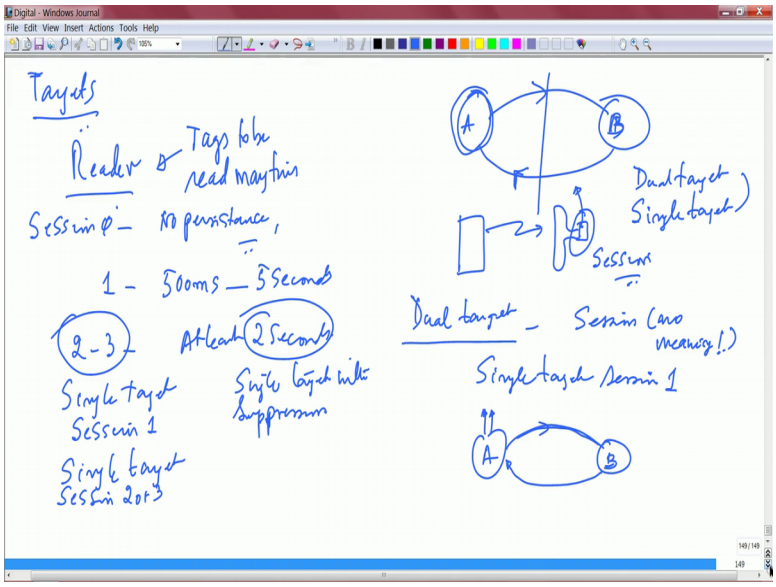

what is the other use of this target do not complicate by if you do not complicate the scenario by multiple and multiple readers even if you have a single reader even if you

have a single reader and you want many times to be read tags to be read many many times tags to be read many times.

Even then the sessions are useful you have a target you have B target and you can have you can use this targets very effectively this is the; so, let us put back cover beautiful picture which is the chip like this and inside this chip this is happening and you are saying to the reader if it is a single reader case read the reader is telling configuring the tag and say give me your EPC gen 2 id not only in target a, but also in target B. So, you can be talking about duel target you can be talked about single target and so on this combination of.

So, while you do not have the control of persistent time you have a provision to instruct the tag to remain in a particular session; session is in your control. Therefore, there are 4 types of sessions there is something called session 0 which is no persistent no persistent tags reset each time the power of happens no persistence tag 0 which means this part is actually cut off you do not even go to B it is equal and talk each time the tag powering itself up and tags reset.

So, the there is a tag reset each time the power up and then there is session 1: session 1 is 500 milliseconds to 5 seconds and 2 and 3 sessions is at least at least 2 seconds something like in between the 2. So, that is about duel target you can be talk about single target you can have single target with suppression that is another possibility and you can basically talk about dual single target session 1 single target session 1 you can be talk about single target session 2 or 3 single target session 2 or 3 you can be talking about single target with suppression.

So, all of this is possible I encourage you to read up quite a bit on the these sessions and targets for you to configure in a manner depending on the number of tags that you might want to use in your IoT application right just to summaries all this in. So, if you talk about dual target if you talk about dual target the tag will be read continuously regarding regardless of whether it is in a or B the session has no influence. So, when you talk about dual target session does not make sense session no meaning single target single target session 1 if you say the tag will be read and then move to from a it will move to B it will move to B it will move to B state and after some period it will revert back to a right it will move back to a and B read again.

So, you will read only here it will go to B and then come back and read this tag all over again the as I mentioned to you a 500 milliseconds to 5 seconds I mention to you this is one of the ways by which when you put it to session 1 right. So, that if the reader search mode is set to single target with session 2 or 3 if you are talking about 2 or 3 now. Then the tag will be read once then switch to B state, and then remain quiet the entire time it is in the read feel it is just remain quiet in the read field once the tag I leaves the read filed it will have a persistence for a time period of 2 seconds time right with no maximum define.

Now, when you say using the single target with suppression it provides the advantage of session 2 and 3 in that it will remain quiet while in the read field. Once inventory does allowing other tags which may be quieter to be read where do you see an application for this.

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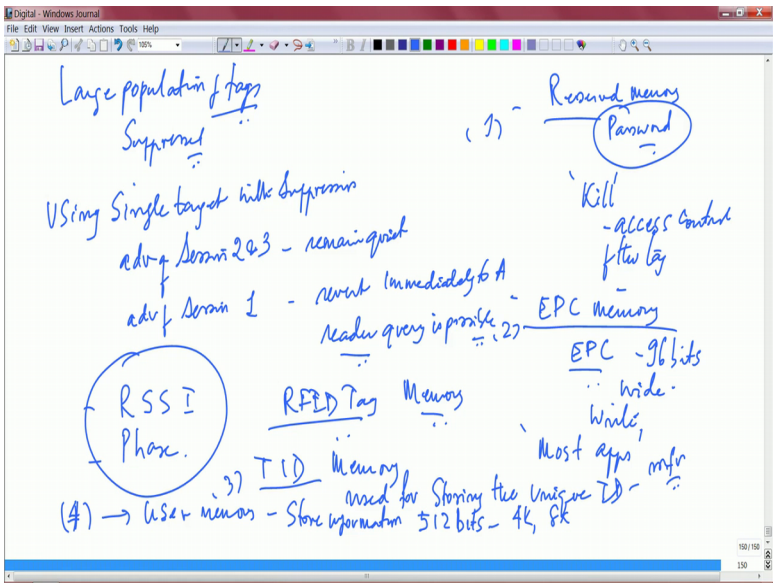

You see an application for this when you have a large population of tags you do not want the same tag to be repeatedly coming back if it is read once it should be surprised if realizes that it is done and it should not respond back and therefore, allows other tags to come back large population of tags you may want to use single target with suppression you are using you are using single target you are using single target with suppression.

So, you get the advantage; advantage of session 2 and 3 advantage of sessions 2 and 3; 2 and 3 advantages of sessions 2 and 3 in that it will remain quite it will remain quite while

in the read field once inventory. So, that other tags can read it also gives you the advantage of session 1 advantage of session 1 that it will revert immediately to immediately to one it will immediately revert to a sorry immediately revert back to A. So, that it can be available by the reader for any query reader query is possible that is other important thing 2 other important parameters after the demonstrations which will be with respect to RSSI and phase oh ok.

Before we move on to demonstrations and RFID tag RFID tag has memory and you must know what are the different types of memory banks available inside the small little chip one is called reserved memory and this reserved memory is used to store any password supposing you want to you know password protect the chip you could essentially put it into this into this reserved memory. So, the memory bank stores the kill password and access password.

So, all password related parts are stored in the reserved memory the kill password permanently disable there is something called a kill command it will permanently disabled anytime and you should be very careful not to pass this command from the tag and the access password is set to lock and unlock the tags read write capability. So, you have access control of the tag essentially is all part of the reserved memory this memory bank is only writable if you want to specify a certain password most users do not use this memory area unless their applications are contain sensitive data the second type of memory is the EPC memory.

This is the memory bank it stores the electronic product a code memory a code essentially it is 96 bits wide its 96 bits wide is the length is 96 bytes it is writable you can write to this memory a part EPC memory is what is typically used in most applications. So, we are mostly worried about EPC memory and there are some tags that have the capability of a lot more bits to the EPC memory from the user memory. So, if you want to a lot more bits to the EPC memory you could do it.

Then there is something called after reserved memory and EPC memory there something called TID memory. So, this is one this is 2 and this is 3 TID memory it is used for storing used for storing the unique id of this chip of the manufacturer this comes from the manufacturer you can say this is like the MAC id for instance medium access control

MAC id of a network intern network interface cards right. So, that is TID then there is the fourth I want to still use the same sheet.

So, let me put it here no it does not seem to let me try fourth one is the user memory here if the user needs memory for the other than the EPC section certain to have extended user memory which can store information when it comes to user memory there is no standard in how many bits of memory are writable on each tag. So, essentially you can have extended memory of 512 bits; 512 bits I am, but in some there are up to 4 k and even up to 8 k of memory this is the second writable memory bank of the EPC gen 2.

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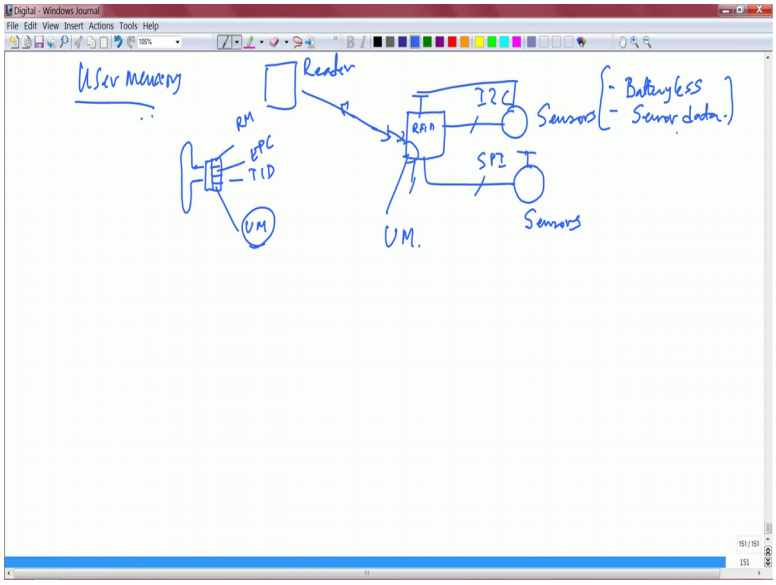

See this user memory alone has created user memory; memory has created fantastic number of applications I will give you one simple case of how the user why is this antenna not symmetrical consciously I have to make it symmetrical right this is let us see reserved memory this part is let us say EPC memory this is let us say TID which is the tag id memory and this part is the user memory what can you do with it up well it app it appears. Now that this single RFID chip offers you either I 2 C or even some chips give you SPI communication what can you do with it yes it is interesting that you can connect sensors to this RFID chip and store it in u m and when will you do this you will do this every time the reader A; reader powers the RFID chip.

So, what will happen RFID readers power transmitters power RFID chip powers up intern powers the I 2 C sensors reads the same power is actually applied also to RFID

that also to the sensors and sensors read the data put it into user memory and RFID chip can now backscatter this information back to readers what a beautiful system completely battery less completely battery less sensors data sensor data can now actually go via RFID right of course, it simply means in the presence of the RFID reader this is you have to. So, this is a very nice application which many companies are actually promoting.

Now before we before we go into the demos I want to tell you last thing about the number of slots this number of slots essentially is related to the basically its related to the number of tags which population of tags which are available if you have a large number of tag population you may want to increase the number of slots and. So, that tags can respond a tags have a slot in which they can communicate their EPC code or sensor data if it is coming from user memory back to readers. So, this is completely related to tag population and one can be talking about a complete inventory cycle and you can be talking about configuring the number of slots in that inventory cycle and so on.

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So, let us move on to some demonstrations and after that we will come back and 2 phase and RSS what I am going to show you and Tejaswini who is here is going to demonstrate a few things, but before me move on look at this you have a choice of tags to by these are waiting list by the way and they are stuck, and they are like paper you know that stuck on paper this part is the antenna you can see a black spot here a black spot here and back black spot there those 3 essentially are is nothing but that RFID chip. Now why do you

need these 3 different types of antenna? I mentioned to you about the problems of polarization and the effective polarization between the reader and the tag antenna.

And therefore, if you want better reading you use this type of tag this is called a frog thee d tag this has a certain application this has a certain range then this is called dog bone tag and this is called a short dipole a tag. So, you get different choices of tags like this you can have aviation tags you can have automotive tags you can have wield shield tags and so on and. So, forth metallic tags for instance. So, all of these are possible and you may have to choose the right type of tag for a given application.

Now, let us move on to see what the RFID infrastructure is all about essentially this is the reader you can see this is from imp pinch this is called imp pinch speedway reader and it has multiple ports and its powered here and then it is connected to essentially on this side it is connected to a computer. So, that you will be able to see few things this is the antenna and there is a certain gain associated with this antenna and it has a gain of 6 dB I gain. So, this is a 6 dB I antenna gain how do you do that now Tejaswini what she will she will bring take this tag and show it in front of this antenna and she will show you a few parameters on this computer screen. So, let us start.

To begin with she will show this tag and you can see that this tag is being read continuously the tag id as you can see the second parameter is RSSI which we will cover subsequently when we discuss further discuss RFID technology the third parameter is phase.

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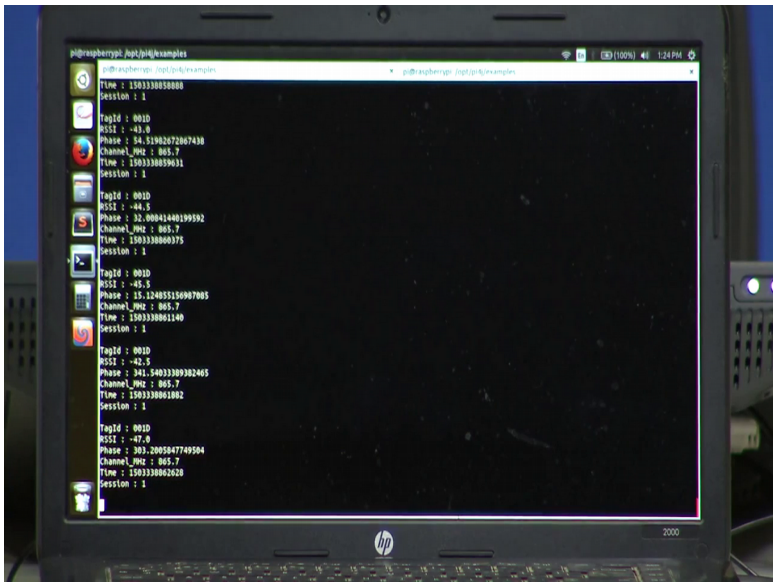

And the forth parameter is the channel of interest basically you can configure up to 4 channels and this is a configure to 865.7 megahertz and this is the time at which the tag has been read. So, this is a simple way by which you can have RFID tags and information about the tag being read. So, let us look at demonstrations of sessions right now.

What we will do is we will begin with session 0 we will show you that there will be many tag reads then we will do session 1 there will be a certain time delay then we will do session 2 and 3 will be a delay of 2 seconds. And then will also do sessions with dual targets which means all sessions are ignored and continuously tags will be will be read. So, let us start with session 0 you must have many tag reads. We will see many tag reads happening moment she puts the tag in front of the antenna you can see that and you see it comes its reading continuously its reading continuously and this is session 0 right.

Now, let us move on to session 1. So, this is session 0 and now we are enabling session 1 what should happen there should be a time delay there should be a time delay from one read to the other read you can see that it is in session 1 now there is a delay then again there is some delay then there is some delay and so on. So, this is session 1 then. Now let us move on to a much more sluggish method which is session 2 and 3 which gives you a delay which you can actually observe which is 2 seconds right you see one tag read there is some significant delay after which there is another tag read this is the last

demonstration to show you about the targets you should be able to read continuously here and soon after you can see that its reading quite rapidly many many tag reads and ignores all possible sessions with respect to these tags good. So, that is about the session's demonstration.

Now, let us go ahead and show you how you can change the EPC code which is sitting on this tag there is any EPC code sitting on this there is the EPC memory and let us see how to change this EPC you know code how do you configure any EPC code on that tag. So, let us show you the programming of the EPC tag let us first look at what is the existing EPC code. So, let us write. Now, Tejaswini will in work the reading of a tag and its connecting to the system and tries to read the tag let us stop and read the tag first. So, the tag id is 0 2 0 B. And this is what will now change and let us see what is the new tag the new tag the new tag id is 0 3 0 C and she is now going to program this into the system it connects and uses the r f energy from here hours this tag and writes data into this tag and it says its completed programming the tag. So, we come out of the programming mode.

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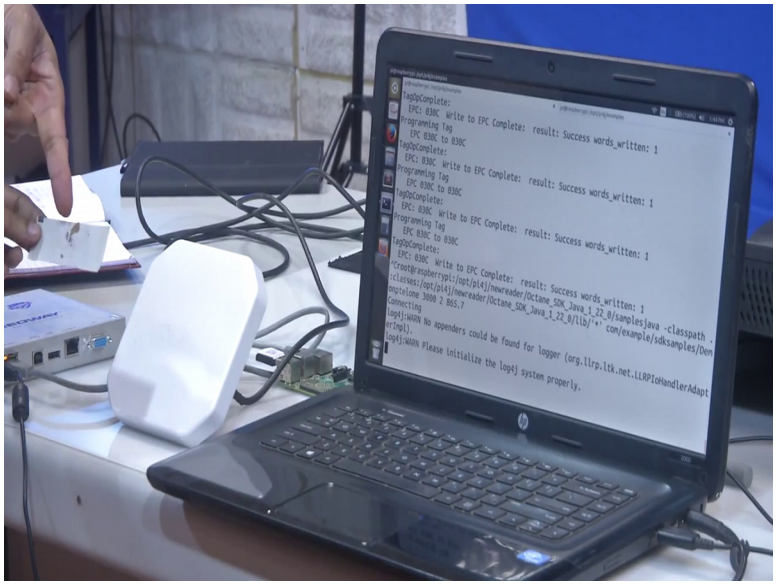

And then we read the tag back and write and execute the code to read that tag again r f energy is being thrown on the tag the tag cheap is powered and the tag chip is powered the EPC code which is 96 bit is backscattered from the tag to the antenna and that is what

we are reading here. And you will see that the new code can you stop that for a moment yes indeed is 0 3 0. So, this completes the demonstration related to change in EPC time.

Now, let us see how very interesting things can actually happen where buy you can be talking about a RFID chip and lot of day on a lot of interface prince through which you can connect sensors right you can connect sensors and I used this RFID chip. And in fact, this was done in the lab you can see this is an RFID antenna on either side we were trying to few things and we were trying a few things in the antenna and got this and you know I design this antenna and the chip here.

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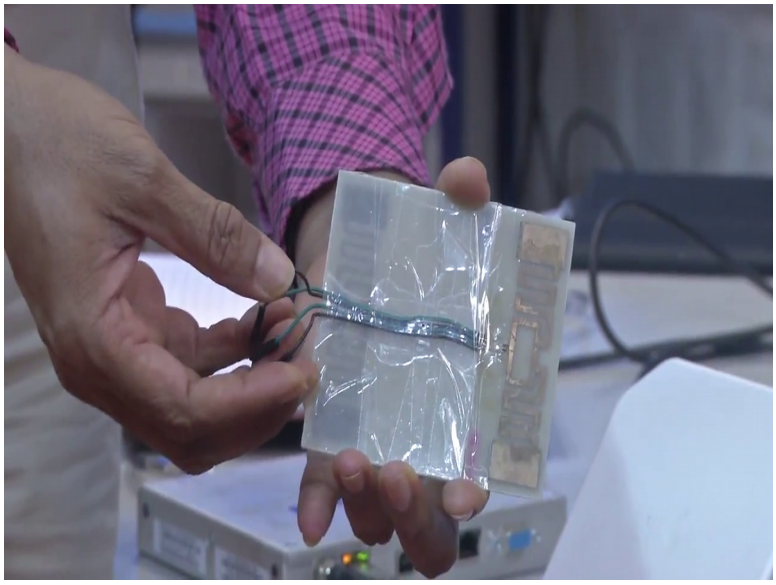

And you can see these wires are used for connecting sensors which is a clear indicator that anything that is connected to these through these wires you will have to write to the user memory.

So, now next demonstration is to see how you can read and write into user memory of the tag we will execute a code where by which will allow us to access the user memory of the EPC gen 2 compatible tag. So, you can see that you are we are going to show you first to read the user memory and we will see what is the memory content there you will see again the RFID chip is being powered through the RFID reader antenna it is transmitting power the Rayleigh comes and the voltage is available on the chip the chip powers and the chip backscatters information back to the reader antenna.

And can we stop this, and we will have look at the user memory code and use memory code currently is all 0s. And we will now see what kind of sensor value we can actually put into that system for this we will invoke command by which we write something into the user memory and what she does is she writes 0 1 2 3 4 5 6 7 into the user memory you can say that this is equivalent of some sensor data which is available either on I 2 C or SPI bus essentially through this wires we could essentially writing into the user memory.

So, EPC write is completed now let us see whether user memory is accessible. So, now, we invoke a command to read the user memory the tag read reading of a tag and then you will see that the. We stop this and we can see that the user memory is actually a written successfully. So, that is about user memory the last demonstration now is related to we mentioned about 2 important things that we need to cover in theory one is with respect to RSSI and here.

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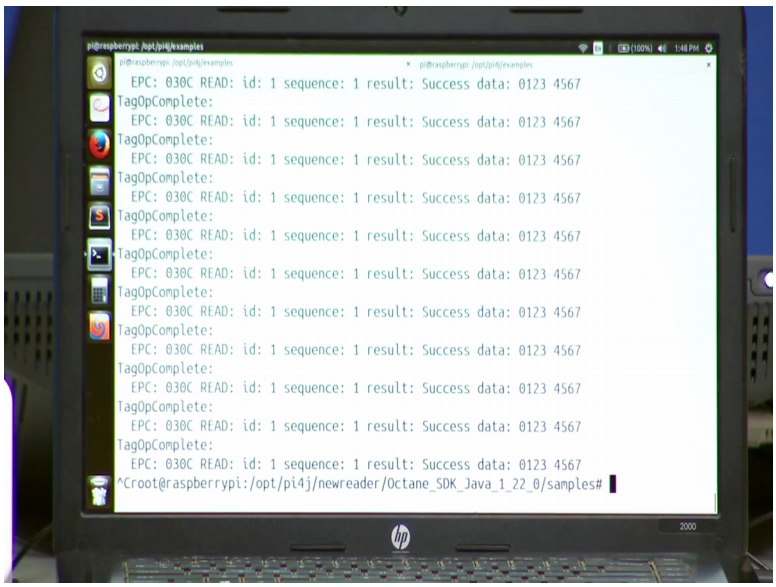

This is with respect to phase we will show your demonstration of how the with the increase or decrease in reader transmission power which she can set here and you can actually have different range right you can have different read ranges of the tags. So, she will now start with the power of A plus 10 DBM transmission power you will see that you can you can see that. So, we will pan it along with this. So, she goes back you can see that it continues to read now and now it has if she goes closer into the reads, but if

she moves a little back it stops reading right and the RSSIs shown here is minus 47, but when she comes closer the RSSI minus 30; you can see sometimes it is even minus 35 and so on.

What does it mean it simply means that ranging between the reader antenna and a tag there is a small indicator by which she can one can leverage RSSI for the purposes of ranging between the reader tag and the other the tag and the reader antenna all right. So, now, she changes the transmission power to slightly higher transmission power 30 DBM plus 30 DBM. And obviously, the range has to be much more much more than what is available right. Now you see RSSI is changing as she you can see that is already an indicator that she is going further and further away minus 47 minus 47 minus 48 minus 52 there it goes, but it still reads minus 60 minus 68 minus 64; 66, it is not stable RSSI is not stable; 7, it reads minus 60, but yet this able to read the tag and at this instant already she is pretty far off at minus 60, it is now a bit more consistent that minus 61 minus 62 and so on and anything beyond the tag refuses to read you can see that it has stopped reading now because the distance has gone over and above the receiver sensitivity the sensitivity of the tag.

So, that is about what we have in terms of a possible demonstrations we will handle this notion of what we see with RSSI and phase of course, I did not demonstrate to you the phase part, but phase is the another important parameter, that most readers will also provide to you and using phase and RSSI many exciting application related to localization is possible thank you with respect to localization as I mentioned to you; you will need 2 things one is the you can use RSSI.

And you can also use phase and both are actually being demonstrated here you can see tag id is shown RSSI is shown phase is shown channel and so on are also shown. So, will use these 2 as nice indicators and. In fact, when the tag is moved both phase as well as the exercise actually varying and this can be used for the purposes of ranging see this is the last part this is a bap tag bap RFID tag there is a nice battery you can actually put small coin cell batteries, but being a lab demonstration.

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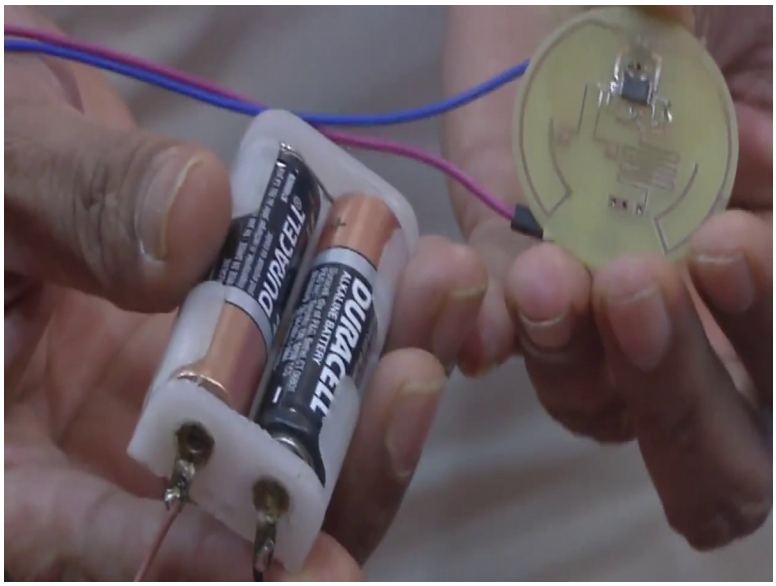

We have connected this Duracell batteries to this is giving you the Rayleigh directly range improves the RFID chip is here the antenna is here which is RFID antenna is here.

Thank you very much.