Optical Wireless Communications for Beyond 5G Networks and IoT

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Lecture - 40
Mat Lab Tutorial - Part 1

Hello everyone, I am Anand Singh, PhD student triple IT Delhi. So, today we are going to discuss about how we can using MATLAB software simulate the indoor visible light communication system, how we can plot the received power, delay spread, how this reflections from the wall can be simulated. Because you are going to require these simulations and if you are going to plot any performance matrices such as bit error rate, outage probability.

So, you require to get this received power profile across the room. So, in this lecture, we are going to see the simulation part of it theory, not the theoretical part how those theoretical equations can be simulated using a MathWork software, which is known as MATLAB. So, MathWork have both coding platform, which known as MATLAB and Simulink, but in this analysis in this lecture, we are going to use MATLAB as our simulation tool.

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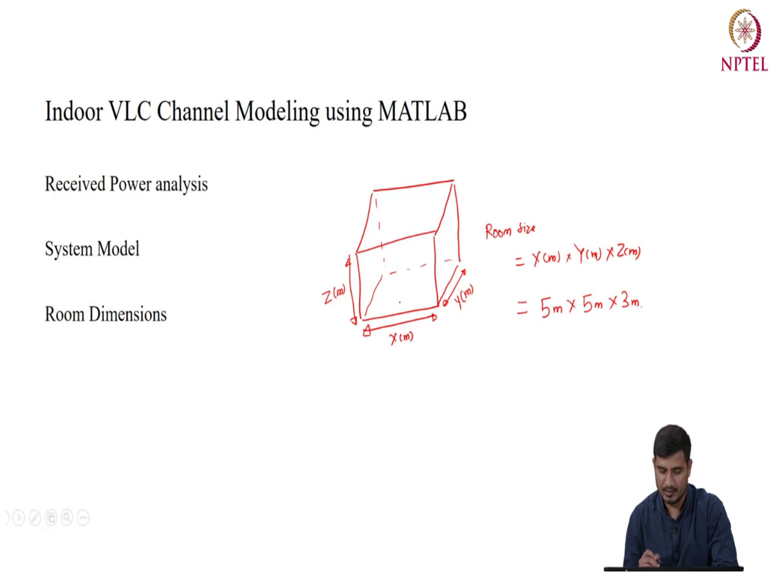

So, going ahead. So, we are going to simulate the indoor VLC channel model, indoor such as office room, factory environment, you can change the room dimension. So, the first thing that you require is that we are going to simulate is received power analysis. So, in received power analysis with the help of received power, you will be able to plot the bit error rate, outage probability, the delay spread analysis.

So, the first thing that we require in order to simulate any indoor system is the system model. What is the system model? That you want to simulate using MATLAB? So, that system model may be an office room, any industry environment of varying room dimension and varying room height. Next is the room dimension.

So, generally that in literature, we use a standard room size of 5 cross 3 meter. So, if I am going to show here, suppose we have a room which looks like this. So, this is actually an office room I am trying to show here. So, this is an office room. So, it may have dimension of suppose this width is of X meter and this length is of suppose Y meter and height of the room which I am mentioning in Z coordinate of suppose Z meter.

So, if you have a room size of X meter cross Y meter cross Z meter here. So, the very first thing you required in order to simulate is the room dimension. So, generally in the literature, we consider a room size of 5 meter cross 5 meter cross 3 meter. So, this is the first thing that you require you need to know the dimension of any room where you want to deploy this visible light communication system.

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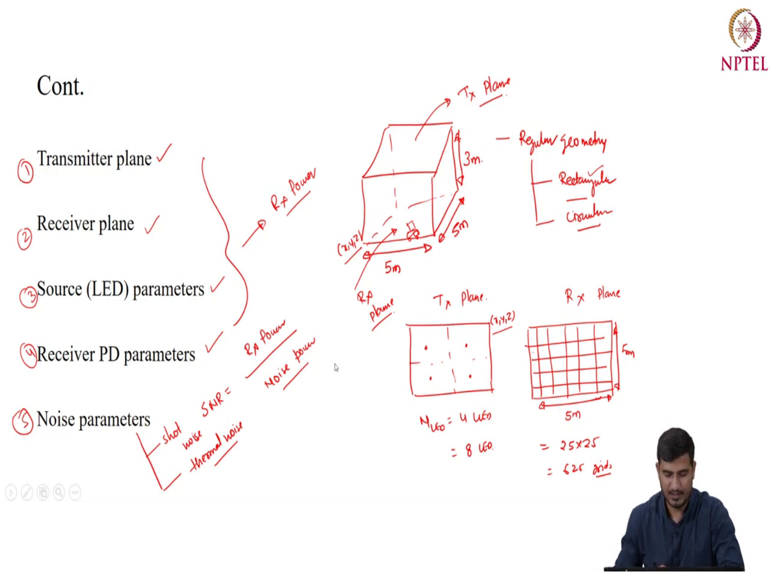

The second thing that is necessary is the transmitter plane, receiver plane, source LED parameters and the receiver PD parameter. So, by means of transmitter plane is like I have shown you earlier. Suppose, this is a room size again I have mentioned the dimension earlier

5 meter, 5 meter and height of 3 meter. So, we are going; we are going to deploy LED on the ceiling. So, this ceiling is our transmitter plane.

Now, this transmitter plane in order to deploy the LED, you can deploy in different configuration. There are a geometries available, like regular geometry we you must have heard of regular geometry. So, it may be in rectangular configuration or in circular configuration and what are the number of LED that you want to deploy here.

So, this ceiling in indoor VLC system behave as a transmitter plane. Similarly, this floor we will consider it as receiver plane. So, this receiver plane this floor we can use as a receiver plane. Now, as you know the room dimension x comma y comma z of it, it means you have the knowledge of the respective coordinates.

So, in order to first deploy the LED in transmitter plane, if you are deploying it in rectangular configuration and suppose you have an LED which suppose I am considering 4 LED. So, you can divide this room into 4 sub coordinate and then you can deploy the LED the center of the each sub coordinate. This is how you deploy in rectangular configuration.

Similarly, if you have more number of LED suppose 8 LEDs then you can further divide this room into 8 equal sub coordinate and place the LED center of the each sub coordinate. And for that you are going to require again this coordinate of transmitter plane. So, in simulation what we are going to do? We are going to give these LED location in terms of x, y and z coordinate.

Now, how we simulate this receiver plane? So, in order to simulate receiver plane in practical environment this movable PD can be anywhere inside the room. So, in order to get the overall performance of the system or the average performance of the system what we do? We study the analysis of received power with this PD across the whole room.

And in order to do so, what we do? We divide this whole floor or you can say receiver plane into a number of grids. So, as you know the dimension like it is of size 5 meter cross 5 meter.

So, what we do? We divide this floor into number of grids and each grid will be equal to the location of the PD or you can say the number of PD is here.

So, generally in a standard format we divide this into 25 cross 25 and equal to 625 grids. Higher the number of grid, grids better will be the resolution you can divide into 10 cross 10 also 5 cross 5 also depending on the simulation or the hardware or you can say the system capacity of yours.

So, as in order to simulate this VLC system first you need to simulate your environment which is a transmitter plane. So, it as where we are going to mount the LEDs in practical scenarios, it may be in rectangular scenario, it may be in circular scenario. So, we need to give the coordinate value in MATLAB. Because MATLAB is simply operates on mathematical equation that you provide. So, any phenomena that you want to work out in MATLAB you need to give a mathematical expression of it.

Similarly, for the receiver plane and then one by one we are going to show what are the source or you can say the LED parameters and the receiver PD parameter that we need to give. Like in case of LED there will be a transmit power, LED semi angle and the Lambertian order of it. Similarly, for the PD what is the responsibility and what is the field of view of the receiver. So, these are the all of all these value you need to give as a input for the MATLAB.

So, going ahead again when so, these first 4 parameters like transmitter plane, receiver plane, source LED parameter and receiver parameter will give you the received power value. But in order to get the better rate performance or outage performance you need to plot you also require noise parameter; you can say the noise value. Because your SNR is nothing but received power divided by the noise power.

So, again in VLC as you have studied there are 2 types of noise. First is short noise, another one is thermal noise. So, again you need to use their respective expression, their parameters value, what is the practical values they have. So, you need to give them as a input for the overall SNR analysis of the indoor VLC system.

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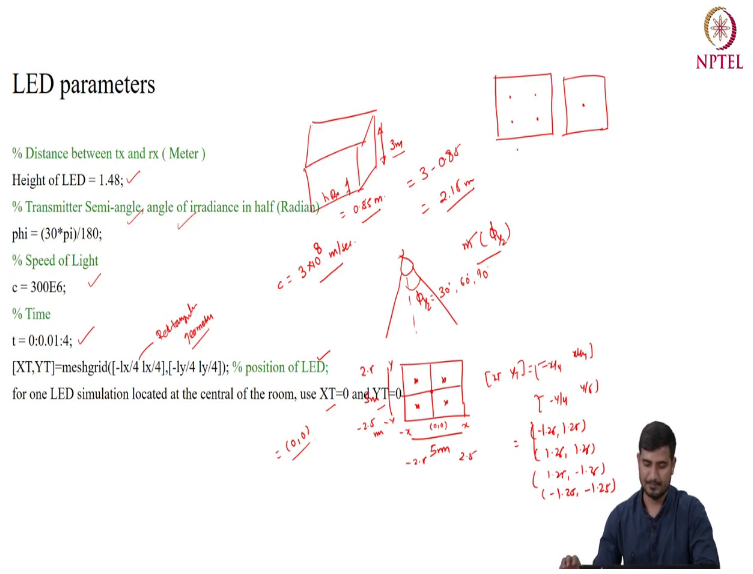

So, moving ahead now we are going to discuss one by one what are the LED parameter that we need to provide as a input. So, the first is the height of the LED or you can say the distance between the transmitter and the receiver. So, how we can calculate? So, actually generally in any practical system this height of the LED like earlier we have shown you the room size and we have given that the height of the room is 3 meter.

But the height of LED is the height from the PD, from the floor you can see here the exactly the value will be 3 meter. But generally, what happens we consider receiver height at the height of the table which is generally 0.85 meter. So, you can subtract this 3 and 0.85. So, you will get 2.15 meter as a height of the LED for a given room dimension of 5 cross 5 cross 3 meter. Like here for example, we have taken the height of LED value as a 1.48 meter.

Next transmitter semi angle or you can say that semi angle or angle of irradiance in half radian. You can also give this value in degree form, but as of standard value I have taken it as in radian so. So, here I have taken the value of 30 degree you can say or in radian 30 in to pi divided by 80. So, what is this LED semi angle? As you know each LED mounted will transmit its power with this LED semi angle 5 1 by 2.

So, here we have taken this value 30 degree or we can the standard value generally 60 degree, the maximum value that it can go is 90 degree as you know. And based on this LED semi angle we will be able to calculate this Lambertian order because your m generally it is a function of LED semi angle value 5 by 2. So, first in order to calculate the m you need to give the input value of LED semi angle. Next will be the speed of light because as we know we are working on visible light communication which is a light technology.

So, this is the standard value everybody must be aware of 3 into 10 is to the power 8 meter per second. So, this is the practical value we have given here. Because it is going to require when you are going to calculate the delay spread. So, for the for that you require the speed of light and again the time like what is the symbol duration that you are operating. So, here I have taken a maximum value of 4 with a interval of 0.01 second. So, this value is in second actually.

Again, now as I have discussed earlier what should be the position of LED? As I have mentioned we can deploy LED generally in transmitter plane in rectangular configuration where we divide this transmitter plane into the subgrids and deploy at each grid at the center of it.

So, if you can see here like if the dimension is from minus x to plus x and this width is from minus y to plus y the LED will be in the center of each coordinate. So, we have given this coordinate of X T, Y T is equals to minus x by 4 to plus x by 4 and minus y by 4 to plus y by 4.

So, if these values like for the standard room is 5 meter. So, it is varying from minus 2.5 to plus 2.5 similarly here minus 2.5 meter to 2.5 meter. So, these value will nothing but will be a coordinate of minus 1.25, 1.25, 1.25, 1.25, 1.25 and minus 1.25. And similarly, minus 1.25 comma minus 1.25.

So, this is how you deploy LED in rectangular geometry. So, that thing you need to keep in mind like anything you want to do, you first need to find out mathematical expression of it and then you need to give as a input to the MATLAB. Now, suppose you are working with single LED only.

So, the LED can be mounted exactly center of the room. So, for that what you need and if we are going from minus x to x. So, this center will be 0 comma 0. So, what you need to do? You can simply give input XT and YT equals to 0. So, there will be a only one coordinate and that will be 0 comma 0. So, this is how you are going to. So, now what we have done?

Now, we have simulated a transmitter plane. So, what we have done? We have transmitter plane and we have deployed 4 LED in a rectangular configuration and for single LED at the center of the room and their respective parameters like LED, semi angle, their time, their height from the receiver plane, ok.

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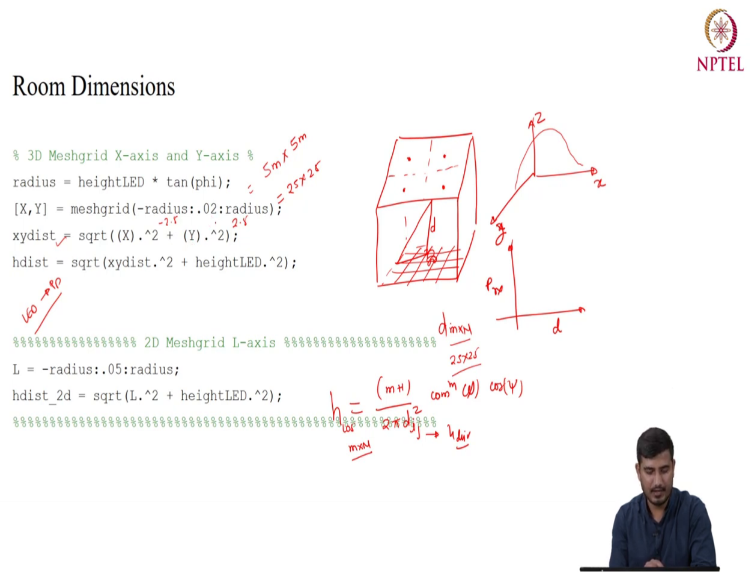

Again, like I have shown you earlier in order to calculate the received power you require this room dimension and where you are going to place the PD. So, for the same like this is the room here, what we have done is, we have already deployed the LED in a rectangular configuration and we have also identified or given input the LED parameter.

Now, in order to plot this 3D received power profile, you need to divide whole room into the number of grids or you can say this receiver floor will have this number of locations. So, in order to give this in mathematical format, you need to generate a meshgrid and mesh grid will be a size of minus of radius with resolution of 0.0 radius. Like I have given you the example, we can divide room into 25 cross 25 subgrids.

So, this is the resolution and this radius value is nothing but minus 2.5 and 2.5 for a standard room size of 5 meter cross 5 meter of receiver floor. So, this r value will be minus 2.5 and

2.5. And based on that, you can like if we as you know this VLC channel gain is a distance dependent. So, if suppose some PD is lying somewhere here and if this is the line of side path. So, in order to calculate this distance, you require this horizontal and vertical distances.

So, for that you can calculate this X distance X, Y distance by simply using this X under root square of X square and Y square and based on that, you can calculate this h distance where there will be the height of the LED will be involved. So, this h distance will be the distance of LED to PD, which will be the function of this X and Y distance and the height of the LED.

So, this is how you will be able to calculate the distance from LED to the receiver. So, again this distance as we are dividing room into number of grid. So, it will not be a single distance. This distance will be of matrix order m cross n, where this m cross n nothing will be the number of grids that you have divided. Like in my case, I have divided into 25 cross 25 subgrids.

So, like as you know this channel gain equation of VLC is or you can say the line of side is m plus 1 divided by 2 pi d ij [FL] whole square cos m phi cos psi. So, here this d ij we are going to calculate with the help of this h distance equation that we have mentioned here. So, again as your distance is of order of m cross n. So, similarly your line of side channel gain will also be order of m cross n matrix.

So, you will get these m cross n values and you can respectively plot those values. You will get the channel gain profile across the room. Moving ahead, you can also draw a 2D mesh grid if you are interested in only in 2D power profile where there will be a received power function of there is a distance and P received is a function of distance. So, you can done with 2D meshgrid as well.

But with the help of this 3D meshgrid, you will get a 3D power profile. So, it will be a function of both length, width and height of the room. So, you will get some 3D power profile, it will be a function of all the 3 coordination inside the room. So, this is how you give input your room dimension. So, they can be adaptive in nature like you can take any room size and whatever the resolution based on your hardware capacity you can choose here.