Satellite Communication Systems

Prof. Kalyan Kumar Bandyopadhyay
Department of Electronics and Electrical Communication Engineering
Indian Institute of Technology, Kharagpur

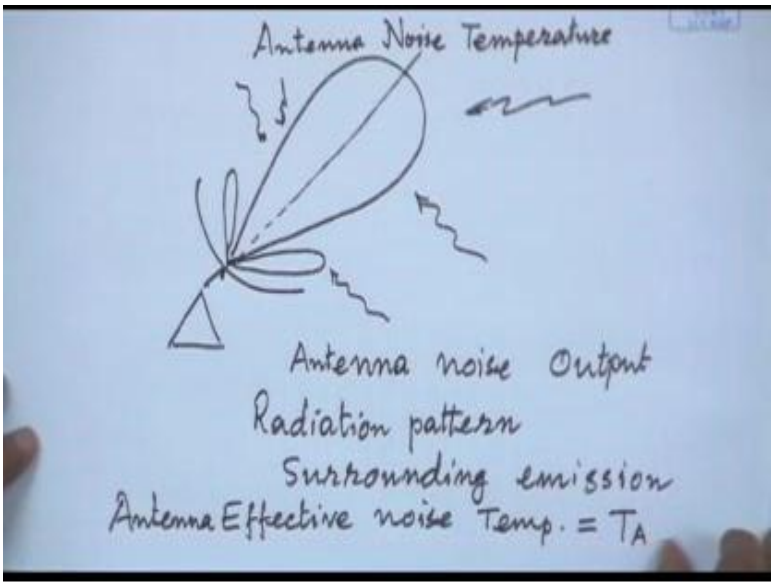
Lecture - 15
Link budget -5

Welcome, we were discussing on Link Power Budget and on that we have discussed the power part of it that is signal power how which is transmitted, how much it is revived, what are the losses and then we have also briefly discussed about the noise how it is generated and in the conference and that how that noise figure and noise temperature is defined and in a cascaded system how it can calculate and the receiver noise temperature and noise figure how it can calculated.

Now, in the addition to the receiver in front of the receiver in fact, we have antenna that is there in the satellite receiver as well as in the ground receiver. So, let us see whether antenna receives a noise in addition to a signal and what is it is characteristics.

Today we will discuss about the antenna noise first. So, we will call it antenna noise and the since we talking about the converting the noise into a temperature form. So, we will call Antenna Noise Temperature.

(Refer Slide Time: 01:25)

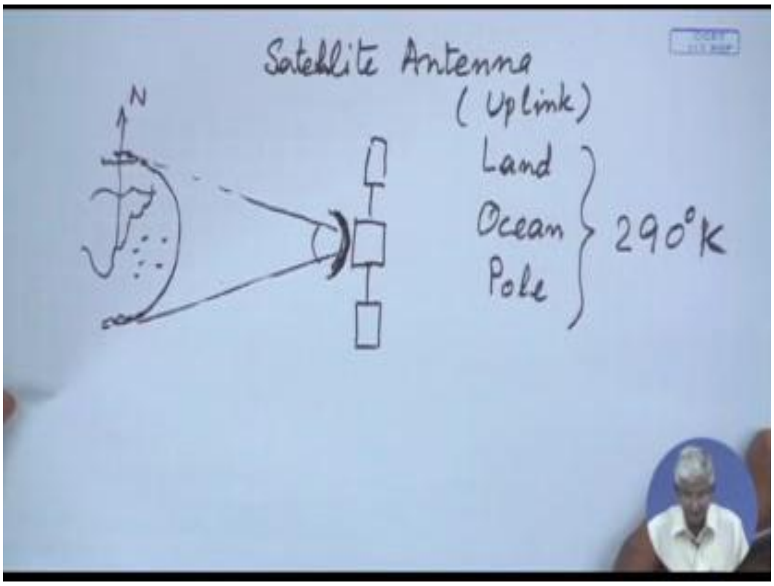


Now antenna is let us try it from the ground. So, this is antenna which is in the ground and it has a beam which is like this and we have seen that the center of the beam which is both side the gain is the maximum and as it is deviates from which axis of the maximum gain the gain slowly falls depending on the how the antenna is designed. In this case I have shown Parabolic Reflector antenna. Now gain is reduced means whatever signal or power it is coming in this direction, antenna output will revive less compare to if it is received at the on axis maximum gain. So, the noise when it is looking towards let us say ground antenna is looking towards the sky, the other objects are radiating from the sky, noise is coming like this, noise is coming from here, noise is coming from there are small loops through which also it revives and there are nulls in between that is the antenna characteristics.

So, some power is revived here and whichever noise is coming in this direction goes in to null. So, like that from various angle noise is coming. So, therefore, the antenna noise output that is antenna noise output it depends on the radiation pattern which is depends on in r theta 5 co-ordinate system which is depends on azimath elevation or the pi and theta. So, it output depends on the radiation pattern and in this radiation pattern in all direction the surrounding radiations are not coming surrounding emissions are not coming uniformly noise is coming from one direction more some direction it may be less. So, it depends on surrounding emission.

So, the whole thing of this how much noise is received at this point can be called as if a resistive noise is appealing we can call it a effective noise temperature as we have seen in the other part of the receiver, and since it is if all the antenna. So, antenna effective noise temperature let us term it as T of antenna the as if equivalent noise resistance or noise source is there who as affective noise temperature which is appealing at this point. So, whole thing is modeled now. Now let us, see there are scenarios which are in two directions. One is the Satellite Antenna.

(Refer Slide Time: 05:28)



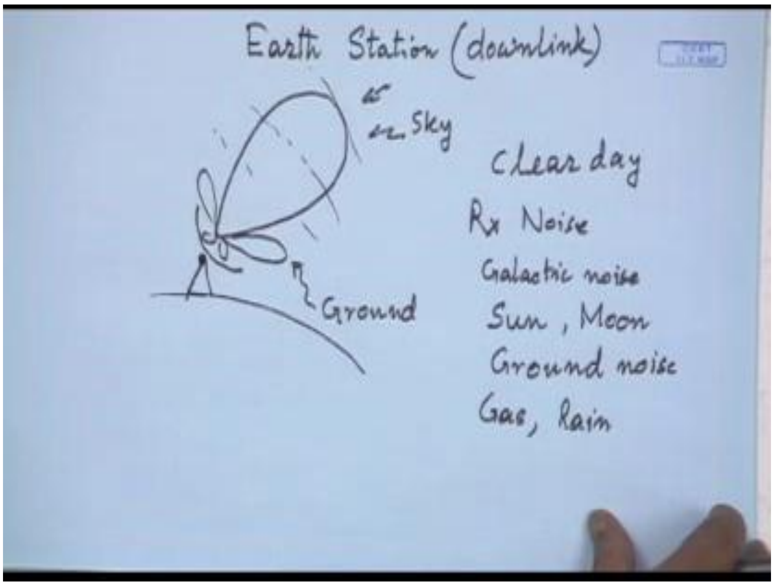
Now, Satellite Antenna is a let us say this is the satellite solar planets and here is the ground let us see this is the north part and satellite antenna is looking towards the ground. We have seen we have calculated that geo stationary satellite for a global beam we have beam of 17.4 degree which is a 3 dB (Refer Time: 06:14) with all these things. So, for our purpose if there are smaller than global beam then also the purpose is communication with earth.

So, the satellite antenna is looking at the earth. So, all in addition to the signal power the noise power which is coming from earth will be seen by these satellites received antenna and what really that noise perceives. In this there are land parts, there are ocean parts, and there is a pole which is the ice at there. So, therefore, we it sees a land which as a higher temperature; obviously, it is radiating more temperature. Then it sees ocean comparatively less temperature and then it may see the polar region which is almost ice that is that is much more a temperature.

So, different part of the earth will have different temperature and the satellite is moving around the earth depending on which location it is located. So, therefore, different antennas on satellite we will see depending on the antenna beam where that is global beam or spot beam you see some different type of temperature on the average people saying it is strict to 290 degree K just a thumb rule number, 290 degree Kelvin is taking getting from the earth side ok. That is now satellite antenna you can see that it is towards the satellite the communication is towards the satellite. So, in other way we can say this satellite antenna seeing this noise he needs up link that is from earth to space that is what we called Upward.

Now, here it is drawn like this it is upward to the satellite. So, it is called Uplink. So the received part of the antenna will be seeing the noise. The transmitter part of the antenna also will see the noise, but it is transmitting. So, it is not going to the receiver. So, the receiver noise is not getting affected by the transmitter antenna it is a received antenna. So, up link antenna will see all this type of noise and for the satellite generally on the average it is taken as 290 degree K. If it is looking to be other star or other purpose then the communication for the communication noise as to be differently estimated.

(Refer Slide Time: 08:57)

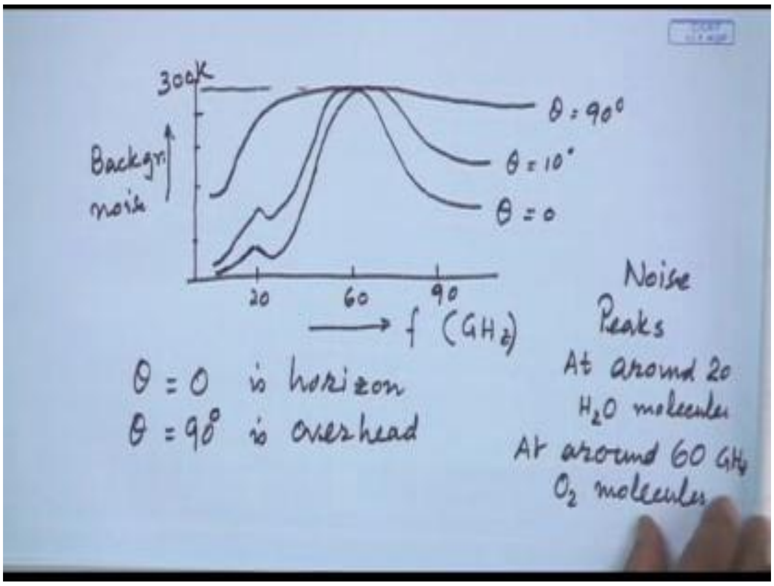


Let us go to that other part of the link which is the Earth Station Antenna. On the earth we have Earth Station, which now is at the down link. We have a station and it as a radiation pattern and it is the now receiving. So, it is on the down link. So, we will see it is as a station antenna down link will see the noise. Now this radiation pattern there may be side loops and main loops there may be smaller, smaller loops towards the ground also. So, therefore, it will see the noise coming out from the sky also noise this is the ground noise coming from the ground. From the sky there may be clouds there may not be clouds.

So, let us see the first condition which is deeding a clear day. Deeding clear day, the receive noise at the antenna will see towards the sky mostly, which we will see the galactic noise. Which is all over the sky you know enormous number of stars at that some of them visible in clear eye or not visible in the eye depending on the other light, but the noise is coming all around stars are there. So, there is a basic galactic noise which is here. In addition there have noise sources radio sources and radio noise sources major of them nearby is sun, then there is moon there could be other radio sources which are relating noise which will be coming.

Now, if it falls in the main beam or some part of the beam of the received antenna that receive noise will be appearing to the antenna. Also there is some noise which is coming from the ground depending on our elevation angle of the antenna or which is either the main loop or the side loop there may be some hills here that may give some noise to the main loop very small portion of the main loop (Refer Time: 11:33) or it may be give it to side loop or from the ground itself the back loop also will give. So, there is a ground noise. Also other than the galactic noise and the planetary or other solar noise is there is atmospheric gas present in the atmosphere which it is beam, seen. So, gas also will generate certain noise gas noise oxygen nitrogen and other hydro materials rain they also generate noise which is not clear day of course. So, all these noises are picked up and that will be appearing as a noise at receive a station at the Down Link.

(Refer Slide Time: 12:37)

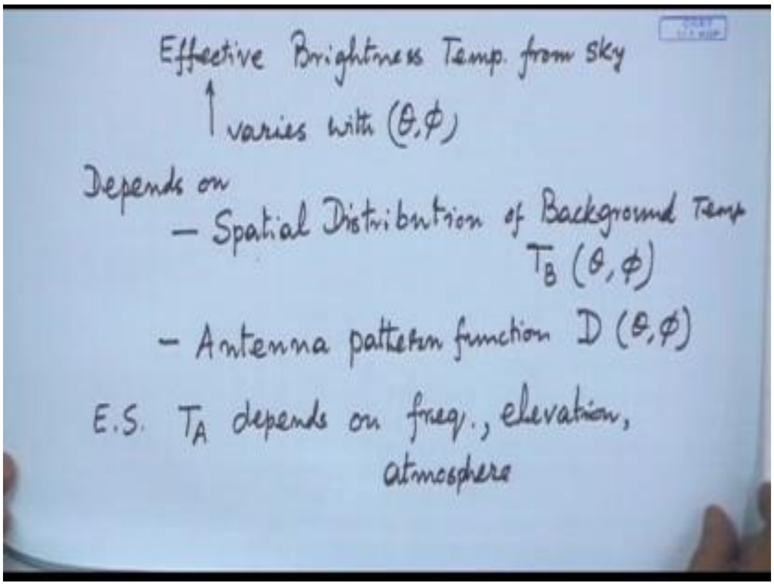


Now, sky noise was experimented and it varies on elevation angle and the frequency. Frequency in gigahertz let us say and let us say this is called the Background Noise and let us say 300 degree K is here, this is 20 gigahertz, let say this 60 degree gigahertz, this is let us say 90 gigahertz. So, generally I will try to give a schematic plot at very low elevation angle, main (Refer Time: 13:35) angel is let say theta is equal to 0 degree just on the horizon. the noise is like this skiers and at in a little higher theta it is like this there is theta is equal to 10 degree, at much higher theta which is let us say vertically above it is like this theta is equal to 90 degree.

Now, we will cut the things that we observe that has increase the theta from 0 degree to 90 degree that is from horizon to the over head that is theta is equal to 0 is horizon and theta is equal to 90 degree is the overhead. This sky noise is almost 290 degree 300K here almost 290 degree most of the part of the micro wave frequencies. And at low elevation angle it reaches to very high that is 290 degree. Now there are also other things like we have seen 2 peaks here one 1 as at peaks that is the noise peaks at around 20 gigahertz there is a peak. This is due to the h two o molecules into water vapor that generates some type of noise and also we see other peak at 60 gigahertz at around 60 gigahertz to get a another peak which is due to oxygen molecules.

Now, there can be used it lies for various purposes, but these are certain observations these are measured values plotted. You can see this graphs in a text book many of the textbook. So that means, it is varying on elevation angle also depends on the frequency these are the two observation from the sky noise.

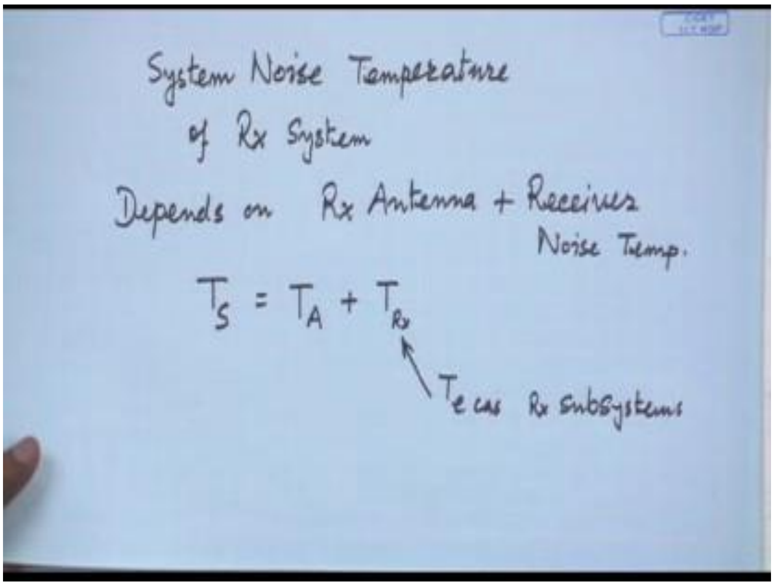
(Refer Slide Time: 16:32)



Now, we can always background noise as effective brightness temperature, it is bright, so called brightness temperature from sky. This effective when I say; that means, it varies with theta pi etcetera. You were seen that theta it varies at different elevation angle. At different angle you some moon may come some galactic stars become a different times. So, it varies with theta and pi. So, we got effective bright brightness temperature, which depends on one is Spatial Distribution of Background Temperature curve we have seen which we can term is at a T background which varies on theta and pi and another distribution which is the Antenna Pattern that is the radiation pattern we can say which we will know directive gain d depends on theta and pi which direction it is.

So, in short the Earth Station Antenna Temperature depends on couple of parameters one is frequency we have seen the card it varies which frequency the background temperature varies with frequency as we change there is big peaks some small lower temperature is also there some places then it depends on elevation azimath etcetera and also it depends on atmosphere that is if there is gas, rain, scrolls etcetera. It will have a different temperature we will discuss that one in much more detail during our discussion on propagation.

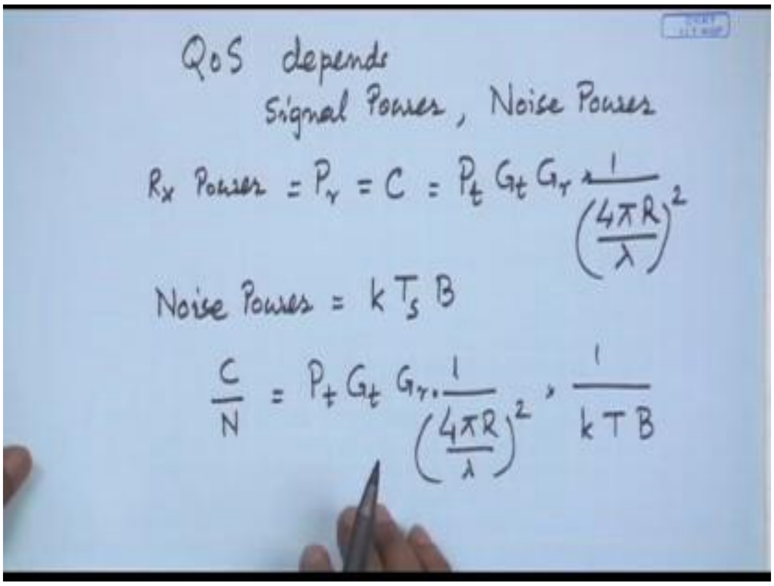
(Refer Slide Time: 19:40)



So, the mainly it depends on the pattern and the background temperature distribution of that. Instead of going to the details of the theoretical or analytical way we can straight away say System Noise Temperature of a Receive System Depends on Received Antenna and Receiver Noise Temperature. We have learnt this one earlier period the receiver effective noise temperature in short I can say T system is TA that is T antenna and T receiver which is nothing but T effective the cascaded value of the received subsystems.

So, that is about the received noise temperature and from the as we see on the on the Antenna Side and from the Receiver Side put together we have seen that how the system noise temperature that appears. So, we have discussed till now the power signal power and the noise power.

(Refer Slide Time: 21:26)

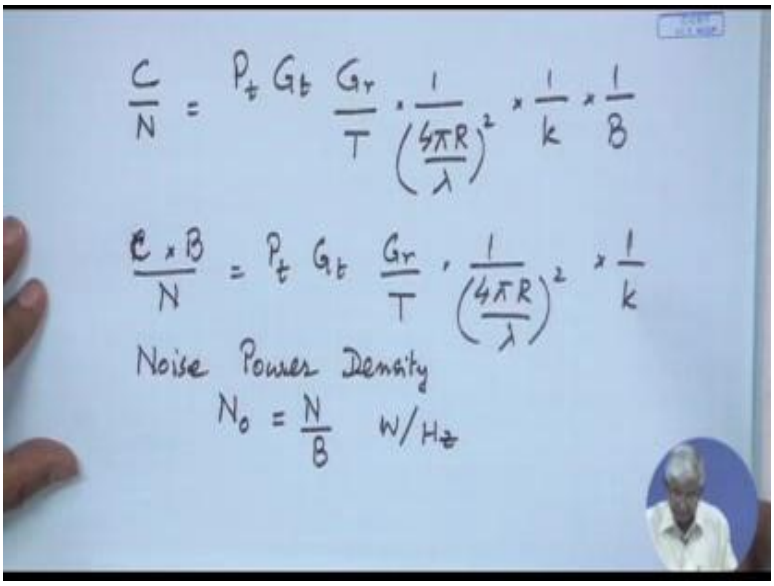


Now, let us see that a Quality of Service, what we are looking for that depends on what we know signal power and the ratio of Signal Power Ratio (Refer Time: 21:45) and Noise power and the Receiver signal power received power. We have calculated which is signal power Pr. Let us term it is a carrier carries the signal. So, let us call it C and that we have seen it is the transmit power, multiplied by transmit antenna gain, multiplied by the received antenna gain, multiplied by a term which we called Path Loss because it depends on the distance from the transmitter and receiver and depends on the frequency of operation that is lambda.

So, this is what we have derived earlier and also we now know that Noise Power is k T system noise of the receiver and the Bandwidth on which it is operating. This is the system noise which includes the Antenna noise as well as the Receiver noise. So, signal to noise ratio or carrier to noise ratio here we commonly use carrier to noise ratio is Pt into Gt into Gr into 1 by 4 pi r by lambda whole square and N is 1 by k T in this case instead of T as I am writing T and B this T stands for system Receiver system.

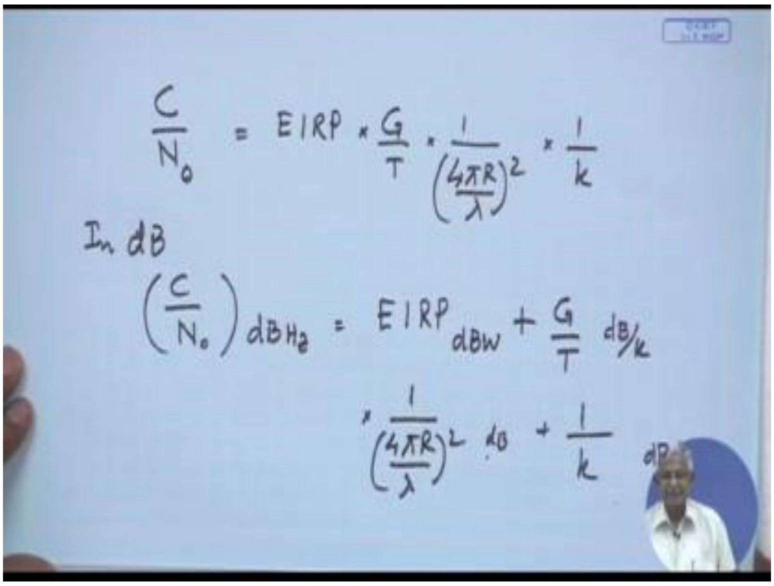
Remember this Gr is the received antenna gain not the receiver gain Gt is the transmit antenna gain not the transmitter gain. So, these will this term let us readjust this thing and let us see how they signal to noise ratio or in this case always we refer to carrier to noise ratio systems.

(Refer Slide Time: 23:54)



So, carriers to noise ratio is Pt Gt then I call it Gr by T and then I call it 1 by 4 pi R by lambda whole square 1 by k and 1 by B. That k T B is there and instead of things at transmits power. I have simply rearranged there is a reason for rearranging, this one is our transmitter characteristics and this one will see the that is a receiver characteristics, this one is the distance that is the path free space characteristics and there is a bandwidth coming now this bandwidth can be adjusted in a different way. Let us call there is a noise; first let us take the bandwidth this side. So, there is called C into B by N is equal to Pt Gt Gr by T 1 by 4 pi r by lambda square into 1 by k. This C into B by n, can I rewrite this one in a term I call a Noise Power Density in horizon that this I call it N zero as n by b noise power by the total bandwidth. So, it is what per hertz. Then let us rewrite and let us see how does it look like.

(Refer Slide Time: 26:04)



So, it will look like C by N 0 that is equal to EIRP multiplied by G by T multiplied by 1 by 4 pi R by lambda whole square which is the loss multiplied by 1 by k. I can put it into d these the whole thing is coming out in the hertz in db if I write then it will be in dB terms it is C by N naught it is in dB hertz EIRP it is in dBW plus G by T it is dB bar k and then into 1 by 4 pi r by lambda whole square it is a path loss which is actually in dB and 1 by k which is dB bar k per hertz. So, since the time is up for this period we will continue our discussion in the next period.

Thank you.