Satellite Communication Systems

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Lecture - 25
Ground Segment-4

Welcome back. We were talking about the one of the important parameter of the stations earth station is G by T that defines the receive characteristics. And since there are different types of antenna small to large which is available G by T is the antenna gain G and T is the noise temperature. Measuring this G by T because difficult because you have to put two noise sources at the input of the antenna of the receiver; so how do we do it in case of particular in case of very large station.

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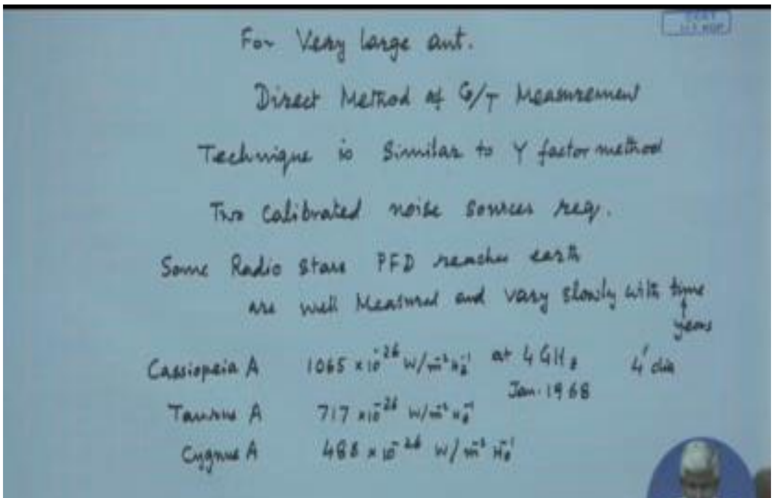

So, for a very large antenna which is of the order 9 meter or even bigger than that direct method of G by T measurements are there and technique is similar to Y factor measurement. So, two calibrated noise source required. How can we get it? Now sky is one of the very important area through towards which this receive antenna is looking. Now we can use the sources in the sky itself, so we can use some radio stars; that mean, some stars or a combination of stars in that particular direction emits radio noise in various frequencies. In our frequency of interest which may be 4 Gigahertz or 12 Gigahertz things like that it emits, we receive on the earth some power flux. And people have done lot of measurements on that our radio astronomy people and those are very helpful to us.

So, it has been found that in some direction in some of the constellations these radio stars are there and this some radio stars their flux density or power flux density reaches earth are well measured and they vary slowly with time, and this time is of the order of years. So, during the measurement it does not vary. Therefore, during the measurement we can assume it is a constant source. And where the radio stars are not there other direction of the sky, of course sun and moon excluded other direction of the sky there is general galactic noise which is coming in which is almost constant. So, we can call it old sky.

So, we find two reference noise sources in the sky; is the radio stars whose directions and locations are well known based on the time, and other than that is cold sky. We exclude of course sun and moon. Some of them I show you some numbers; one is Cassiopeia A it is a radio star. It emits an earth receives 1065 into 10 to the power minus 26 watt per meter square per hertz. And this was at 4 Gigahertz measured in January 1968. And the diameter of this radio star is 4 minutes dia. There is another one which is Taurus A, whose emission is 717 into 10 to the power minus 26 the same unit watt per meter square per hertz. Then similarly another is Cygnus A 488 into 10 to the power minus 26 watt per meter square per hertz.

So, like that many are there we can point to any one of them. So, let us see how the measurement is done.

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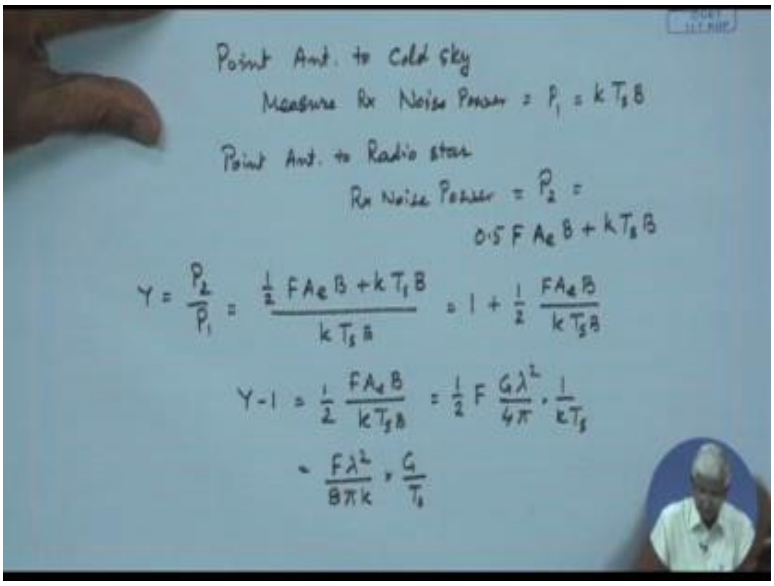

So, point antenna to cold sky that means, the direction on which this radio star is not there. So, measure through the receiver including the antenna the noise power is P 1 is equal k Ts B, this system at temperature which includes the cold sky noise temperature through the antenna. Now then point antenna to reduce star any one of them, then receive noise power P 2 is now 0.5 the flux density the aperture of the antenna and the band width plus its own k T B noise.

So this is P 2, where F is the flux density Ae is the receive receiver antenna effective aperture, and 0.5 is because of the polarization is random; the noise which is coming its polarization is random 50 fifty percent is taken. So, Y factor is P 2 by P 1 is half F Ae B plus k Ts B by k Ts B. This P 2 is this value and P 1 is k Ts B. Now if we interchange this or first we can do this way that is this k Ts B is 1 plus half of F Ae B by k Ts B. So, we call it this way 1 Y minus 1 is half of F Ae B k Ts B. And then B gets canceled so therefore in case of A if I put the now gains of the antenna so it becomes half F G lambda square by 4 pi then 1 by k Ts. You can rearrange and we can say it is F lambda square by 8 pi k into G by Ts. This G is Gr so it is G by T. So, in terms of this it is coming out.

Now that means you can interchange that is we can write fresh.

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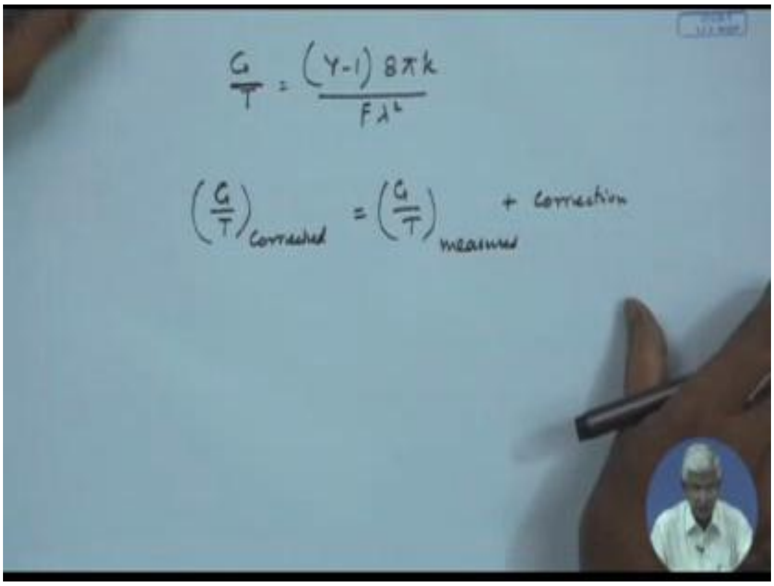

That is G by T is equal to Y minus 1 into 8 pi k by F lambda square. Once we know the clear cold sky power measured through the receiver including receiver antenna and point towards the radio star and measured the power take the ratio of Y. We can calculate that ratio Y, as Y is calculated k is a Boltzmann constant for that particular radio star F is known lambda is the frequency what we use and accordingly we get the G by T.

Now this G by T need certain correction, because if you remember that F we say that 4 Gigahertz it was measured and you may not be measuring this, your earth station main may not be working exactly at 4 Gigahertz it may be slightly away from 4 Gigahertz there has been correction factor based on that. There has to be correction based on the elevation because when you are looking at the radio star which is at much lower elevation angle that other type of noise may come so there has to be some correction.

There has to be some correction based on year to year variation of this flux density F which is coming from the radio star. So, there are lots of corrections which are to be applied which could be in dB and accordingly the G by T which is the corrected value is based on G by T which is measured plus some correction factors. So, this is one method of doing the direct measurement of the G by T using radio star.

Now, there may be some smaller antenna and which can have a larger beam width. Now when you see with a larger beam width the radio star flux density is at one single point and other noises may come in, so it is better to use a different method which is called indirect method. So, for a medium and smaller antenna we use indirect method of calculation.

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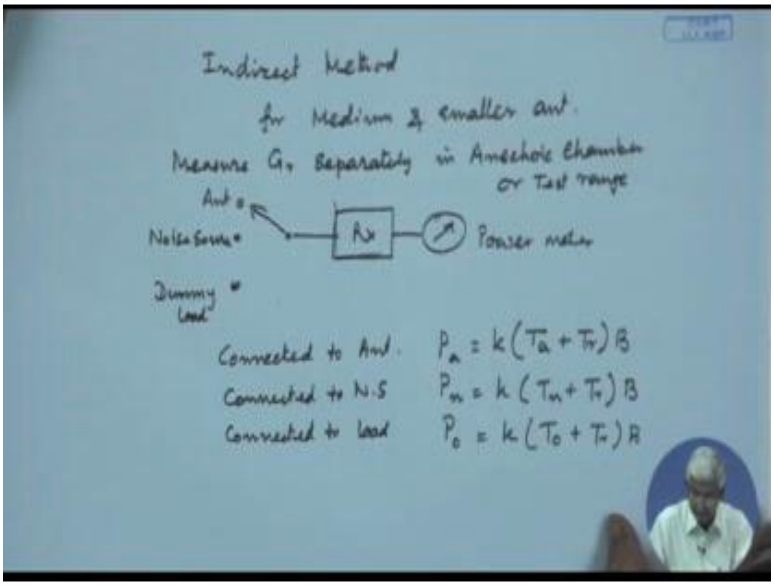

So, this is indirect method for medium and smaller antenna. Here we do it this way; we measure Gr separately in Anechoic Chamber or test range. And then measure T separately, so for separate measurement of T we let us put the receiver whose noise temperature has to be measured and we put three input sources; one is the antenna that particular receiver is antenna, one is a noise source at a higher temperature, and another is a dummy load at normal temperature. So, three measurements are taken on a power meter.

It is a when it connected to the antenna we measure power as Pa which is k into the temperature of the antenna and temperature of the receiver and k T B. So, when it is connected to noise source then Pn is equal to k temperature of the noise source temperature of the receiver and B. And when it is connected to load that is normal temperature we call it P0 is k T0 plus Tr into B.

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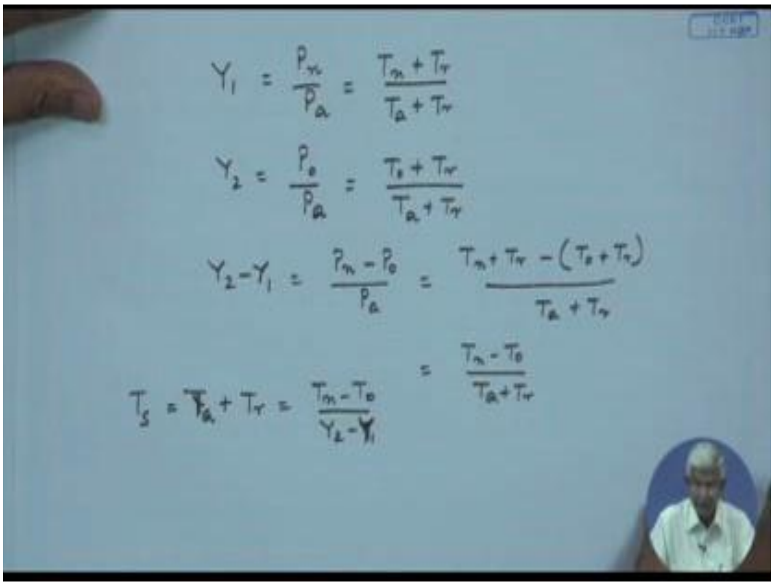

Now, it takes the ratios of this and that we get Y factor Y1 is Pn by Pa which is that k and B get cancels so we have Tn plus Tr by Ta plus Tr. And Y2 we call it P that dummy load by power measured through antenna and then it is T0 plus Tr by Ta plus Tr and you take Y2 minus Y1 which is Pn minus P0 by Pa which is Tn plus Tr minus T0 plus Tr by Ta plus Tr which is equal to Tn minus T0 by Ta plus Tr. Then we can write Ta plus Tr is equal to Tn minus T0 by Y2 minus Y1. Ta plus Tr are is antenna noise temperature and receiver noise temperature so this is nothing but the system noise temperature.

So, the system noise temperature is now Tn minus T0 this is normal temperature and this noise source or which temperature is known which is higher these two are known Y2 and sorry, Y2 and Y1 are already measured power ratios. So, you can find out in this method that Ts G is already measured, so G by T is calculated indirectly.

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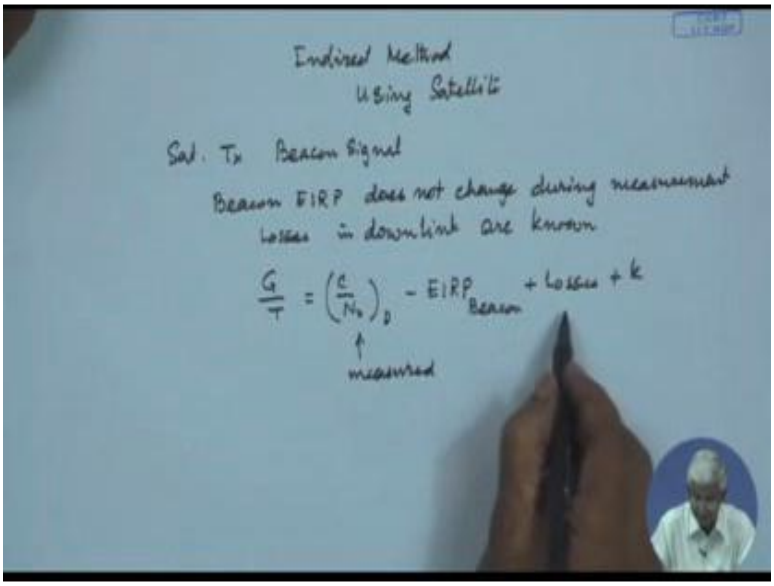

Now, there is another indirect method using satellite itself. The satellite transmits beacon signal that is to track the satellite where is the satellite it is for large antenna point to the satellite there is constant EIRP particular frequency without any modulation it gets transmitted is called Beacon Signal Transmission for that beacon EIRP is very well known and well calibrated it does not change others pointing errors will be there. So, you can use this beacon signal reception as a G by T measurement.

So, it is simply we assume something that is the beacon EIRP does not change during measurement and of course it is known, the value of that is known then the losses in downlink are known. Then the straight equation G by T is C by N naught down minus EIRP of beacon plus losses plus k. If you measure the C by N naught of the downlink this is the measured. And EIRP of the beacon is known losses are known k is a constant so therefore G by T can be found out. So, this is an indirect method using the satellite. Assumption is losses are known and EIRP of the beacon does not vary during the measurement.

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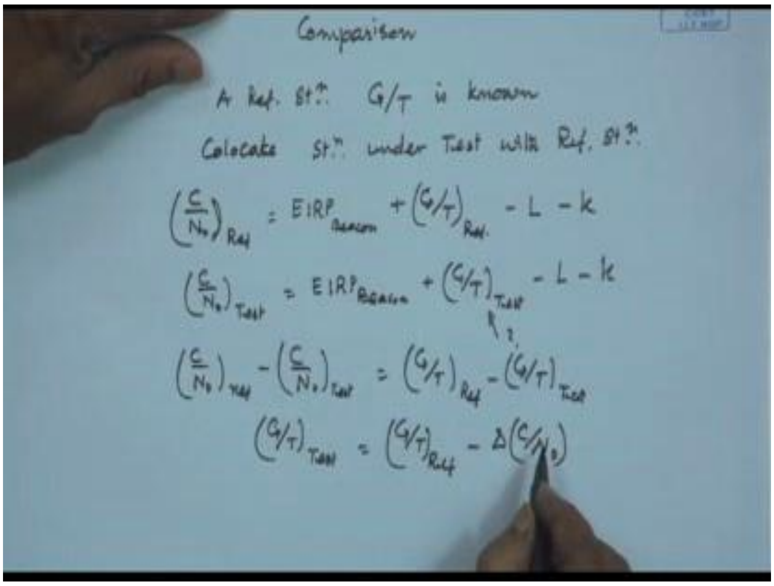

Now, there is a one more method which is called Comparison Method. This is very simple that is this is used for many stations which are small and medium station. A reference station is used with G by T is known, now collocate the station under test with reference station. Since they are collocated their path losses are same and you measure the C by N naught of the beacon. So, the reference station measures C by N naught will be C by N naught reference in the downlink of course is equal to EIRP of the beacon plus G by T of the reference station minus the losses minus k and the C by N naught of the test system is EIRP of beacon plus G by T of the test system minus L minus k, this is unknown. So, C by N naught of the reference station minus C by N naught of the test system is equal to G by T of reference station minus G by T of the test system. These two are measured these delta C by N is measured, so G by T of the test system is equal to G by T of reference minus the delta C by N naught of these two measured value.

So, this is simply by comparison by collocating station you can measure the G by T of a test system. Now the G by T many methods we have talked that is direct method, an indirect method and indirect method two of them from the satellite and using some power meter measurement and also by comparison.

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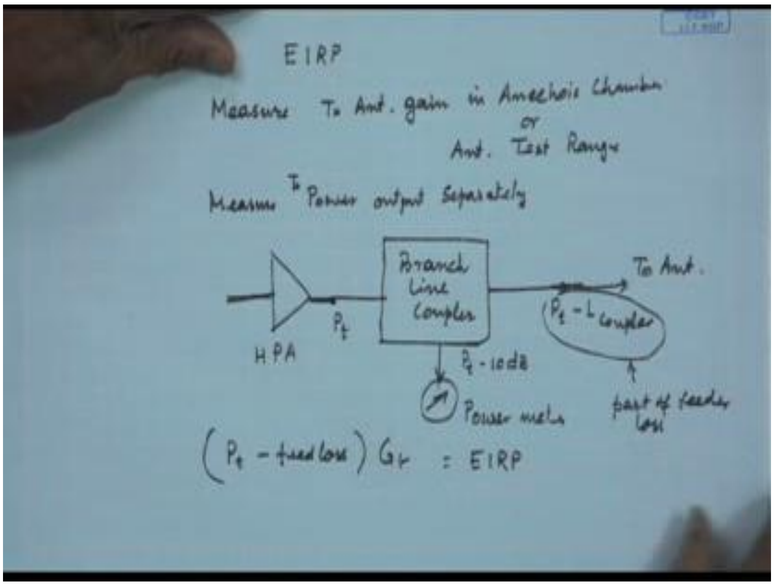

The other important parameter is EIRP. In this case of course we have a certain separate measurement that is; measure transmit antenna gain in Anechoic Chamber or Antenna Test Range. And then measure transmit power output separately multiply these two you will get the EIRP. Now this is the power amplifier or high power amplifier, so this is our Pt now that is passed through a directional coupler or branch line high power coupler. So, couplers does what it keeps a throughput through which directly the power goes and it couples some sampling power out of it that is at certain ratio say, if it is a 10 dB coupler. So, you will get Pt minus 10 dB is 20 dB coupler Pt minus 20 one hundreds of that is taken out and that you put on a power meter.

So, as you go on increasing the power Pt changes. So therefore, a coupled power is measured rest of the power goes out, but simply rest of the power does not go out there is some loss in this, so the power which goes out is Pt minus the coupler loss. So, this is our transmission which is going to the antenna. And in between them may be the wave guide loss which, so there will be a total feeder loss so this part is part of feeder loss. So, now the Pt is known and feeder loss is known, so this multiplied by Gt which is measured gives us the EIRP.

So, that is how we can calculate the pertly measured and partly calculate the EIRP of the system.

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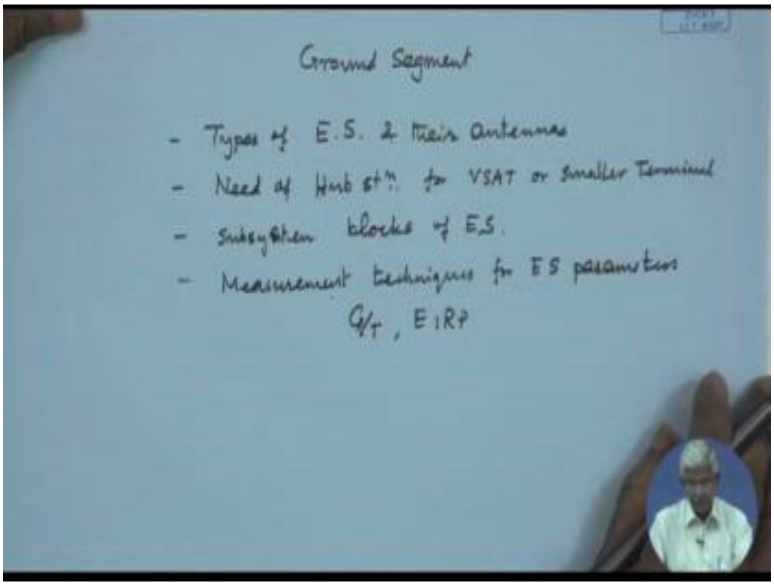

So, with all these things in last couple of classes we have covered the ground segment. And what was covered is the types of earth station, and where antennas. Then the need of Hub station for VSAT or it is true for smaller terminals by that I mean that the mobiles or sat phones also will need Hub station, the need for that we did some calculation. Then we have sub system blocks of earth station and then also we have measurement techniques for station parameters like G by T or EIRP etcetera.

So, the ground segment more or less we have now good idea, we did not go into the detail of the devices used in the ground station these are a common for any type of a transmit receive wireless communication system. But in general for satellite communication what type of ground station and how it is measured, what are the antenna characteristics all those things we have seen, and how the antennas are mounted etcetera.

Thank you very much. We have covered up to ground segment will continue with other topics in next class.