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

Lecture - 23
Ground Segment – 2

Welcome, we were talking about the ground segment and in the ground segment we discussed different types of ground segment and their sizing based on the way they communicate and for type of service they provide and then we came to the different types of antennas that can be used in the ground segment and in that we were last point we were discussing about the ITU Regulation of a ground segment. So, that more number of satellites can be used.

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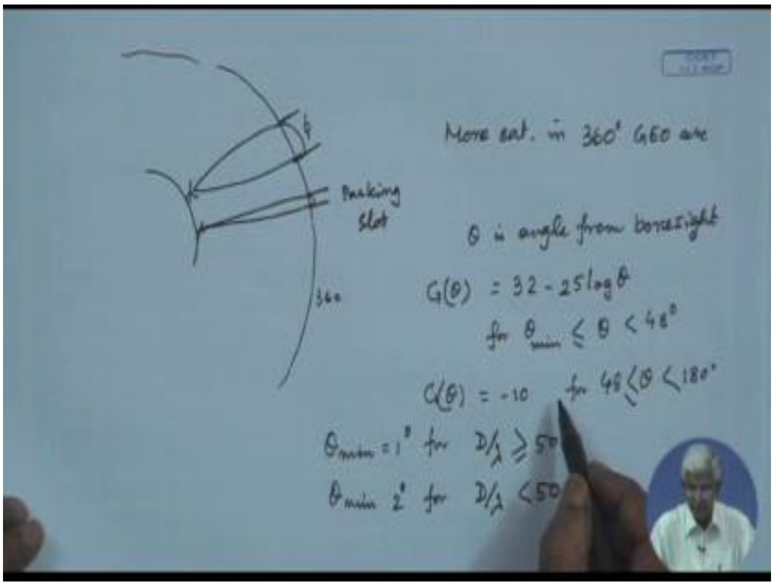

Let me draw the picture again. Let us have this is the earth literacy and this is a this there is a antenna here and this is the geosynchronous arc and if this antenna Beam is this peak this much part of out of the total we have 360 degree geosynchronous arc out of that this much area this a station is occupying I should say can have a satellite on which it is communicating.

If I try to put one more satellite here and if there is working in the same bandwidth they will interfere to each other. Therefore, if I use a smaller Beam I can have a smaller parking slot. What used is parking slot. So, there is certain ITU Regulation that what should be the ground station antenna pattern and they have provided to write the mask you should not exceed that mask. So, that you can have more satellite in 360 degree G E O an arc. I should say arc I am calling arc, it is actually G E O of full or with the 60 degree.

Now, what is that regulation it says that the gain of the antenna that ground station antenna in theta, theta is angle from peak that is bore sight should be thirty 2 minus 25 log of theta for theta minimum theta should be between theta minimum and 48 degree and G theta is equal to minus 10 for theta between 48 degree and 180 degree full.

Now, this is true the theta minimum could be 1 degree for D by lambda of greater than 50 and theta min is 2 degree for D by lambda of less than 50. So, when D by lambda is less than 50; that means, diameter is smaller and Beam is larger. Theta minimum is 2 degree here itself you can understand by it is much larger. So, this is a mask given and internationally all ground operators, who are working on the satellite communication they try to follow this mask otherwise it will start interfering with others.

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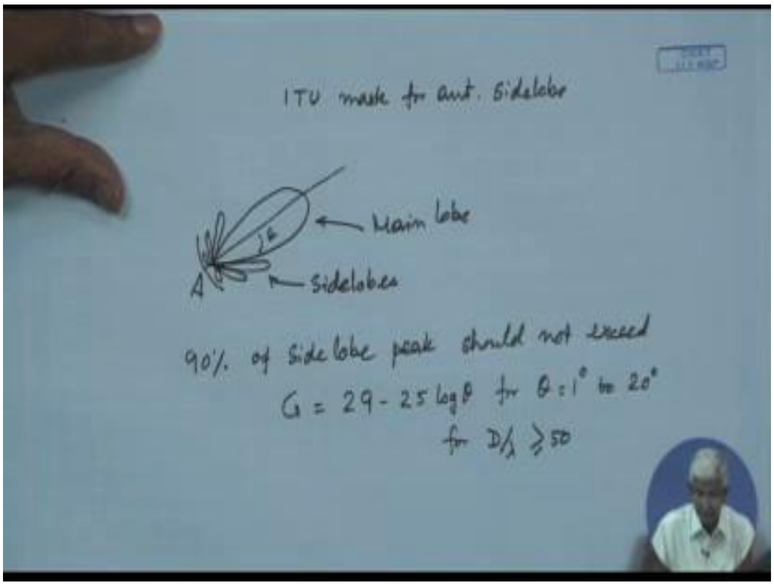

And of course, there are side lobes specification ITU mask for antenna Side lobe I think you remember what is Side lobes and this is the Main lobe and these are Side lobes, smaller peaks. These are Side lobes and this is Main lobe. So, ITU says that Side lobes should be restricted such that 90 percent of Side lobe peak should not exceed this relation g is 29 minus 25 log theta.

For theta equal to 1 degree to 20 degree and for D by lambda of greater than 50 for larger station; theta is angular from the bore sight this is theta. So, these are certain regulatory aspects for large station antennas.

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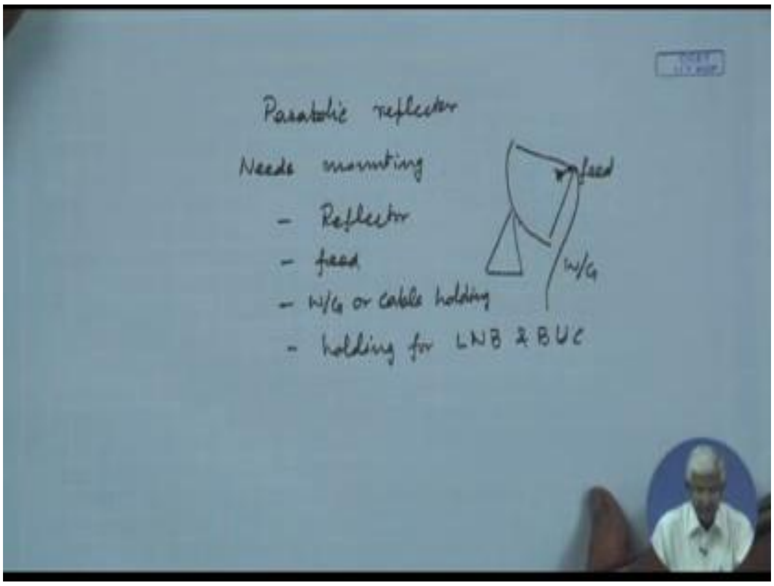

Now, there are different types of mounting the antenna that is the Parabolic Reflector as Needs mounting; that means it has to hold the Reflector this is a Reflector. So, there has to be a at the focus there has to be a Micro Radiators which we called feed, it would be in the form of a horn or dipole of generally horn is used. So, the mount has to hold the Reflector also it has to hold the feed, feed cannot float in the sky. So, feed has to be held and of course, there is a Wave Guide or a Cable run.

So, that is a Wave Guide. So, it has to make some arrangement for holding the Wave Guide or Cable holding and sometimes LNB or BUC will be mounted here. So, that is the holding for LNB and BUC that is Low Noise Block converter or Block Up Converter as we discussed earlier. So, therefore, this mounting arrangement and the radiation which is happening from the feed will interact and let us see different types of mount that is used. I have assume ready diagram for you let say, this is a prime focus mount this one is called prime focus mount here the Reflector is here Parabolic Reflector and at the focal point we have a feed horn and feed horn has radiation pattern like this some of the main Beam of the radiation pattern is captured by the Reflector and then it is transmitting back, if it is ideal case then you go in parallel line, but in reality it will start forming.

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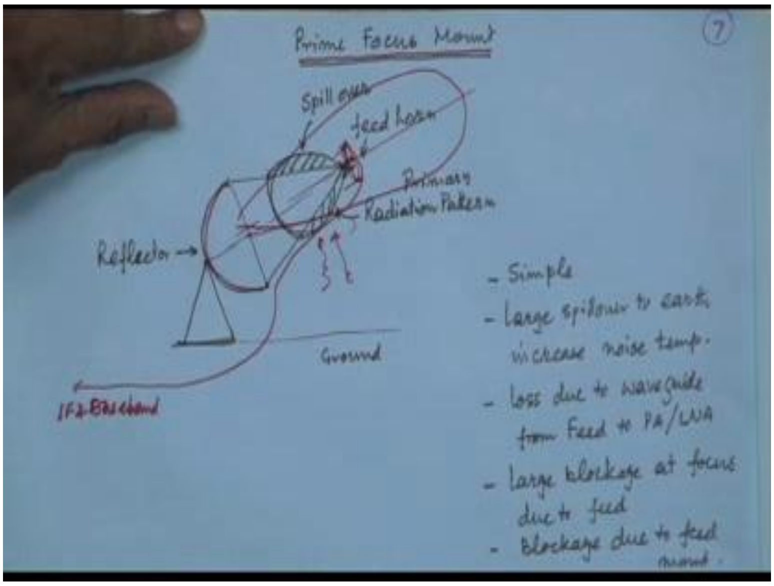

So, a Beam will be like this. This is a secondary pattern it may have some side lobes and (Refer Time: 8:21) all things now this primary pattern will have certain spill over which is from the ground it will pick up noise and full energy is not falling over this. So, shaping this is very important. Now these type of Reflector with a prime focus is very easy very simple, you hold the parabola and from the parabolic edge you put some studs they are you mount the feed along with that you can put a put a block converter block of converter LNB etcetera and then run a cable along with this to your set up box or whatever a that is the IF and Baseband unit.

Now, one problem in this is that it picks up noise from the ground. So, G by T would be poor and the second is there is a lose due to the Wave Guide run if you put the RF unit later or if you put the RF units here then it will give a larger blockage. Now generally the antenna efficiency these type of antenna is of the order of less than 60 percent approximately people take less than 60 percent is the efficiency. Efficiency of this antenna is of the order of less than 60 percent or sometimes 60 percent (Refer Time: 9:56).

This is very commonly use thing and in fact, receive only you might have observe these things, you have seen the cable operator hidden the from the building or from the roof top where the cable operators receive the satellite signal and then transmits through the cable our TV cable operator. So, there you will see a lot of this prime focused and simple type of mini antennas they are which looking at different satellites and then they are picking up the TV signals which broadcast by those satellites and then multiplexing and selling through the cable. So, this is one of the common place where you can see this is very common, but then we have these blockage coming into picture that is why people use another type of antenna which is called Offset fed antenna it is called Offset fed Mount to reduce the blockage of the feed assembly they use the Offset fed Mount.

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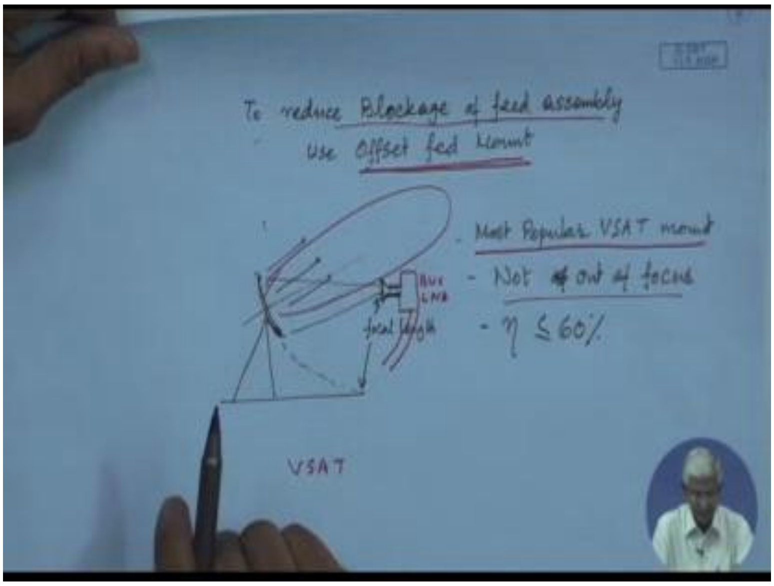

Hence as if there is a total Reflector is there, but only a small portion of the Reflector material is used rest are the things removed another focal point the feed is turned towards the metal part of the Reflector which is kept. Rest of the things is not there. So, feed is not of out of focus it is not out of focus it is Offset it was suppose to look in this direction we moved it a little. So, it is Offset the advantage is in this path where the main Beam of the Reflector is coming out secondary Beam the feed is not coming back and along with that feed if you will use the BUC or LNB they that blockage is not happening here. So, to reduce this blockage of feed assembly these type of Offset fed antenna is used is of the order of 60 percent efficiency you can get, but it is most popular as a VSAT mount. You can as I always tell you that you can go and see near their bank ATM's many of the bank ATM's they have this VSAT antenna and it is a Offset feed Mount you will find that from the feed assembly you will find two cables are coming out; one for the uplink one for the down link.

So, it's very interesting you should always look at the how people really use the satellite communication terminals. So, this antenna is the most visible part of it since large antennas are there now these are the of the order of 1 meter to 1.5 meter sometimes 2 meter 2.5 meter antennas are also there. So, this is another type for much larger antenna and where you need to improve the efficiency.

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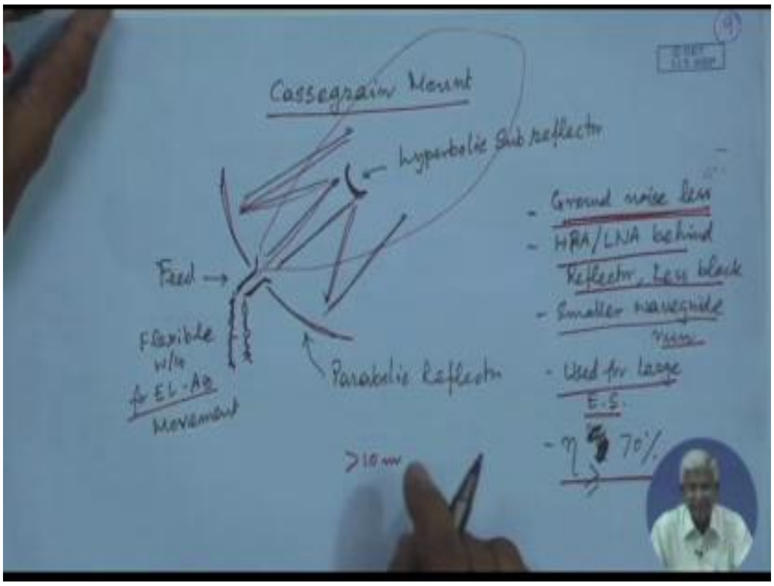

This Cassegrain Mount is used Cassegrain Mount you can see trying to draw, this is the Reflector and then the primary feed horn is a hole made at the center of the Reflector and it is there. So, how do I reach the focus from here the radiation takes place and then there is a secondary parabolic sub reflector is there. So, from here the energy goes up for radiating out from Feed it goes up gets from the sub reflected it gets reflected comes to the primary Reflector and from the Reflector it goes out.

So, this is the path it takes, then it is Beam is like this now one big advantage on this is that you can mount your LNB, HPA, LNA all these things behind the Reflector and since the secondary Reflector as well as the primary feed both are looking towards the sky the ground noise pick up is less from the ground noise it is not falling into the Beam of this as well as not in this Beam. So, the ground noise level is lesser the g by t can be controlled and of course, the there is a very small Wave Guide line because you can mount, one difficulty is there that is in case by chance if this these antenna has been move to another satellite to look at the another satellite or it has to track some satellite your Azimuth Elevation has to be moved you have to move Azimuth and Alevation and then fixed Wave Guide will not work in that case you have to use a flexible Wave Guide along with an flexible Wave Guide will introduce some loss.

So, this is one of the drawbacks in this system, but generally these are used for larger station and it is efficiency is 70 percent or sometimes larger than that. This is a for 9 meter 10 meter antenna the Cassegrain Reflector or larger is greater than 10 meter antenna in general I can say they use the Cassegrain mounting of the antenna. But then this turning of Elevation an Azimuth since that create a problem you make a 360 degree or 180 degree turn and then all the this Wave Guide is fully twisted it creates a problem .

So, therefore, people have come with innovative solution what are the solution is like this.

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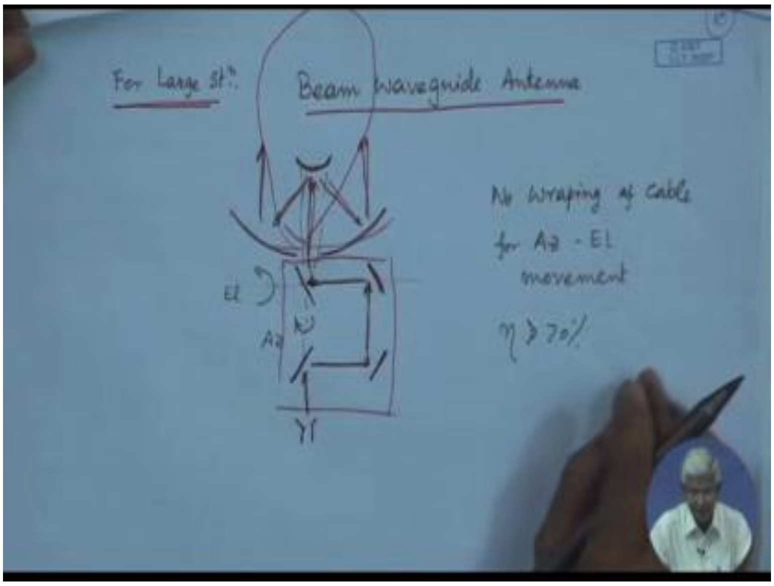

That is for very large station they use Beam Wave Guide Antenna. I am trying to sketch it, that is this is the Parabolic Reflector and this is the Secondary Hyperbolic Reflector and my Feed horn is here and there are small Reflectors flat Reflectors are there. So, the power goes from here gets reflected from here to there and then these goes to another pair of small sub Reflectors goes like this like this and then it goes out through this hole. at the center of the primary Reflector goes to the secondary Reflector and like this it goes out.

So, our final Beam is like this. Now the advantage is since there is no Wave Guide here you can turn the Azimuth Elevation axis like this. So, the antenna will go will up and down like this and Azimuth can be on this axis. So, this set of 2 pairs of Reflectors is combination avoids us of having a flexible Wave Guide which is a losing Wave Guide. This is a very big advantage when one very large station in some of the cases people uses Beam Wave Guide Antenna. So, like that there are many many innovations on the antenna I will try to give you a glimpse of this antenna system.

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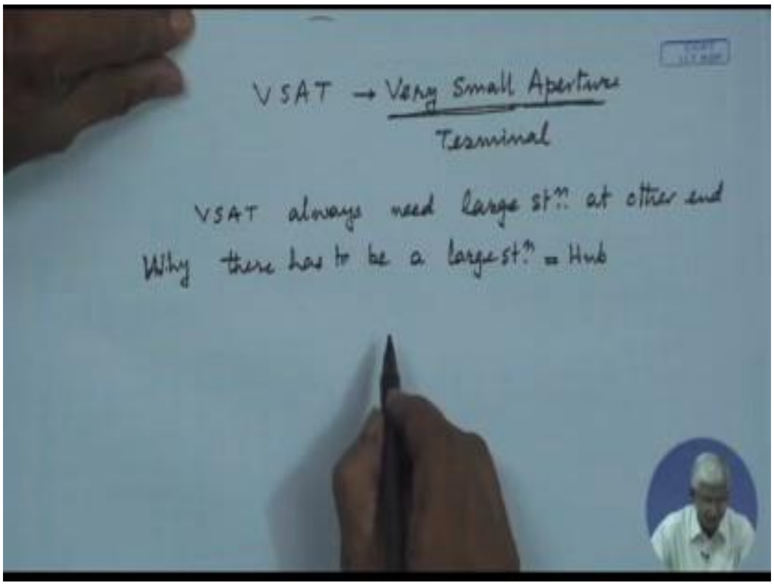

Now, one of the basic issues will is go back this is that we said that there are VSAT's. VSAT is called in Very Small Aperture Terminal. Of course, this what Very Small came in the year 1980 I should say earlier than that in satellite communication people were using antenna of the size of the order of a 7 meter 9 meter the smallest one was of that of 4.5 meter also. So, when people started talking about 1 meter antenna 1.5 meter Antenna; obviously, it was called Very Small Aperture Antenna. Aperture it was smaller diameter of the antenna is Very Small.

Now, it has big advantage, the advantage is it is easily handle able you can mount it on a roof top it does not have much weight you can mount it on a lone. So, why not a VSAT can communicate with another VSAT, I mean it has been seeing that VSATs are not communicating directly with another VSAT. Let us see, that is VSAT always need a large station at other end, it means why that there has to be a large station or it is which is Hub we call.

The term Hub will see why it is call Hub, but why they are has to be a larger station now to understand these let us do some small calculation I think for this part, I will give you some familiarity of doing the calculation what we have to done in our c by n calculation earlier we will go through a quick calculation and try to see how much power is required how much power amplifier ratings are required for a VSAT. If a VSAT has to directly communicate with another VSAT you should keep your calculator ready and I will try to show you some calculations you must verify these calculations and do it yourself.

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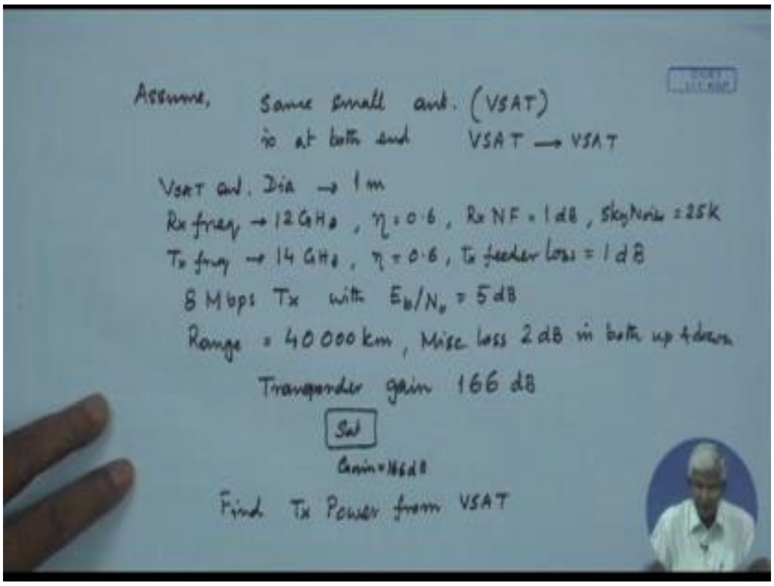

So, let us start with a some assumptions of numbers assume that Same Small antenna that is for the VSAT is at both end that is VSAT to VSAT communication directly (Refer Time: 20:45) satellite of course, and we will estimate the power amplifier requirement let us assume some numbers VSAT antenna Dia for both side let us take easy numbers 1 meter then frequency the let us call Received frequency is 12 Giga hertz from the satellite and the antenna efficiency is 60 percent, receiver Noise Figure is 1 d B, sky noise or antenna noise is 25 K that transmit frequency that is from earth to satellite is fourteen Giga hertz higher. F or the timing we keep transmit and received both antenna efficiency same and then there is a Transmit feeder loss of 1 d B.

Let us say the bit rate of transmission is 8 Mbps transmission with E b by N 0 of with error correction it is 5 d B that is with error correction for a particular d e r. Range from VSAT to satellite and back is 40000 kilo meter both for the transmit side and the receive side. That is 1 VSAT is communicated with another VSAT for both side is roughly about 40000 kilo meter and Miscellaneous loss which may be due to d pointing due to atmosphere many other losses that may come is loss is 2 dB in both up and down and for easy calculation will take Transponder or we should say satellite including the antenna ever thing Transponder block gain is let us take their number 166 dB this when I say transponder gain it is as it is the block the satellite block is gain is 166 d B that includes the gain of the satellite antennas also. So, with this number if we try to calculate what is the power requirement from the find Transmit P over from VSAT Transmit Power Amplifier output let us say.

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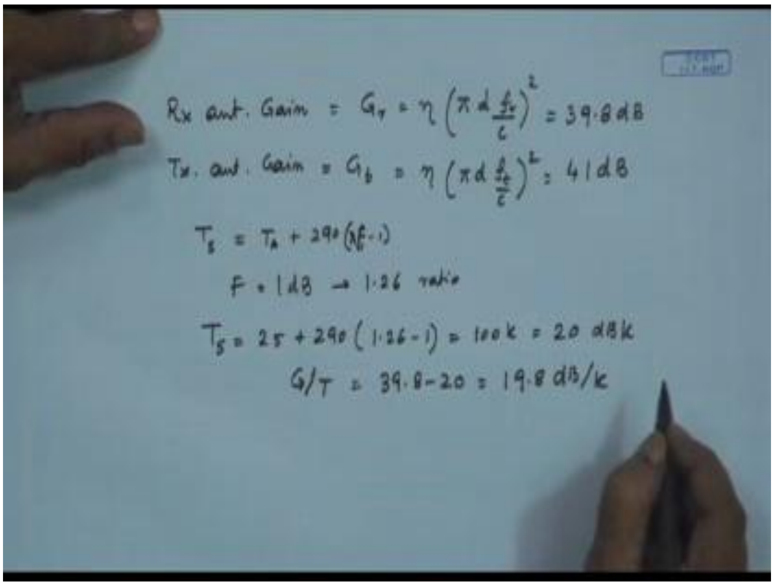

Let us do this calculation slowly. Now let us, say Receive antenna gain you have to calculate G by T. So, for that Received antenna gain will G r is efficiency time pi diameter of the antenna lambda is written in f by c whole 2 and if you put 0.6 here these 1 meter this is received. So, it is 12 Giga hertz f c is the velocity of light or electromotive wave in this case, 10 to the power of 8 you can take and with this remember all this was given in kilo meter. So, this if you calculate it will come to about approximately 39.8 d B.

Similarly, you can calculate the Transmit antenna gain which is G t similar thing only the frequency changes, this is frequency received then this is frequency transmit eta is same diameter is same. So, only frequency changes you will find a number like 41 d B and if you calculate the transmit sorry received system noise temperature which is the sky noise or antenna noise plus 290 that is F minus one F should be I should say n F, if you get in ratio. So, 1 d B has to be converted you will get 1.26 in ratio F is equal to one d B if you remember. So, T s will come out to be 25 plus 29 1.26 minus 1 which is about hundred k which is 20 d B k. So, G by T is received antenna gain 39.8 minus 20 is coming out to be 19.8 d B. d B per Kelvin. Since time is going up.

So, we will continue this discussion in the next period for the time being. Thank you very much, but do this calculation with your calculator we will continue with it.