Satellite Communication Systems
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Lecture – 27
Multiple Access-2

Welcome back, we were discussing different types of Multiple Access, out of that we started with the frequency division multiple access FDMA and we were trying to estimate, first we try to understand what is FDMA? Very simple way and then we try to estimate again with lot of assumption and make it very simple. How do we calculate the number of carriers that can be supported by a FDMA technique in a transponder? So, you are going step by step.

So, first we have covered in terms of power when we considered when we considered total power of the satellite transponder and individual power the ratio of that are in the be the difference of that would be in terms of power how many carriers can be support. Similarly, it can be done in terms of bandwidth we are discussing that point.

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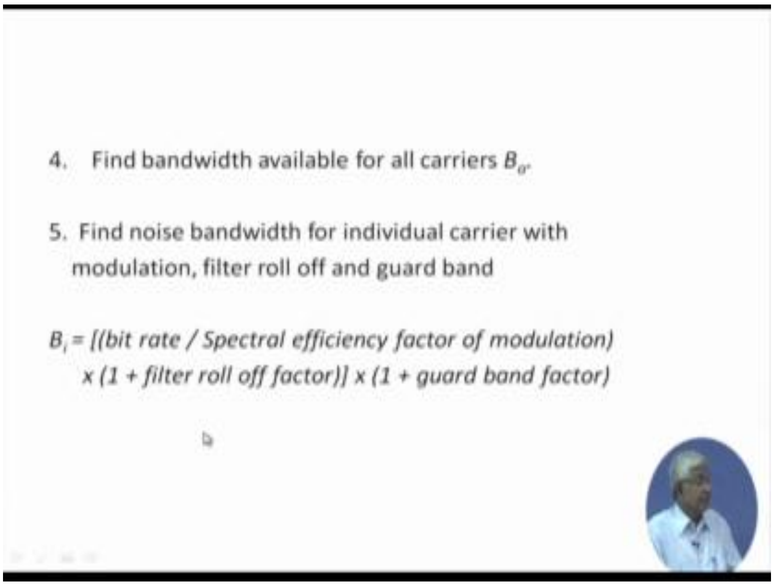

So, let us go back to that slide and this slide, if you recollect it shows that find the bandwidth available for the all carriers that is the, if it is total transponder full bandwidth have transponder noise bandwidth of individual carrier what is noise bandwidth of individual carrier depends on modulation that is the bit rate defined by the spectral efficiency in case of b p s k. It would be saying b p s k is a half that is divided by 2. So, like that different type of m s k at that a number will appear and then, you have once the modulation is done there is a filter a based on the filter roll of factor in the band with will be expanded and then between the 2 carriers, there are certain guard frequency is given that guard band factor is taking and the individual carrier bandwidth is taking.

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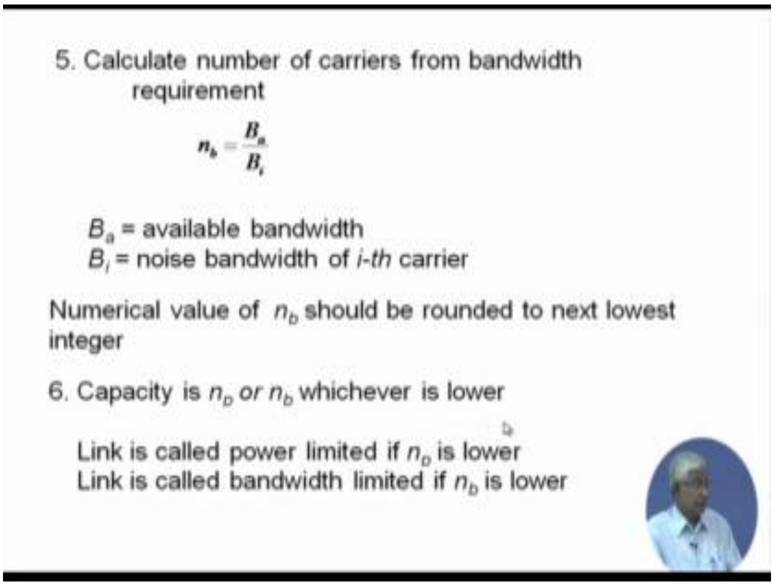

So, calculate the number of carrier from bandwidth requirement we have b a and b i calculated it is ratio or in terms of log you can put it log way also and width available bandwidth noise bandwidth is 1 citizen ratio. You can take citizen ratio if, we are b a and b i r n log term in the b term then, it would be b a minus b i in log and n b also will come in log term conferred back in ratio.

So, the numerical value of n b should be rounded to the next lower integer as i explained last time that a it will give this calculation will give is the maximum limit theoretical limit that may come out as a fractional of number of transponder which is not possible. So, the possibility will lower one and we as you will get some advantage the other way now you have calculating in terms of bandwidth the number of carriers that can be supported in case of in terms of power how many can be support that n p and n b, now a particular transponder it gives together that total bandwidth and total power that can be supported. Now; that means, whichever number is lower you have to take the whichever is higher you cannot take because this, if you do in terms of bandwidth it is coming must larger and you say that is the carriers will support. So, if you put that many carriers in terms of power you refined it is exceeding EIRP at the other way it is also true. So, therefore, the lower one has be used the capacity would be lower of n p and n b; that means, both have to be calculated.

Now, when it is limited whichever is lower if the n b is limited is a term it is called power limited transponder of power limited case. In case of bandwidth is lower bandwidth number of transfo a numbers carriers that can be supported in terms of bandwidth is lower. So, it is bandwidth limited whichever is limiting whichever is lower it is called that way. So, is bandwidth limited case of power limited case you have to take any way? Whichever is lower some time we will try to balance way because the transponders are sold or rented in terms of power interview than with how much is taking by the user both power and bandwidth. So, therefore, people try to balance it. So, that maximum advantage can be taken with best thing is to try a very simple type of calculation.

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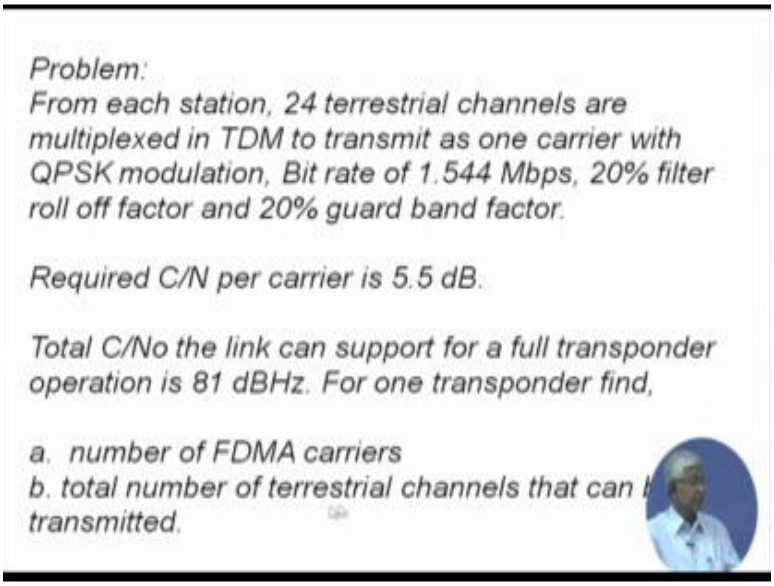

And then, we will see what really happens solve the calculation next take a quick calculation we lot of assumptions at this very simple calculation there is a each station is having multiplex 24 terrestrial channel forget about terrestrial part 24 channels had coming and a t station it is put in TDM and then, it is transmitted as a one carrier multiple channel and going as a one carrier and such many carriers are there. So, its multiple channel multiple carrier case. So, it transmit as one carrier and the modulation is QPSK modulation you have to remember expected efficiency of QPSK and bit rate multiplex bit rate is 1.544 mega bits per second filter roll off factor is 20 percent of whatever bandwidth you get out of these bit rate and modulation.

And then over and above that there is 20 percent guard band factor. So, how do you calculate of course, there are other things given there is c by n per carrier is 5.5 dB, you see here, what is not given is what is a total c by n n or c by n naught supported by the transponder, its power carrier given here total c by n naught the link can support. Now it is given for full transponder is 81dB hertz. So, for 1 transponder you try to find out number of FDMA carriers that can be supported by transponder and the number of channels terrestrial channels in the whole network, how many terrestrial channel that can be transmitted. So, we as remember this total c by n naught is given individual c by n naught is not given we have to work out that individual bandwidth is also not given. So, let us see how we proceed.

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B_i = 10 log [$(1.544\times10^6 / 2)\times(1+0.2)$] x [1+0.2]
=10log(1.112 MHz) = 60.46 dBHz

No = N/B, C/No = (C/N)xB, or C/No= C/N + B in dB

$(C/N_0)_i = (C/N)_i + B_i$ = 5.5 + 60.46 = 65.96 dBHz

Number of carriers in the transponder
= $[(C/No)_t - (C/No)_i]$
= 81- 65.96 = 15.04 dB = 31.91~ 31 carriers

Number of channels in full transponder
= no. of TDM channels per carrier x number of carriers
= 24 x 31 = 744 channels

So, individual band rate per carrier is in dB form is 10 log of bit rate 1.54 4 mega bit and because of QPSK it is 1 by 2 multiplied by roll off factor which was 20 percent 0.2. So, 1.2 and then whole thing is multiplied by again guard band factor which is 20 percent 1.2. So, that comes out to be 60.46 dB hertz in this bandwidth. So, and it is in d b. So, it is dB hertz it is just approximate you can be your country you get this like different number depending on here how am do the calculation. So, one thing you try to recollect that noise power density is noise power divide by the bandwidth. So, n naught is n by b, c by n naught is c by n into b there is n by the denominated n by b or you can say c by n into b which is c by n naught is c by n plus b in dB this is in part of dB these part is in in the ratio. So, c by n naught ith carrier each individual carrier all carriers are same each individual carrier is c by n i plus the bandwidth i the c by n i is given.

If you remember c by n as given as 5.5d b and bandwidth you have calculated. So, c by n naught of individual carrier we have calculated as 65.96 dB hertz. So, therefore, the number of carriers, now we have total c by n naught is specified and individual c by n naught we have get we have got. So, in dB it is attracted and we get a number like 15.04 dB which converting to ratio we get it 31.91 carriers which is maximum that is possible because it based on total c by n naught that is available. So, that n 0.91 is a maximum as possible we cannot make it 32 because, that will violet the total c by n naught. So, you have to transmit 31 carriers.

So, you will have some extra bandwidth is available that is the advantage again, if you do the calculation your efficiency will be different and it may be that extra carriers space, what you get 0.91 can be distributed in terms of guard band or in terms of slight lose filters. Whichever be, but here is 31 carrier is maximum possible in this particular case just take one more case number of channels, we forward one point that is one more question was there number of channels in full transponder. So, there is number of t d m channel per carrier multiplied by the total number of carrier. So, that was 24 channel per carrier and 31 carriers. So, in these transponder total 744 channels transmissions are possible.

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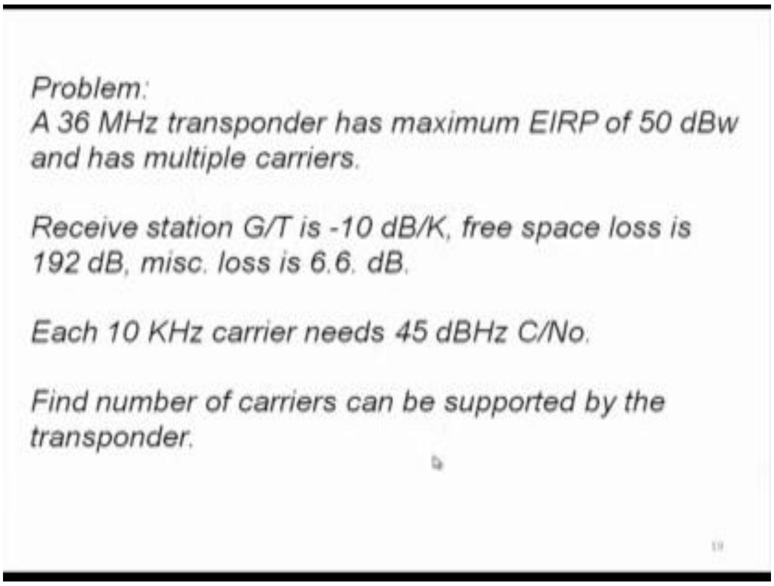

Now, lets take a another problem in terms of yeah that was on in terms of c by n. So, it is a 36 megahertz transponder that has maximum EIRP of 50 dB w last time it was given sixth c by n naught 81 dB hertz. So, it has multiple carriers and here our information given is receive station g by t is minus 10 dB per k just do not take this number as it is then, do not do the calculation think a little g by t is negative. So, gain is very low gain is very low normally this term negative g by t stations are very, very small station gain is very low most probably we say portable station or satellite phone type of the always look at the number and try to interpret how why this number is happily. So, we free space loss is one ninety 2 dB and at 40000 kilo meter if you. So, and that rough back calculation you will find the this probably it is in lower frequency where not at when, not at twelve gigahertz it is much, much lower at twelve gigahertz it comes out to be 205 200 205 207 dB depending on len arrange.

So, these much lower this probably at its band. So, try to mentally interpret the number which may not be useful for this particular problem, but you will know you will enjoy this then they will miscellaneous loss 6.6 you can see from the miscellaneous loss larger ha, therefore so, it most probably it is the portable or mobile scenario of the station because in that case pointing loss and many other loss will come into picture miscellaneous loss is loss is any forget about that go back to our calculation there is each 10 kilo hertz carrier needs 45 dB hertz c by n naught the carriers bandwidth is very small. Obviously, it is definitely not a video transmission is voice or data transmission which 10 kilo hertz carrier needs 45 dB hertz. So, the bandwidth of the carriers is given and then c by n naught of individual carrier is given ok.

Find the number carriers that can be supported by the transponder this is the individual carrier and the receive sight is given fully. So, you can find out the transmit for carrier and the total EIRP is given and of course, bandwidth is also given this is the noise bandwidth in kilo hertz and total bandwidth is given. So, you can do it in terms of power and in terms of bandwidth and then find out whichever is lower which is that type of problem.

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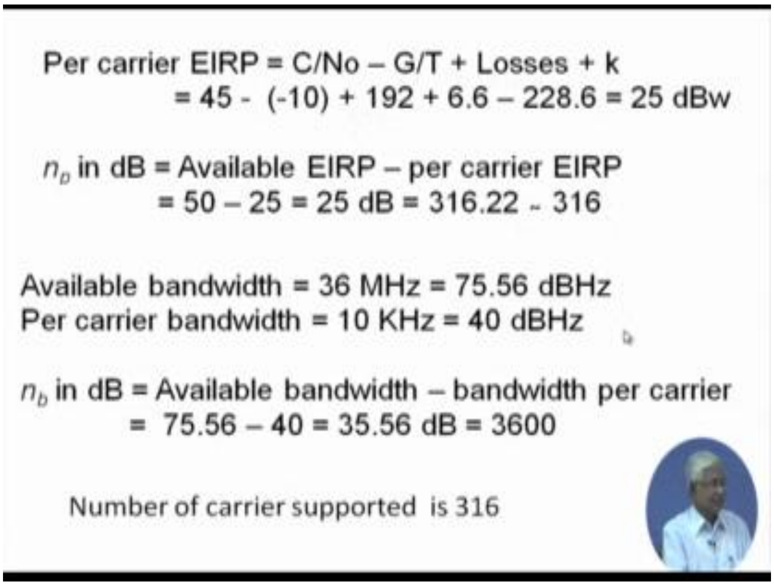

Lets look at it. So, per carrier EIRP is c by n naught minus g by t plus losses plus k that mean same transmission equations is written in a different way in terms of EIRP or carrier EIRP from the satellite EIRP. So, that is where put the numbers from the problem and you will get 25 dB w the k value in dB, if you remember it is minus 228.6 this is all we have to always remember constitute. So, 25 dB w is per carrier EIRP and total was 50. So, n p is available EIRP minus per carrier p n d b. So, its 50 minus 25; 25 dB again you get a fraction 316.2, 2 carriers from the n p that is from the power point of you. So, you take the lower one otherwise you at a it the available EIRP. So, you will be working with 3, 300 and 16 carriers. Now this is power wise there is look at it from bandwidth wise.

It is very easy because individual auctorial bandwidth is already told 36 megahertz you can be convert into dB hertz and individual part carrier bandwidth is given 10 kilo hertz 40 dB hertz. You can do it in dB hertz and subtract and come back to the number or you can say it very right 36 megahertz by 10 kilo hertz which is available in number whichever very easy for you. So, n b is in dB available and here it is done in dB and we got a number three six zero; obviously, 36 megahertz divided by 10 kilo hertz is 3600.

So, n b bandwidth wise i get there a possibility of put 3600 carriers where as power wise it is possible to put only 316 carriers somebody can argue to i am getting this one is higher. So, i we should use this now just from bandwidth wise we definitely support because 10 kilo hertz is a bandwidth. But if 3600 carriers are put in the transponder each carrier is 25 dB w and convert this 3600 into into dB form and add these 2 and you will get exceed the available EIRP 50. So, your requirement will be more than 50 which the transponder cannot support. So, this example shows that definitely the sheft a lower one otherwise you getting into problem. So, here out of these 2 the layer one is m p 316. So, therefore, it is power limited case number of carriers supported is 316 and it is based on the power calculations. So, it is a power limited case is not a bandwidth limited case right.

So, to improve include you have to improve the individual carrier EIRP that can be improved by various ways either you select a transfer which has more EIRP or you improve the in terms of losses or improve in terms of g by t losses are natural thing. So, its better to improve by g by t we will see this type of problem of system designed later. So, this is one example.

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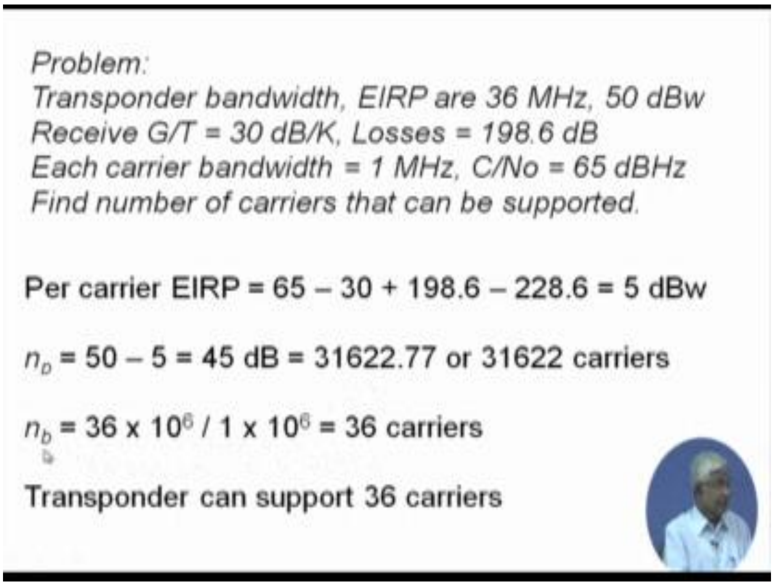

Another example; let us say transponder bandwidth EIRP is that 36 megahertz its 50 dB w EIRP and bandwidth is 36 megahertz receive g by t is thirty dB per k receive means is it ground station d by t losses one ninety eight point six now see earlier example it was minus 10 dB per k here it is thirty dB per k receive gain is very large is very large station; obviously, you have individual EIRP much less, but we have increase a bandwidth one megahertz is your 10 kilo hertz and total c by n is sixty five dB hertz and its not total that is individual requirement because its one megahertz here c by n c contains bit rate. So, sixty five dB hertz is a each carrier bandwidth each carrier c by n naught required.

So, number of carriers see a numbers of changed. So, per carrier EIRP is you can put into that transmission equation you will find it is five dB w and total is 50 dB w. So, therefore, forty five dB w dB in terms of number is available which is very large number infraction you take the lower integer. So, it is 31thousand six 20 2 carriers. So, since our g by t is higher your n p has become very good very large where as in terms of bandwidth you have 36 megahertz and one megahertz part carrier. So, ratio of that is only 36 carriers. So, here also the other way that is bandwidth limited because n b is limiting the case. So, it is a bandwidth limited transponder can support 36 carriers.

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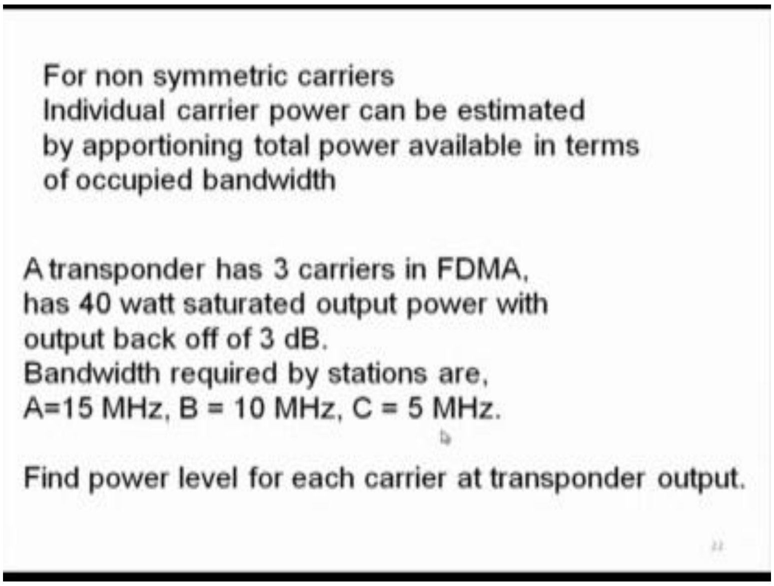

So, non symmetric carriers individual carrier power can be estimated the solve a basic assumption was all symmetric, but non symmetric also you have to submit up by apportioning total power available in terms of occupied bandwidth you have to some submit up in terms of power and bandwidth.

Ah this one small example i will go through quickly that is a transponder has three carriers in FDMA has 40 watts saturated output power with output back off of 3 dB you can see. So, you are actual available power is 40 minus 3. Now bandwidth required by each stations are fifteen megahertz now different bandwidth 10 megahertz, 5 megahertz a b c, find the power level for each carrier at the transponder output. So, a i p part carrier each carrier would be different because the sizings are different.

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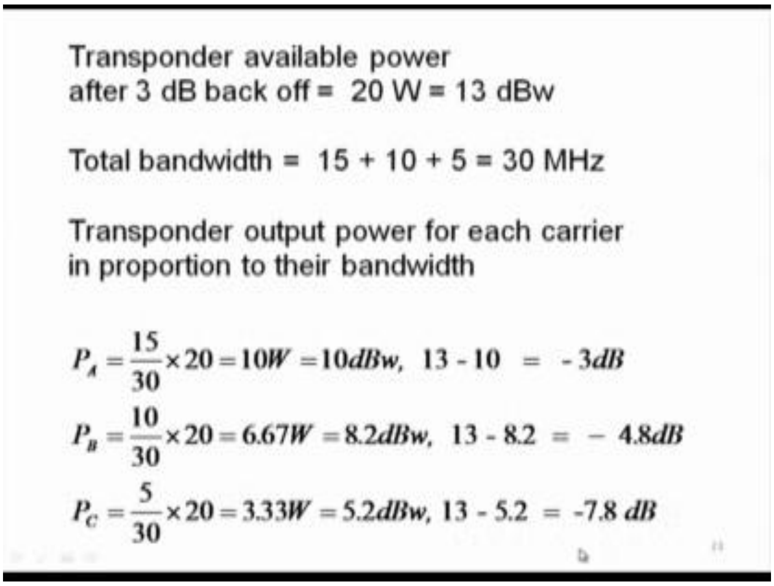

So, how do you do transponder total available power with 3 dB back off is three dB is half power. So, 40 watt divided by 20 watt in terms of dB w is thirteen dB w total bandwidth that is required each individual station its different bandwidth. So, total bandwidth is required is thirteen megahertz transponder output power. So, you can apportion in terms of bandwidth is 15 this is station a 14 megahertz is required out of 13 megahertz and total 20 watt this power is available.

So, the power should be allotted 15 by 30 is half? So, powers would be only 10 watt which is 10 dB w and in terms of dB you can get 13 minus 10 is minus three dB is taking by the by the station a at the at the at that transponder. Similarly for station b there again bandwidth ratio is over 10 by 30; one-third of 20 watt. So, 6.6 watt and 8.2 dB w is required and this is the apportionment in types of dB and section c takes a 5 by 30 because, is a 5 megahertz bandwidth. So, it it takes less power 3.33 watt which is in terms of dB w 5.2 dB w and this is the apportionment.

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For previous problem, if satellite gain is 105 dB
Find input powers to satellite for each carrier

$$P_{inA} = 10 - 105 = -95 \ dBw$$
$$P_{inB} = 8.2 - 105 = -96.8 \ dBw$$
$$P_{inC} = 5.2 - 105 = -99.8 \ dBw$$

Now, if the satellite gain is hundred and five dB then, input power to the satellite based on that those apportionment how much power it is transmitted out power carrier from station a and the gain you subtract. So, input to the satellite from station a is minus 95 dB w you simply subtract the game of the satellite. So, each carrier now what is the input to the satellite coming from that particular station that is listed here.

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For the previous case,
If 20 W transponder output can be achieved
By transmitting 250 W from a station
Find EIRP of each station.

$$250 \ W = 24 \ dBw$$
$$EIRP_A = 24 - 3 = 21 dBW = 125 \ Watt$$
$$EIRP_B = 24 - 4.8 = 19.2 dBW = 83.3 \ Watt$$
$$EIRP_C = 24 - 7.8 = 16.2 dBW = 41.6 Watt$$

And then if, the 20 watt transponder output can be achieved by transmitting 250 watt from a station another way without knowing the loss. If you can know that how do i saturate the transponder here it is not saturating with back off. So, if a 250 watt transmission can generate 20 watt output find the EIRP. So, here in the apportionment of the 250 watt is 24 dB w. So, 24d b w minus 3 that is 21 dB w is 125 watt from station a 83 watt point point 3 watt is station b station c 41.6 watt then, these are another way of calculation which is simply by apportionment of power and bandwidth.

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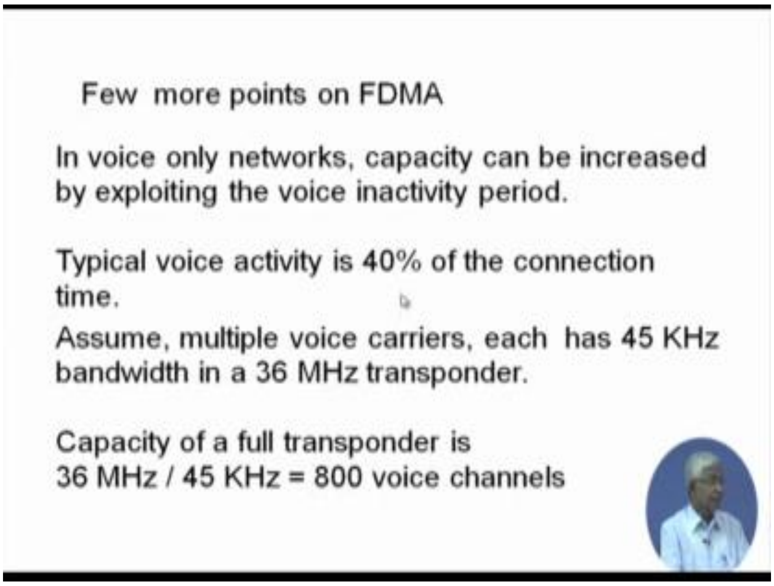

Now, lets get into some more some more issues on FDMA. If you try to take advantage of that when, we talk about voice it is not continuous. So, that non continuity, non use of the channel by voice that can be utilize you have seen that FDMA is most efficient when continuous traffic is there. So, there is non continuous traffic that you can you can know i hope you are aware of this that voice is inactive many many time when i am speaking to you between sentences i put a pause between 2 words i put pause.

So, there is lot of inactivity. So, a complete channel given to me for this transmission there are lot of time, i am not using for a long time. If it is observed people have seen that is the forty percent time is not used. So, voice activity sorry voice activity is 40 percent, 60 percent time is not used that it is that say statistical estimate people have done many such. So, if there is multiple voice carriers and each has 45 kilo hertz bandwidth in 36 megahertz. So, just ratio of these 2 that many voice carriers can be supported which is nothing, but 836 megahertz by 45 kilo hertz is 800 voice channel can be support, but always these 800 voice channel are not busy only forty percent of that is busy.

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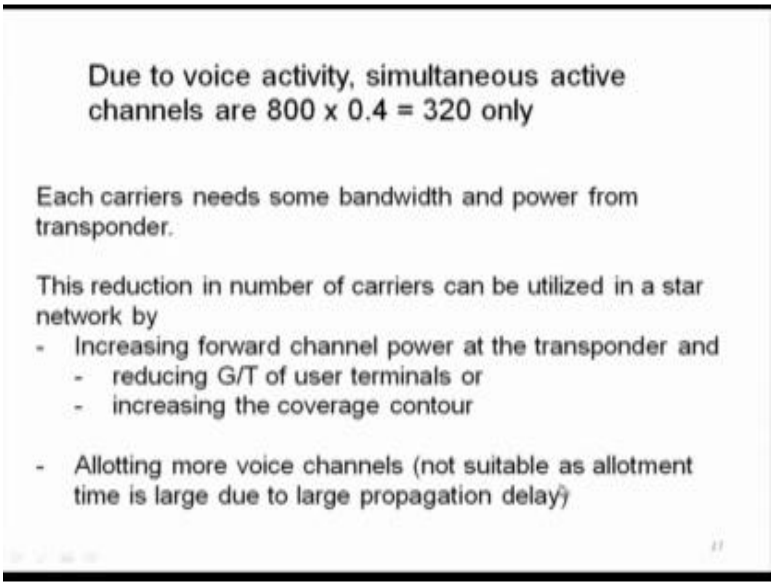

So, therefore, actually at a time at any instance not at the transponder only 220 carriers are a present, but satellite is giving that much bandwidth and that much power. So, bandwidth wise and power wise 60 percent of that is not used at any time. So, how many can use each carrier needs some bandwidth and power from the transponder. So, this reduction of this carrier number of carriers you get a advantage of bandwidth. Let us look at the power it can be utilized a network by increasing the forward channel power at the transponder reducing the g by t of the user terminal or increasing the coverage contour various ways it can be interpret or allotting more voice channel ideally it is true.

But many people do it in lower delay network, but in case of satellite it is very difficult by the time it detective activity and do an allotment and the receiver has to know that which particular frequency is allotted to him. So, these allotment procedures take each is one half. So, allotment procedure will take some time and you have to hold the voice for that. So, its not suitable for with a large propagation delay network, but for small propagation delay network it is theoretically possible can allotment voice channel in this satellite case, it is at always used, but you can do the other things in terms of power.

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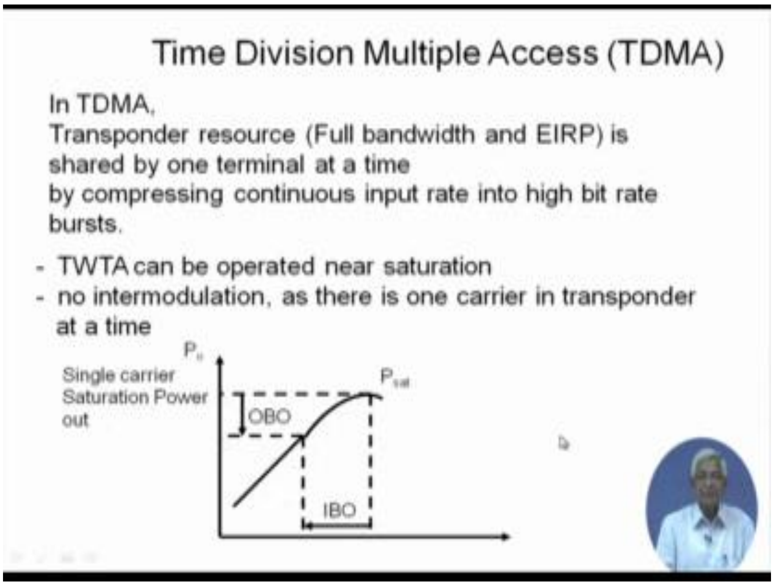

Now, that very in short we have covered the interesting some aspects of FDMA and how the capacity of the SDMS, FDMA can be achieved and really calculated in terms of power and bandwidth and we have given certain examples, quick examples or full transponder mod that is 36 megahertz.

How it can be use and then the same thing is true for a smaller bandwidth allotment of the transponder in terms of power and bandwidth. Now let us going to the on another multiple access techniques which is quite popular which is called TDMA that is time division multiple access let us see on that. So, time division multiple access here the resource that is the bandwidth and power available from the satellite is shared by one terminal at a time that is one terminal is given the full bandwidth and full power available at the satellite that then, to do that see let us say voice is going and you have some 12 stations. So, other 12 other 11 stations are had to hold the voice and then, wherever their term comes they have to transmit. So, this can be done by compressing the continuous input into a high bit rate burst. If there is continuous inputs are coming you can compress it in to high bit rate and in one bit period you will allot to each of them.

So, then advantage one big advantage is that you have get got full bandwidth and full EIRP and there is no multiple carriers. So, TWTA can be operated at the near saturation that is maximum power you are extracting you are not coming down to the near reason by putting some back off biggest advantage this advantage is your increasing the bit rate and operating TWTA at near saturation means you are you can increase a coverage control or the g by t of the stations received stations can be deduced. So, no intermodulation as there is only one carrier represent at a time and you are not operating in the back off that is this is the non-linear, you are operating at the saturation power single carrier saturation power since the time is complete from this period we will continue the discussion in the next period for the time being.

Thank you very much.