Analysis and Design Principles of Microwave Antennas

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Lecture - 29
Dual Reflector Antenna

Welcome to this NPTEL lecture, we are continuing our discussion on Reflector Antenna system. In the last lecture we have found the expression for gain of the reflector antenna system and there we have seen that there is a blockage of the reflected rays by the feed. Also we have, we should point out that not only the blockage actually the feed also scatters this feed and it is accessories

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As you can see here the feed and the accessories, that the reflector the reflected rays from this aperture that gets scattered from these. So, that also increases the cross polarisation of the fields because, whatever polarisation the aperture has given now that gets disoriented by this reflection. So, sizable cross polarisation also takes place.

So, for systems where side lobes and cross pole are desired to be 30 dB down 30 dB or more down this creates a problem, actually 30 dB down is required for many of the satellite communication systems; then radars etcetera. So, one solution is to go for an offset feed.

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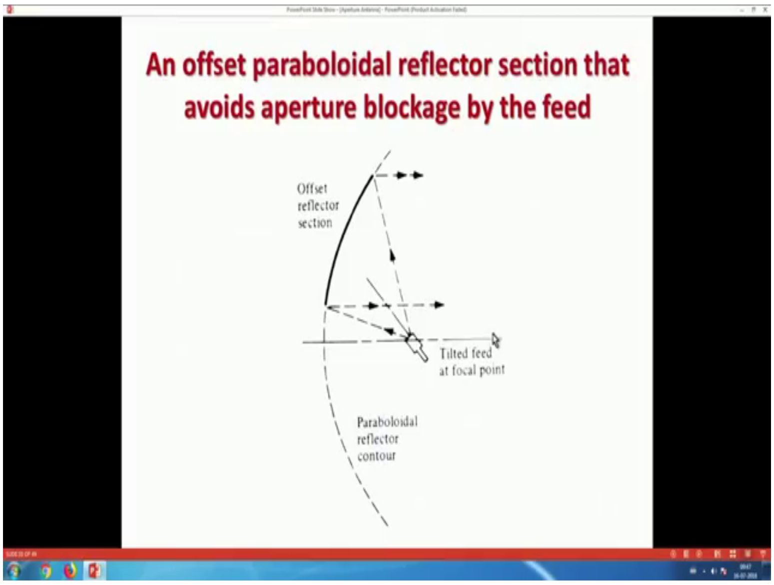

Now, you can look at the diagram that, this is a offset feed what is offset you see. That certain portion of this paraboloidal reflector contour is cut. So, the feed is not present in the actual zone, feed the reflector is not present here and also the feed is tilted, previously feed was pointing to these now feed is tilted. So, here you see that that it is such that this is this ray from this and this is the maximum that can be reflected. So, this one comes here and this one goes and that comes here so, that means, the reflected rays only in the this zone and these zone you see the feed is not blocking.

So, this is called offset paraboloid reflector. But so, that means, a circular section of a paraboloidal reflector may be cut out such that the focal point lies outside the main beam of the reflector. This improves blocking efficiency, but due to non symmetry between reflector and field cross polarisation is not improved for this. So, in some radio astronomy applications the problem is the radiation pattern of the feed that is generally do not go to 0 at the edges of the reflector. That means, look at here that, the feed at the edges of the reflector they generally do not go to 0 they goes beyond that.

Now, so with the reflector pointing towards the sky the feed is pointing toward the ground. So, it will receive thermal noise from the ground which reduce the sensitivity of the system and that is crucial for this radio astronomy people. Because, they do not want this thermal noise actually their signal will be solo it is almost a noise, there if this thermal noise comes then they would not be able to detective. So, that is why they do not go for these single reflector system sorry not single reflector single feed. So, what they go for various choices are there single feed and single reflector etcetera. So, there thing is dual reflector antenna system. So, actually this type of feed which is the classical feed that is called prime feed or front fed feed. So, the feed is in the front of the reflector

So, another problem is that this; obviously, there will be a transmission line to feed these. So, a transmission line from the feed to the transmitter or receiver because you are you may be using this for a transmitting system or a receiving system. Now, that will be placed behind the aperture or below the reflector this necessitates long transmission line which may give also a significant loss. Now, sometimes the transmitter or receiver that is directly put after this feed, but then the blockage again increases also generally these reflector system are put in the outside. So, putting a transmitter or receiver at the outside creates cooling problem and other problems also.

So, that is why this prime feed or this front feed is in the very sophisticated systems they are not used, but you see our home transmission, DTH transmission, this is the standard thing because our systems are not so, sophisticated we have enough signal available. And this losses are taken care of by the thing that is why we will see that actually when rain comes, then there the suddenly the signal goes, I think in the this football world cup matches also you have seen that sometimes the due to rain the signal is going. So, what they do actually that time the pump more power to overcome that loss and then after some time you can get it, if they that is manageable etcetera.

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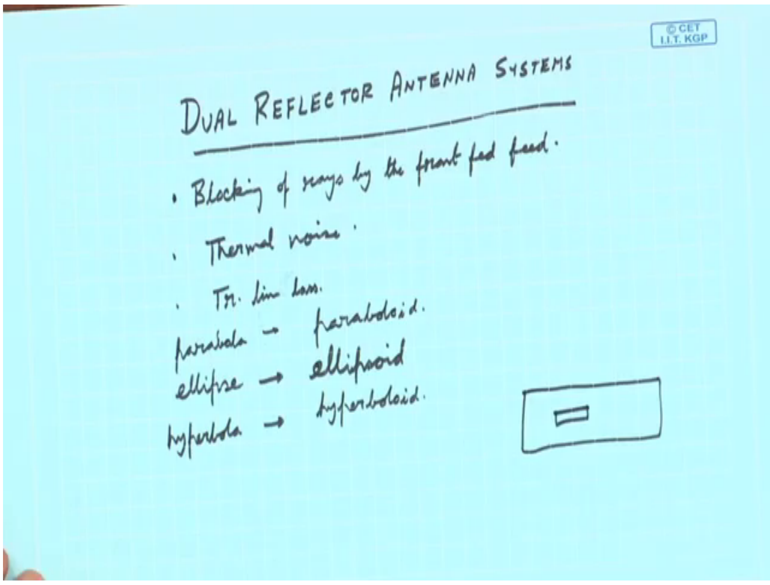

So, this actually motivates to use for the sophisticated system, a dual reflector antenna systems this will be the topic of this lecture. Here we will do just qualitative wave will a because, this things each is a topic on it is own and it takes several times to analyse these several hours so, we would not do that. So, we have already discussed about blocking, blocking of rays by the feed by the front fed feed or prime feed, then we have discussed the thermal noise problem, then we have discussed about the transmission line loss. Now we know from our knowledge of coordinate geometry in intermediate classes, that reflectors made by rotating and ellipse or hyperbola about the respective axis can form various conic sections.

So, ellipse if it is rotated about this axis we get ellipsoid. So, ellipse is a two dimensional thing, but if it is rotated we get a section called ellipsoid, similarly, hyperbola if it is rotated we get hyperboloid, already we have seen parabola if it is rotated we get paraboloid. Now, the importance of this is why we are coming here? Because these structures are having two focal points; so, the feed may be placed at one feed point the second focal point can be made to coincide with the focal point of the paraboloidal reflector.

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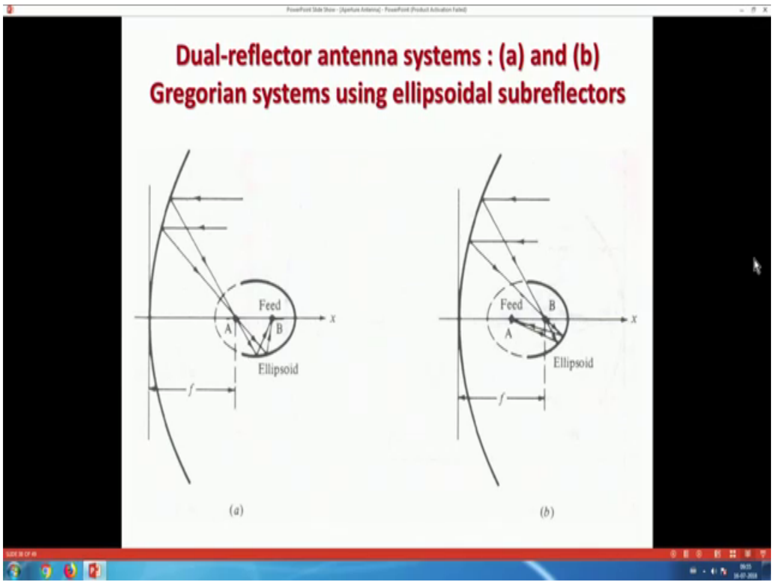

You see that what I said is that you have for the let us say the ellipse you have two focal points A and B. So, suppose I put the feed here, now the rays this A is such that it is focusing the rays here suppose it is a receiving system. So, parallel rays are coming from distance things then, they gets focused at the other focus A, we allow that to proceed fall on this ellipsoid. So, they will come to feed now by that also; that means, I can put it the this thing similarly, the other thing here that this is a suppose a same thing is coming and here; that means, here we after getting focused we are allowing it to get again reflected by the ellipsoid.

Here it is that thing that it is focused on the other weep thing and it gets reflected and come to feed A. Now this A is much nearer to paraboloid this B was much distance from paraboloid so, these are your choices. Now, these systems are called Gregorian systems actually these are all present in optics. Actually when lenses were developed that time one famous optician Gregorian Gregory after his name it is a so they use ellipsoidal subreflectors in Gregorian system. So, you can summarise that rays from feed gets reflected by the subreflector so, this one is called subreflector; that means you see that our this is another subreflector. So, this is the main thing is paraboloid reflector, but this is the subreflector ellipsoid this is also subreflector ellipsoid.

So, in Gregorian system the rays from feed gets reflected by the sub reflector and gets focused at a point they are allowed to continue and gets reflected from the paraboloid to become parallel ok. Now there is another system which uses the hyperbola and that is called Cassegrain system this is called Cassegrain system there the subreflector is again Cassegrain was a scientist so, in his name this thing. In Cassegrain system show the figure Cassegrain system the rays from feed gets reflected by the subreflector instead of converging to focus which was the case in Gregorian, but here instead of converging to focus they fall on paraboloid and produces parallel ray. So, they the rays do not meet at any point here, because of the hyperbolas things.

Now, the hyperboloid subreflector in Cassegrain system may have its convex space spacing paraboloid or concave space spacing paraboloid so, this systems can be analysed etcetera. Also with these the blockage we can say the blockage of aperture rays is less in Cassegrain than in Gregorian, also the feed and receiver and transmitter can be placed behind the primary reflector. Also a modest amount of shipping of the sub reflector and the main reflector can be carried out in order to give a more uniform aperture field distribution. Hence higher efficiency is obtained by the shipping the subreflector alone the desired effect may be obtained such reflectors are known as shipped reflectors.

In general for Cassegrain reflectors feed is in a convenient position as you can see that feed is here. And actually so, feed you can see that feed is not looking at the sky the feed can look like sorry, the feed is looking at the sky like the paraboloid. So, it is not collecting the noise from the ground. So, feed in a convenient position reduction of spill over and minor lobe loss now, capability for scanning or broadening the beam can be done by moving one of the reflectors. So, this is another thing that you have more play because, where we will put the subreflector or the paraboloid reflector since you have two things your play is more. So, I think there are some offset, no this is this is not that, this is an offset Cassegrain dual reflector antenna system.

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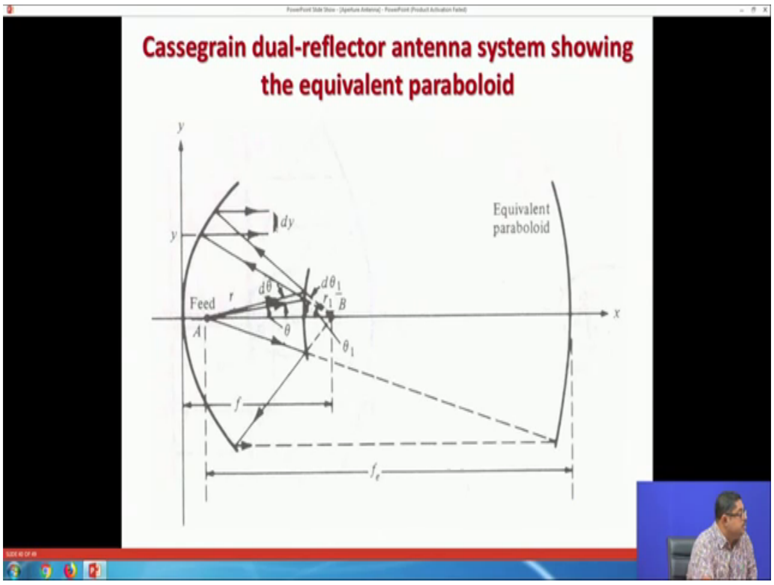

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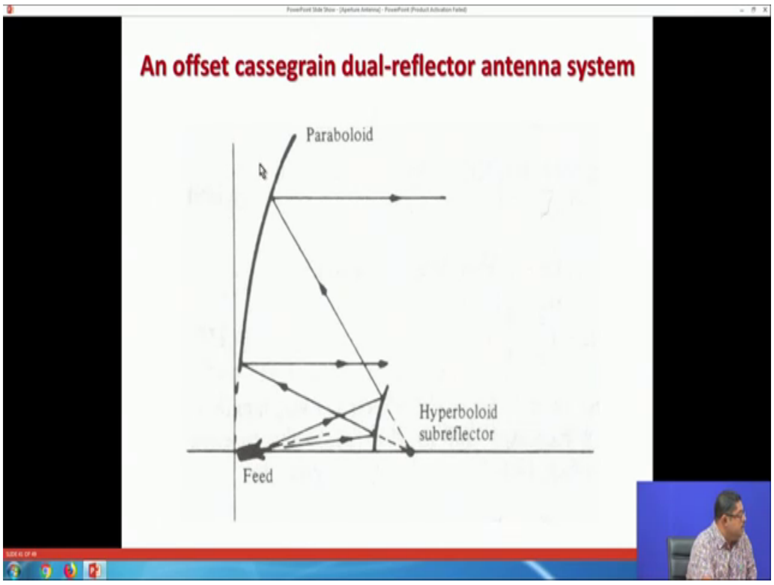

So, you see the feed is not looking at the ground and feed so, this paraboloid can be shaped. So, now the total ray they are neither blocked by the hyperboloid nor blocked by this feed. Here feed can be placed behind the reflector also, actually you can put it actually this thing if you properly shape this feed even can be put behind the paraboloid reflector by shaping the subreflector aperture amplitude distribution can be controlled independently.

And by shaping the this paraboloid reflector aperture phase distribution can be controlled independently. Actually this is the main thing in a single reflector system actually both the amplitude distribution and the aperture phase distribution we cannot control. Actually everything is determined by the power pattern of the feed, but here these two are totally independent, actually subreflector controls the aperture amplitude distribution independently. So, there whatever taper etcetera I need to give; that means, for side lobe what is to be done that I can do by playing with the sub reflector. And the main reflector or paraboloid reflector that actually controls the aperture phase distribution. So, that can be controlled independently the; that means, the cross pole problem that I can easily tackled by the playing with the paraboloid.

So, these two independent things makes it so popular, actually Cassegrain systems are more popular compared to the Gregorian systems. So, actually these are from telescopes these concepts came to microwave antenna and as I said that optical laws hold good here also. So, they are analysed the way we have analysed the paraboloid reflector same analysis technique can be used here to analyse this systems. And hopefully any of you those who are interested you can see that these are once you know that paraboloid reflector analysis, you can just sit down and see books to do that it is same technique is used.

So, with that we conclude these aperture antenna things, but here we have learnt a new technique that Fourier transform technique for a finding aperture. But one problem I will say that we have seen that some of the aperture antennas can be readily analysed by this technique, that is if you know the field distribution over a plane you can easily find it out. But, you see if you have a curved surface, suppose you have a cylinder on which you have an aperture cut or a some sphere on which aperture cut etcetera there you cannot put this technique because there you cannot find the field.

Similarly, another thing is suppose I have open in so, waveguide top wall and there I cut a slot. Now what is the field distribution there? I do not know because I know the field distribution in the transverse plane, but there on the top wall what will be the field? I cannot directly find out from this thing, but knowing the actual electric field there will be you will see. So, this method that what is the aperture field distribution so, if you know aperture field ok, but always it would not be known. So, we will see a general technique by which you can find out and that will be based on the technique we have used for wire antennas that there we have seen that what is the current on the wires.

Now, wires, apertures or any antenna general antenna they are the can we find an current on the antenna suppose for apertures, can we find the current we know the field. Now our fields and currents related by something we will see that actually they are related thanks to electromagnetic fields their propagation and their properties that we can have some current type of things even for fields. And then by that we will be able to say that if you have any type of antenna beaten, wire antenna or a thing. If I know suppose partly I know the conduction current through wires partly I know that aperture from where it is radiating, I know the field either electric field or magnetic field or something we can find out some sort of generalised currents.

And from that we will make a general method for finding; what is the far field radiation? We can find other fields also sometimes, but generally we are interested in the far field. So, at least far field we can always find out that will be a generalised technique that will be the theme of our next week's thing ok.

Thank you.