Analysis and Design Principles of Microwave Antennas
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Lecture – 19
Broadside Uniform Linear Array

So, welcome to this lecture, today we will see Broadside Array. Now what is a broadside array? When the progressive phase shift we make 0, that is a broadside array.

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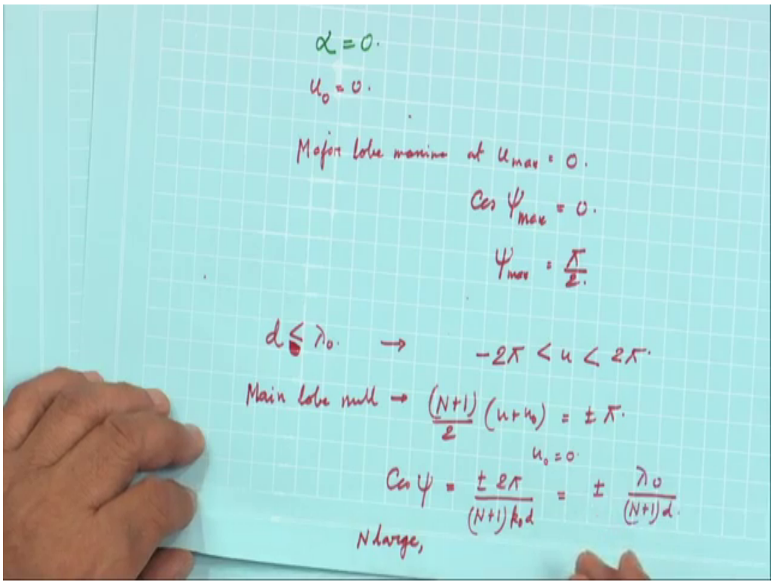

So that means no progressive phase shift between elements. So, all elements are fed in phase. So, the moment we do this we are getting u 0 is equal to 0.

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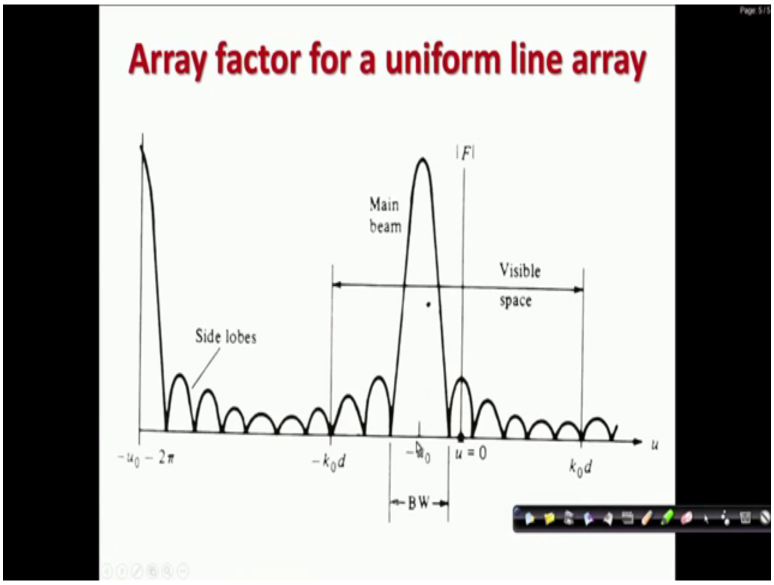

So, if we look at the diagram the major lobe is immediately u 0 becomes 0 means major lobes comes here so, major lobes maxima at u max is 0.

So, cos phi psi max is 0 so, psi max is pi by 2. So, it is proved that; the maximum radiation occurs broadside to the array axis, physically also this is expected as all elements fed in phase should be producing maximum radiation along the broadside. Now grating lobes are plus minus 2 pi array from the main lobe at u is equal to 0.

So, you see that if the main lobe comes here so I have a k naught d here I have a minus k naught d here. So, if I want to put that even if the grating lobe starts appearing here there is no problem. So, if we keep d equal to lambda naught actually slightly less than lambda naught, just d is I should not say equal, d is equal to less than lambda naught the grating lobe gets avoided. So, the visible regions become minus 2 pi less than u less than 2 pi, provided d is less than lambda d.

So, you can make that for broadside arrays you can say that inter elements spacing is equal to lambda naught. So, we have already seen that main lobe null occurs at null major lobe we have seen now main lobe null. We have generally seen that N by 2 u plus u naught is equal to plus minus pi, but for broadside u naught is 0 so in this case u naught 0. So, let us find out so, can I say that cos phi you put the value of psi so you get cos psi is plus minus 2 pi by N plus 1 k naught d which is plus minus lambda naught by N plus 1 d.

For N large cos psi value will be very small so we can say that psi is equal to pi by 2 plus minus delta psi, can I say these see that; N large. So, cos psi small it is not 0, but very near 0 so psi is pi by 2 plus minus something in both sides.

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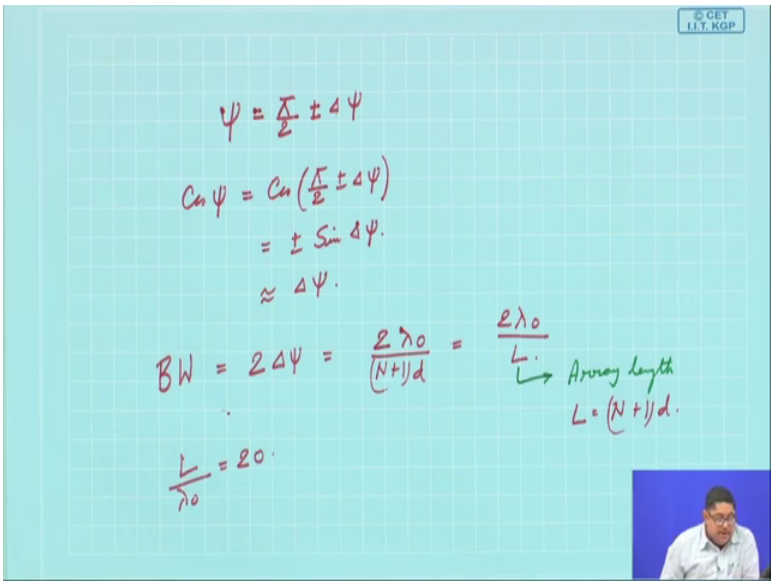

So, we can write cos psi is cos pi by 2 plus minus delta psi, this is small that is why am writing delta psi.

So, this is plus minus sin delta psi; that means, delta psi. So, I got the value of delta psi, now what is the beam width this is the null, u is equal to 0 is my main min this is one side plus delta psi. So, beam width is 2 delta psi and that is 2, what is the value of delta psi? Previously I found value so 2 lambda naught N plus 1 into d is equal to 2 lambda naught by L, what is L? The length of the array L is array length, L is equal to N plus 1 into d.

So, this is the general property of a broadside array; the beam width is inversely proportional to the array length in wavelengths or arrays electrical length. So, for a beam width of 6 degree an array of L by lambda naught is equal to 20 is required. And if lambda naught if d is almost equal lambda naught you can say 20 element array is required.

So, as an antenna designer specification given what is the beam width required, null to null beam width you can easily find out how many elements are required. At high frequency this is quite visible, 6 degree thing, but at 1 megahertz. This will require an array length of 6 kilometer so; that means, that is why this array antennas for broadcasting is not. So, popular you see this is a 1 megahertz is a broadcasting thing.

So, broadcasting people generally take only single length antenna dipole or monopole basically, with a huge tower fir normal communication it is impractical, but for weather radar or research stem for extraterrestrial observations looking at distance stars this type of arrays are made.

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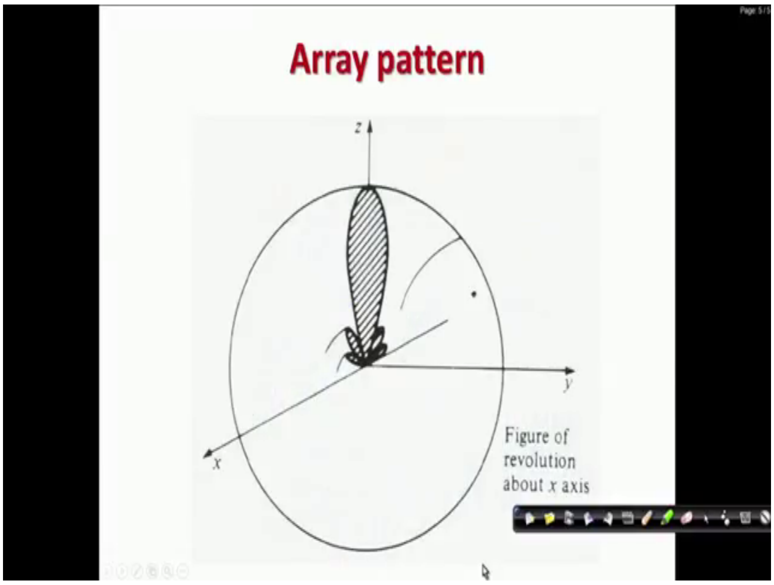

So array pattern is like this for broadside array.

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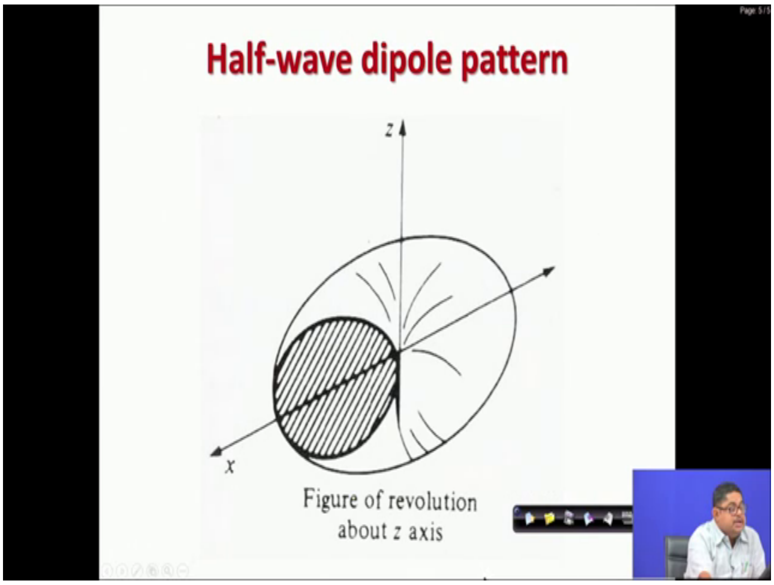

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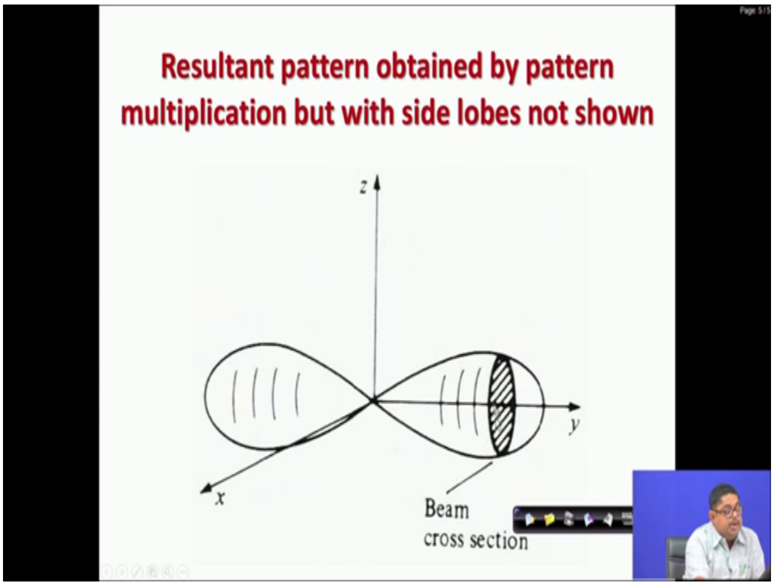

And this was the half wave dipole pattern so if you do resultant pattern obtained by pattern multiplication. So, here side lobes are not shown, but if the array the array of dipoles broadside dipoles you get a patterns something like these, where arrays are x is the array axis you get the pattern this is much smaller remove it this much smaller than the array thing (Refer Time: 09:16) this (Refer Time: 09:17) that way from.

Now if we want to estimate the directivity it is difficult for half wave dipole you see that the actually, the way we defined directivities for antennas they are will have to have an integral something like this.

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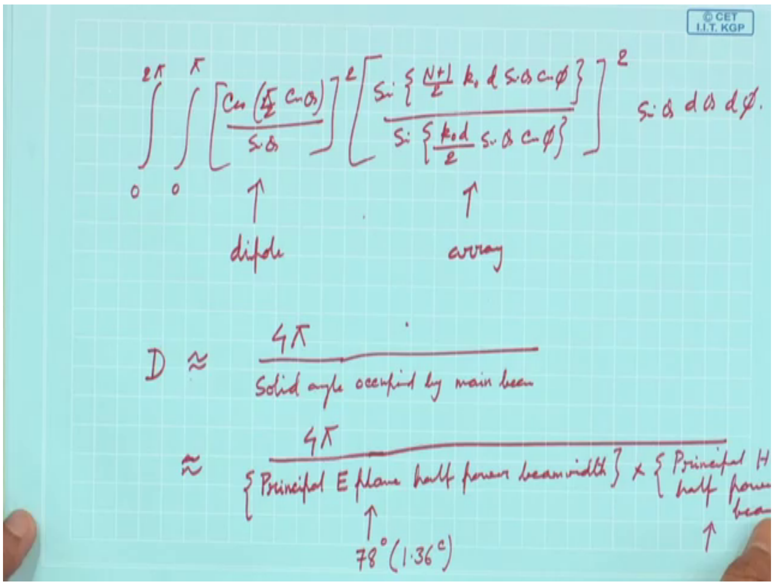

Will have to relate this that is why; this is actually dipole pattern this you are taking square of that this is the broadside array factor. Now this is difficult instead what we do; we approximate d by like this, you see if you remember the basic definition of directivity then I can say what is it? It is 4 pi is the total solid angle for the isotropic radiator divided by solid angle occupied by main beam. This is an approximate definition, but approximately my antennas main beam the solid angle it occupies, if I that is in the denominator and 4 pi is the solid angle occupied by the also propagated.

So, this should approximately give you the same thing. Though I again caution that actual thing is from their intensity of radiation the power radiated etcetera, that is the actual expression. So, here again I can approximate this 4 pi divided by principal you see; solid angle occupied by main beam now while we came and actually you see our this is the array pattern.

So, this is figure of revolution about x axis; that means, this has input you see our azimuthal pattern. Now what we said that the generally the job of array is to change the azimuthal pattern and we are using dipoles. So, can I say that principal E plane half power beam width into principal H plane half power beam width. This will be the solid angle of occupied by the thing approximately.

Now for the array we have shown approximately we can say that principal E plane half power beam width is same as the dipoles principal's E plane half power beam width so; that means, what is this value for dipole? This is 78 degree or 1.36 radian. And these will be given by this H plane pattern this is given by array. So, this will come from array factor, now this is half power beam width we have calculated null to null bam beam width that will not do.

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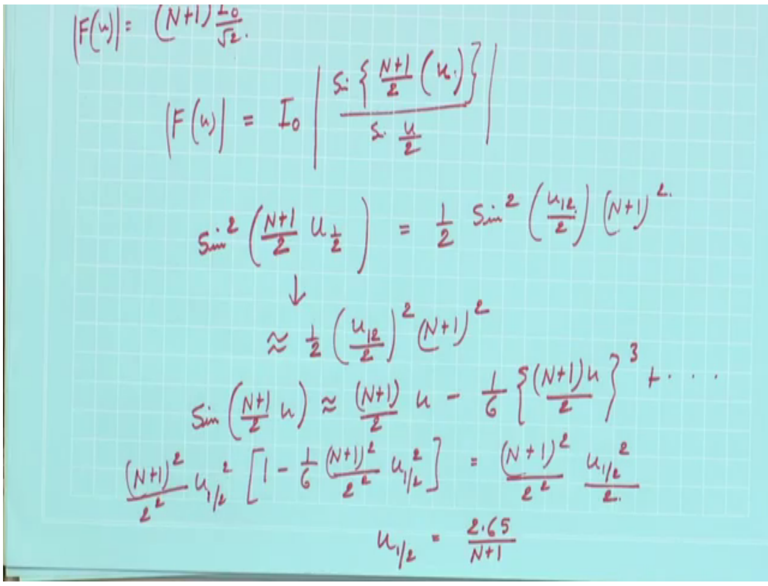

So, we will have to calculate the half power beam width from our array factor. So, please note that at 3 dB points the array pattern will be, what is the value of the array pattern F that will be N plus 1 I naught by root 2 because p equals N plus 1 I naught. So, it will be N plus I by root 2. Now already we have seen that F u is I naught sin N plus 1 by 2 u; u plus 2 I am not writing by sin u by 2.

So, we can put these value N plus 1 N naught by these and then we can write sin square N plus 1 by 2 and this angle we are calling u half is equal to half sin square u half by 2 N plus 1 whole square. Now u half is very near to u is equal to 0. So, u half is small and this variation is much slower than N plus 1 u half.

So, we can write that this is approximately half u half by 2 square N plus 1 square; that means, here I can replace these u half. And we can expand this sign function; sin N plus 1 by 2 u as N plus 1 by 2 u minus in the series expansion of sin. So, you can put these that N plus 1 whole square by 2 square u half square 1 minus 1 by 6 N plus 1 whole square by 2 square u half square is equal to N plus 1 whole square by 2 square u half square by 2.

So, if you solve these you will get 2. 5 by N plus 1 ok you note down these do this it comes I have done it myself so, but what is u half?

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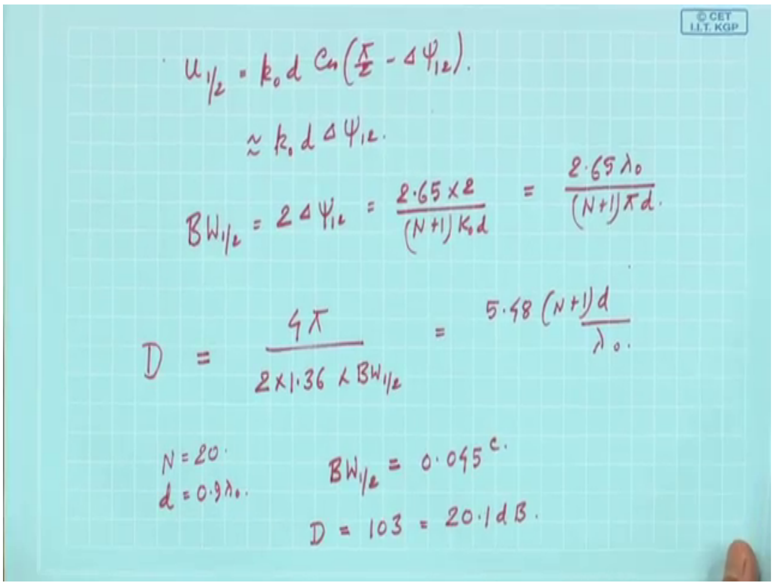

This k naught d cos pi by 2 minus delta psi 12, this is k naught d. So, half power beam width is 2.6 into 2 by N plus 1 k naught d, 2.65 lambda naught by N plus 1 pi d.

So, ultimately we got the h plane bam beam width is this. So, you can put it into the directivity that will be 4 pi by 2 into 1.36 into beam width half and that will be 5.48 N plus 1 d by lambda naught ok. So, this is the expression of the directivity for an uniform broadside array. So, for example, suppose 20 element and d is 0.9 lambda naught, we will see that this array antennas beam width that if you do it will become as 0.045 radian.

And if you put that in to the directivity it will be something like 103, which is 20.1 dB. So, a 20 element away has a very substantial directivity and also large gain. And also losses due to array antenna there is not much loss so; obviously, there will be some losses, but you see you can make almost the gain was multiplied, almost I can say how much that typically the for an dipole array to it was 1 or 1.5.

So, it is 60 70 times the 20 element array has multiplied these. This is a very sizeable factor and in very sophisticated applications also this can give in RADARs etcetera, this keeps a very good antenna array antenna. So, we can compare that if the array elements are isotropic radiator instead of half wave dipoles. Then the pattern will be a circle about array axis and same way will have this thing. So, what will be if you do that instead of dipole if I give the isotropic radiators.

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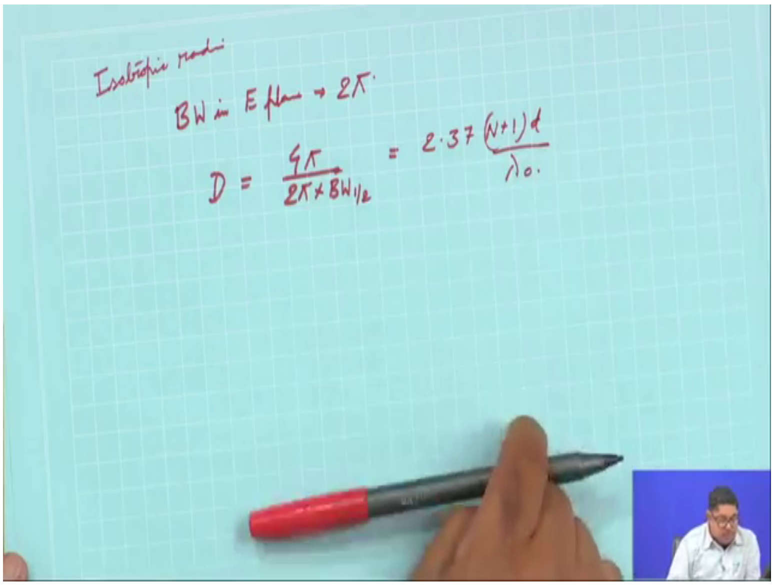

So, in that case band width in E plane since isotropic plates. So, in E plane we does not have any band width. So, we will take band width E plane is 2 pi because it will be like a circle the E plane also. So, beam width is 2 pi so we can say d will be 4 pi by 2 pi in to whatever is the arrays beam width remove it, say this will become 2.37 N plus 1 d by lambda naught.

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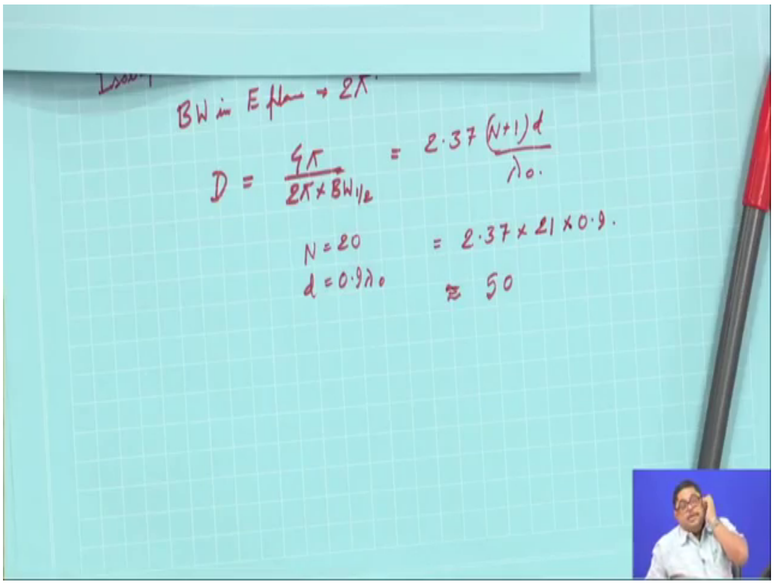

So, this is substantially you can put those values again that N is equal to 20 and d is equal to 0.9 lambda naught so this becomes 2.37 into 21 into 0.9. So, you can get is something like 50 or something so something like 50 I can say. So, you see that compared to 100 I have 50 half. So, not that; that means, I actually that is why; in array antenna the main contribution comes from the array factor. So, you can put any antenna they are actually; obviously, dipole will be preferred to bar isotropic radiator in the sense that you will have to have the power handling capability and other things.

So, any type of practical antennas will do, we will see later that actually in real life this wire antennas actually they get protruded instead; if array is on a ground plane and then the open ended wave guides flush to the ground plane that is much preferred because they will only the one front surface comes of the array antenna. So array antennas with open ended wave guide is the very good choice because the open ended wave guides can handle sizeable amount of power.

And even if they are not good radiators like dipole, but for array antenna their ideal can be there that is why, in missile guidance system or radars etcetera, this open ended wave guides are very preferred. Actually will see when that is why open ended guide antenna will see, that has an antenna element for array antenna this is quite good. With these I conclude the broadside array and in the next class we will find end fire array.

And then we will see some parasitic array particularly one array, which is very popular as the TV antenna was very popular. So, that is Yagi-Uda antenna that also is an good example of antenna, that how array antenna can improve the performance.

Thank you.