Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Applied Electromagnetics for Engineers

Module – 14
Further application of Smith chart: Part 2

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Hello and welcome to the Applied Electromagnetics for Engineers. We will move on to another application okay.

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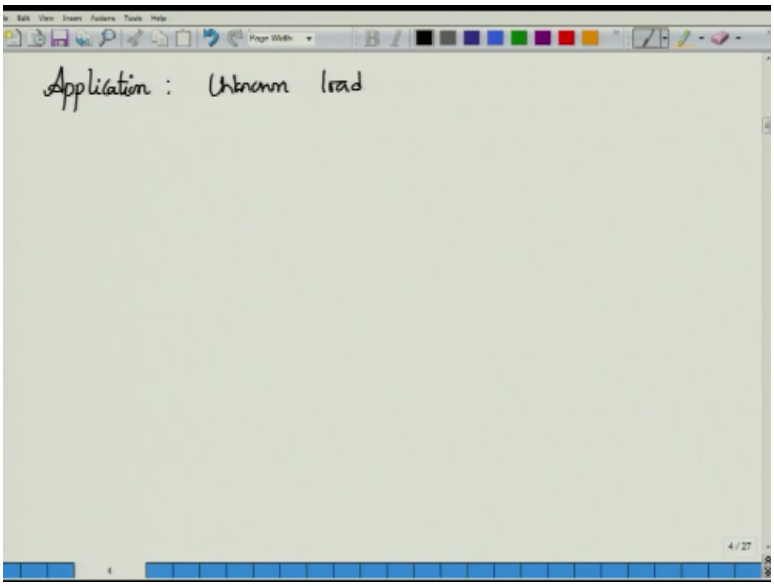

Describe what were interested is to find the value of the unknown load. In all the previous cases we have given what is the load value and then we manipulated this picture in order to find out other quantities. In this application we do not what is then load that is given, that is the one of the reasons for studied here in this application because you want to measure that the incident value for 2.

Of course the measurement from the measurement will be able to extract what is the unknown load. This problem usually occurs when want to no perform incident matching for you have a certain component in the trained used heading okay. The load is suppose to be normalized value of one plus J2. For instead is acting is like a different. There is want to be find out what is the exact value of the load so that you can adjust a semi circuit a mating network of the circuit.

We will have to measure its unknown loads. The only problem is measuring a load at very high frequencies is that is a piece if wire that you connect to the load and will act like a transmission line right. At the low frequency is very easy to measure the value of n unknown incident. I can for example, is I am working only with the resistant incident or resistances and I can put a brick series.

One like will contain unknown load or unknown resistance value and all the other fields like will contain the unknown value right. And then we are at least one of the other value will contain the variable loads. As I told the other load I have this unknown load in one leg and have a variable load in the other leg. And I told this loads here of some point in the current coming out will be equal to zero. And that point I know whatever the tuned value of resistance that will become the same unknown load.

If you load involved inductance and capacitances it will take the load and then certain and then apply a certain voltage and measure the current to the device you can find out core sense in order to doo that one. And from the ratio of way to high we can find out from the face value you can find out what could be the unknown load in resistance. Unfortunately none of these methods can work at high sequentially.

Because the modally tried to collect any wire or a connection to it. But the small correctively it can act like an inducted capacitor or a resistor or a very mastic combination of all these going to the transmission line as. So how do you solve this problem how you measure unknown loads using I mean how you measure unknown loads in a high frequencies. Well in earlier days this measurement was carried out by across called as sorted line measurement.

This very same as microwave measurement in which use a calibrated line called as a slot line. Slot line is a selfish slot or other a slot in a wave side. In that slot you actually collect the rope okay. And then you read the rope actually will be measuring the power because you will connect

a crystal detector at the other thing. And then you would be having the power or a voltage meter. Always the voltages will actually going to the power meter okay.

I mean a power value. So you connect that rope to the slot and then the slot will be adjustable. So you have a line which is called as a sorted line and I think move along this rope will keep checking you different values of the power and many case mainly here about the power value because you are only look up the magnitude of the voltage you are not going for the sign of the voltages okay.

So power will be high voltage is high, power is low voltage is low to keep moving along measuring the voltage power converting the power into voltages and eventually constructing the voltage standing way pattern. We construct the voltage standing pattern with the load captor one end. You have no idea of what that load is but because the measurement is available with you at this end you connect the load to the slot line. You simply move the slot line the rope here record the power voltage and do all the other measure the voltage standing the pattern.

Like could have been very simple and differ the only measurement that you needed to unfortunately the load that you connect the minimum that its produced by a load that is not exactly short circuit or an open circuit will actually create a problem. Because the values of we mean and we match that you obtain will not be sharply defined okay. I will draw a few picture to show you what it what it to look like but it won't be sharply defined.

But if you want to be measure this distance is that you know that even a small changing point 0, 1 λ for actually move can large distance on the switch chart hence the values could change a no in a large way you want to be minimizing that in this case, therefore you want a very sharp nulls or the sharp voltage minimum okay. To obtain sharp voltage minimum you have to option either open circuit the other end of the slot line okay. By removing the load you open circuited. But the open circuited have this problem because it normally radiates okay. You do not prefer for to have an open circuited output stair okay. If you have an open circuit you can short.

And if you have a short it is very nice it could be normally and inducting short. It will produce reasonably sharp nulls along the line. So as before the slotted line is here with the sharp here are put a shot and left end. And then we move measure the voltages you will be able to find out the voltage minimum values.

Why I am I telling you that is only voltages minimum. It is also that the minimum or much sharper than the maxima. So the measurement that will move with minima or much more reliable than the measurement that we make with maxima. So for this reasons you should tends to use sharp volts and measure on the minima. So what is the advantage of doing it shorted load. What does the shorted load dose to used.

To establish a reference plain from the reference plain you find out what is the position of the voltage minima. And the distance between those two should be the distance to which you are going to move on snip chart in order it find the unknown the infidence value okay. Let me lecture this by of your pictures. Suppose I start with the transmission line whose characters to incident that 0.

I know and then connect this unknown load to it okay. I connect this unknown load and I actually have a scale and usually on the slotted line I will have a scale okay. So I have this to use so this scale is not very nice but please excuse this scales so I have a scale which might be all the way up to this side. I do not okay this is the scale that I have usually I will have some 0 marking at one particular point and then go please occur that the scale 0 is not the same as load location.

Mathematically represents the same Z = 0 is the load location but on the scale that I have is not the load location. In fact it will be usually slightly away from the load location okay. On this load with an unknown one that I have connected what I observe. Let us show I observe a voltage that's looks like this okay. On this scale is I look at the voltage on this way okay. So this is my voltage standing way pattern that I have formed okay.

So this the minima so minima occurred at – 41its also assume 240 mm is the wavelength okay. So 240 + 41 forever 240 is the wavelength so 240/2 that 120 so 120+41 is about 161 then the next minima occur at -161 and so on this scale is in millimeters okay. This is what I have measured on the transmission line using my slotted line or slot line equipment okay. Now what I do is I replace this load by short circuits okay. I replace this load by short circuits and when I do that I find this type of a voltage measurement okay.

These nulls are fairly well defined okay and ca quick any null that wants as my load. I can pick this null may be for the example which is located at -1 of course the next null must occur at -1

-120 that is -121 so this much to occur at -121 and then and so on right again one more at -121-120 that could be -241 so I will again at this one more minima at -241.

So these are the different locations with the short circuit that I am able to find the minima right. Now you observe here if I take this as my reference plain if I take this as my reference plain what is this -41 telling me this the reference plain which will now act as the load okay. And the minima now with the unknown load which is occurring that 40 mm always from the load. 40 mm is the actual physical value is the terms λ 40 divided by 240 λ lambda units okay.

So what will be the finally about 4/24 and the 1 by 6 λ units away from the load we have a voltage minima. This is the first voltage that I have okay then the orbit rally chosen by -1. If I wanted you can choose this as a reference then my minima would be at -161 which incidentally is again 40mm above. These are all of course periodic. Now what is the value of this I mean what is the usefulness of this 1/6.

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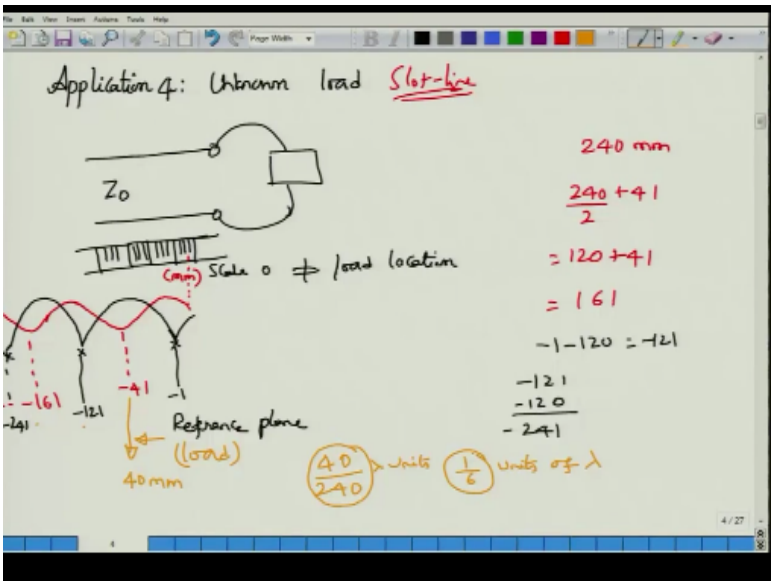

Here is there switch are will help us okay. Let's look at the snip chart construction then very hastily for this is the snip chart. I am not interested in anything else. Now with an unknown load I can also measure what is the max and what is the min therefore find out the standing

wavelength ratio to be V_{max} by V_{min} okay. And someone have already this measurement and given to me the value of SWR.

So what I do is I actually draw a circle which I would call as the SWR circle so in this case may be SWR is equal to 1 or may be sorry 1.5. it doesn't matter what SWR is. You please in the next example that I will discuss I actually this is a values in order to find this. So SWR is some 1.5 is right. And I know that the minima always occur on the left side of the axis right. On the horizontal axis on the left side of this snip chart is where I have a voltage minima.

So which means this should be the voltage minima on the SWR circle the infidence can be anywhere over here. But this is there we landed on the minima. Now from the minima instead of what the generator if I start travelling to watch the load and reach this point -1 which occurs to the reference plain or the load plain to me. Then I would have ended occur to the load point right. So I actually start travelling towards the load.
Please remember that you have travel this load for the generator. That is clockwise and you travel anti clock wise in order to go to the load. So I keep moving in the load a distance of about 1/6. And lets I will under this point. Now order to do is draw this r or draw this line read the values of this one and then I would have known the values of normalized value. If I want to un normalized, I simply multiply by Z0.

In case we don't know where to land on here we have a scale called as WTL scale you on the WTL scale is to find out the scale you find out this point this the voltage minima point call it as A prime. To this A prime add 1/6 in terms of lambda you add okay. And then you know the distance and then draw a line but this point to call as B prime from B prim we move to as from the center by drawing the line and point load you intersect this SWR circle will b the normalized value of the ingredients. And then you can un normalized span okay.

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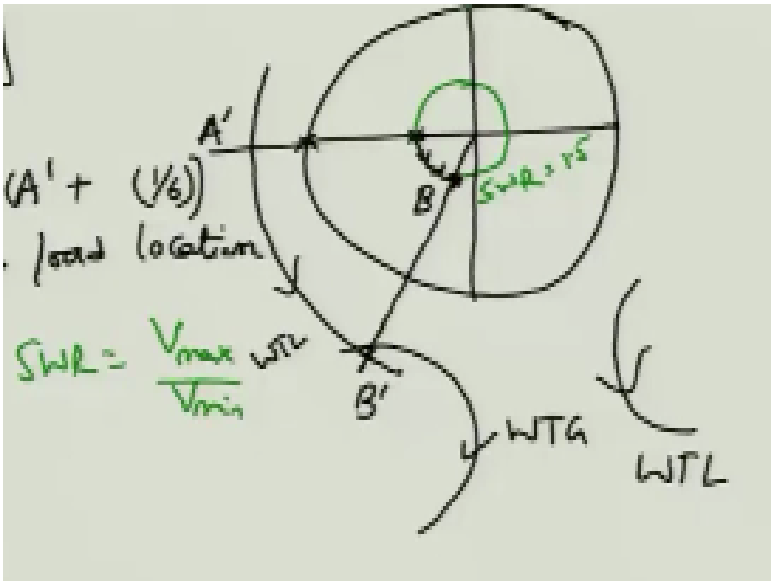

So this is very widely used or used to be used in order we are finding infindences and which more accurate that the simple slot line measurement that e have consider is what is called as the vector network analyzer. But to explain the concept behind the vector network analyzer is not possible in this course. If you ever take a microwave course then you will be knowing the vector network analyzer.

You will know the hat is the construction of a vector network analyzer okay. You finally consider one very interesting application okay. This application of this snip chart may be I don't the number may be the number 5th number here okay. Find the unknown load which we don't know but someone has measure the value of the reflection co efficient. And find at the value of the co efficient is actually greater than 1.

Well in the last few modules I am telling you that magnitude of Gama you can never Exide 1. Except under no circumstances, and what is circumstance? Magnitude of Gama L greater than 1 immediately implies that resistance in negative right. Resistance is negative. The real part of the load that you considered will become less than zero. And this is actually the case for active or gain devisers have talked about.

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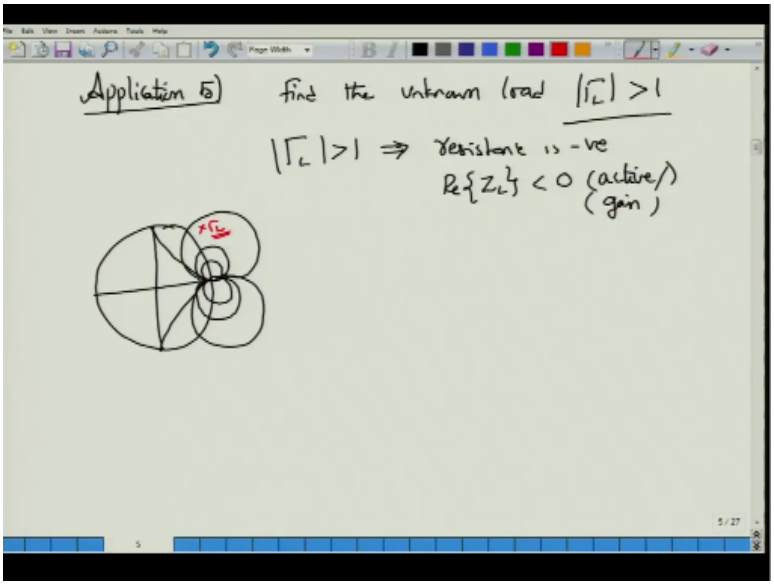

How do we find out the infidents that is one simple way is to use what is called as the negative resistant chart? Which is gain developing by snip itself okay? And this negative resistant chart actually completes some of these circumstances okay, so the arc that we are drawing it will completes some of these arcs and it will be the negative resistance circles over here. It doesn't matter now that here Gama L is a twist point to if you find this chart you will be able to find out what is the corresponding infidents.

Unfortunately this negative resistance chart is slightly concern the, if you are not designing the amplification or amplifier. So what our usual method is to use the existing standard snip chart itself. And try to find out what is the value of the unknown loads. And the idea is very simple we know the relationship that exists between Gama and Z bar Z bar being the normalized infidence. Why the relationship between these two well I know that Gama is given by Z be minus one divide by Z bar plus one right.

Someone has given me the value of Gama helps here which is greater than one no matter if I write down this Gama l is here call is as Z_L bar and Z_L bar okay. With the value of reflection co efficient expressed in the form of molar form we have. Gama L and an angle which I will in the different negation called θ. So on the standard snip chart it would like somewhere over here I mean I won't be on the standard snip char it actually would be like lying outside but don't worry about this okay.

From the center of the chart I can draw a line is find the line θ. The length is here will be magnitude of Gama $_L$ okay. And the angle of θ, I also know that the normalized value of the infidence here will be of the form –r + j x is would be –j x but I am considering here up lox j x. And I know that r have to be negative okay. So I can substitute to the –r +j x into this equation and obtain something like this –r +j x-1divided by –r+ j x +1 okay. r of course have to be positive because we already taken the next fine negative over here.

So let me simplify this what I now consider I very interesting thing let we consider what is 1/Gama $_L$. 1/ Gama $_L$ will be equal to –r +j x +1 because it goes onto the numerator and this will go to the denominator right. And what will happen to this Gama $_L$ and to the angle θ that will become 1 by magnitude Gama $_L$ at the angle of –θ which is okay. Now I do one more thing I conjugate this right.

So when I conjugate I have to conjugate everywhere magnitude doesn't matter what we conjugate but the angle –θ now become =θ. Where is +θ which is on the same line, but what is the magnitude that you need to consider that 1 by magnitude Gama L. So let's say this value. Corresponding to this magnitude Gama $_L$ this is one by magnitude Gama $_L$. so let see this is that length that I am considering and it likes exactly on the angle θ, but what happen to this quantity well.

Let's as expand this quantity here okay. I am see what can be simplified by taking the complex conjugate the sign of this +j x will become – j x by so I will get – r – j x + 1 divided by –r –j x- 1 if I take this -1 as a common factor everywhere in the denominator. So I can replace minus values here by plus values right. And I am that minus values here when we go something multiplied becomes plus here plus here and the plus sign to the + 1 value will become -1.

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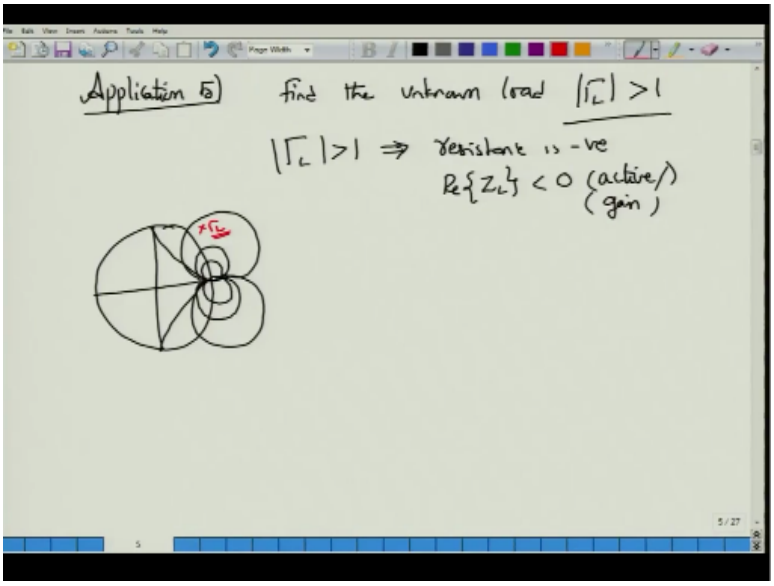

Let me also remove this plus here and this can understanding that r is always positive here because there is already done that here but what is this quantity if I could brackets around the into able to easily recognized that what is the quantities is simply nothing but some infidence normalized by some Z_L bar prime – one divided by Z bar prime plus one.

So here what to have is that correspondence of some Z_L prime with one by Gama complex conjugate by so what you do now find out the corresponding value of constant r and constant x circles find out the value of Z_L bar prime here okay. so from this acts I mean this point to which will corresponding A. which will find out what is Z_L bar once you find Z_L bar you simply replace right.

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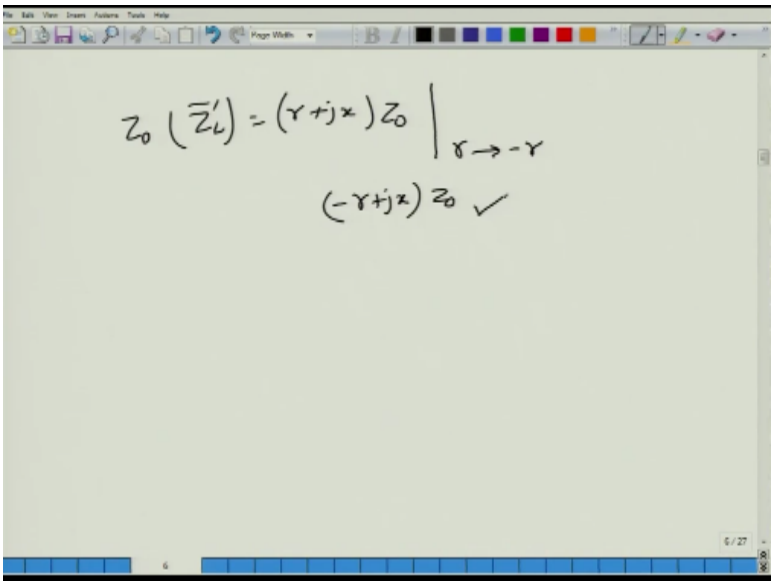

Once you find Z_L bar which will be some r + j x. If you want you can un normalize this by multiplying with Z_0 okay? And then you simply replace r by –r here so that we obtain –r +j z into Z_0 which is the correct value of the unknown load infedence. This is how you can actually is the standard snip chart in order to find out the unknown load value even then the mod Gama $_L$ is greater than one.

One notable point about all this applications let we have develop is that all this development happen with last left transmission line. We calculation with last we calculation transmission line is slightly complicated. And unfortunately we will not consider that last line transformation we split already possible to use snip chart calculations. But its slightly more radius you will be able to do that one in this course okay.

And one final point that the values but you obtain this snip chart or reasonably accurate but if you want to design real you know the systems you snip chart is not advisable but snip chart helps you in visualizing what is happening to the infidence I can move through different connection. So the value of snip chart in all actual value that you will find which I reasonable accuracy only.

If you want better accuracy you will have to plug in the order to solve those equation will have to solve those equation like a code may be you want. Don't rely on snip chart but if you want to understand what is happening graphically how the infedence is changing or a voltage you know what is happening to the magnitude of Gama how the angle is tuning. So all those manipulations is different elements will become very easy when you use snip chart. Thank you very much.

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