Basic Tools of Microwave Engineering

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Lecture – 05
Problem Solving Using Smith Chart

In this lecture, solve some problems using Smith Chart, so that whatever is taught in the lectures you grasp and I also advice that you practice this because both to do the assignments of this course and doing at the examination will also test your ability to do smith chart calculations that will be tested, and also as a professional advice I will give you that if you one to x l in this are a profession you need to thoroughly understands smith chart and this should be a true like calculator helps and any scientist is studies. If we scientist do not know how to use scientific calculators then lot of time we waste for doing simple things which is not our aim. When we do a scientific calculation our aim is not to do those things that can be done by calculators, but we try to concentrate our efforts in other philosophical things.

Similarly, here that in transmission line if you get bog down into doing those calculations manually then lot of time gets wasted, that thing can be much simply done by this tool of smith chart so please practice those things.

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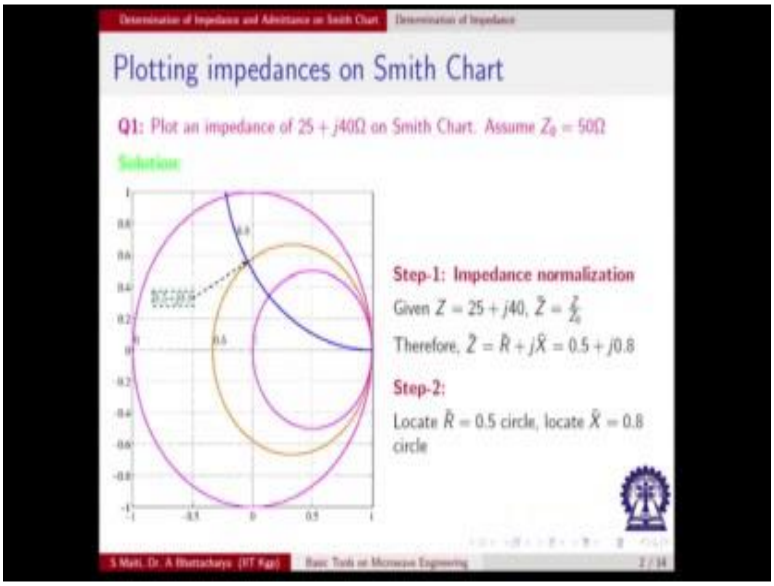

So, let us see the first thing that we will do is whatever is showing that plot and impedance of 25 plus j 40 ohm on smith chart. Assume characteristic impedance to be 50 ohm. So the first thing that you need to do to solve this problem is you normalize because this impedance smith chart is normalized impedance so that it is independent of characteristic impedance.

So that is why it has various values which are plotted in normalize day. So, first you normalize the impedance with respect to the characteristic impedance, it is given 50 ohm. So, Z bar will be division by the Z naught, so you get that R bar is 0.5 and X bar is 08. Then you need to locate the R bar is equal to 0.5 circle.

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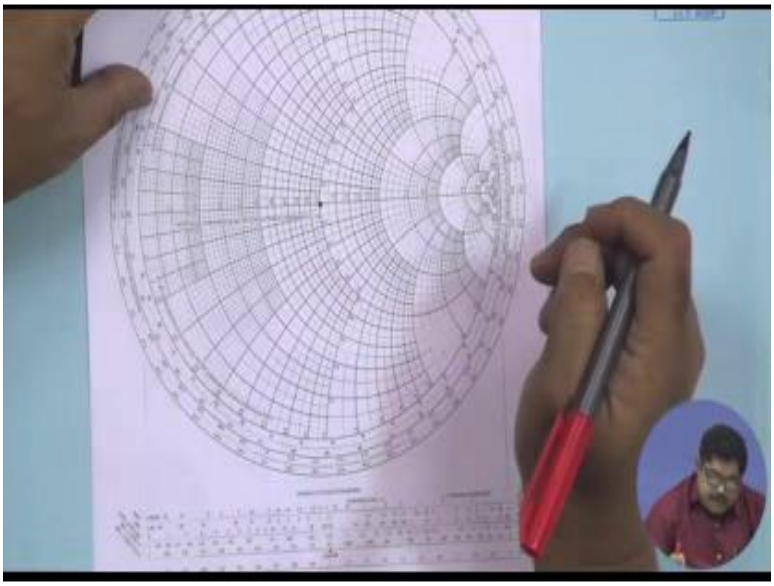

You see in the uploaded smith chart you can take because there is software freely available in internet which is call black magic design, I think the people who have done that they have put you can download that also we have kept sample copies of this things in your extra material portion of this course. So, if you see that thing you locate that along the real axis the values of the resistance is constant resistance circle values are given so there you locate.

As we have shown that you first locate the central portion of smith chart and then you see that, since it is R bar is 0.5 it will be to the left of this and as we have shown in the slide that 0.5 is the circle you will find out the circle which is passing through 1 0 right most point and 0.5. Then you locate what is the constant reactants 0.8 circle. So, X bar is equal to 0.8 you locate n r. So, you see that on those R's the values are given, these are given at the inner side of the outer most periphery thing so there I am locating 0.8 something, here.

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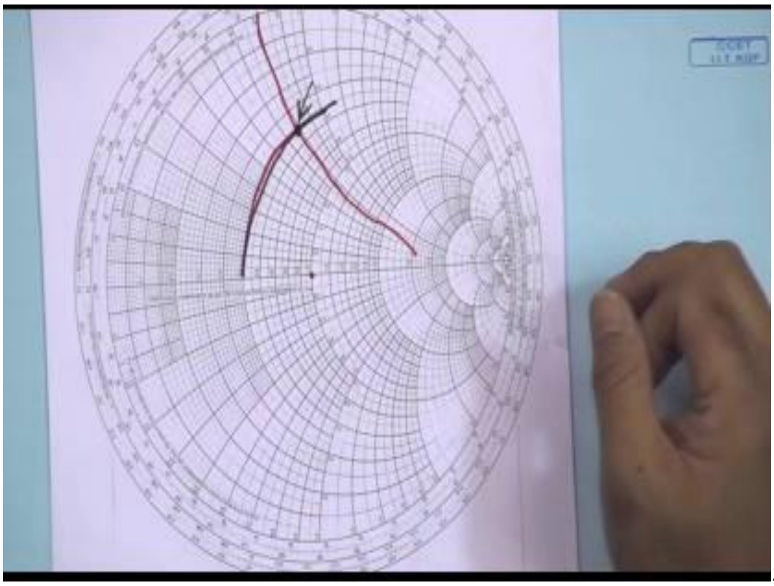

So, this one is that and 0.5 by thing is this circles sorry, so these intersection points somewhere here is our desire that point. So, by this I can locate any impedance if I want to locate on the smith chart this is procedure.

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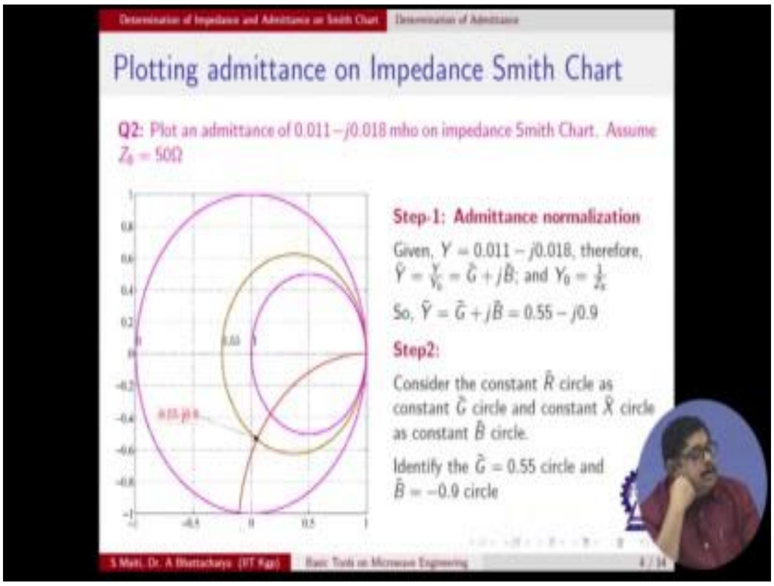

The next, let us do this that inside of impedance. Suppose, I have an admittance of 0.011 minus j 0.018 mo, plot it. Now there are two things we can do; either we can plot it on an impedance smith chart, or we can plot it on admittance smith chart. Now let us do both the things so first let us see the impedance smith chart thing, then the next problem we will see the same thing we will plot it in admittance smith chart. Again the first step is the normalization. So, you do the normalization with respect to characteristic admittance.

Now for characteristic impedance given as 50 ohm, so characteristic admittance is 1 by 50 mo. So you divide the character admittance sorry, you divide the admittance by the characteristic admittance you get that the normalized characteristic admittance Y bar is 0.55 minus j 0.9. So, now you think that in impedance smith chart if you want to plot an admittance smith chart then in your mental plain in you will up to thing that constant R bar circle is constant j bar circle and constant X bar circle is constant B bar circle. So, identify these two things. Now G is equal to 0.55.

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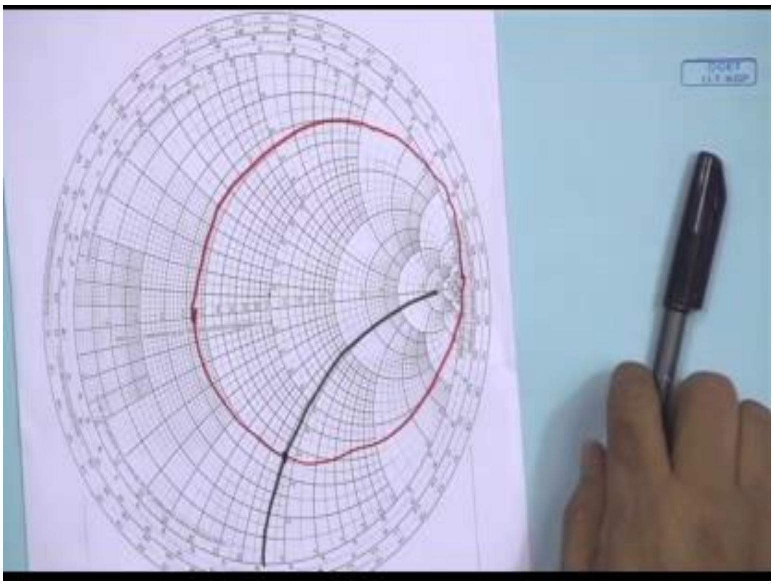

So find out in previous case you have found these so now 0.55 circle will be somewhere I think here, so this circle in this chart this is something 0.55 circle and then the minus j 0.9. So this we will have to locate whereas, this one will be j 0.9 these are. So this in the section point is our desired thing. Now you can see that you could have done another think also that if you know a, ok so you have located.

The third problem will be this.

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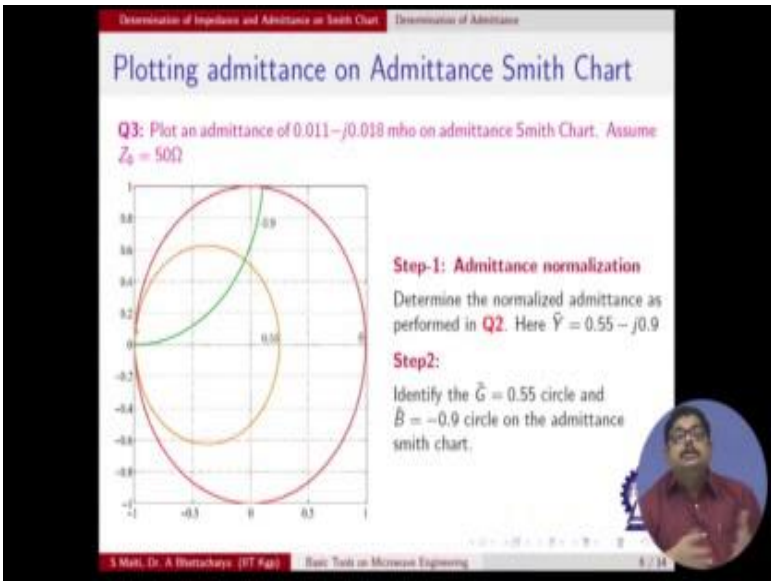

To this the same admittance value, but on admittance smith chart. On admittance smith chart the labels are different, and the admittance smith chart as I shown they are all the circles are passing through minus one zero point and they are values are different as can be seen here. So, here you see the same point is getting located 0.55 is here, in previous case or admittance case is here. So the point comes somewhere here, but here you see the point is somewhere here. Now can anyone tell me that are we making mistake or this is ok. The point is actually we have already seen that if we reflect any impedance point 180 degree in the smith chart we get an admittance point. So, this points this we got from impedance thing that if we take a reflection basically we get the admittance thing.

Now only problem now out of this which one is easier, obviously in admittance if you want to plot an admittance you should plot it into admittance graph, admittance smith chart, if you want to plot impedance you should plot it in impedance smith chart. But as I say that sometime to you need to convert and impedance to admittance because some portion of the circuit is series some portion is parallel so after doing series things you need to convert to that, that time this problem comes.

So, if we are in an impedance thing then to convert that to admittance we need to take a 180 degree shift, but if all the calculations are in admittance is then the impedance smith chart you can consider as an admittance smith chart there is no problem.

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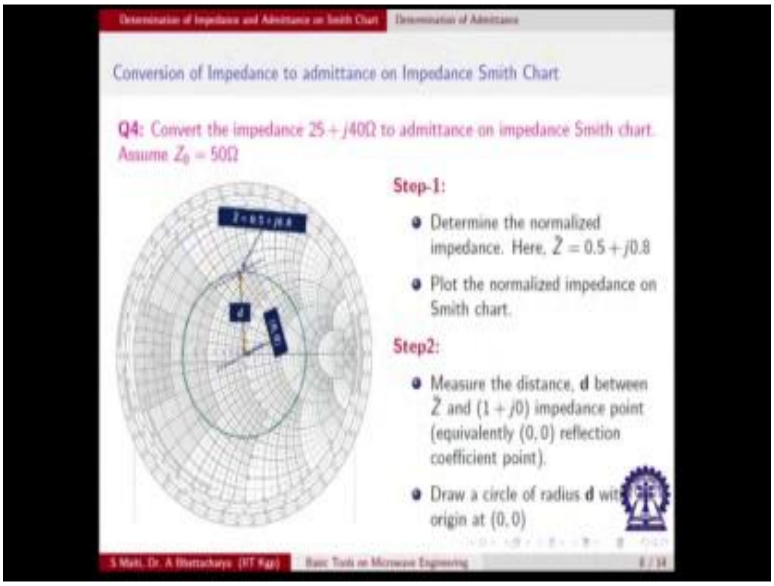

So, you can see this. Now the question of that conversion we are addressing here, that same impedance 25 plus j 40 ohm which have done in first problem. You would convert it to admittance on impedance smith chart. So, you do as before plot the normalized admittance, so you see that we have plotted it in this figure and this is the point where we have plotted it. Now to convert it to admittance what you need to do from this point to we need to connect to the center of the chart and with this radius and center draw a circle. So basically, now you know what we are drawing. Basically, we are drawing a constant VSWR circle. So in the transmission line one of the line impedance is these.

Now if you draw this circle we are basically moving on the constant VSWR circle. So, now it is easier that this point you just proceed to the other diametric end that will be the admittance. So, that is where draw a circle of radius d with origin at 00. Basically, draw a constant VSWR circle then and admittance will be 180 degree opposite to that an inflection.

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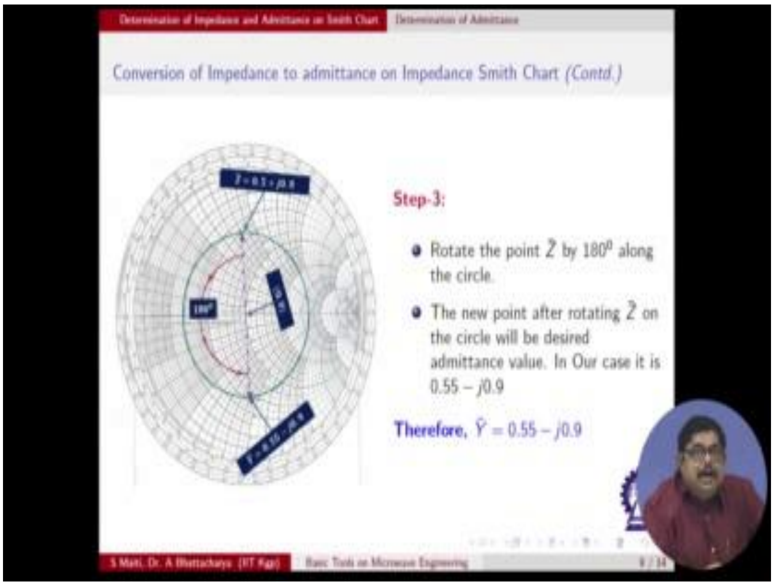

So, here we are showing that reflection means basically you are at the other end of the diameter. Now, we can read and you see that you are getting the correct value, so this shows that the procedures that whether you are in impedance smith chart using or admittance smith chart using you will be able to plot anyone correctly. So, these four I think examples.

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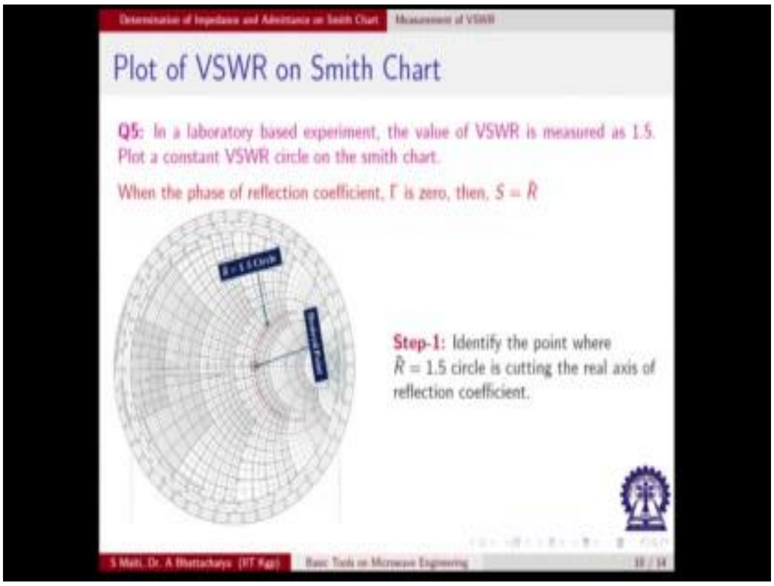

I have Shown you that how to plot any impedance or admittance on whatever smith chart available to you. Now let us do this that in a laboratory based experiment. As we say that the VSWR meter is measured, VSWR to be 1.5. Plot a constant VSWR circle on the smith chart. So, whatever discussion we have we know the step one, never forget this that identifies the point where R bar is equal to 1.5 circle. Remember R bar not VSWR because the smith chart is not graduated for VSWR, but it has graduation of R bar we know that (Refer Time: 14:31) R bar is equal to 1.5 circle. R bar is equal to that same circle and find out where it is cutting the real axis. That is one point of the VSWR circle. The other is origin the center, so you know center you know periphery.

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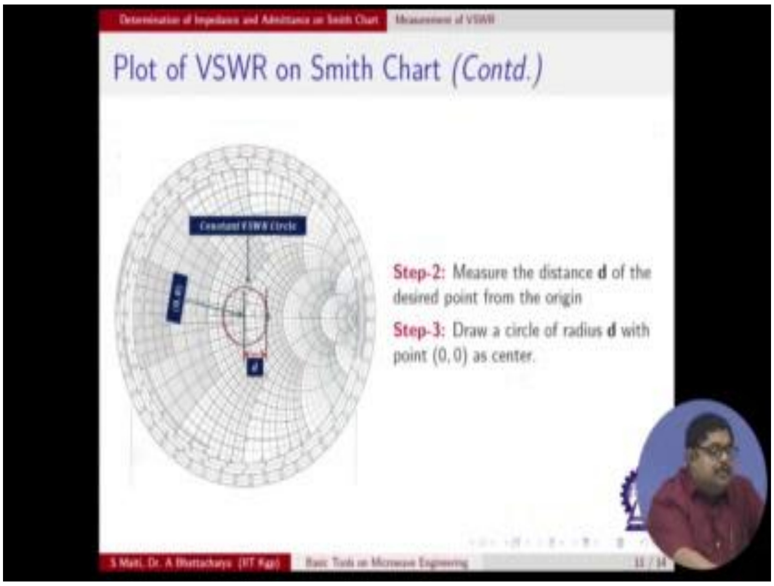

So, to the step two measure and find the distance, draw a circle of radius d which centers you know how to do the constant VSWR circle. So, if you measure something by VSWR meter you know how to plot it here.

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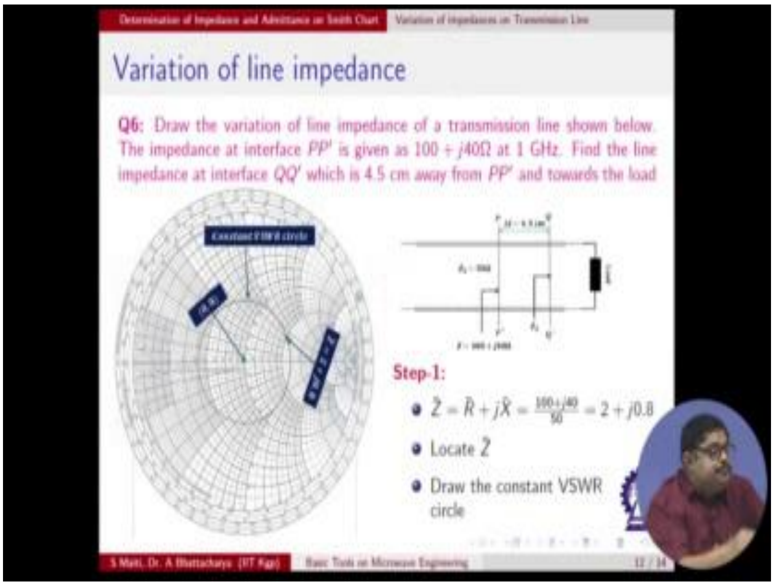

Now let us do this problem. This is about line impedance calculation. If I move along the transmission line how I can calculate the thing from (Refer Time: 15:24). Now I will also advice you that if when you of you or finding smith chart complicated please find out you solve this problem, analytically do not do it smith chart wise. Now you will understand how much problem you have and it is much easier to do it a smith chart. If you understand smith chart clearly this is very easy, that is why RF engineers are very passionate about using smith chart.

So, first step is what is that given that at this interface I am finding that line impedance is 100 plus j 40 ohm at 1 giga hertz let us say frequency. Now at QQ dashed which is 4.5 centimeter away from the PP dash point and it is towards load, find the impedance. So, first thing is this 100 plus j 40 you put then move towards load that distance and then you can locate.

So what he has done first we will have to do that you normalize that is always to be done. So, 100 plus j 40 you divide it is given that or we assume that characteristic no it is written here that characteristic impedance is 50 ohm so you divide, and it comes that Z bar is equal to 2 plus j 0.8. You can know locate Z bar that means, find the intersection of R bar is equal to 2 circle and X bar is equal to 0.8 arc, so by that you see that here this is the point which is the Z bar point.

Now here since you are moving along transmission line, we know moving along transmission line means we are on the same VSWR circle. Once you got an impedance you can always find out that if that impedance is one any transmission line, any impedance whether it is load impedance, line impedance, on transmission line then you can draw the constant VSWR circle. So, you draw constant VSWR circle that means this is the center, this is the peripheral point, you complete the circle, and now movement means I am moving on this constant VSWR line.

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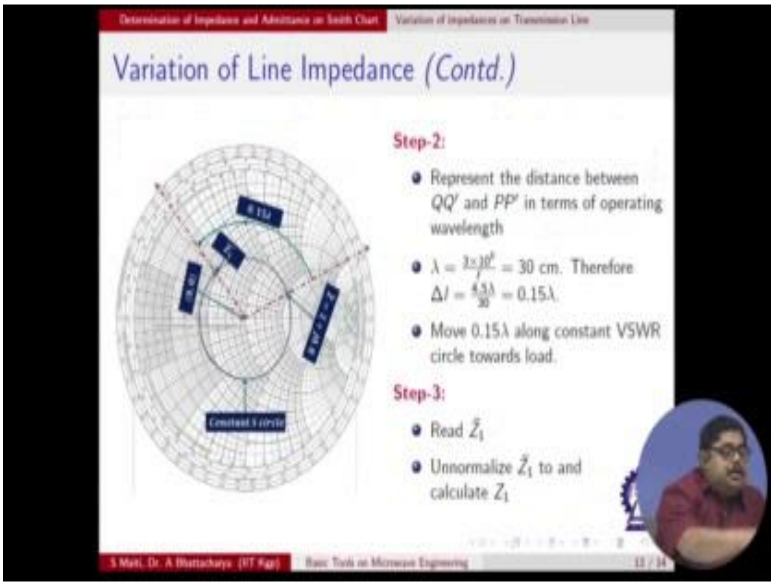

So, step two, since the smith chart movement markings are in terms of lambda so you find out that in the problem it was said 4.5 centimeter, but that is how many lambda, so that you need to convert. As shown here that lambda for your 1 giga hertz frequency, so it is 30 centimeter. Simple calculation the 3 into the speed up light, 3 into 10 to the power 8 meter per second this are speed up light by f, so that is 30 centimeter.

Lambda is 30 centimeter, so how much is 4.5 in terms of lambda that is 0.15 lambdas. That means, from the earlier point which you have located the z one point this one you will have to now move towards load. See this diagram you are to give move towards load by an amount 0.15 lambda. So, that you look from here that towards load so which side in a smith chart towards load means anti clockwise. So, you move from this point on this constant VSWR circle anti clockwise if distance 0.15, that means see it from the outward one thing you move by 0.15 that will take you to this new point then you connect this.

Because actually your moving though I am reading from outer boundary, but on the constant VSWR circle I am moving. So, on constant VSWR circle basically I have come to this z one point come to this point and this value if I read that what is the resistance value and reactance values then that I can find and then my job is to ab-normalize it to that. So, by this we can find the line impedance.

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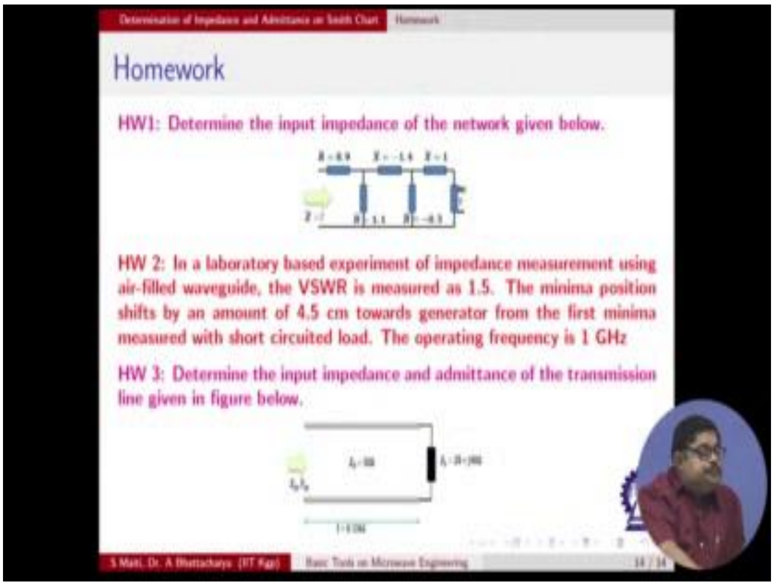

And this will be the homework, so your assignment will be this. So, you see these assignments, so by whatever we have thought you will be able to do this the first problem. You see that we have given various combinations of this R and b. That means, acceptance and resistances, reactants, etcetera some are in series, some are in parallel. So, you will up to find the input impedance. What I advice that since your ask to find input impedant you start form the load side, so there is a load and that is in series with something so in the impedance plane you find out those two things their sums and then you find out. Then there is a parallel circuit.

So, you convert yourself to admittance and connect that find out what is the admittance, then at this admittance then again convert to impedance then add that impedance like that you can always come here at this point and find out what is a input impedant. So, this will test you whether you will understand this thing. And now you will understand that come doing this same thing without smith chart will be lot of trouble, lot of calculations, but in a smith chart graphically you can do it very easily if you have understood this.

Similarly, the second problem is like our laboratory problem. That in a laboratory we have found the VSWR, and also we have noted that minima shift by certain amount frequencies given, so you will up to find the impedance and also the third problem. You will have to find out what is an input impedance and admittance of the transmission line given in figure. You have given the line you have given the think also we have said the line link so you can find out from load if you are moving along the transmission line. Again the same think first you locate the load then you draw the constant VSWR circle and in that circle you moved by the requisite transmission line distance you will be arriving at a point that is your input impedance within that impedance you then need to convert you admittance and reverse the answer. So, assignment will be similar to what we have done, I think will be able to do it.

By this we are completing one thing that you now know smith chart the first tool your known and we have given example that how smith chart is used for finding the impedance in laboratory. Also will see later also in impedance matching and others in any design of networks we can do that later you will see that if I want to study design and amplifier and I want to study whether that amplifier is stable or not then also this smith chart is helpful. If you want to carry out that whether it is having the noise figure is acceptable to you or not, whether is gain is what you desired or not, whether from that amplifier your getting good gain, whether your having its noise kept at a minimum.

So, all those designs that time you require you use smith chart ably you understand, so that smith chart is a tool which will help you to attempt this designs. How to design and amplifier when a gain is specify, what is the base possible gain I can get from that amplifier? Under given impedance a thing, given the load condition can we do anything to achieve based at the maximum gain from there, can we design need for a given specify noise figure value that my noise figure should not go there. Those are required for low noise amplifier designs.

So, all this circuitry where there were oscillations possible you can do that then you can design for oscillator design also which is the design of an active device. Then you can take this smith chart though you have introduced smith chart for passive devices that is standard smith chart with some conversion you can make it for active devices and you can do that. That is another technique, but the same smith chart fundamentals will be needed there at m those oscillators design what is its stability, which zones are under which impedance conditions you are stable etcetera all this your smith chart will be doing.

So, we have completed in this whole module that the smith chart has a tool has been introduce. So please go through the assignments try solve those assignments submit and if you can have this assignments then it will give you confidence that you have learnt something how to use this tool smith chart as an RF engineer.