Computational Electromagnetics
Prof. Uday Khankhoje
Department of Electrical Engineering
Indian Institute of Technology, Madras

Application of Computational Electromagnetics
Lecture – 14.14
Antennas – Circuit Model

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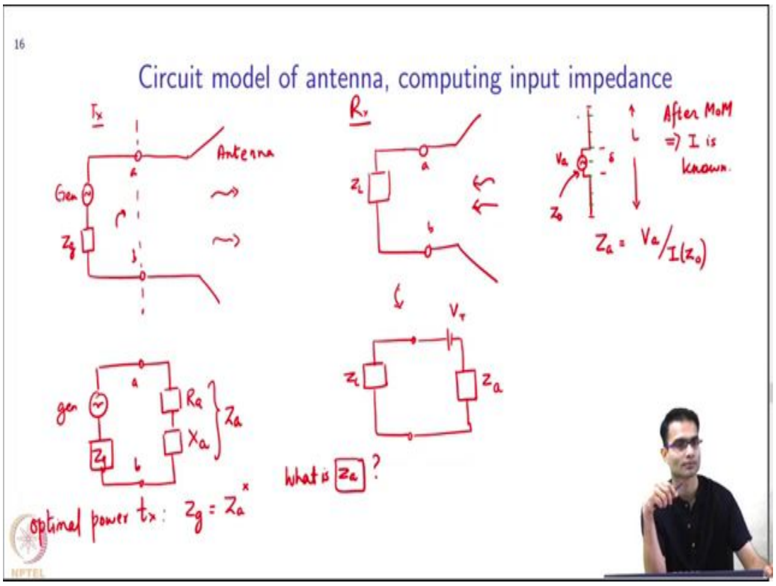

Right so, having seen how we calculate how we introduce the source the next I think that we have to find out is why are we doing all of these in the first place ok. So, from an antenna designer point of view why would, how can you motivate an antenna designer to get interested in computational electromagnetics. So, we said if the currents are not known on the surface of the antenna in very general way we need to solve Maxwell's equations , therefore, we can get the current next question is so what, once you get the currents you can get $\vec{A}$, from $\vec{A}$ you can get $\vec{E}$ and $\vec{H}$ ok. Any other aspect you can think of why should us antenna engineer care about CEM? The sort of the answer is on the slide it is about the impedance of the antenna.

So, normally I mean traditionally what has the RF world and the antenna world are two different worlds right. So, you have some RF circuit which generates your signals and all and you have an antenna, now when you combine two different electrical elements what will happen?

Student: Mismatch (Refer Time: 01:24).

There can be a mismatch of impedance and because of mismatch of impedance what will happen?

Student: Reflection.

Right so, all the power is not I mean the optimal power is not dumped into the whatever load you want some of its gets reflected back which is undesirable right. So, how do we know what is the impedance of the antenna? Right so, let us have a look at the back and I follow the major application of CEM for antenna design right. So, in the transmitting mode I am going to draw the circuit equivalent of antenna right. So, what is in let us take the transmitting case. So, you have some you know generator it has some impedance of its own Z_g is the complex impedance.

So, this is what the RF engineer design skill and gives it to you. Now, it is now you connect your antenna to it right. So, we can think of this is a two port over here and this is your antenna right. So, here is where these two worlds will meet and this is your antenna right. So, it is sending out radiation like this, correct what is the circuit equivalent of this? It is very simple. So, looking from either of suppose I look from here, this whole thing can be replaced by another impedance right.

So, this I can replace like this. So, this generator remains here, I have some Z_g this is my port a and b right. So, there is some reactive I mean some resistive part and some reactive part ok. So, the antenna has been replaced by this lump parameter and so, this together is Z_a. So, I need to out what this idea is otherwise how so, for optimal power transfer what do I want $Z_g = ?$

Student: Za conjugate.

Z_a^* right. So, for me to know that I need to find out what Z_a is right I do not exactly know what Z_a is. And similar problem comes in the case of your receiving antenna right. So, receiving antenna is so, I can just draw this. So, here I will have some load right, this is a load over here this is my two antennas terminals this is my receiving case and the circuit equivalent will become Z_L is the load across which have connected it what you think will happen over here across from here? What should I draw? What will be the equivalent?

Student: A voltage source.

A voltage source there is some voltage induced in the terminal. So, I have some V^- should not write I guess some V_T is induced and Z_a remains the same, usually, by reciprocity. So, this is the same is that fairly intuitive right some voltage is induced across the antenna terminals that voltage is falling across both the impedance of the antenna and the impedance of the load.

How do you find Z_a is the question?

Student: Using Z parameter.

Using?

Student: Z parameter.

So, you mean using the do the measurement.

Student: No if we will get the equivalent circuit for the antenna it is very easy to (Refer Time: 05:32) terminates impedance.

No when you say how do we get the equivalent circuit I have drawn a box which say Z_a, but how do I know the value of Z_a is? That has to come from somewhere.

Student: That is equivalent circuit distribution.

Either it will come from measurement.

Student: Ha.

Or it will come from where? It has to come from some Maxwell's equations or some approximation or something of this are.

Student: (Refer Time: 05:53).

Where will it come from?

Student: Come from.

Yeah, I have made it into lumped components, but I do not know the value of the lump parameters what should I put for the value of R_a and X_a? It should depend, for example, on the length of the antenna all of the physical parameter of it; that means, if all of these things are involved, Maxwell's equations are involved boundary conditions are involved. So, there is a large theory of approximations which are used to calculate this lump parameters, it will assume sinusoidal current, it will assume linear current all of these approximations are there which will give you some form of Z_a ok. And I am not covering those theory there is a lot of one is called induced EMF method so, on various methods are there ok.

The point of this course is to tell you how to do it rigorously and exactly, without any without I mean with as little approximation is possible that is the objective over here ok. So, the main question is what is Z_a? That is the sort of million dollar question ok. And more so, as you go towards more sophisticated technology this becomes more important because you have think of 5G antenna array board right, the antenna elements are all very interesting, very complicated structures. So, all your original approximations if a nice sinusoidal current, they are no longer valid. So, you have to do this numerically right. So, that is the thing.

Now, based on what we have seen so far. So, we have studied Pocklington integral equation right. How will I calculate this Z_a? So, what did we do? We just to remind you we had let us let us check this delta gap approximation right. So, delta gap was Va volts applied across the distance of Δ right, this length was some capital L right. What did I do over here? I broke this into segments and applied a method of moments over here on each of the segments ok.

So, end result after MoM, what is it that is known? I is known after I solve the integral equations very good what is Z_a now? V . I is a function of space right I have got I expanded I on the pulse basis along the length of the antenna. So, now, which I will I put?

Student: Near the sources.

Near the source right after solving I will get Z_a will be equal to the applied voltage. So, basically what is the current and voltage at the input terminals that is the impedance right. So, it is $V_a/I(z_0)$ right. So, we can say that this coordinate over here is z_0 ok. So, this is how your CEM is going to tell you what is after you have done the calculation what is the value of the input impedance over here. You cannot match the free space impedance.

Student: I mean (Refer Time: 09:03).

Yeah, you cannot match that know yeah. I mean you have your circuit impedance as let us say 50 Ohms, 75 Ohms and then you have to match it over there you yeah you cannot match free space. Not all the radiation is going to go into free space newly with that ok. So, the procedure is clear how do I calculate the input impedance ok.