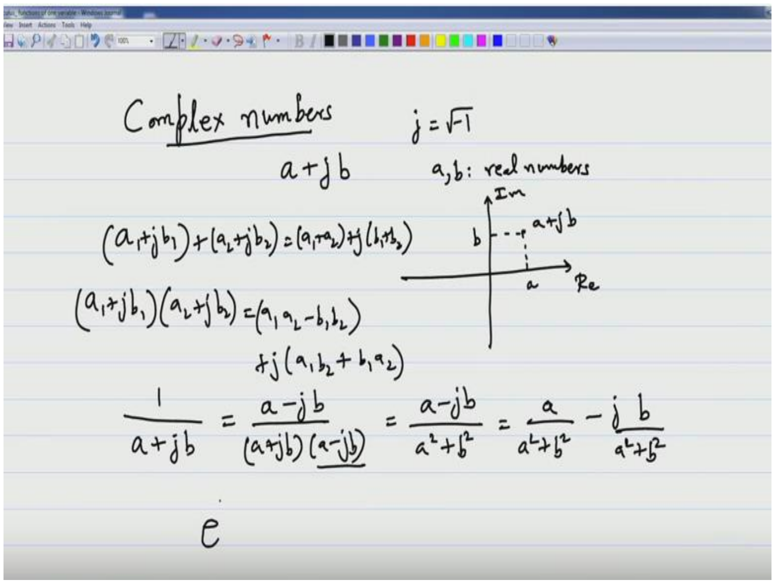
Networks and Systems
Prof. Andrew Thangaraj
Department of Electronics & Communication Engineering
Indian Institute of Technology – Madras

Lecture-3
Prerequisites: Complex Numbers

Okay the last prerequisite that you need for understanding things in this course is complex arithmetic and complex numbers.

(Refer Slide Time: 00:20)



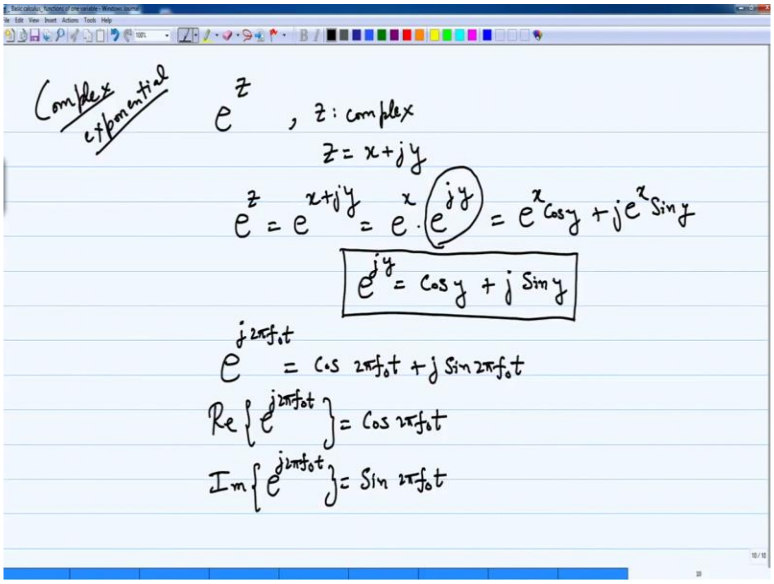
I think most of you would be familiar with this but still it is good to revise what this what complex numbers are. Now complex numbers are pair of real numbers and they usually denoted a plus jb and this j is actually square route of minus 1. Okay and a and b are real numbers and one can plot this on the complex plane if you like. In case you have the real part here, imaginary part here and a plus jb is just a here and b here.

Okay it is exactly like the 2-dimensional plane its complex plane. Now addition and multiplication are easy to see a plus jb1 plus a2 plus jb2 simply going to be a1 plus a2 plus j b1 plus b2 is quite easy multiplication is also quite easy to you simply use the fact that j square is minus 1. Okay, so if you do that you will get a1 a2 minus b1 b2 plus j a1 b2 plus b1 a2.

Okay you just multiplied term by term and group the terms together you will get this. And the other little trick you might want to remember about complex numbers is inversion if you want to do 1 by a plus jb. This you have to multiplied by complex conjugate which is a minus jb and if you do a plus jb times a minus jb. You get this magical cancellation of the imaginary part and it becomes real.

So, you simply get a minus jb divided by a squared plus b squared so which is just a by a squared plus b squared minus j b by a squared plus b squared. Okay, so a minus jb is called the complex conjugate of a plus jb and if you multiply a plus jb and a minus jb you get a real number which is a squared plus b squared. Okay, so this isa basic complex numbers most important thing to know I guess in this course is this complex exponential.

(Refer Slide Time: 03:00)



Okay, so just like we looked at e power x for x real okay one can look at e power z where z said is complex. As the z islet says x plus jy okay and if you look at e power z its e power x plus jy and thats nothing but e power x times e power jy and it turns out this type of an expression as a very simple simplification it turns out and just you might want to remember e power jy is cos y plus j sin y.

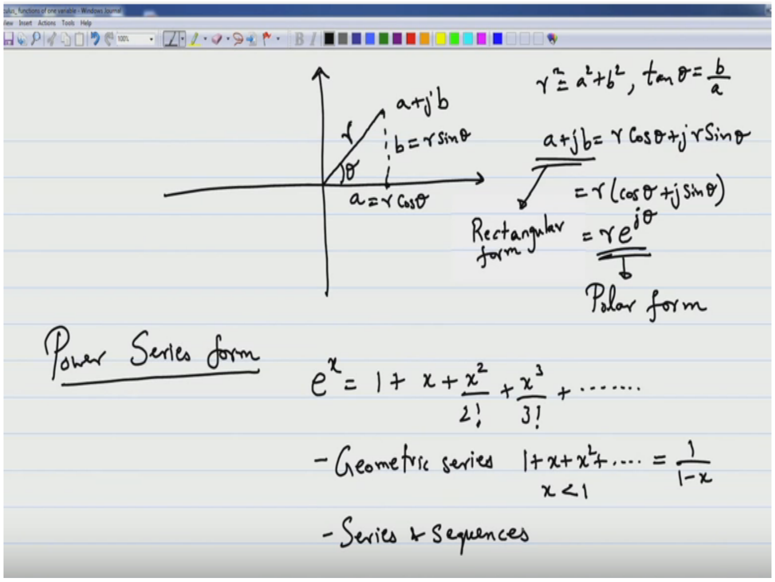
Okay, so this is very important identity let you should know as part of this course e power jy is cos y plus j sin y. So once you write that out this simply becomes e power x cos y plus j e power x sin y. Okay, so this is the definition of the complex exponential okay and it is very crucial and it will show up again and again in this class. For instance a very commonly seen exponential is e power j 2 pi f 0 t and this you will c is cos 2 pi f 0 t plus j sin 2 pi f 0 t.

Now you might wonder everything that we deal with in real life is real of course all the voltages and currents are real why do you need complex numbers. Okay, so usually in analysis complex numbers are much much easier so for instance there is same argument why did we complex numbers at all in the first place. If you remember why we needed it there are quadratic equations for which there are no solutions in the real numbers. For instance x squared plus 1 equal to 0 has no solutions in the real numbers.

On the other hand if you imagine that there is a complex route then you get nice answers. Okay, so like wise here in the complex signals are useful in solving for real circuits as well you will see it is very powerful and it gives you wonderful transform ideas etc and it simplifies a lot of the analysis if you use the complex exponential as supposed to the real exponentials in real sinusoids in many cases.

Okay and this identity is quite important and you can see that the real part of e power j omega 0 j 2 pi f 0 t is actually cosine 2 pi f 0 t and the imaginary part is sin 2 pi f 0 t. Okay, so these are important identities which you should be comfortable with and it will show up quite often in this class.

(Refer Slide Time: 05:59)



Okay and the other thing about complex numbers is the polar form okay so if you look at complex number a plus jb one can write it in the polar form which involves the radius r and the angle theta. It turns out if this is radius the distance from the origin to a plus jb r we know that r squared is a squared plus b squared. For instance and we also know that this coordinate is a and this coordinate is b which means b is r sin theta and a is r cos theta.

Okay, so a plus jb is the same as r cos theta plus j r sin theta which is the same as r cos theta plus j sin theta and what we know as cos theta plus j sin theta r e power j theta. So this is called the polar form of a complex number while this is called the rectangular form of a complex number. How do you go from one to the other? I wrote 1 equation down r square is a square plus b square and the other equation is tan theta equals b by a.

Okay, so use these 2 equations you can go from 1 to the other and there are standard calculations that you can do to go from rectangular to polar form. Okay and one last I want to emphasize about the exponential function is the series form power series form for the exponential function e power x is actually 1 plus x plus x square by 2 factorial plus x cube by 3 factorial plus so on.

Okay, so this the series form is useful to remember in some cases it will show up in some derivations etc and it will help you and there are so many other series that you might know from your school you might know the geometric series. It is worthwhile knowing the sum of the geometric series 1 plus x plus x squared plus 1 for x less than 1 is going to be 1 by 1 minus x. These kind of summations which are quite a bit and in general revising series and sequences will also help you in understanding this course.

It is not strictly a prerequisite for the course to might do okay without it but if you know series and sequences really well it will also help you. So the many references that we are giving you have a description of this also and in a first semesters course in mathematics and engineering you would have read about series and sequences and that will also help you understand a lot of the concepts in this course in a very deep fashion.

Okay the last bit of a prerequisite that you need is knowledge of integration and differentiation and going to talk about integration and differentiation as part of this prerequisites. On the other hand the material we point you to has a lot of interesting information on that particularly integration by parts is going to be useful various different types of integrations and the formulae for integration will also help you in this class.

So I will encourage you to go through all the prerequisite materials that we have put up on the course portal and be prepared for seeing the next seeing the real part of the course when it comes to you and not be surprised by it. The mathematics is not very heavy I think a lot of the mathematics supported by a lot of circuits and good examples and you can quickly grasp what is going on if you spend a lot of time with the examples.

But nevertheless knowing the mathematics well is a great advantage and you might find the course you might appreciate the course much more if you are comfortable with this basic level of mathematics. Okay, so with that with those words I welcome you to this course once again. Hopefully you will have a great time learning about network and systems and appreciating some other deeper aspects of circuit analysis and system analysis. Thank you very much for being part of this course I wish you all the best.