Network Signals and Systems

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Lecture - 28

Parts of Network Functions (Contd…)

Good morning friends we shall continue with the topic on parts of network functions.

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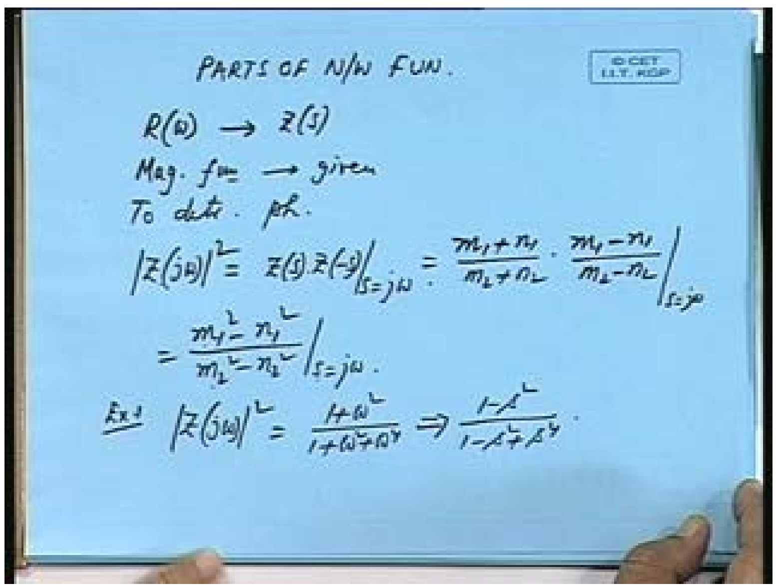

Yesterday, we discussed about functions r omega being given how to get z(s) okay so we desorb this by substituting omega square equal to minus s square, we took the roots in the left of plane and finally from the co efficient of the numerator a_0, a_1 and so on.

Now today we shall be discussing of about the magnitude function, the magnitude function, if the magnitude function is given how to calculate phase magnitude function is given to calculate to determine phase. Now the magnitude z square can be written as z(s) into z minus s at s equal to j omega is that all right and what is z(s) if I write in terms of even and odd parts m_1 plus n_1 by m_2 plus n_2, this is z(s) and what is z minus s, m_1 minus n_1 it is only the odd part which will be having a negative sign now divided by m_2 minus n_2 is that all right at s equal to j omega. So what you are getting is m_1 square minus n_1 square by m_2 square minus n_2 square to s equal to j omega is that all right.

So if you given z magnitude square it is basically m_1 square minus n_1 square by m_2 square minus n_2 square at s equal to j omega see if I make reverse substitution I will get m_1 square s minus n_1 square s by m_2 square minus n_2 square s from here okay. So there if I factorize and drop out the roots in the right up plane I will get m_1 plus n_1 and correspondingly m_2 plus n_2 it is very simple. So let us take one example z j omega square is equal to 1 plus omega square by 1 plus omega square plus omega to the power 4, so that gives me if I make reverse substitution it will be 1 minus s square by 1 minus s square plus s to the power 4 okay.

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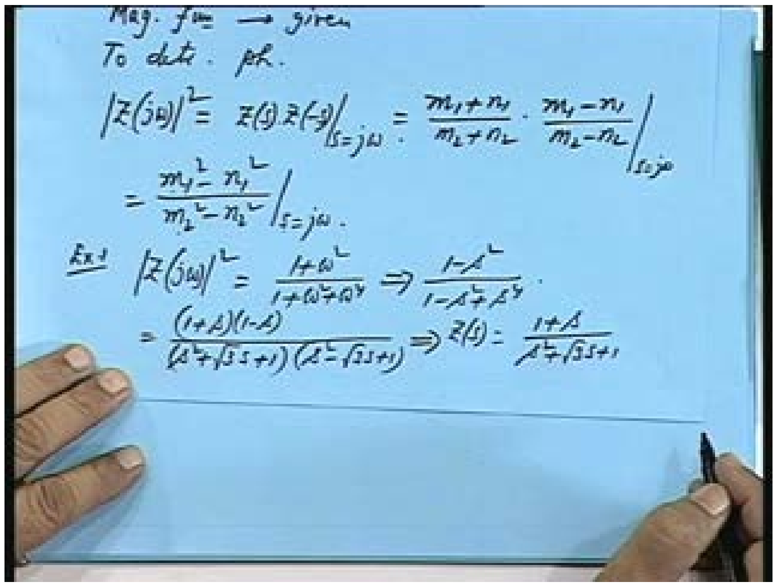

So what are the roots of this 1 plus s into 1 minus s okay what are the roots of this s square, see 1 plus s to the power 4 plus twice s square minus 3s square, so it will be 1 plus root 3 s into s square minus root 3s plus 1 all right. Obviously, the quadratic be the negative sign this is m_2 minus n_2, this is m_2 plus n_2, this m_1 plus n_1, this m_1 minus n_1. So that gives me z(s) equal to the left up plane roots the factor corresponding to that is 1 plus s divided by this 1 s square plus root 3 s plus 1 is that all right s_1 plus s by s square plus root 3 s plus 1 realization of this you can realize this by Bott Duffin or Brute synthesis okay we are not going to the realization part at this stage z(s) is this much.

Let us take another example z omega square is equal to omega square plus 16 by omega 4 plus 10 omega square plus 9. So I can write z(s) into z minus s as 16 minus s square divided by s to the power 4 minus 10 s square plus 9 which gives me 4 plus s into 4 minus s, this gives me s square minus 9 into s square minus 1 which gives me finally 4 plus s into 4 minus s by s plus 3 into s plus 1 into s minus 3 into s minus 1. So what will be z(s) 4 plus s by s plus 3 into s plus 1 okay is this all right. Like this you can see for any function mind you z magnitude square will be a function of omega square only there is nothing like omega, omega to the power 3 and so on, this will be an even function of omega, this will also be an even function of omega. Next we go to phase to magnitude, phase to magnitude, phase to magnitude okay.

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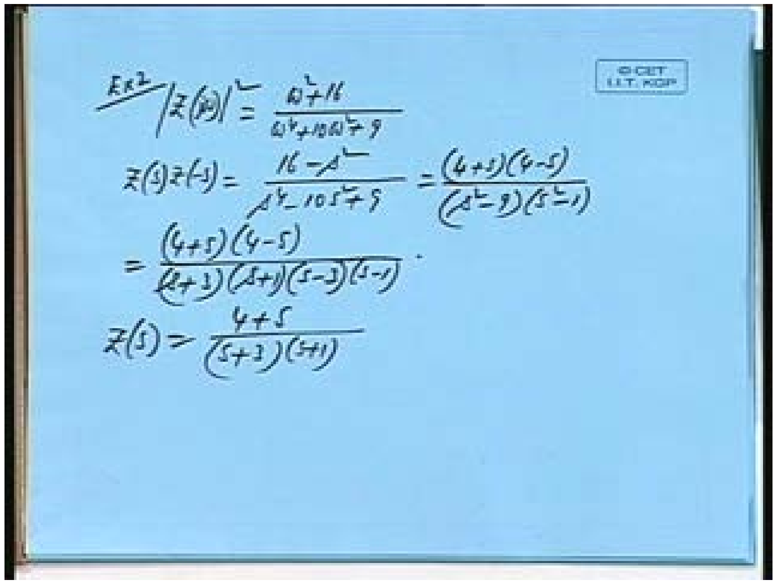

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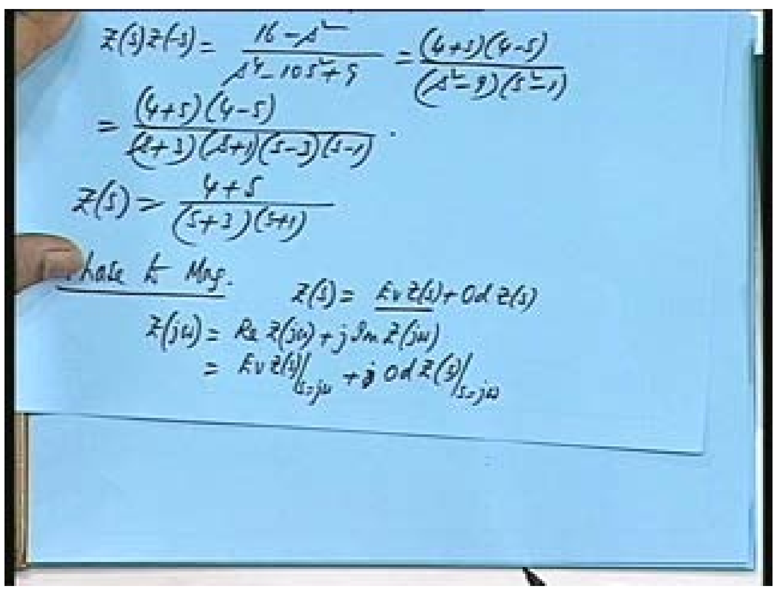

Now if I see the angle z(s) if I write as even z(s) plus odd z(s) then z j omega this will correspond to a real part this is nothing but even z(s) at s equal to j omega and this gives me odd z(s) okay at s equal to j omega j will come out of this, is that okay. So what is tan theta you would give an say the angle tan theta is odd z(s) at s equal to j omega but odd z(s) will generate j term okay mind you divided by even z(s) all right. So this is nothing but if I write j tan theta, j tan theta you will get n_1, m_2 minus m_1, n_2 divided by m_1, m_2 minus n_1, n_2 okay at s equal to j omega all right this is nothing but okay.

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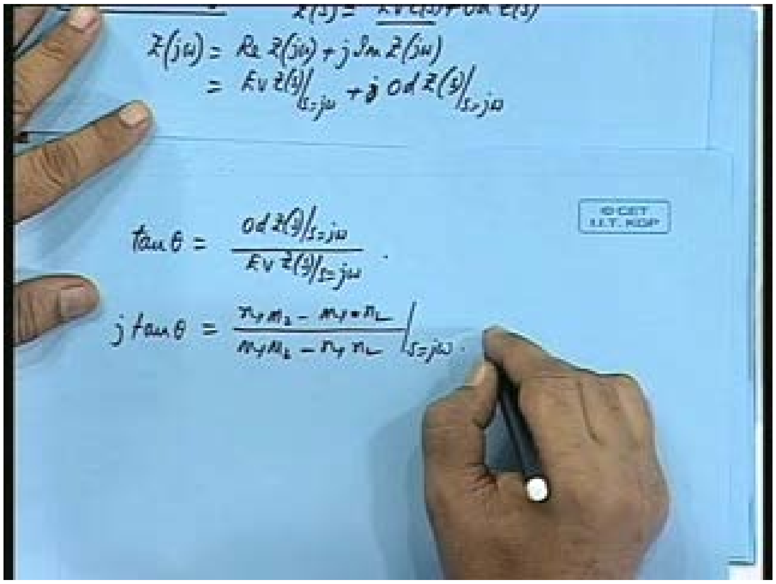

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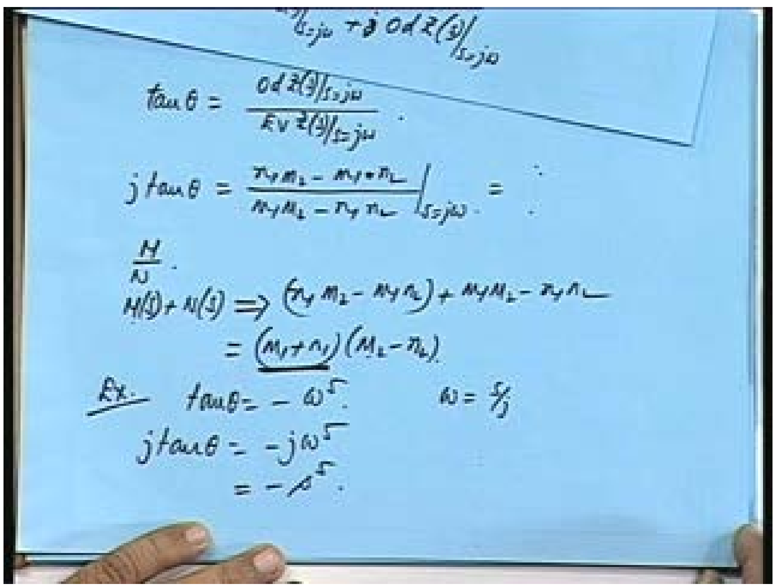

Suppose this is equal to this 1 even z(s) plus odd z(s) is say after division I am making a reverse substitution suppose we get m by n okay m by n. So m plus n(s) if the ratio is m(s) by n(s) if it is m(s) by n(s) then what is m(s) plus n(s) this plus this okay which will be n_1, m_2 minus m_1, n_2 plus m_1, m_2 minus n_1, n_2 which means m_1 plus n_1 into m_2 minus n_2 okay. So the 1 with m_1 plus n_1 term that is roots in the left up plane will be numerator and roots in the right up plane will if you shift those roots in the left up plane that is m_2 minus n_2 you get so you just change the sing of n_2 that will give you the denominator all right. So let us take an example it will be clear.

Suppose tan theta is given as minus omega to the power 5 okay. So you substitute omega is equal to s by j so j tan theta you are computing j tan theta that is minus j omega to the power 5 and that gives me minus s to the power 5 all right. So this you are calling as m by n, so s to the power 5 by 1, is it not this will be s to the power 5 by 1 with a negative sign.

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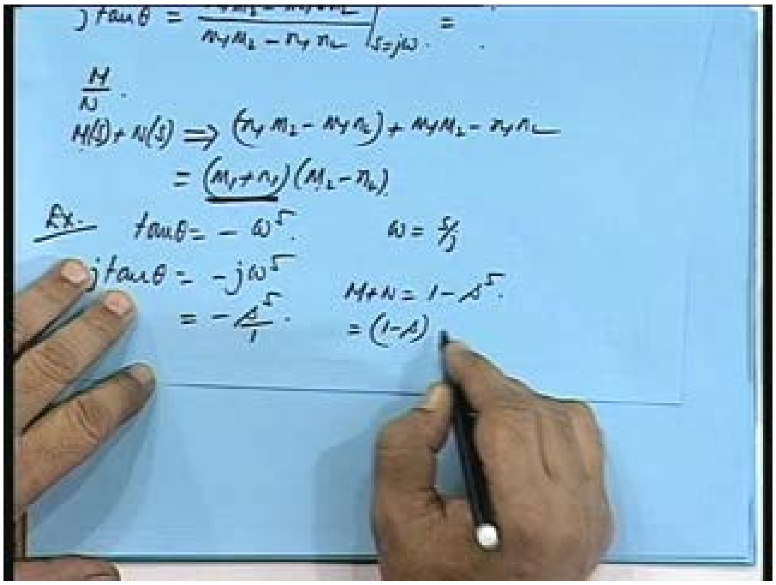

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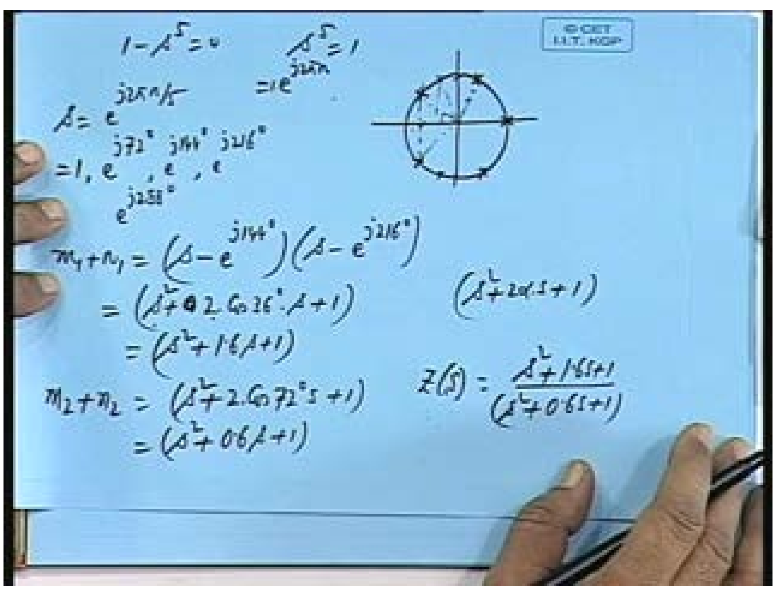

So what will be m plus n, 1 minus s to the power 5 is that all right. So 1 minus s to the power 5 what are the factors 1 minus s, now let me work it out here, s to the power 5, no you do it this way 1 minus s to the power 5 equal to 0 you want to find out the roots say s to the power 5 is equal to 1 so on the unit circle, so that is equal to e to the power j2 phi n. So what will be s e to the power j 2 pie n by 5 put n equal to 0 1 to so if I put n equal to 0 this is 1 root then 2 phi by 5, 72 degrees, this is 72 degrees 2 phi by 5 then 2 into 2 phi by 5, 144 degrees okay then 3 into 72 so 216 degrees, so the values are 1 e to the power j 72 degrees, e to the power j 144 degrees, e to the power j 216 degrees, e to the power j 288 degrees, these are the 5 roots is that all right, that equal to be 1. Obviously 1 into e to the power so 1 to the power 1 by 5, so that will be 1 they will not be on the unit circle.

So what are the factors corresponding to m_1 plus n_1, it will be this this is giving me m_2 minus n_2 so m_2 plus n_2 will be just images of this. So m_1 plus n_1 will be s minus this a to the power j 144 degrees into s minus a to the power j this one 216 degrees all right. So that gives me cos 144 degrees okay that means this one how much is this angle 180 minus 144, 36 degrees 36 degrees, so cos 36 degrees so s plus cos 36 degrees and this will also give me cos 36 degrees so 2 into cos 36 degrees. So s square plus 2 into cos 36 degrees into s plus the imaginary parts alpha square plus beta square is 1 it will be 1 is that all right. Any quantity coming out of complex pair of roots on the unit circle will be s square plus 2 into the real part which is cos 36 degrees into s, s square plus 2 into alpha into s plus 1 alpha square plus beta square is 1. So it is s square plus cos 36 degrees approximately .8, so 1.6 s plus 1, 36.8 degrees is .8, m_2 minus n_2 you know so m_2 plus n_2 will be this is 72 degrees.

So s s square plus 2 into cosine 72 degrees into s plus 1 straight away images of these will be on this side all right. So the real part of this will be 72 degrees, cosine 72 degrees s square cosine 72 degrees is approximately .38 degrees approximately .3, so 2 into .3, so 0.6 s plus 1. So z(s) is this one will be the numerator s square plus 1.6 s plus 1 divided by s square plus 0.6 s plus 1 approximately this will be the function, is that okay. So we have seen how to calculate the function z(s) from the phase.

Now from here you can calculate the magnitude, once you know the actual z(s) you can calculate the magnitude sir, yes please, that kind of problems when when we can be in practical use, no in the practical system sometimes we measure only the phase we are not in a position to estimate say the gain then what will you do okay. Sometimes you try to track both magnitude and phase all right and try to find out z(s) it is a cross check, it is a cross check.

Suppose the magnitude function is known we take only the real part or the only the total magnitude with frequency then you approximate it by even polynomial ratio, ratio of even polynomials all right and then only from there you can find out just previous to this you have found out z(s) into z minus s, is it not. So factorize it find out the right up plane roots left up plane roots all right take only the left up plane roots and that gives you the function z(s) you are tracking only the phase then from the phase if you can estimate again phase function in the form of polynomials then you can estimate z(s). In the laboratory depending on your facilities available the accuracy for measurements of phase and magnitude may be different. So you try to find out z(s), approximate z(s) from both sides another example tan theta equal to omega cubed minus 3 omega divided by 1 minus 3 omega square all right.

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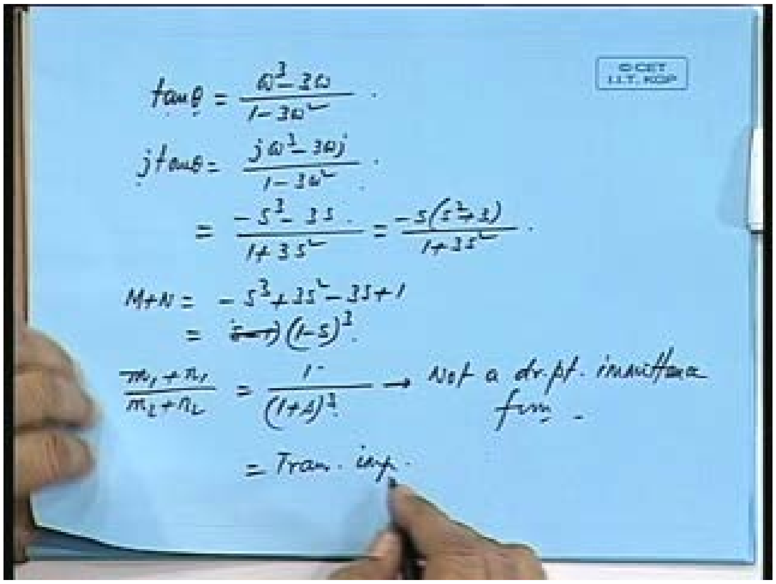

So how much is j tan theta whenever the phase function is given in the form of tan theta we write j tan theta that will be j omega cube minus 3 omega j by 1 minus 3 omega square make the reverse substitution s equal to j omega. So that gives you j omega cube means minus s cubed minus 3 s okay divided by 1 minus 1 plus 3 s square all right. So this will give me minus s into s square plus 3, correct me if I am wrong, 1 plus 3 s square all right. So what is m plus n, what is m plus n minus s cube just add these 2 plus 3 s square minus 3 s plus 1, so that gives me s minus 11 minus s whole cube is that all right, 1 minus s whole cube.

So where are the roots in all on the right up plane at s equal to 1, so what will be m_1 plus n_1 by m_2 plus n_2 this corresponds to m_2 plus n_2 this does not give any finite roots that is 0s, so 1 by 1 plus s whole cubed is that all right. So this is not a driving point impedance, it is an impedance function, it is a transfer impedance function, in case of a transfer impedance function you may have difference in the degree more than 1 but in case of a driving point impedance or admittance function, we know the difference in the degree should be restricted to 1.

So here you can have more than 1, so this is not a driving point function sir why do you sir de difference is 1 and the difference is greater than1, not greater than 1 it may or may not be 1. So transfer function is a ratio between 2 voltages or voltage and current, so the transfer function can be anything it can have only thing the roots must be in the left of plane that is poles must be in the left of plane yes, this is an insist able system any stable system may have a phase function like this but this is not a impedance function, driving point impedance function not a driving point impedance or admittance function. I will call it immittance function all right, so this is basically a transfer impedance about the properties of transfer impedance we will discuss later on when you go for 2 port synthesis.

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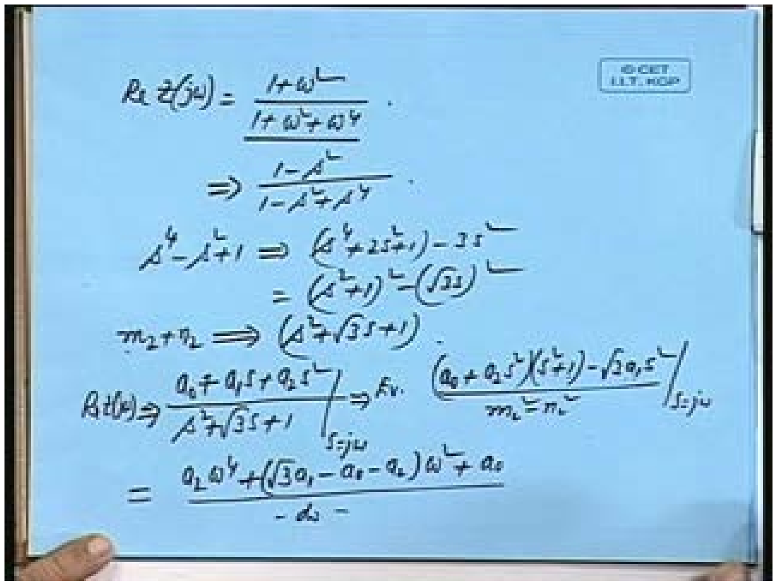

Now we shall take up 1 or 2 more examples, it is all about realization of networks from given parts. Let us take another example real part of z j omega okay 1 plus omega square by 1 plus omega square plus omega to the power 4 what will be z(s). So yesterday we had handled this kind of problems, so what will be 1 plus omega square plus omega to the power 4 did, we discuss about this particular problem yesterday, 1 plus omega square by did I take this very example then otherwise we will skip to another problem, no I do not think so.

We took up another example, 1 plus omega square by omega to the power 4, no no not this example okay, I do not think we did it okay. I have chosen this because we want to see 2 types of functions given by the same expressions. So what we do here make a substitution s square equal to minus omega square so that will give me 1 minus s square by 1 minus s square plus s to the power 4. So what are the roots of this s 4 minus s square plus 1 gives me s to the power 4 plus twice s square plus 1 minus 3 s square. So it is s square plus 1 whole square minus root 3 s square.

So the roots corresponding to m_2 plus n_2, m_2 plus n_2 will be having the left up, left up plane roots or this. So s square plus root 3 s plus 1 this is the denominator, so numerator let us assume a_0(s) a_0 plus a_1(s) plus a_2(s) square divided by s square plus root 3 s plus 1 okay. So even part is how much a_0 plus a_2(s) square into s square plus 1 minus root 3 a_1(s) square divided by m_2 square minus n_2 square which is this. See if I put s equal to j omega here I get real z j omega okay and that gives me how much a_0 sorry a_2 omega to the power 4 plus a_0(s) square all right plus a_2(s) square minus root $3a_1$ is that okay. So a_0, so plus root 3 a_1 minus a_0 minus a_2 into omega square plus a_0, this is the numerator is that okay equate the co efficients.

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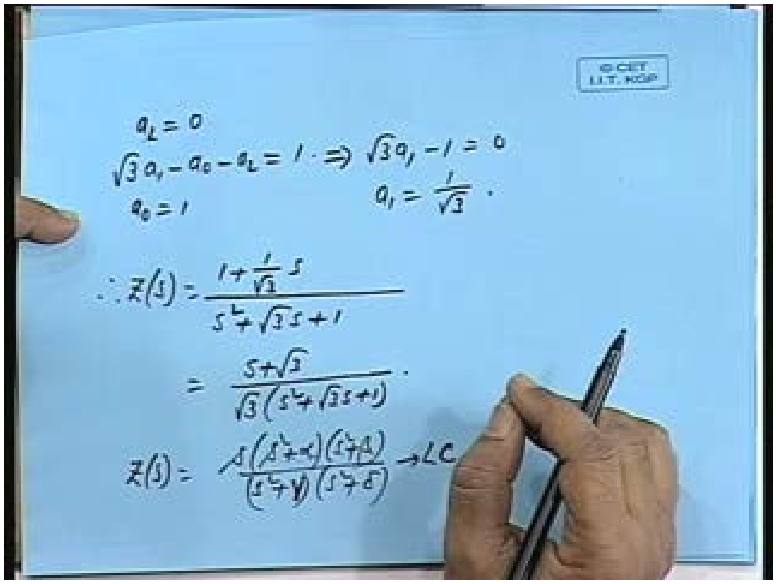

So a2 omega 4 omega 4 is absent so a_2 is 0 next root 3 a_1 minus a_0 plus a_2 root 3 a_1 minus a_0 minus a_2 is equal to 1 co-efficient of omega square and a_0 is equal to 1 substitute here a_2 is 0 so root 3 a_1 and a_0 is 1 minus 1 is 0, so a_1 is 1 by root 3 therefore z(s) will be a_0 that is 1 plus a_1(s), so 1 by root 3 s a_2 is 0 divided by a square plus root 3 s plus 1. So that gives me s plus root 3 divided by root 3 into s square plus root 3 s plus 1 this is z(s), is that all right.

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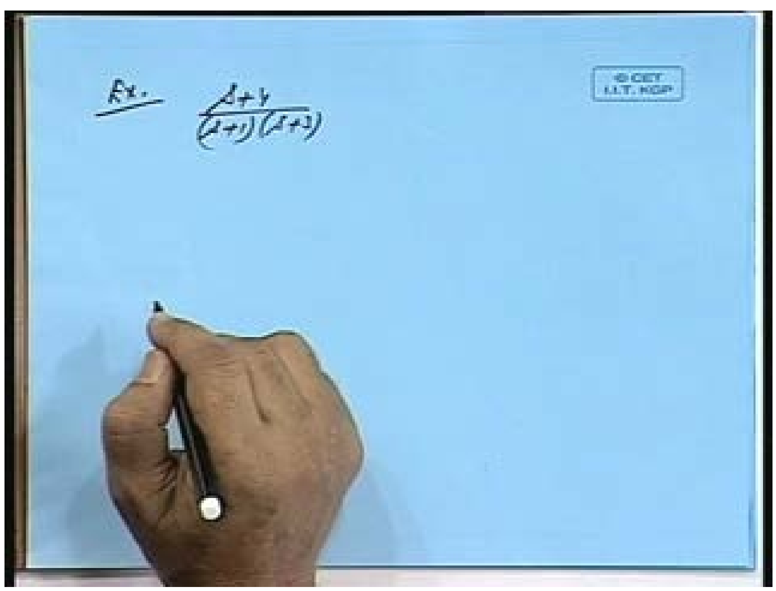

That is an interesting point to be noted in case of synthesis that if you have a 2 element synthesis if you have a 2 element synthesis from the network function, you can identify whether it will be a_2 element synthesis or a_3 element synthesis. For example z(s) if you are having functions like s square plus alpha s square plus beta and so on s square plus gamma, s square plus delta functions of this type and if the poles and 0s are interlaced they are coming alternately then it is an l c function, is it not l c. You can have Foster1, Foster2, Cauer1, Cauer2 realizations and in those realizations you have minimum number of elements they are canonic forms if z(s) is having real roots s plus alpha, s plus beta and so on and if they are interlaced then they can be either a r l or r c depending on whether for z(s), whether the pole is closest to the origin. The first one starts with a pole or not then it will be an r c with the first root is a 0 nearest to the origin is a 0 then it will be an r l function and we can realize it again by 4 canonic forms.

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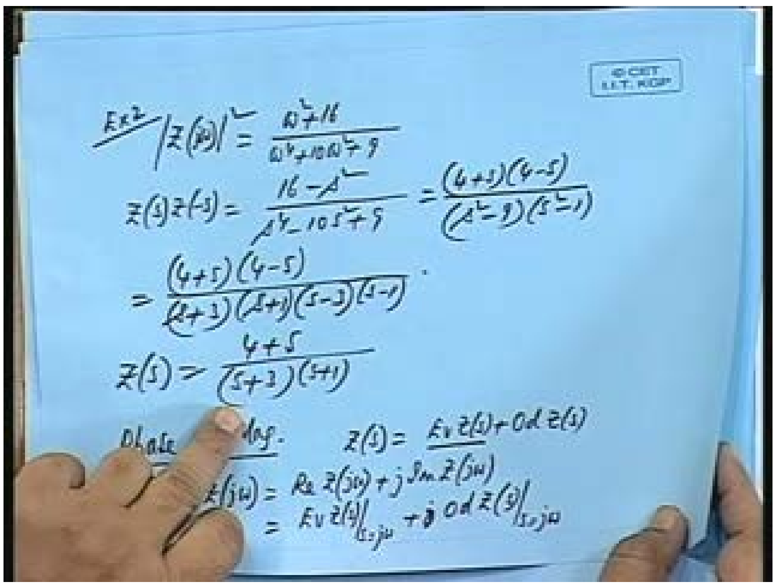

Suppose it is a positive real function but roots are not alternately coming then it is neither r l nor r c, it will be an r l c network. This is also what we saw earlier, if it is tested for positive realness, if it is tested for positive realness and the conditions are satisfied then it is realizable but if the poles and 0s are not interlaced then it will not be an r l or r c then it will be r l c and if it is an r l c network then we will find now you cannot have necessarily a Foster 1 or Foster 2 realization you have to go for Bott Duffin or Brune's synthesis, well not that you cannot factorize it I will give an example, you cannot factorize it so easily. Let us see, I will take a simple example, let me see if I have that okay.

Let us take a function s plus 4 by s plus 1 into s plus 3 okay. This is a function which we got just sometime back if you remember the first example but I worked out yes it is the 1 s plus 4 by s plus 3 into s plus 1 okay. So how to realize this, it is a positive real function though poles and 0s are not coming alternately there are 2 poles first then there 0.

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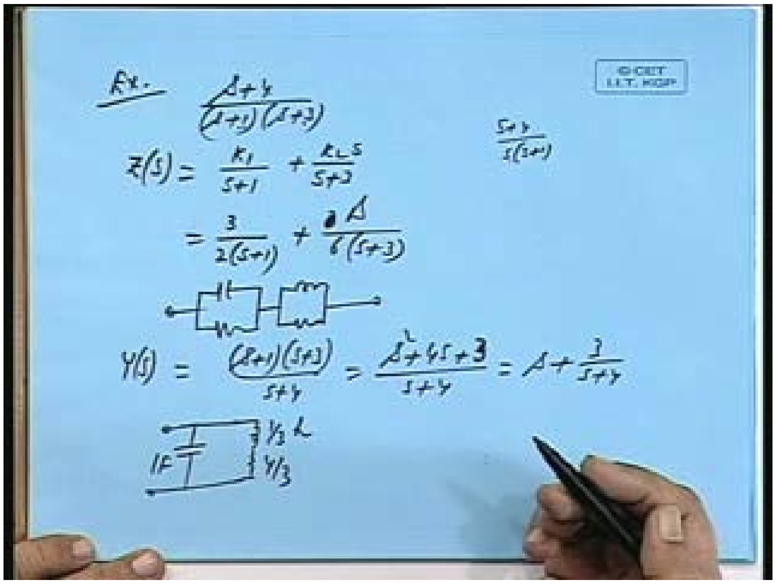

So it is neither r l nor r c, so I thought of trying to realize it z(s) suppose it is k_1 by s plus 1 plus k_2 by s plus 3 obviously, one of them will be negative because poles and 0s are not coming alternately. Let us see how much is k_1, how much is k1 multiplied by s plus 1 put s plus1 equal to0 so 0, 3 by 2, 3 by 2 into s plus 1, so this will give me an r c combination.

Now here it is k_2 s plus 3 here 0 if I put this will be 1 this will be 3 minus 3, so minus 1 third, so it will not work. Suppose let us put it as s into this then how much is k_2 multiplied by s plus 3 divide by s, so it will be s plus 4 by s into s plus 1 and then make s plus 3 equal to 0. So this will be 3 divided by sorry, 1 divided by 3 into 2 minus 3 into minus 2, so minus 6 plus 6, 1 by 6 into s plus 3 into s, what is this an r c combination, what is this an r l combination. So if someone goes by Foster1 realization it is possible for such a simple function it is possible to get this, problem comes when you are having quadratics and not so easily factorizable, for in a factorizable form then you have to go for Brune's synthesis or Bott Duffin synthesis, not necessarily all ways you will be having that kind of synthesis even by Bott Duffin synthesis also you may be landing up in similar functions all right. Let us see what canonic means let us this is Foster 1 synthesis all right means we are putting series elements z_1, z_2, z_3, let us try y s Foster 2 then it is s plus 1 into s plus 3 divided by s plus 4 and that is equal to s square plus 4 s plus 3 by s plus 4 okay s square plus 4 s by s plus 4 is s, s into s plus 4 s plus 3 by s plus 4.

So this is an, this is a capacitor in parallel with and s plus 4 by 3 is the impedance. So it is 1 third 4 by 3 ohm resistance and 1 third Henry inductor is 1 Farad capacitor. Now you see here you are having 3 elements, here you are having 4 elements. So y(s) and z(s) you see the difference all right if someone goes for Cauer synthesis, ladder synthesis, let us see what it gives, z(s) equal to s plus 4 by s square plus 4 s plus 3 is it not I can write this as1 by s square plus 4 s plus 3 by s plus 4. So let us carry out the division s square plus 4 s plus3 s into s square plus 4 s here so 3 s plus 4, s by 3 s 4, 3 3 by 4, 3 okay.

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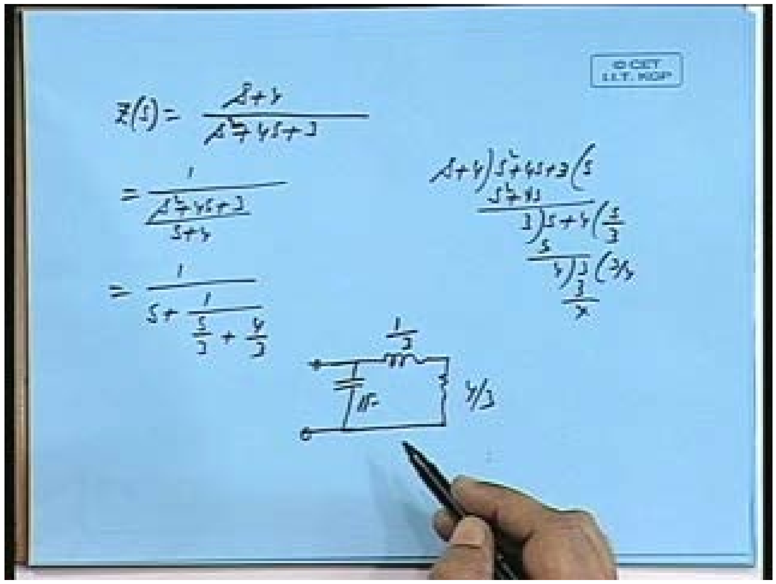

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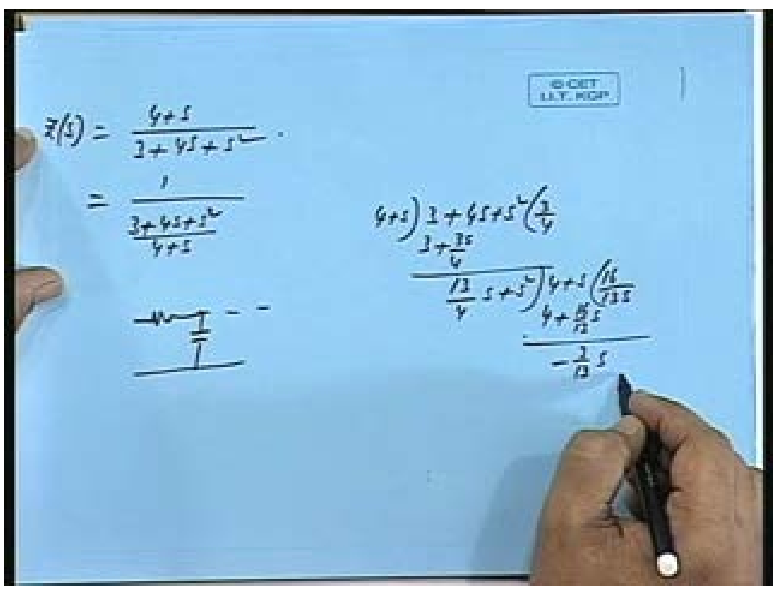

So it starts with 1 by s plus 1 by s by 3 plus 1 by 3 by 4, so 4 by 3 so what does it give me admittance of capacitor then an impedance of 1 third Henry and 4 by 3 this is Cauer 1 okay, Cauer 1 synthesis is same as Foster 2 the same thing 1 Farad, is it not, it is coming as Foster 2, Cauer 1 and Foster 2, Cauer 2 you reverse the order and then see z(s) equal to 4 plus s divided by 3 plus 4 s plus s square equal to 1 by 3 plus 4 s plus s square divided by 4 plus s. So let us divide 4 plus s 3 plus 4 s plus s square so this will be 3 by 4, 3 plus 3 by 4 s, so 13 by 4 s plus s square 4 plus s how much is it, 16 by 13 is that all right that gives me 4, 16 by 13 s in the denominator all right.

So that gives me 4 plus 16 by 13 s now that gives me minus 3 by 13 s. So since there is a negative sign it is not possible to realize the Cauer 2, Cauer 2 does not exist that means you cannot have something like resistance and then capacitance and so on then an inductance or resistance, it will feel.

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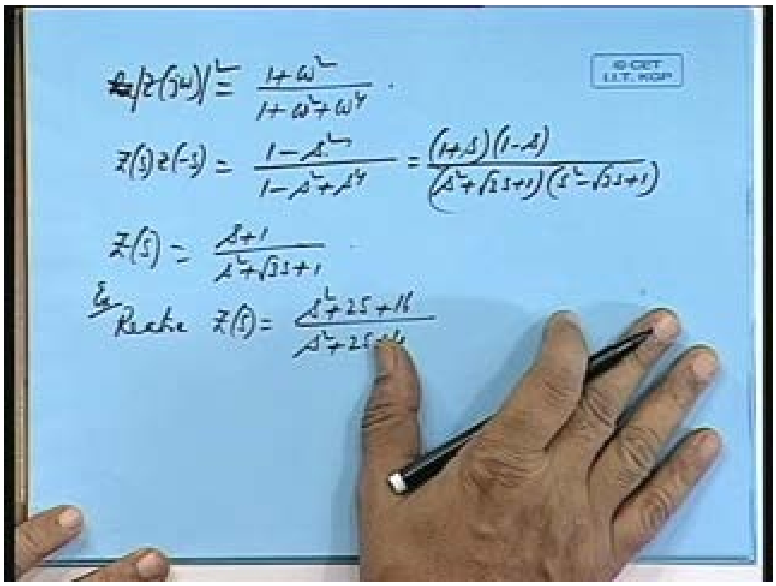

So canonic forms of that kind Cauer 1, Cauer 2, Foster 1, Foster 2 all may not be applicable here in 3 element networks, some of them may succeed, some of them may not not obviously, that you have seen just now I have tried all the 4 methods and number of elements also differ in some case we have got 3 element, in some case we got 4 elements in Bott Duffin synthesis we have seen we can avoid the use of that Brune's transformer with 100 per cent coupling but number of elements will be more all right, number of elements will be more.

Let us take 1 or 2 examples on z(s) with 3 elements that is Brune's and Bott Duffin's synthesis. Some of the interesting networks okay sorry before we go to that there is another function suppose real z j omega equal to 1 plus omega square by 1 plus omega square plus omega to the power 4 already it was sorry, real z was given Suppose this is magnitude square suppose this is equal to magnitude square then what will you do have you understood if z(s) square is there then you make substitution z(s) z minus s will be 1 minus s square 1 minus s square divided by 1 minus s square plus s to the power 4 have I have I done it sorry, just now, it was the real part, no I did the other problem that was the real part. So this will be 1 plus s into 1 minus s okay and how much is this s square plus root 3 s plus 1 into s square minus root 3 s plus1 okay so how much is z(s) choose only the left up plane roots. So s plus 1 by s square plus root 3 s plus 1 is that all right. Earlier while computing for the when it was given as real z equal to this we, we got the same denominator but the numerator was remember 1 plus s by root 3 something like that know I will just yes 1 plus1 by root 3 s ,1 plus s by root 3 that was the function.

So you can see the difference yes, 1 plus s by root 3 was that so that is the only difference in the numerator denominator remains same okay. Now I will take general r l c synthesis by both Brune's method and Bott Duffin's method this is just a devising what we have learnt earlier. So realize z(s) equal to s square plus 2 s plus 16 divided by s square plus 2 s plus 4 okay.

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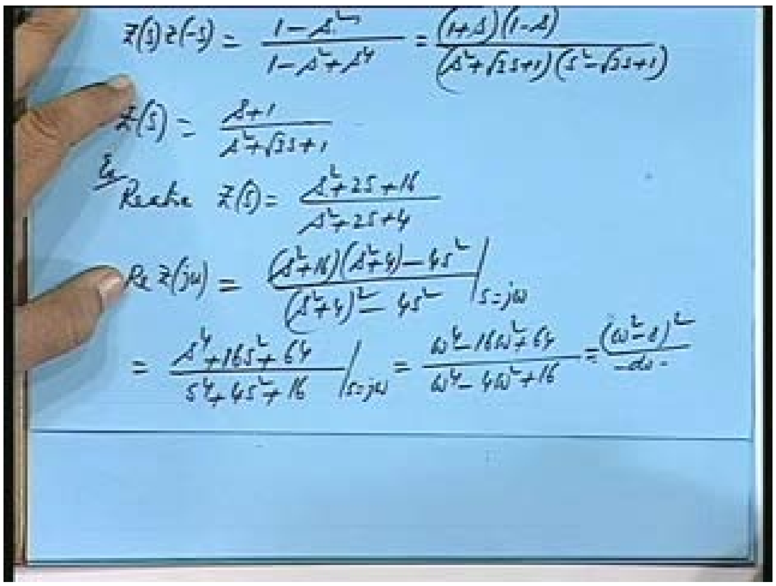

Let us try by Brune's synthesis so what was the starting point a real z j omega we compute that is m_1, m_2 minus n_1, n_2 by m_2 square minus n_2 square so s square plus 16 even part into s square plus 4 minus 2 s into 2s, 4 s square divided by s square plus 4 whole square m_2 square minus 4 s square n_2 square s equal to j omega is that all right.

So that gives me s to the power 4 plus 16 plus 4, 20 minus 4, so 16 s square plus 64 divided by s to the power 4 plus 8 s square minus 4 s square plus 16 is that all right, s equal to j omega. See if I put s equal to j omega omega to the power 4 minus 16 omega square plus 64 divided by omega to the power 4 minus 4 omega square plus 16. Now this you can see is omega square minus 8 whole square okay, omega square minus 8 whole square. So this function becomes 0 at omega square is equal to 8 we have to first of all track that frequency at which the real part vanishes, is it not.

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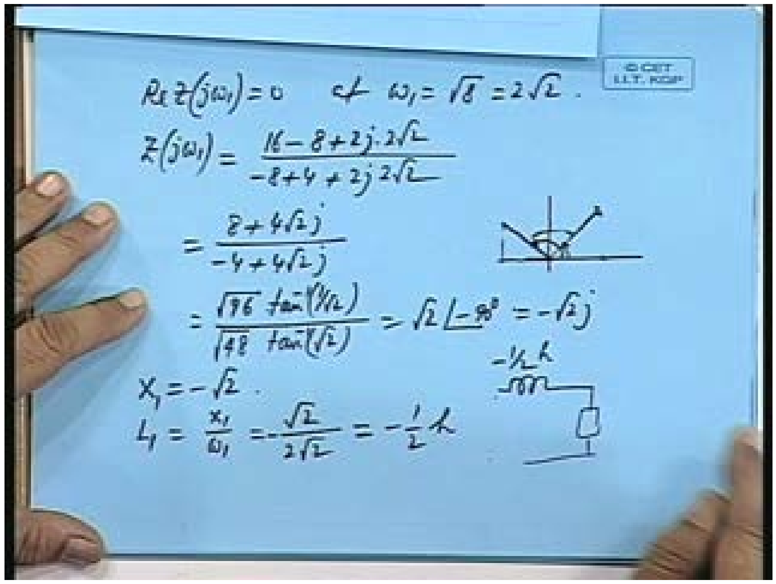

So the real part z j omega 1 equal to 0 at omega 1 equal to root 8 that is 2 root 2. Once you have traced that frequency omega 1 calculate z j omega 1 that will be the imaginary part is it not that will be the imaginary part. So if I put omega equal to 2 root 2 in this how much is it 16 minus s square is minus omega square that is 8, correct me if I am wrong, okay plus 2 into s 2 into j into 2 root 2 divided by s square plus 4. So minus 8 plus 4 plus 2 j, 2 root 2 so that gives me 8 plus 2 2's are4 root 2 j divided by minus 4 plus 4 root 2 j is that okay.

Now you can see for yourself 8 plus 4 root 2, 8 plus 4 root 2 somewhere here 8 plus 4 root 2 how much is the magnitude 8 8's are 64 plus 32, 96, square root of 96 okay tan inverse 1 by root 2 and this is 4 4's are you see some where here 4 4's are 16 plus 32. So root 48 tan inverse root2 this is tan inverse 1 by root 2 okay and this is tan inverse this magnitude is tan inverse root 2 but it is more than 90 degrees. So how much is this angle, how much is this angle the difference is 90 degree, it is the denominator angle which is more.

So if this is theta this is 90 plus theta is that all right magnitude is root 2 and denominator is having an angle of 90 degree that means minus 90 in the numerator. So 90 degree in the numerator, so minus root 2 j is that all right, it is just a simple competition. Otherwise also by rationalizing you will get minus root j I thought it is better to write in the polar form and you can imagine the angles very clearly okay one is alpha the other one is 1 by alpha tan inverse alpha and tan inverse 1 by alpha, so find out the difference in angle is that all right. So z is known so x is minus root 2 I call it x_1 so in Brune's synthesis if you get a negative reactance to start with what will that be it represented as l_1 is equal to x_1 by omega 1 which is root 2 divided by minus root 2 divided by 2 root 2, 2 root 2 is the frequency, thank you all right.

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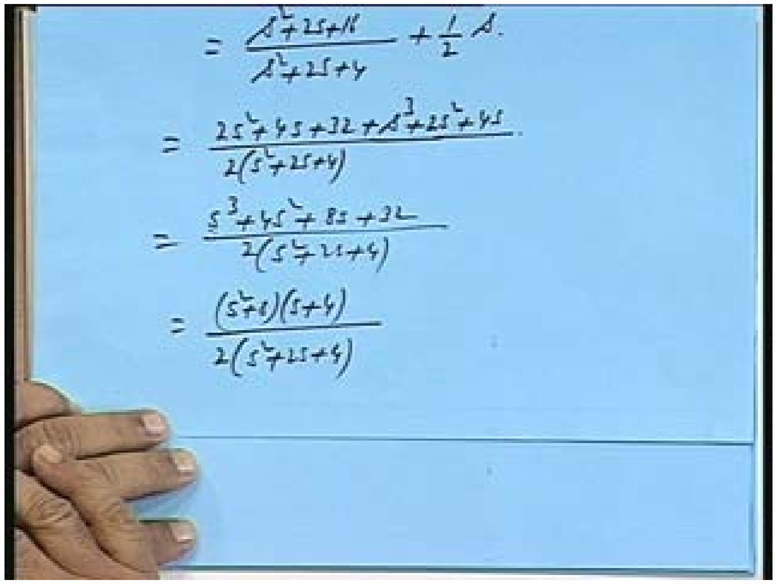

So this will be minus half Henry so to start with you will have a minus half Henry inductor, do not get frightened in the realization in a transformer you will find that minus can be accommodated. So once you have identified this then you go for the next impedance z_1 what is $z_1(s)$, $z_1(s)$ is z(s) minus $l_1(s)$ which is nothing but what was z(s) sorry, s square plus 2 s plus 16 divided by s square plus 2 s plus 4 minus $l_1(s)$, l_1 is minus half so minus and minus will make it plus half s is that all right. So add these what do you get by adding this, so s cube s square plus 2 s plus 4 s square plus 2 s plus 16 by s square plus 2 s plus 4 plus half s is that all right.

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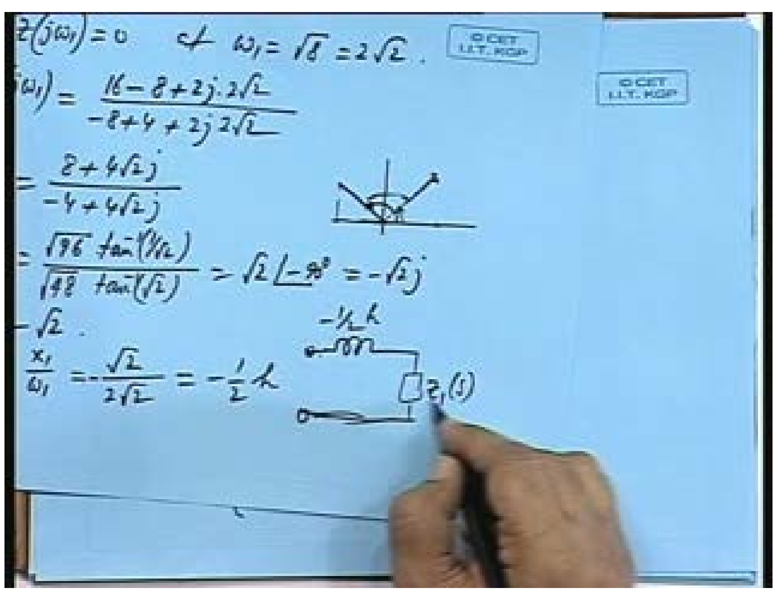

So you get 2 into s square plus 2 s plus 4 and here it is twice s square plus 4 s plus 32 plus s cubed plus twice s square plus 4 s, correct me if I am wrong. So that gives me s to the power 3 plus 4 s square plus 8 s plus 32 divided by 2 into s square plus 2 s plus 4 is that all right. This you can write as s cube plus 8 and s see s square plus 8 s square plus 8 into s plus 4, 4 into s square plus 8 s into s square plus 8 divided by 2 into s square plus 2 s plus 4. By the way, why did I take s square plus 8 as a fact factor, if you remember, if you remember in the network this function z(s) is having a value minus half sorry root 2 j at that frequency all right and it is also the value of this that we have equated.

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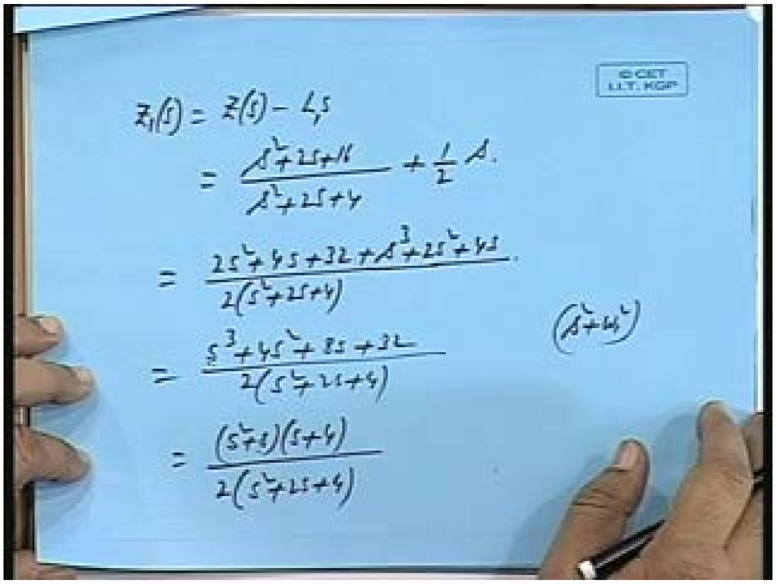

So this will be a_0 at that frequency if you remember this element $z_1(s)$ must be 0 at that particular frequency omega 1 okay. So this $z_1(s)$ at omega 1 that is 2 root 2 that is s square plus omega 1 square will be a factor in the numerator and omega 1 square is 8. So s square plus 8 will be a factor that we know because what we try to ensure is this impedance at that frequency is equal to the reactance at that frequency of this coil. So what will be the impedance of this it has to be0 because this impedance is equal to this impedance so this has to be 0, so $z_1(s)$ must have a_0 at that frequency, so s square plus 8 must be having a numerator factor, must be a numerator factor of z(s) this $z_1(s)$ allowed obviously, we are making it equal to that inductor okay, thank you very much we will stop here for today. We will continue with this in the next class.

Preview of Next Lecture

Lecture - 29

Tutorial

Good morning friends, we will continue with the numerical problem that we are discussing in the last class.

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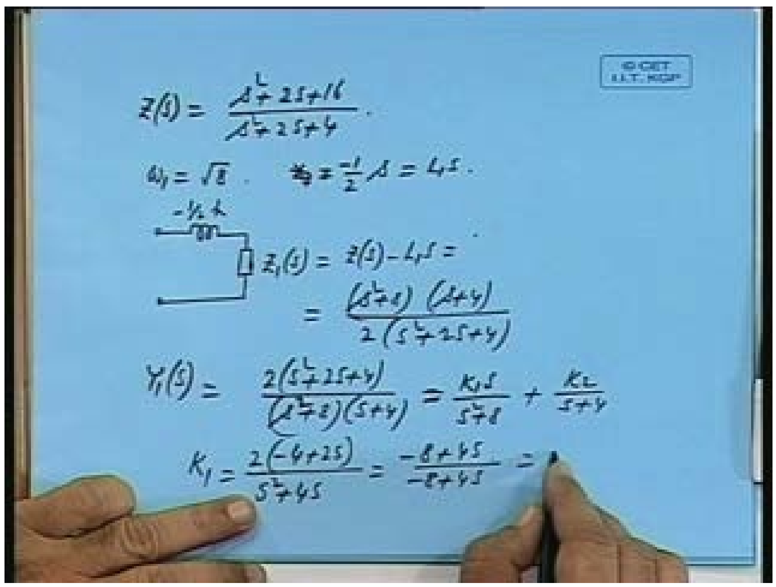

We took at function z(s) equal to s square plus 2 s plus 16 divided by s square plus 2 s plus 4. We started of with this function and we found that at omega 1 is equal to root 8 the real part vanishes and we also obtained the value of x_1 as half s whether corresponding impedance this was $l_1(s)$ all right and this was minus half s minus half Henry, this is $z_1(s)$ which will be equal to z(s) minus l_1 s and that give me l_1 is having a negative sign, so that give me a plus sign. So we got s square plus 8 into s plus 4 divided by 2 into s square plus 2 s plus 4 okay.

To realize a pole to realize a pole we know we can make partial fraction, so this 0 is to be converted to a pole so we can very easily realize $z_1(s)$ in terms of admittance function which will be 2 into s square plus 2 s plus 4 divided by s square plus 8 into s plus 4, you write as $k_1(s)$ by s square plus 8 we know whenever there are roots 1 the imaginary axis it will be realized in terms of an l c network $k_1(s)$ by s square plus 8 plus k_2 by s plus 4, this is to be seen later.

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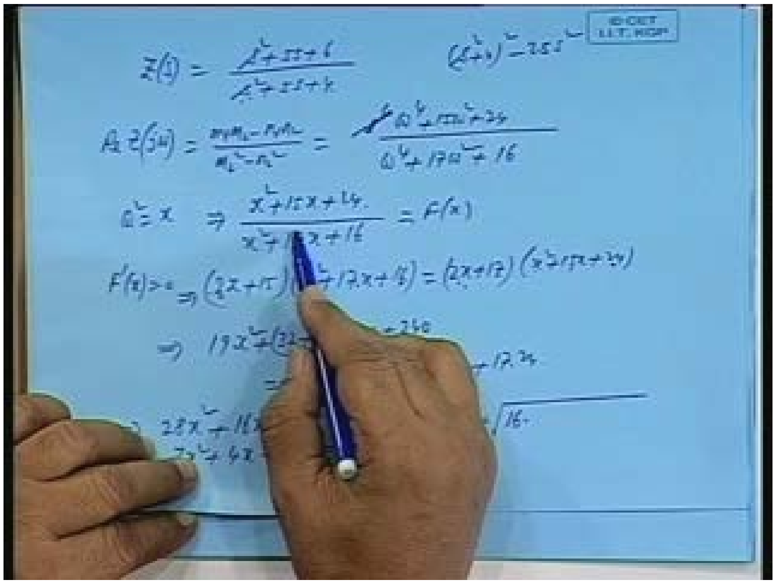

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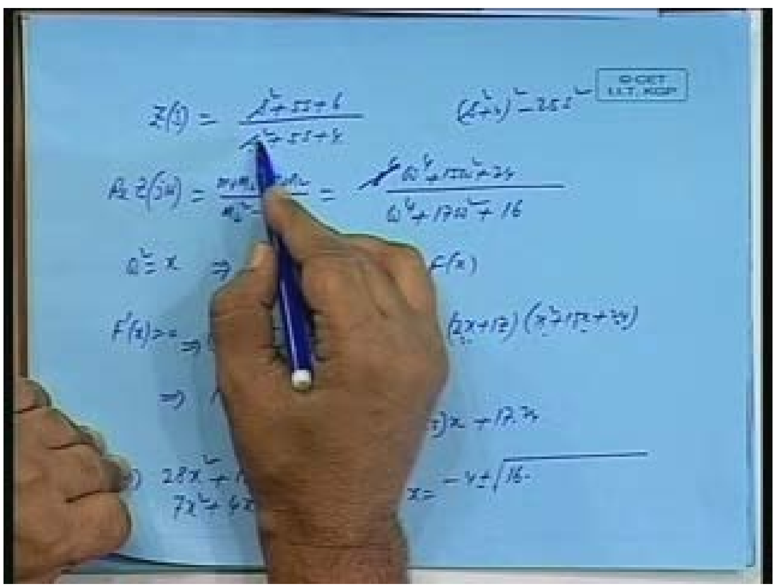

Let us see what this means how much is k_1 multiply by s square plus8 divide by s make s square plus 8 equal to 0. So this will give me 2 into minus 4 minus 8. So minus 4 plus 2 s divided by s into s square plus 8, so s into s s plus4 so s square plus 4 s which gives me this is minus 8 plus 4 s divided by minus 8 plus 4 s, so that is equal to 1, there must be some frequency where it is minimum omega square is equal to x square plus 15 x plus 24 x square plus 17x plus 16, I hope this is all right okay then 2 x plus 15 into x square plus 17x plus 16, 2 x plus 17 into x square plus 15 x plus 24. So 2 x cube 2 x cube they get cancelled 2 x into okay. Let me rewrite it any way what I wanted to stress is you will get a real value of x that is equal to omega square.

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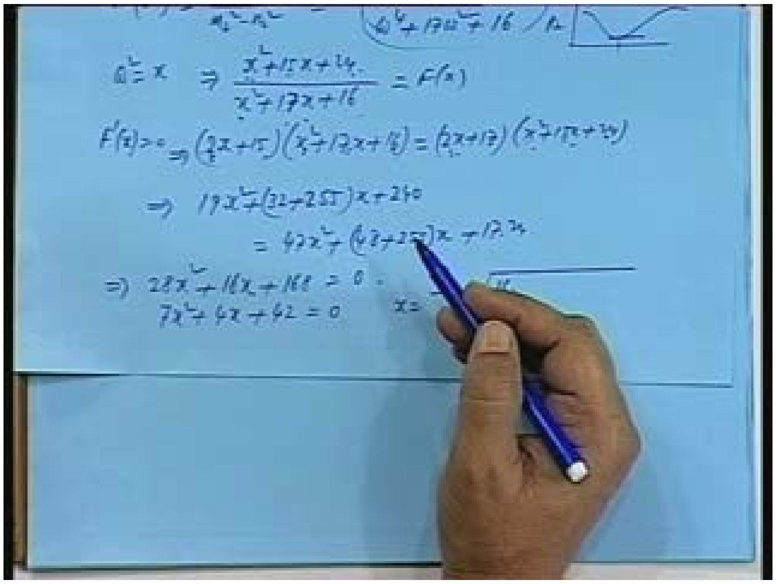

So calculate omega omega and substitute that omega here in the real part that will give you the minimum value that is when the real part, real part varies like this it is this minimum value and after computing that r minimum subtract it from z(s), subtract it from z(s) whatever is left over you start realizing that z(s), the remainder z(s) there may be a small slip some where here we will discuss it in the next class, if time permits. Otherwise, you work it out your self and since there is not much of time okay, thank you very much. We will continue with this in the next class.