Circuit Theory
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Lecture - 49
Resistance Terminated LC Ladder (Contd.)

This is forty-ninth lectures on resistance terminated LC ladder we started this yesterday and continue this today.

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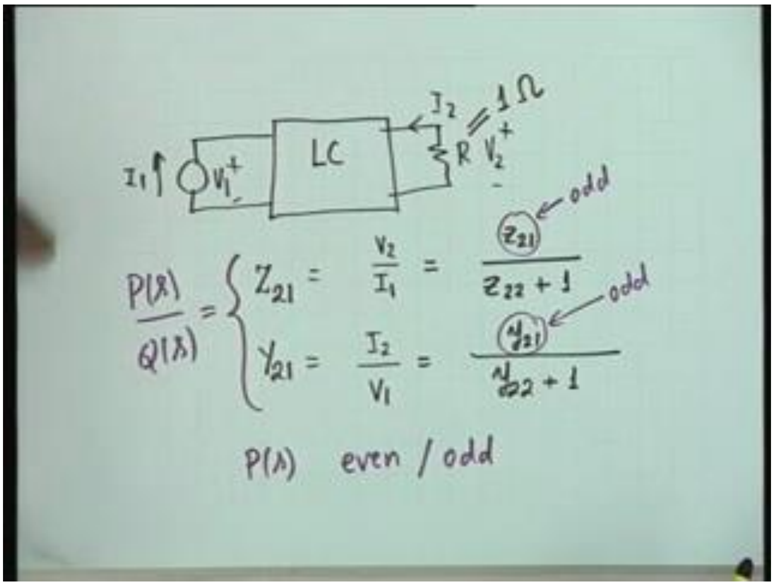

The problem that we were discussing is that we want to realize and LC 2 port in the form a ladder, which is terminated in a resistance R a voltage across this is V2, the current is I2 and is driven by source which could be a voltage source or could be a current source 1 of the 2. And therefore, the transfer functions should be either a transfer impedance or a transfer admittance Y21 Z21 is V2 by I1 that is the input is now current source and the output is a voltage Y21 is I2 by V1 that is the input is voltage source.

The output is the current through the resistance and these can be expressed. We also normalize R2 1 Ohm. Because, you know, how to scale, how to scale element values if R is 1k, then correspondingly we increase every inductance and we decrease every capacitance.

So, we normalize capital R2 1Ohm and a that condition the transfer impedance Z21 can be expressed in terms of the Z parameters of the LC 2 port as Z21 by Z22 plus 1. This 1 comes, because of the normalized resistance normalized load of 1 Ohm. If it was not 1 ohm it would have come Z22 plus R that is the simplification. Similarly, y21 can be expressed in terms of the 2 port parameters of the LC network, admittance parameters

Y21 divided by y22 plus 1 if this R was not 1 Ohm than this would have been Z that is 1 by R that is the only difference. We argued yesterday that, because LC parameters are odd because Z21 is odd.

So, is y21 these are odd functions therefore, if either of them is given as P of s by Q of s. The, the numerator polynomial P of s must be either purely even or purely odd.

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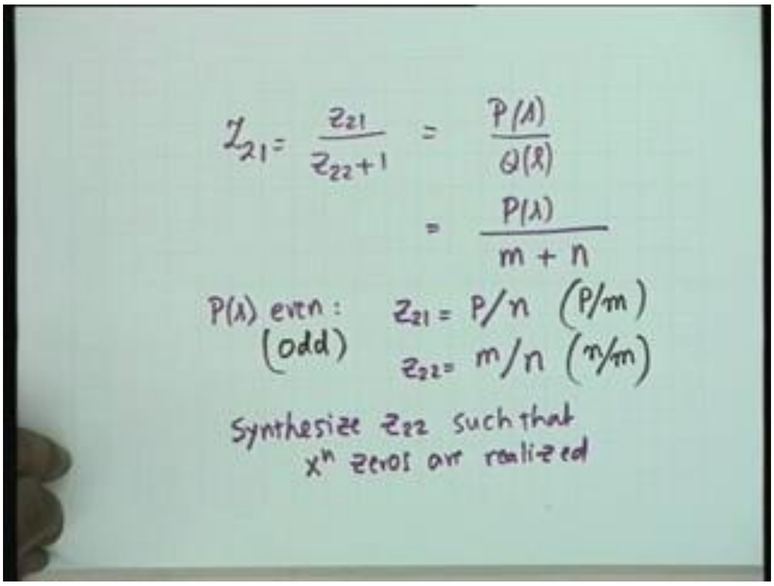

And therefore, if the problem to be specific let us, is Z21 if the problem is to synthesize the given P of s by Q of s in the form of and LC ladder terminated in the resistance. Then, what we do is in the given P of s as to be either purely even or purely odd we breakup Q into it is even part and odd part. And, then we argue like this that if P of s is even, then we divide both numerator and denominator by the odd part of the denominator.

That is we identifies Z21 as P divided by n and, then in the denominator we get 1 plus m by n. And therefore, Z22 is identified as m by m Z22 we argued yesterday that it is and LC driving point and impedance, because it is the ratio of the even to odd parts of a Hurwitz Polynomial all right.

And therefore, the problem now the problem was synthesize then resolves to the following, that is synthesize the driving point impedance Z22 in such a manner such that this 0s of Z21 which are the 0s of P are realized. Because, they have the same poles n and n realizing Z22 shall mean that we have also realize the poles of Z21 the only care that we have to exercise is to see that the 0s of Z21 which are the 0s of P, which are in turn the transmission 0s of the network are realize such that, transmission 0s are realized. This is the strategic, what we have said about Z21 also applies to Y21 exactly the same procedure. In case P of s is odd. If this is odd, then Z21 with the P divided by m. That is you shall divide the numerator and denominator by the even part of the denominator. So, that this becomes an odd function and, then this would be Z22 would be n by m. We have indicated the odd case if with the black or and the even case with pink all right. And we started illustrating this by means of an example the example that we took was.

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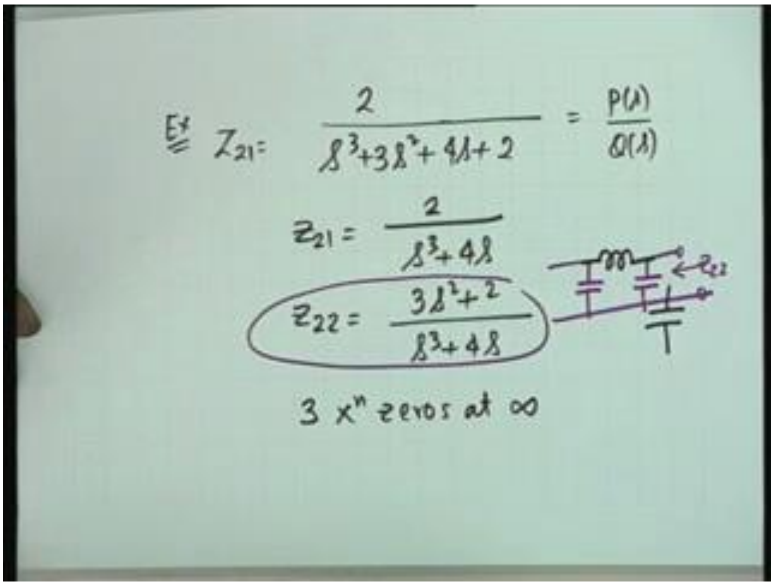

First example that it took was Z21 is equal to 2 divided by s cube plus 3s square plus 4s plus 2 this was the example. And you notice that, if you write this is P of s by Q of s, then P of s is purely even. And therefore, you identify z21 as 2 divided by the odd part of the denominator that is s cube plus 4s all right. And you identify Z22 as the even part 3s square plus 2 divided s cube plus 4s is this ok?

The problem now, is to realize Z22 in such a manner the transmission 0s are realized. They transmissions 0s if we look at this function or this function are 3 in number and there all at infinity 3 transmission 0s at infinity. And we have now, to guess the structure, the structure as to how 3 transmission 0s can be realized. Obviously, if there are transmission 0 at infinity, then it shall be either a series inductance or a shunt capacitance in ladder network it shall be either a series inductance or a shunt capacitance.

And we argued that, in this case in order to realize 3 transmission 0s our structure must be of this form 2 capacitors and 1 inductor this is what we want 2 capacitors, in 1 inductor it could not be 2 inductors and 1 capacitor. Because, the driving source is a current generator for current generator anything in series is in effective and therefore, you this is the structure.

And all that you have to realize now, is that this impedance; the impedance looking to the write from port number 2 should be equal to Z22 with port number 1 open and therefore.

Student: (Student: (Refer Time: 08:04)

3 capacitors in series is equivalent 1 capacitor and therefore, they do not realize 3 transmissions are there they realize only 1; there must be an isolation between the capacitors. Now, what I saying is all that you have to do now is to realize this function in this particular form. And you see that this is cover 1 structure and therefore, in can be mechanized by continued fraction expansion starting with the highest powers.

Now, you cannot start continued fraction expansion of z22, because z22 does not have a pole at infinity. And therefore, you have to start continued fraction expansion of 1 by z22, is 1 by z22 Y22?

Student: (Refer Time: 08:56)

No.

Student: (Refer Time: 08:57)

That's right. No covered 2, convert 2 will come capacitors in series we want capacitors in shunt.

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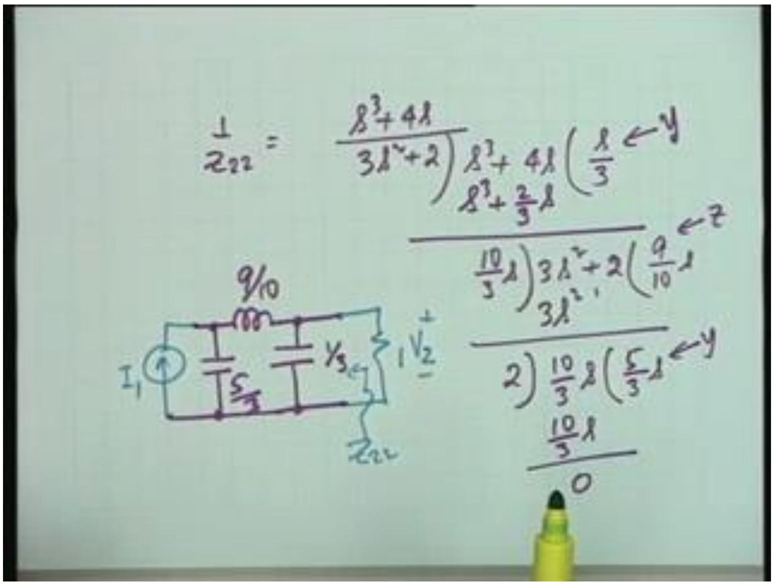

Therefore, 1 by zZ22 which is equal to s cube plus 4s divided 3s square plus 2. We make a continued fraction expansion of this s cube plus 4s and you see s by 3this is the dimension is and admittance. And therefore, the first capacitor would be equal to one-third, then we have s cube plus 2 by 3s this is 10 by 3 as this divides 3s square plus 2.

Student: (Refer Time: 09:45)

9 by 10s and this an impedance therefore, the next inductor would be 9 by 10. Let us, go ahead and draw it. 9 by 10 s this gives me 3s squared I am left with 2 divides 10 by 3s. So, I have 6 by 10, 5 by 3 that is correct. 5 3s and this is admittance. So, 10 by 3s admittance 0 which corresponds to open circuit there has to be there is no other way.

Therefore, the next capacitor is again 5 by 3 and the circuit is complete all that we have to do now to complete this circuit is to is add this 1 Ohm resistance here. This is my V2 and the current generator here I want this is the complete synthesis of the given specification.

Student: (Refer Time: 10:53)

Cover 2 concentrates and poles at the origin the structure here, this is the structure dictated by the transmission 0s. I could have expanded z22 in cover 2 or even foster 1 foster 2 no problem. But in order to realize transmission 0s at infinity I do need this structure. I cannot do it cover 1, cover 2.

Student: (Refer Time: 11:22)

Capacitors could have been. What?

Student: (Refer Time: 11:28)

These capacitors could have been on the other side, these 2 could be exchanged. No.

Student: (Refer Time: 11:35)

No that will change the z22 it will not keep z22 the same z22 with these 2 exchange will be quite different. The coefficients will be different any other question?

Student: (Refer Time: 11:49)

We went from left to right say here we are expanding z22, z22 is measured from port number 2. So, you go back you must be careful in this circuit we are not developing z11 we are developing z22. And the last element there are saving features that a. I mean this a kind of automatic error correction system, automatic control system that unless the last admittance is 0 it will come as open.

The last element must come in shunt, because your inputs source is the current generate. These are all automatic correction mechanism. If does not come then you suspect that something is wrong all right. Let us, take a second example let us a the other extreme that is all the 3 transmissions 0s.

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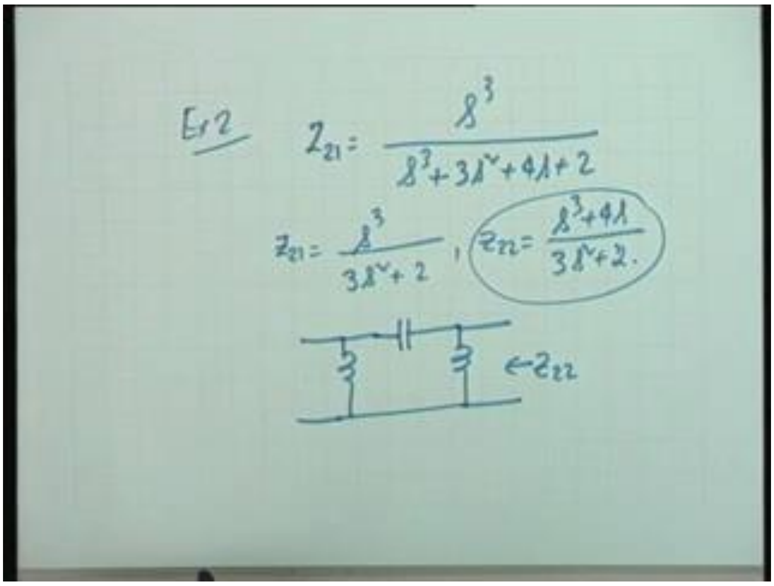

Let us, say R at the origin that is example 2 let us, say Z21 is equal to s cubed divided by the same example s cube plus 3s square plus 4s plus 2 all the 3 transmission 0s are at the origin right none at infinity. And therefore, cover 2 shall now be appropriate let us, see the numerator is odd and therefore, your z21 would be s cube divided by 3s square plus 2 and z22 would now be s cube plus 4s divided by 3s square plus 2.

Now, a structure that I want is transmission 0s at the origin and therefore, I want a series capacitor and 2 shunt inductors 1 and 2 this is what I want this is what I want to be z22 agreed? You have to guess this structure 3 transmission 0s all at the origin. So, series impedance pole 1 capacitor and 2 inductor, it could not be 2 capacitors in 1 inductor.

Student: (Refer Time: 14:05)

No, that is no transmission 0 of z22 was driving point function. You have to develop z22 in such a manner that the 0s of z21 are realized 0s of z21 at the same transmissions and.

Student: (Refer Time: 14:28)

Student: (Refer Time: 14:32)

We will come to s squared also if it was s squared, then 2 0s at the origin and 1 at infinity. We will do that example also in fact, we will do for s to the fourth also all right we will do that. Now, so what do I expand z22 in cover 2 z22 does not have a pole at the origin.

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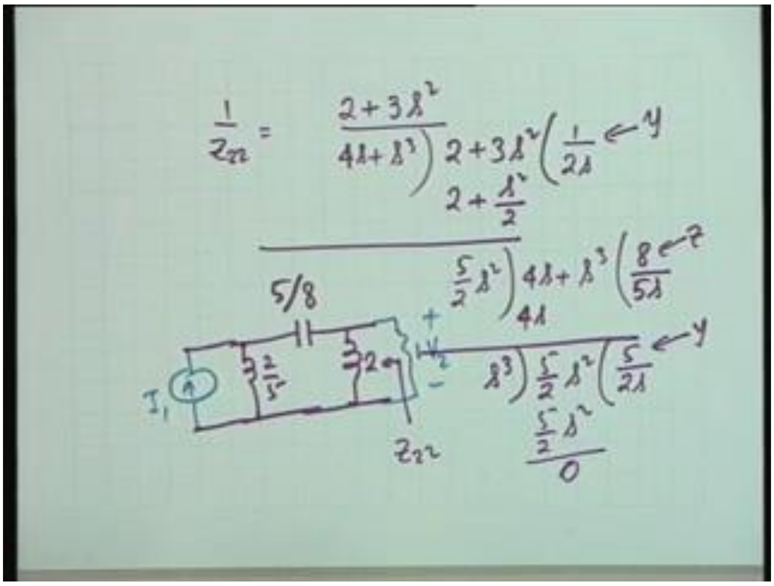

Therefore, I must take the reciprocal of this all right I must take the reciprocal of this 1 by Z22 is equal to now, I write has cover 2 means continued fraction expansions starting at the lowest power. So, 4s plus s cube let us do that 2 plus 3s squared the what is this?

Student: (Refer Time: 15:21)

1 by 2s correct and this is in y this is an admittance this 1 by 2s all right? Yes, this is all right 2 plus s squared by 2 this is the admittance. So, the first inductor this must be 1 by SL this is 2 agreed. Next 3 times 2 6 minus 1, so 5 by 2s squared is that correct? 6 minus and right 4s plus s cube and I shall have here 8 by 5s is that correct? This is Z and therefore, the next capacitor is.

Student: (Refer Time: 16:07)

5 by 8 1 by s see 4s, then I am left with s cubed and 5 by 2s squared. So, 5 by 2s, 5 by 2s squared 0 is an admittance y and therefore, the next inductor is.

Student: (Refer Time: 16:29)

2 by 5 and there is 0 of admittance. So, this must be open all right this is Z22 and all that I have to do to complete the network is to add this 1 Ohm resistance here and they current generator here. The network is complete this is indeed high pass filter it is high pass filter all transmission 0s are at the origin. What is the infinite frequency response of this network? Common sense look at the network in picture.

Student: (Refer Time: 17:13)

1 infinite frequency this is open, this is open, this is open, this is short. So, the total current come outs and a since, it is 1 ohm. So, V2 equal to I1 all right. So, it is 1.

Student: (Refer Time: 17:26)

You would have a got different circuit surely, we will do that to bring variety into experience let us, take admittance now.

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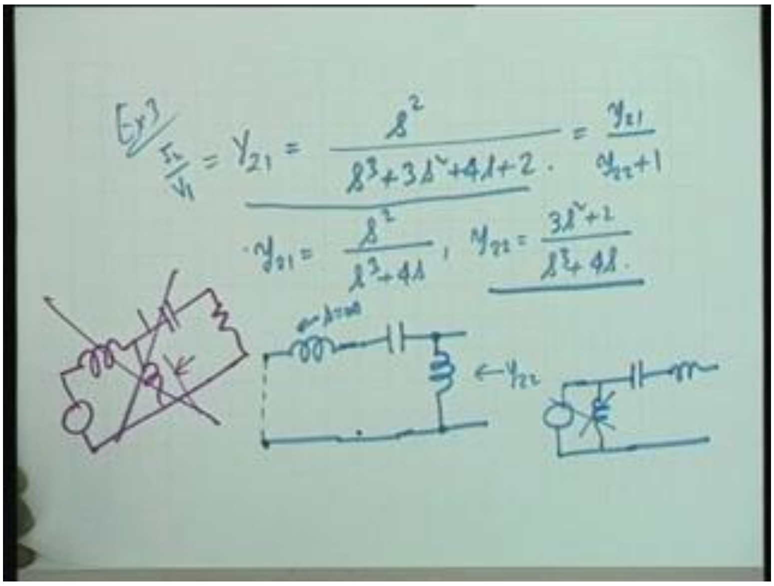

Let us a Y21 third example and we take his case that is s squared or shall you we take s? Whatever, you like s squared is s cube plus 3s square plus 4s plus 2. I will not complete the example I will the indicate have to all let us complete 1 we will complete, then we will lead things and settle for you to settle. Since, this is even therefore, my this is to be y21 divided by y22 plus 1 agreed? So, y21 shall now be s squared divided.

Student: (Refer Time: 18:20)

S cube plus 4s agree and y22 shall be.

Student: (Refer Time: 18:25)

3s square plus 2 divided by s cube plus 4s. Now, I argue what kind of structure first you have to decide on this structure. The structure is 2 transmission 0s at the origin. Now obviously, I require 1 inductor in shunt and a capacitor in series, a capacitor in series.

Student: (Refer Time: 18:51)

All that does it change we transmission 0s, transmission 0s I have of Y21 we can do that. But that not, does not settle the transmission 0s that does not I am change transmission 0s.

Student: (Refer Time: 19:09)

Look at y21 there is an s squared factor s over, so 2 transmission 0s at the origin and 1 at infinity s square s by s cubed all right. And 2 transmission 0s at the origin we require and inductor in shunt and a capacitor in series. We also have a transmission 0s at infinity and to take care of that obviously, we require.

Student: (Refer Time: 19:36)

An inductor in series, so we shall have indeed and inductor in series.

Student: (Refer Time: 19:44)

You guys not take it is not a current source now, it is a voltage source. Because, it is y21, y21 is I2 by V1 I were respecting this question the how come the last redundant in series. Because, it is a current generator and you see you will develop now y22 which means that, this should be y22 under the condition that this terminal is shorted to this terminal. Isn't that right? Is this clear? This terminal, because it is a voltage generator, so when you measure y22 you short circuit this. So, y22 would come and that the condition that this is shorted.

Student: (Refer Time: 20:33)

Say it again.

Student: (Refer Time: 20:39)

A parallel inductor what does the parallel inductor mean?

Student: (Refer Time: 20:44)

Looking from this side.

Student: (Refer Time: 20:46)

In shunt right, then

Student: (Refer Time: 20:53)

Series.

Student: (Refer Time: 20:56)

That is inductor in series where this will not do the job, because there is voltage generator here. This inductor will therefore, be.

Student: (Refer Time: 21:05)

We this is to take care of the transmission 0 at s equal to infinity.

Student: (Refer Time: 21:12)

Third transmission 0s, so there is voltage generator and this inductor in series will cause a transmission that.

Student: (Refer Time: 21:20)

Can we interchange this and this; that means, can we have the inductor here.

Student: (Refer Time: 21:29)

No that is an interesting question. I let us, do this what Soumya suggest it is this is this what you are suggesting? Now

Student: (Refer Time: 21:44)

Current output is to be a measured. So, it is method we have voltage source here will this.

Student: (Refer Time: 21:55)

Why?

Student: (Refer Time: 22:00)

No, the current here will be effect by the capacitor. That is why the point there is some a something else.

Student: (Refer Time: 22:07)

No, wait a second there is more fundamental and more common sense.

Student: (Refer Time: 22:15)

No. If this I claimed there at a does not.

Student: (Refer Time: 22:25)

That is correct.

Student: (Refer Time: 22:27)

Absolutely wonderful this is the correct only 2 transmission there. Why?

Student: (Refer Time: 22:33)

Because, if we look here.

Student: (Refer Time: 22:37)

That even in equivalent is simply a constant multiplied this V1 series with an inductor and therefore, 1 transmission 0 at infinity and 1 as at the origin.

Student: (Refer Time: 22:51)

That’s all third 1 is not realize you have to very careful. You have to very careful in this. So, this is not at this. All that you have to do now is to realize this structure.

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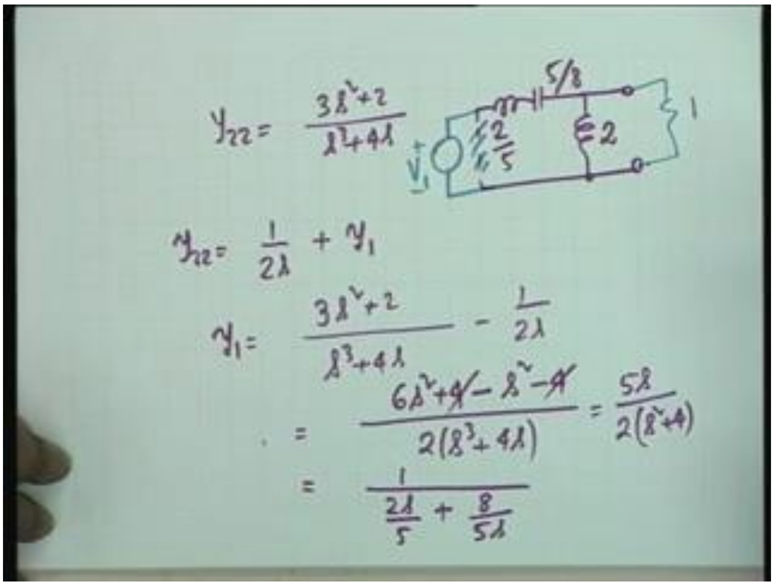

So, what we have is y22 equal to 3s square plus 2 divided by s cube plus 4s this is what you have to realize. In the form, first an inductor then a series L and C and y22 shall be realized while this is shorted. So, what we do? We first take out the pole at the origin of y22. All right it can also be looked upon as covered, but just 1 steps y borrowed. So, what we do is we write y22 as what is the residue at the origin present? Isn't 1 over 2s? Correct when, s tends to 0 it is 1 of 2s.

So, what is this inductor then? 2 Henry agreed plus some admittance y1. Let us see what y1 is y1 equal to 3s squared plus 2 divided by s cube plus 4s minus 1 over 2s which is equal to 2s cube plus 4s all right, then 6s square plus 4 minus s square minus 4 is that ok? My simplification 4 and 4 cancels. So, it is.

Student: (Refer Time: 24:42)

It is 5 by 2.

Student: (Refer Time: 24:47)

5s divided by 2.

Student: (Refer Time: 24:52)

S square plus 4 agreed this I can write as let us, go ahead with the synthesis I can write this as 2s by 5 plus 8 by 5s agreed? Now, since is an admittance, this is an admittance.

Student: (Refer Time: 25:15)

Reciprocal this should be in impedance. And obviously, L and C the other L and C are obvious now. What are they?

Student: (Refer Time: 25:25)

The inductance is 2 by 5 and the capacitance is 5 by 8, so the total a network shall now be add this resistance 1 Ohm remove this short circuit. And add the voltage generator V1 that is it. This takes care of the transmission 0 at infinity, this at the origin and this at the origin 2 transmission 0s at the origin and 1 at infinity what kind of a filter is this?

Student: (Refer Time: 25:58)

Band pass that is correct it is also obvious that when, these resonate the total voltage peers across this correct. This becomes a short circuit only at the resonance frequency.

At 0, it is 0 at infinity it is 0 in between it is 0 in between it has maximum and therefore, it is band pass filter.

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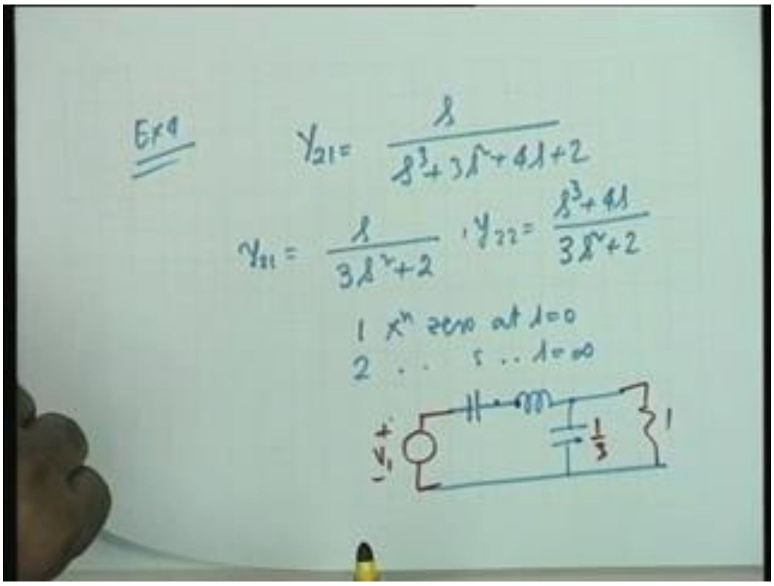

Let us take the another variation of this example 4 suppose, y21 is s divided by the same denominator s cube plus 3s square plus 4s plus 2. Then, my y21 shall be s divided by 3s square plus 2 and y22 shall be s cube plus 4s divided by 3s square plus 2 all right. We have divided both numerator, denominator by the even part of the denominator now. How many 0s are there at the origin?

Student: (Refer Time: 27:02)

1 transmission 0 at s equal to 0 and 2 transmission 0s at s equal to infinity. So, what is this structure 1 transmission 0 at s equal to 0 can be taken care of by.

Student: (Refer Time: 27:19)

Shunt inductors or did you like a series capacitance.?

Student: (Refer Time: 27:23)

Series capacitance all right then? So, then what? Transmission 2, transmission 0s at s equal to infinity. How do you take care of that?

Student: (Refer Time: 27:37)

2 shunt inductors. Shunt inductance does not give a transmission 0 at origin. Shunt capacitance and a series inductance where did you put the capacitance here?

Student: (Refer Time: 27:55)

First series in here.

Student: (Refer Time: 28:00)

Then, a capacitance will this do the job? This takes care of transmission 0 at infinity, this takes care of transmission 0 at infinity and there is 1 ohm resistance here. And this takes care of transmission 0 at the origin this is a perfectly valid synthesis absolutely wonderful all that you have to do now is to add this 1 Ohm. And at the voltage generator here, but we how the synthesize now? All that you have to do is first remove the pole at infinity of y22. Can you tell me what this value shall the?

Student: (Refer Time: 28:42)

1 by 3 that is correct. And if you remove this pole at infinity all that remains shall take care of this series resonance circuit. And I can do it by inspection see if I remove this. What shall remain? If I remove s by 3 well i leave that as an exercise. I will not complete this you understand what we have what we have to do all right.

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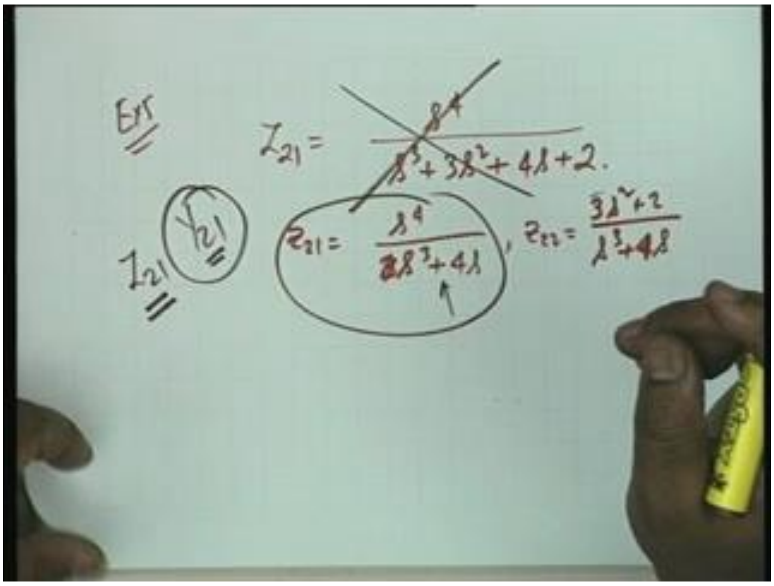

Now, let us take example 5 another variation suppose Z21.

Student: (Refer Time: 29:16)

Direction of current is always to port always going in, always going in that is how the parameters are define. Now, suppose it is a s to the 4 divided by s cube plus 3s squared plus 4s plus 2. Now therefore, my Z21 is equal s to the 4 divided by 3s no s cube plus 4s and z22 would be equal to.

Student: (Refer Time: 29:58)

3s square plus 2 divided by s cube plus 4s. How many transmissions 0s now? 4 transmissions 0s at the origin right none at infinity now there is fundamental contradiction, there is a fundamental principle that is being violated, unless you realized this you will end of in a network all right. But that network we will not realized what you are wanting to realized.

The claim now that I have make is that this function is not repeat, not realizable by an LC ladder terminated in a resistance I make this assertion either you justify or counter.

Student: (Refer Time: 30:51)

Degree of denominator is 3, degree of numerator is 4.

Student: (Refer Time: 30:58)

Poles are not on Z omega the it cannot Z omega axis it is Hurwitz Polynomial, this is Hurwitz Polynomial well these are this poles are on the Z omega axis. S times s square plus 4, yes 1 is the origin, 1 is the any other where are the poles of z22 s equal to 0 and plus minus Z where are the poles of z21.

Student: (Refer Time: 31:31)

There is a pole at infinity.

Student: (Refer Time: 31:36)

Can z21 have a pole which is not shared by z22? No, it cannot have a pole which is not shared and therefore, the degree of the numerator here cannot exceed, the degree of the denominator. So, this function is not realizable by LC ladder terminated in the network, terminated in the resistance.

Student: (Refer Time: 32:03)

Can you have a pole in the right half plane? No network function can have a pole in the right.

Student: (Refer Time: 32:14)

That is correct. Next, that is what I am say no it does not make a pole in the right half plane it makes the pole at infinity. Transfer function can have a simple pole at infinity, but in this case you cannot have, because we are realizing in terms of 2 Z parameters and any pole of z21 must also belong to z22 as well as z11. The pole at infinity here does not belong to z22 at infinity is 0 and therefore, there is contradiction. So, this function is not realizing point clear? This is 1 method of synthesis we will take 1 example in the problem session of synthesis of resistance terminated ladder. But the question that I want you to exercise is please pay attention to whether it is z21 or y21 that is whether the last element that you developed will be in series or in shunt.

If it is current generator that is if it is z21, then the last element must come in shunt whereas, if it is y21 the last element must come in series this is.

Student: (Refer Time: 33:41)

Say it again.

Student: (Refer Time: 33:45)

In y21 the output is current, in z21 the output is voltage right. Now, this is 1 method or synthesis.

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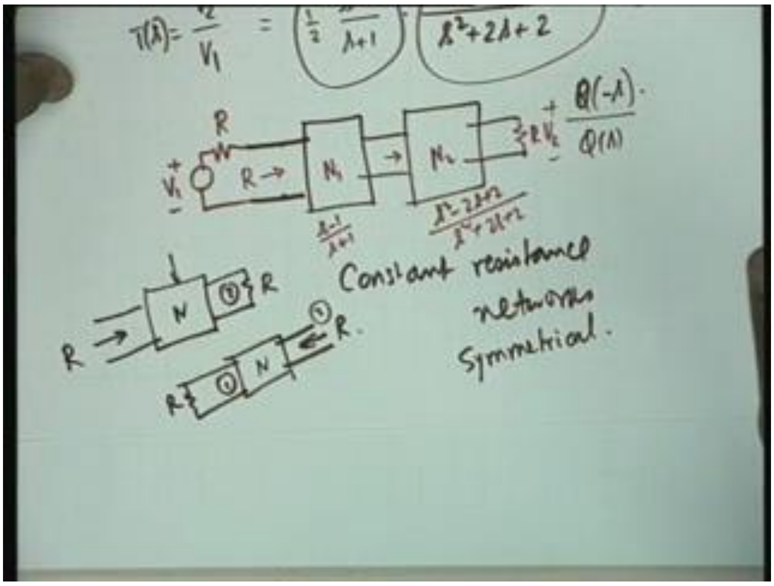


Let us, look at some other element to the methods of synthesis suppose, you have a transfer function V2 by V1 suppose this is to be synthesized A t of s a voltage transfer function V2 by V1. And suppose, it is very complicated maybe of this form let us a s minus 1 by s plus 1 half multiplied by let us, say s square minus 2s plus 2s squared plus 2s plus 2. Where are the poles? Complex right I want it that way multiplied by let us a something else. It is a very complicated function but.

Student: (Refer Time: 44:43)

This is non minimum phase yes, how do you do it is non minimum phase. Because, there is 0 8 plus 1 this also gives 0s in the right half plane. And do you the realize that this is also alpha’s function? These also alpha’s function? What is an alpha’s function?

If the denominator is Q of s that, the numerator must be Q of minus s that is right. So, this is in also alpha’s function, suppose for example: this is what you wish to realize.

Now obviously, the realization would be very simple if we could realize this transfer functions individually and could multiply them. This is like achieve gain 1000 you can have an amplifier of amplifier first stage of gain 100 and the next 1 10 provided the do not load each other.

That is when the second stages cascaded to the first it does not load it does not it does not reduce the gain. Now, a situation like this can be thought of here suppose, you have 2 networks cascaded such that the first 1 realizes, this the second 1 realizes this unfortunately; however, with passive networks. A buffering is not possible with an active network well, if the input with op-amps for example, input impedance when op-amp is infinity.

So, if you cascade an op-Amp to anything it does not load, but unfortunately in passive networks there is no such buffer. But the saving raise the there are networks which are called constant resistance networks, which can perform this job of cascading and the idea is this. A constant resistance network is such is defined as 1, which when terminated in a resistance R gives an input resistance of R and vice versa that is if it is terminated at this side the same networks.

If it is terminated here with the same resistance R it again gives a resistance R that is the definition of a constant resistance network. It has to be we are considering only reciprocal network this cause that the reciprocated no reciprocated something else. That is the generator cause and effect have to be interchange is not a question of reciprocated. We assume that N is reciprocal now, can you make a conclusion about the character of N if this is.

So, that is if when terminated at port number 2 port 1 presence a resistance R the same resistance R. And if it is repeated that if port 1 is terminated in resistance R, it gives resistance R a port 2 can you decide something about the character of the network.

Student: (Refer Time: 37:53)

That is correct. It is symmetrical no bilateral let us , we add this do not make this mistake bilateral is 2 terminal element, bilateral refers to a 2 terminal element. That is current passes equivalent well in both directions. On the other hand, if a network contains only bilateral elements, then it is called reciprocal. Reciprocated is understood we assume that, all networks that we considering and passive, liner time, in variant and reciprocal all right.

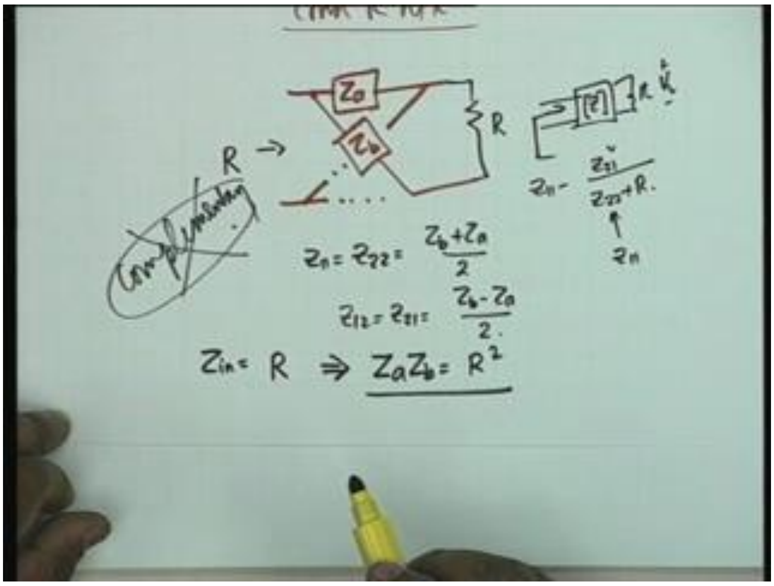
Now, this gives the character that constant resistance networks must be symmetrical. Now, suppose 2 such networks are cascaded 2 such constant resistance network that is if

I have a resistance R here, then what is the resistance here again R. And therefore, the transfer function of this network with a termination of R is not disturbed. In other words, N1 could realize this and N2 could realize this the input impedance see R shall again be R agreed.

So, in fact what we can do is N1 we by N1 with realize S minus 1 by s plus 1, by N2 with realize s square minus 2s plus 2 divided by s square plus 2s plus 2. And to achieve the factor of half what we do is we drive it by a source of internal resistance R all right. Then, what is the voltage here? half of V1.

So, the factor half is realized. Do you understand the importance of constant resistance network? That if we have constant resistance networks. Then, we can realize a complicated transfer function by decomposing it into simpler 1s. And the synthesis in most of the cases is obvious just by inspection.

(Refer Slide Time: 40:14)



Let me, give you an 1 example of a constant resistance networks 1 example. Constant R network the lattice is an example of a constant resistance network. Let us, a have lattice with see with series element Z a and shunt element Zb. As you know, lattice networks usually are symmetrical and therefore, we usually do not draw all the 4 elements What you do is we put a dot here and we put dot here. This means that, cross elements is also Zb and this series element is also Za all right is the point clear?

This is nomenclature so that, you do not have to draw all the 4 elements all the time. If this is to be a constant resistance network it is symmetrical network. Then, that is the first sign of constant resistance network it has to be symmetrical all right. If this is if this is terminated in R, then we what we want is that this should also be R that is what we want right if it is to be constant resistance network. Now, we can work in terms of Z parameters or Y parameters.

You know that z11 and z22 of this network is simply Zb plus Z a divided by 2. And z12 equal to z21 is equal Zb minus Z a divided by 2 all right. Now, we also know that the transfer function what you called that this is a folded version of a bridge network that it you once stated yesterday anyway. You also know, that if a 2 port is terminated in a resistance R can you find out the input impedance in terms of the Z parameters?

The input impedance is we have shown this earlier it is z11 minus z21 squared divided by z22 plus R this is the input impedance. Can you prove this?

Student: (Refer Time: 42:40)

Very simple I will do that.

Student: (Refer Time: 42:44)

You can he can use a T equivalent, because in arithmetically theorem you are not replacing a by physical network and, then you can find is R. Or you can back to the rules V1 equal to I1 z11 etcetera and then you write z2 equal to minus I 2 R. Now, if I substitute these values of Z work what is z22, z22 is same z11. Now, if I substitute these values here and simplify the simplification takes a bit of time you will see that Z in equal R implies.

Student: (Refer Time: 43:36)

That is right implies that the products should be equal to R square this is the condition for constant resistance networks. Za Zb equal R square. In other words, such networks, such impedances why let me introduce a term such impedances. Which when, multiplied with each other gives constant are called no I will not use that term. It is not a very appropriate term I say it is.

It is there called complementary, it is not vary appropriate terms. So, forget it about the question is that Z a Zb equal to R square this is the condition under this condition under the…

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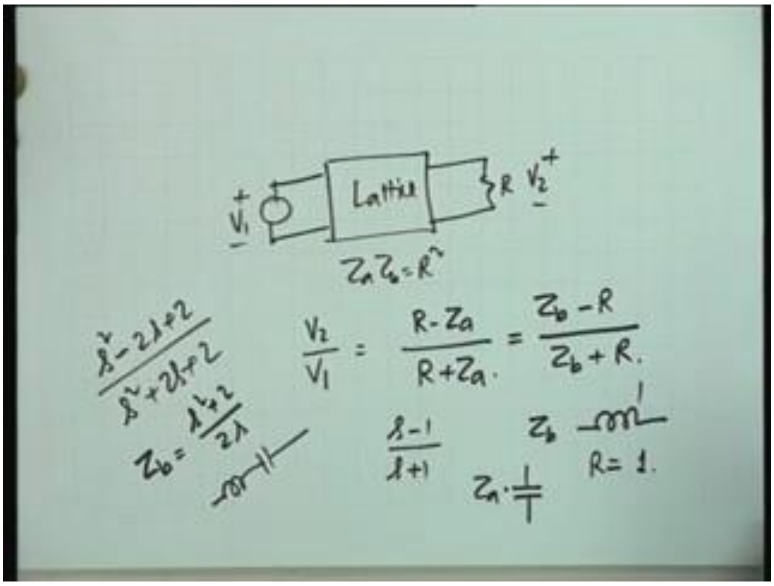

Let us, say this is the lattice where Z a Zb equal to R squared if it is terminated in R and if it is driven by voltage source. It can be shown that V2 by V1 is equal to R minus Za divided R plus Za. This also I will lift to you, I will not do the algebra you can show how do you show this?

Student: (Refer Time: 45:23)

No.

Student: (Refer Time: 45:27)

No it is not, because as it termination R

Student: (Refer Time: 45:33)

You if you find out the equivalent parameters and then decide this, but I am and asking you to do this. Please do verify that this is, so can you write this in terms with Zb instead of Za?

Student: (Refer Time: 45:51)

Yes. Because, Z a is this you can show that is equal Zb minus R divided by the Zb plus.

So, that if the parameter if the function is s minus 1 by s plus 1 all that you require is Zb should be Zb, should be and inductor of value 1 and R should be.

Student: (Refer Time: 46:18)

1 what is Za then?

Student: (Refer Time: 46:21)

The capacitor of value 1 Farad it is it is obvious by inspection. Similarly, if you have function was s squared minus 2s plus 2 divided by s square plus 2s plus 2. What would be our Zb? And what would be your Za? Would you believe Zb? Would be s square plus

2 divided by 2saAgreed? Which is a series combination of an inductor and the capacitor? And what would be Za?

Student: (Refer Time: 47:03)

Za would be simply the reciprocal of this which means, a parallel combinational of inductor and a capacitor. So, the synthesis no other calculation is needed it should be obvious by inspection all right. We will do a few problems in the problem session.

Thank you.