Analog Electronic Circuits
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Module No 01
Lecture 32: Analysis of the Series - Series and other Feedback Configurations

We are going to consider the other architectures, the other 3 architectures,series-series. What did we do yesterday? Shunt.

Student: Series-shunt

Professor: Series-shunt.

So series-series, shunt-series and shunt-shunt. Okay. The general rule, once you understand the general rules then the analysis becomes very easy.

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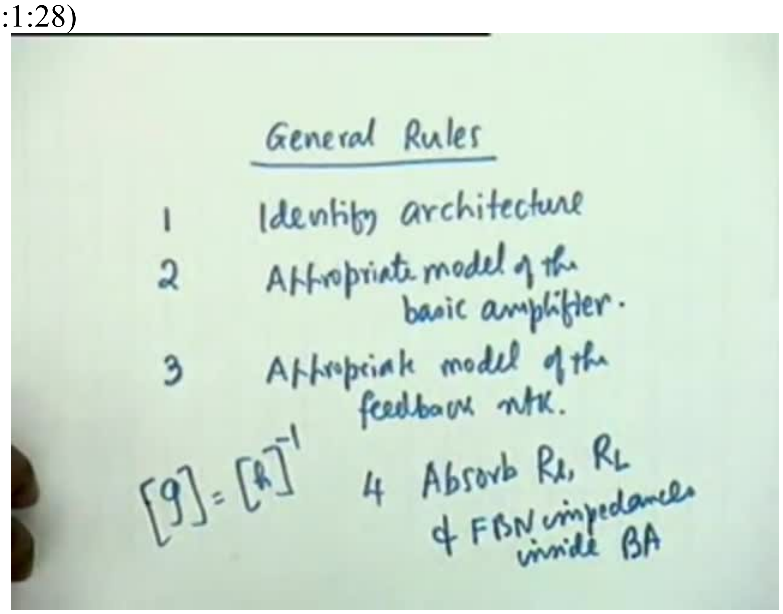

As you will see the general rules are the following for identifying andanalysing a feedback amplifier. The 1^{st} step is identify the architecture, whether it is series-series, series-shunt,shunt-shunt orshunt-series. So 1^{st} step is, identify architecture. Okay. 2^{nd} one is identify architecture, then you have to take an appropriate model of the basic amplifier. So appropriate model of the basic amplifier. Let meexplain what I mean by this. Suppose it is a series-series configuration.

Series-series means voltage, the feedback quantity, feedback parameter is a voltage. Is not it right?

Series-series. So input is a series comparison which means voltages are being compared. So the input of the basic amplifier be a voltage. Output series connection means current is being sampled. So the output should be a current and therefore for the basic amplifier in a series-series, the basic amplifier should be voltage to current transducer. Is that okay? This is what I mean by appropriate model of the basic amplifier. Three, depending on the architecture, you take an appropriate model of thefeedback network.

For examplein the series shunt that we considered, why did we take the H parameter model? Because the H parameter model allows a series circuit at the input, H11 H12 V2 and a shunt circuit, a parallel circuit at the output okay. Similarly, we will see that in all other cases, a different kind of parameter will be needed. Sometimes a small z, sometimes a small y, sometimes a small g, g as in gravity okay. These parameters, small g has not been taught to you I believe.

Small g is the inverse of H parameters okay.g parameters are the inverse of H parameters but we need not know that. Once we get the feel of the whole thing, the parameter identification would be obvious. With a little bit of effort and exercise, you need not do you need not to the 3rd step, you can go right from the 3rd to the 4th step. 4th step is, after you do this, absorb RS, RL, the source and the load and feedback network impedances, FBN impedances inside the basic amplifier. Inside basic amplifier okay.That is absorb them inside the basic amplifier, that would make the A circuit of the feedback amplifier.

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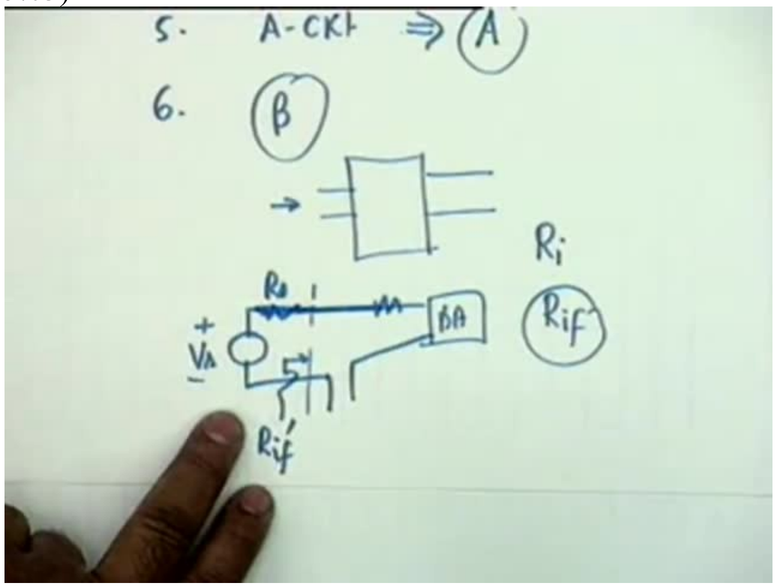

That would make the A circuit. Then analyse the A circuit and find out the gain A. This gain could be dimensionless, could be of the dimension of impedance,could have the dimension of admittance depending on what model you have chosen for the basic amplifier. Then number 6, determining beta. Determine beta depending on the kind of connection that you have made and it is always good to remember that in the absorption of RS and RL, no I am sorry, in the absorption of feedback network impedances, the impedance that is seen from the output port will depend on whether the input connection is series or shunt.

If it is series, then you leave it open. If it is shunt, short it okay. Similarly forwhat you absorb at the RS and, these are the general rules. And once you find the general rules, then once you identify A and beta, you know what is the feedback gain, you know what is the input impedance, you know what is the output impedance. In the matter of input and output impedances, one has to be a little careful in the calculation. Let me make that caution also at this stage.

Suppose you have basic amplifier and you have VS and RS, maybe the connection is series okay. Nowwhat I actually need is this impedance, the impedance that is seen by the source along with its internal resistance okay. When I absorb RS in the basic amplifier, obviously the RS is killed. RS is inside. And in the feedback amplifier, what you find out is RI without feedback and then RIF, both shall involve RS. And therefore, to find out the actual input impedance faced by the source in the total feedback configuration, you shall have to decouple the RIF that has been found out from its RS components.

Sometimes, it will be in series. If it is aThevenin voltage source for example,Thevenin source, then it has to be subtracted. If it is a, if this is to be converted with current source, then RS, GS has to be subtracted from GIF. This you must do with care. But looking at the circuit, it should be obvious what is to be done okay. These are the general rules. Now let us really go through the other 3 configurations. Yes?

Student: Please repeat the last point.

Professor: Oh, last point was that when you absorb RS inside basic amplifier, you have transferred this here to identify the A circuit and therefore the RIF that you shall find out will include RS. On the other hand what I want to find out in the actual amplifier is what is faced by the source along with its internal impedance. And therefore, the feedback input impedance will be different from what you actually want and one has to extract the desired quantity from what you have found out.

And, the A circuit and the beta circuit, they are hypothetically constructed circuits right? And why do you construct it? Because we want to apply the formula A by 1 +A beta or RIF equal to RI multiplied by or divided by 1 + A beta. Rather than writing node equations and loop equations for complicated circuit, the break it upinto the A circuit and the beta circuit and then find all other parameters. Okay, if you remember this general rule, then you will see that the analysis of the other 3 configurations will be very easy.

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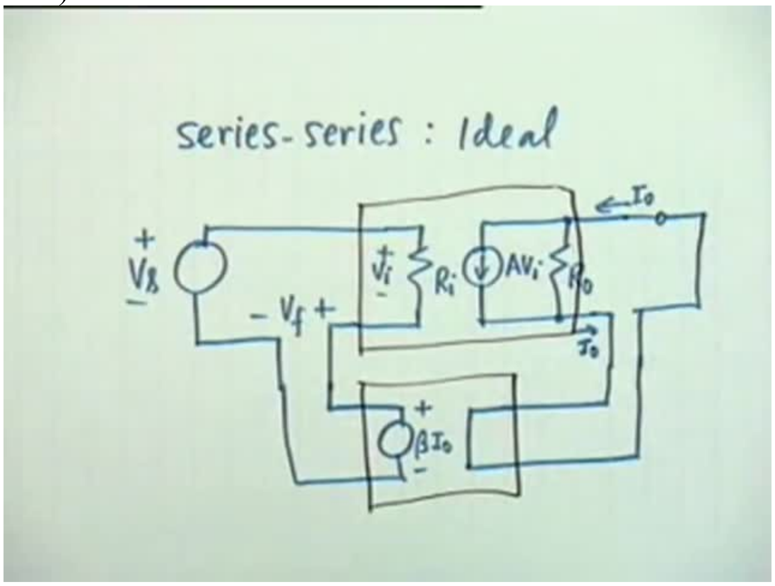

We take 1st, the series-series. Now obviously if it is series at the input, we are comparing voltages and therefore I have a voltage source, the ideal situation would beI have a voltage source, then I have a basic amplifier in which the input impedance is RI, this voltage is VI and since the comparison is series, this would be my VF with this polarity. I am considering negative feedback. Now the output if it is series-series, current is being sampled and therefore the appropriate model would be a current source, AVI. This A now has the dimension of conductor okay.

And you might have its output impedance R0, this is the model of the basic amplifier and then you havea series sampling. So ideally ideally this should be a short circuit. This is myI0 and this is my I0. Then what you want for the feedback network is that it should be a short circuit. So the current here is I0 and what you want here? Ideally you want a voltage controlled. No, current controlled voltage source. So what we want here is a voltage source of value beta times I0 with this polarity.

This is the ideal situation, this is the basic amplifier and this is the feedback network. How does it differ from the practical situation? In the practical situation, this is no longera current controlled voltage source. It is a passive networkand , the source has an impedance RS, the load has an impedance RL. Let me draw the practical network, practical series-series. Then we shall be able to simplify.

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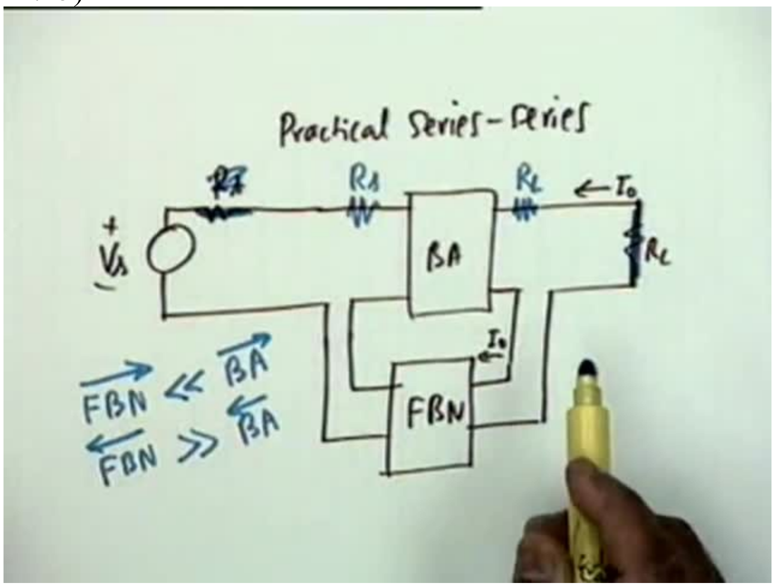

Practical series-series.We have VS, RS. This is the basic amplifier. Then we have a load resistance RL. This current is I0 and there is a series-series comparison and therefore I have a feedback network like this. This current is I0. So in order to analyse us, let us follow the steps. Of course one assumption that we have made, I think I should reemphasise this that the feedback network forward transmission is much less compared to the basic amplifier forward transmission and the feedback network reverse transmission is much greater than the basic amplifier reverse transmission. All right?

On the basis of these, we model the feedback network now. You see, one thing I can do very easily is to shift RS to the basic amplifier and RL to the basic amplifier. If I do that , let me do this in blue. If I include RL here, then obviously this would be a short circuit. That is what I wanted. I wanted the output to be short-circuited okay. If I shift RS here then this is a short circuit and therefore in the basic amplifier, RS and RL come in series. Agreed? Now we have to include the impedances of the feedback network.

Without going into any model, let me do this, let me do this as abypass, through a bypass route without going into an appropriate model. We will argue what the model should be, later on but without going into this see what I should do, let me draw the A circuit right from this one.

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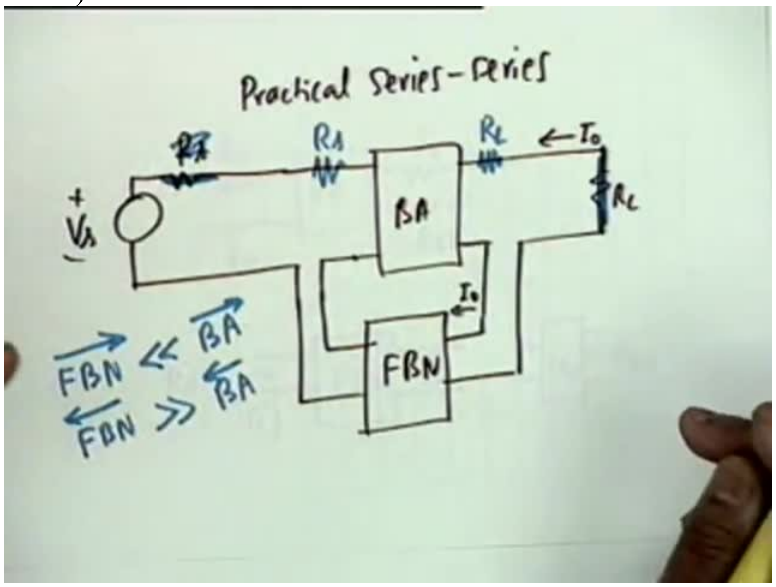

The A circuit would be RS, basic amplifier and then RL. Then obviously what will happen is, two resistances will come at the other end. Okay. 2 resistances. Call this R22 and call this R11. Agreed? From the feedback network. That is the feedback network impedances have to be absorbed inside the basic amplifier. Now what is R11? R11 obviously shall be the resistance measured at Port 1 of the feedback network with this with the port 2. No. Open, port 2 open. Why? Because it is a series connection. All right. And R22 similarly shall be the impedance measured at port 2 with port 1 open okay alright. So we have identified the A circuit the B circuit, the beta circuit. Is this point clear?

Student: No Sir.

Professor: No. Okay what I wanted to do is to include the impedances of the feedback network, the impedances of the feedback network in the basic amplifier.

Now how do I do that? If there comes series impedance here, I will put it here. How does the series impedance come? Obviously, this is the impedance measured here with this port open. Why? This is because the appropriate parameters here are the z parameters, small z,the impedance parameters. Let me justify now the procedure. But before justification, can I complete this and come back here? Okay. Can I complete the beta circuitwithout caring appropriate parameters of the feedback network are.

We can do it by following this rule that ifthe connrection is series, open it. If the connection is shut, short it. And you have to include two impedances to the basic amplifierand each of them is obtained by measuring at the appropriate port and the other port open or shorted depending on whether that connection is series or shunt. This is the general rule of thumb, you can say blind rule but there is a justification.

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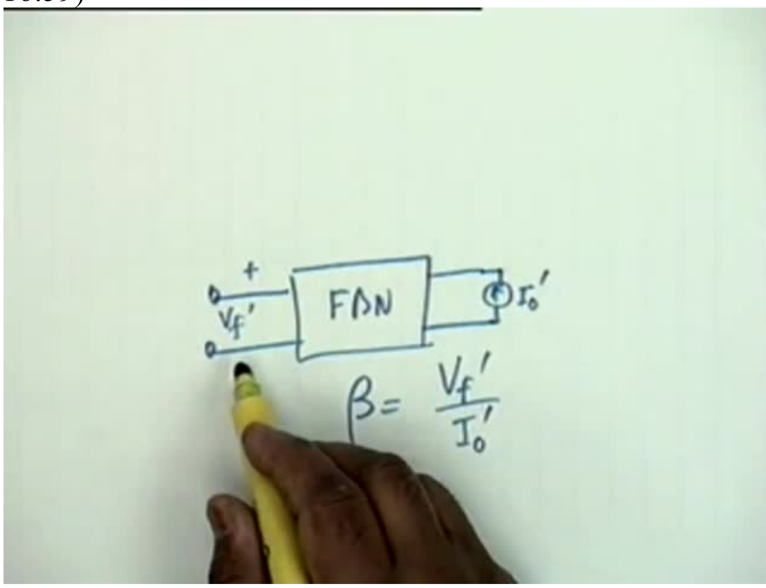

Similarly for the beta circuit,what you want from the feedback network is since the connection is series, you want since the input connection is a series, what do you want from the feedback network? A voltage or current?

Student: Voltage.

Professor: Voltage.

So you want a VF prime with this polarity with these terminals open or shorted? Open because it is a series connection and you have here, what do you feed here? You sample current and therefore you feed here a current source, I0 prime and beta obviously would be equal to VF prime divided by I0 prime. All right? Once you have done this , then you find out RI, R0, RIF, R0F and AF. Yes?

Student: Sir, why did we call? Why do not we directly use VF? Why did we put a prime subscript over here?

Professor: because I do not want to confuse this with the actual voltage. The actual voltage is different.

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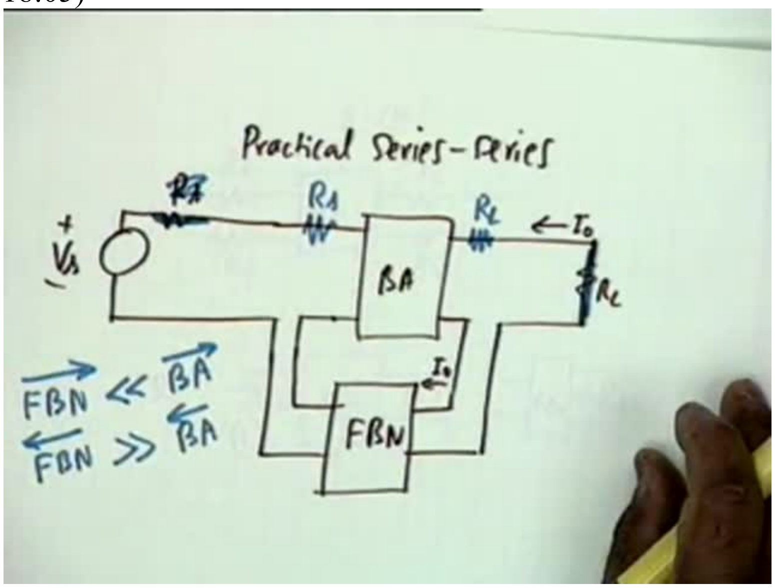

Let me go back. The actual voltage is with the basic amplifier included. Whereas what I find here is the open circuit voltage. So that maybe different, that will be different. That is why I use a prime. Okay. Now I go back towhy this rule works. Because the feedback network here will have to modelled by its z parameters. That is, let me let me go through this. Then in the other 2, I will not explain what parameters I am using. Okay. Let me explain only in this.

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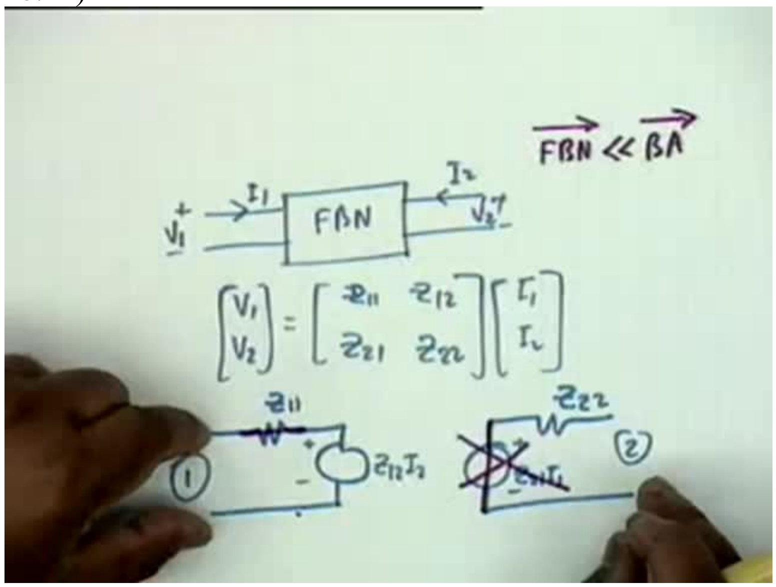

The feedback network, why z parameters? Because series-series, what I want is the equivalent circuit should be a series connection at the at port 1 and a series connection at port 2. And you know, this is offered by the z parameters and z parameters alone. If I have V1, I1, V2, I2 then the z parameters are V1 V2 equal to I1 Z11, Z12, Z21, Z22 multiplied by I1, I2. And the equivalent circuitis if you write this equation V1 equal to I1Z11 + I2Z12. You have Z11, then avoltage source with a value ofZ12 I2.

Then in the other circuit, it would be Z22 and voltage source againZ21 I1 and this is +-. Then comes my basic assumption that is the forward transmission through the feedback network is negligible compared to the forward transmission through the basic amplifier. And therefore, this I make it equal to 0.Z21 takes care of the forward transmission. If I have a current I1 then there is a voltage here. Okay. AndI includeZ22.

Student: (())(20:25) is 0.

Professor: Why that is 0? This is not 0. What I am saying is, our basic assumption is the forward transmission the feedback network is much less compared to the forward transmission through the basic amplifier. And therefore, we ignoreZ21. Agreed? Z21 takes care of the forward transmission. We ignore Z21 compared to the forward transmission through the basic amplifier.

Thisis the 1st assumption that we make. Obviously, then we are left withZ22. What is Z22? Is the impedance measured from port 2 with port 1 open okay.

This is the justification. And there becomes a short-circuit here which is what my ideal series-series configuration is. There is a short-circuit here. So Z22 goes back to the basic amplifier the lower lead. SimilarlyZ11 goes of the basic amplifier in the lower lead, absorb it there and what I am left with if Z11 check-in out there, what I am left out is a voltage source. This is what I wanted okay to be able to measureZ12 or beta. Z12 is now equal to beta. To be able to measure it, what you have to do is apply a current source here and measure the voltage here under open circuit conditions and that gives you Z1.

This is the total justification. In the other 2, I will not make the justification. I will simply draw the A circuit and the beta circuit. But before that, let me take an example.

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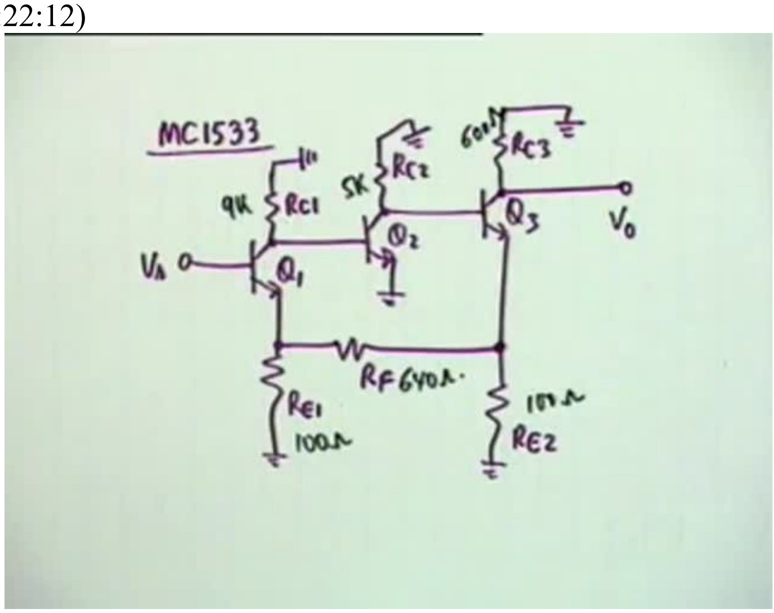

Example of a series-series. It is a practical circuit. There is a chip called,op-amp chip called 1533 and part of the circuit is a feedback amplifier in the series series configuration, is a feedback triple. It iscalled a feedback triple, 3 transistors are used to form a feedback triple. And the circuit is this. I am drawing the simplified circuit.You have a source VS which goes to a transistor Q1. Q1 has an RE1 and the feedback is applied to RE1 so that the comparison shall be series or shunt?

Student: Series.

Professor: Series, okay.

This we are already familiar with. Then this as an RC 1 and let us say it is ground, that it is it goes to the power supply. I am going only the AC equivalent circuit. The output goes to, this is all in part of an IC chip. So there is no positive anywhere. There is no capacitor and these resistances also have to be very moderate values, not exceeding 10 K. RC1 in in the actual circuit,RE1 is 100 ohms and RC 1 is 9K. Let me indicate these values later. Let me draw the circuit 1st. Q2, this is grounded and this has an RC2 which goes to ground.

The 3rd transistor Q3 has another resistanceRE2 in its emitter and the feedback is applied from here to here through a resistance RF. Q3 has a resistance RC3 which is grounded. And the output voltage, output is the voltage taken here, V0. Now let us see let me 1st indicate the element values, typical element values. This is 9K, this is 5K, this is only 600 ohms, this is 100 ohms, this is also 100 ohms and this is 640 ohms. This is the kind of values that we use in the IC chip. Now why am I saying that this is a series-series?

You see the current here the current output current approximately the same current flows here and therefore this is a current sampling okay. This also we are acquainted with. This is a very standard method particularly in IC configuration so it is a current sampling and obviously, there is a voltage comparison and therefore this is a series-series. Now without bothering about any of the steps and the rules, with a little experience, one can draw the equivalent A circuit and the B circuit.

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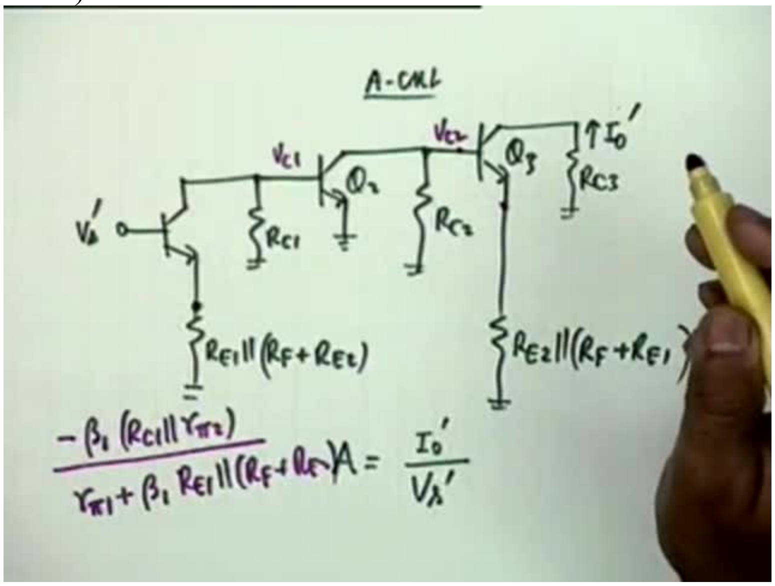

The A circuit for example if you look at it carefully, it would be the following. I am drawing the A circuit right by inspection. It would be the following. You have Q1, RE1. Now this RF is the feedback element. RF is the feedback network all right. So RE1 shall be shunted by if you want to kill this feedback, it is a series series. So you have to open it and thereforeRE1 would be shunted by RS + RE2. Is that clear? So all I have isRE1 parallel RF + RE2 for the A circuit.

Student: last point once again.

Professor: last point, okay. Whatthisimpedance, the impedance of the feedback network?

Student: That is R11.

Professor: R11. It would be the impedance looking from port 1 with port 2 open, which is simply RF +RE2. In a similar manner, RE2 shall be supplemented by a parallel connection of RF and RF +RE1 okay. Once again it would be +. Right. The other part of the circuit is simply RC 1. This goes to Q2, then RC2 and this goes to Q3, this now comes in as RE2 parallel RF + RE1. And this goes to, RC3 goes to ground and this current is I0 prime. Why do you say prime? Because this is the A circuit. Okay. Now the A circuit, what you have to calculate is the gain would be fortunately there is no source or load resistance here. If there was, then you would have put it this here okay. Now the other thing is, how I know that I have to calculate I0 prime by VS? To confuse matters, output is shown here as V0. Why do not we calculate V0 by VS.we would have made a mistake if I calculate V0 by VS. Why? Because it is a series-series configuration and the appropriate gain is the output current divided by the input voltage right which would have a dimension of conductance or admittance.

So what you have to calculate is I0 prime divided by I can use VS but to keep continuity, I0 prime by VS prime. Then the beta circuit, okay. This is the A circuit. The gain calculation for the A circuit is a routine matter,and can be done by inspection. No analysis should be required okay. For examplefor the 1st stage, let us calculate VC1 by VS prime. I will simply indicate how to do it. If you have a problem, ask me. Now actual, effective load is RC1 parallel R pi 2 okay and there is a resistance here.

And therefore, the gain shall be simply - beta 1 RC1 parallel R pi 2 divided by R pi 1 + beta 1. Actually it should be beta 1 + 1 but weignore that. Beta 1 RE1 parallel RF + RE2. Agreed? This is the gain of the 1st stage. Gain of the 2nd stage, if I calculate VC2 by VC1, the effective load the gain would be - GM2 multiplied by RC2 parallel R pi3 + beta 3 + 1 multiplied by this. Is that clear? You should be able to do this by inspection. That is the sure test of astudent who has graduated through SEDS 204. Okay. You should be able to do it by inspection.

Student: Sir, one Question.

Professor: yes.

Student: why (())(30:21) VS and VS prime in this circuit?

Professor: oh, this is simply to keep conformity. Put it I0 prime, this is not the actual current and therefore (())(30:32). I do not have tobut in general if you have a current source for example at the input, then you have to convert it to a voltage source. And then voltage source, you will call it VS prime, not VS. Okay, now for the 3rd stageI0 prime by VC2, what would be this transfer function? Yes? Yes? - GM 3 multiplied by it is the output current which is GM 3 V pi3. V pi3 would be calculated from R pi3 divided by

Student: R pi3 +

Professor:+?

Student: Beta 3

Professor: Beta 3 + 1 multiplied by this. Is that clear? Okay. So the gainyou should be able to calculate by inspection.

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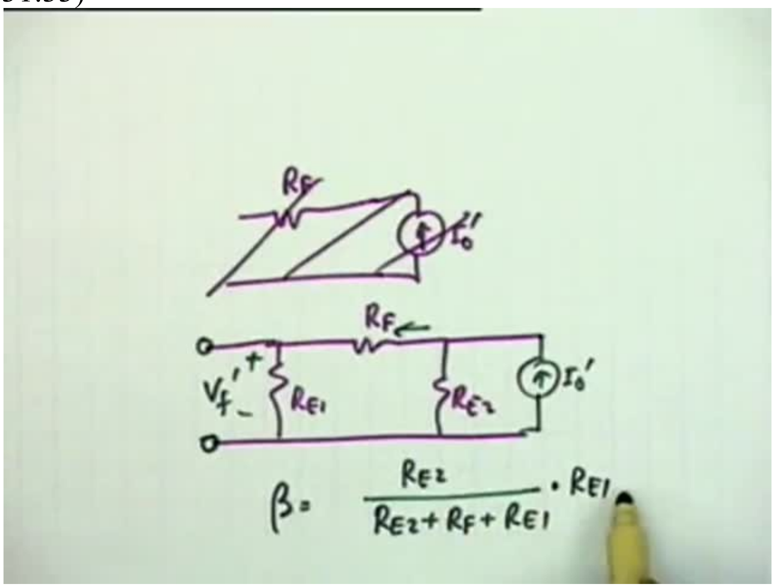

For the beta circuit, let us look at the beta circuit. It is, what you have to apply is beta circuit is simply this, RF. This is the 2 port circuit, is not it? What you have to apply is current source or voltage source?

Student: Current source.

Professor: Current source.

Let us call it I0 prime and I am sorry,that is not the case. The beta circuit is this. RE 1, RF and then RE 2. This is the beta circuit. By itself, RF will not work. If RE 2 is not there, it will not work okay. So this is the beta circuit and I have to apply a current I 0 prime and keepthis open. And therefore beta here, this is VF prime +-, beta here would be RE2, again by inspection. Divided by RE2 + RF + RE 1. This gives the current flowing through RF. This has to be multiplied by yes?

Student: RE1.

Professor: RE1, that is right.

What I have done is I have found out the current through this branch by this proportioning and then current multiplied by RE 1, that is VF prime. So this is my beta. And once you know A and beta, you can calculate everything. Okay. Now with those numerical values, now let me check this temptation.

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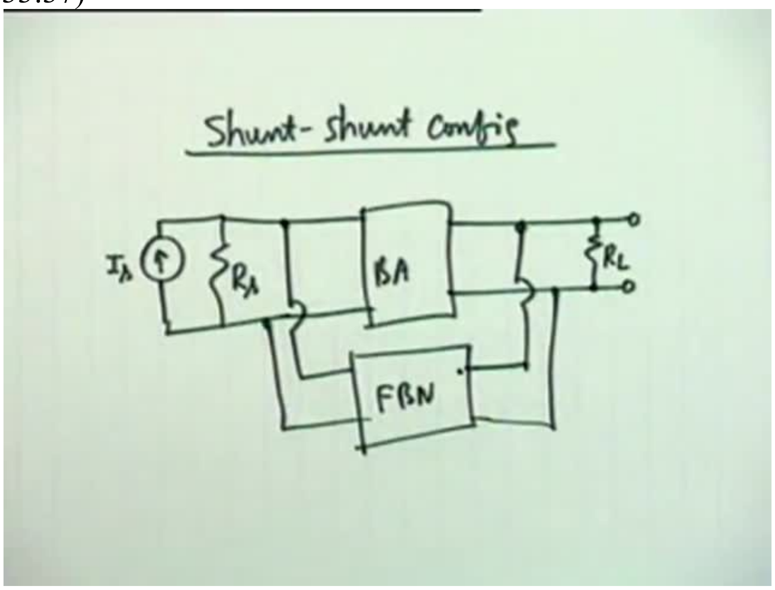

Let us go to the shunt-shunt configuration. Shunt-shunt. In shunt-shunt configuration, what should be your source? Or say, what should be your basic amplifier? Shunt-shunt. Basic amplifier shouldhave an input of?

Student: current.

Student: current.

Professor: Current. And the output?

Student: Voltage.

Student: voltage.

Student: current.

Student: current.

Professor: Output also current? No.

Student: voltage

Professor: Voltage. So it should be a current voltage amplifier. And therefore, we choose the input source as a current source.

And I am drawing a practical practical shunt-shunt okay. I am not drawing the theoretical one and then going over. I am drawing a practicalshunt-shunt. RS, since it is shunt-shunt, I have the basic amplifier and the output should be a voltage and therefore I have the load resistance RL, this is the practical circuit , then shunt-shunt means that I shall have a feedback network would be like this. This is the circuit of a shunt-shunt configuration. The 1st thing I do iswhat? I do not care.

Now, I will not model, I will not do anything. 1st thing I do is, I shift this RS to here, RS and RL, both of them. Okay. So I shift them here. Let me draw theA circuit directly from here. I will not go through any other process.

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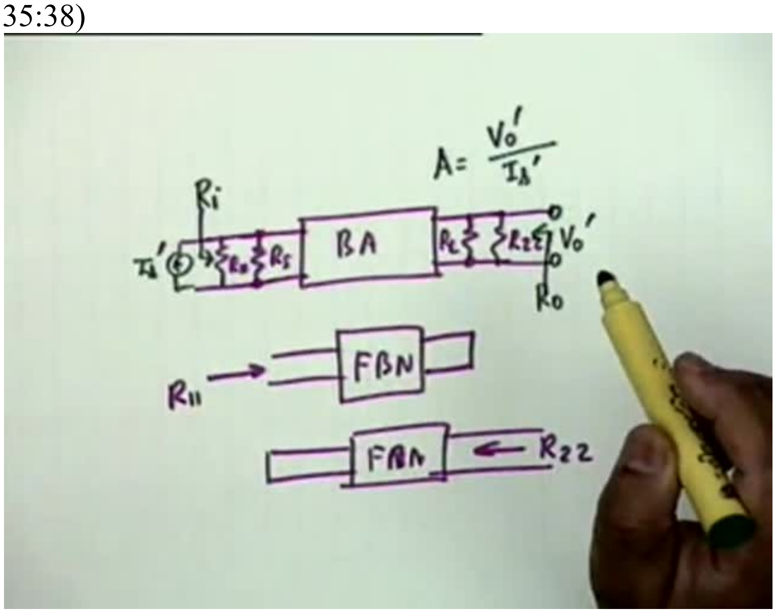

A circuit with the basic amplifier and then you have RS here and RL here. The 1st thing is to absorb them and then I have to absorb the impedances of the feedback network. So the feedback network shall give two impedances, R11 and R22. These will come in series or in shunt?

Student: shunt.

Professor: Shunt because it is a shunt-shunt configuration. So I shall have an additional R11 and an R22 where R11 shall be measured like this. Feedback network with output shorted. This is R11 and R22 shall be measured with the port 1 shorted and impedance looking here. Fine. That is the 1st thing. Then the A circuit, I do not need anything else. That is all the A circuit is. So I drive it, I drive it by a current source and what I do with the output?

Student:(())(36:58)

Professor: I leave it open. So this is V0 prime, this is IS prime. And the A now isV0 prime divided byIS prime. The RIof the A circuit is this impedance, RI and R0 is this impedance, R0. You see, RI includes RS, R0 includes RL. And if I can now find the beta circuit and RIF and ROF, you have to take account of the fact that RIF will include RS and ROF will suit RL. You have to get rid of them. All right? This is a caution one has to exercise. But let us look at the beta network. From the beta network, what do you want? Do you want a current or a voltage?

Student: Voltage.

Professor: No. I want a current because it is ashunt-shunt comparison. So my output port 1 should be open or short?

Student: Open.

Student: Short.

Student: Short.

Professor: Sufficiently confused. Short.

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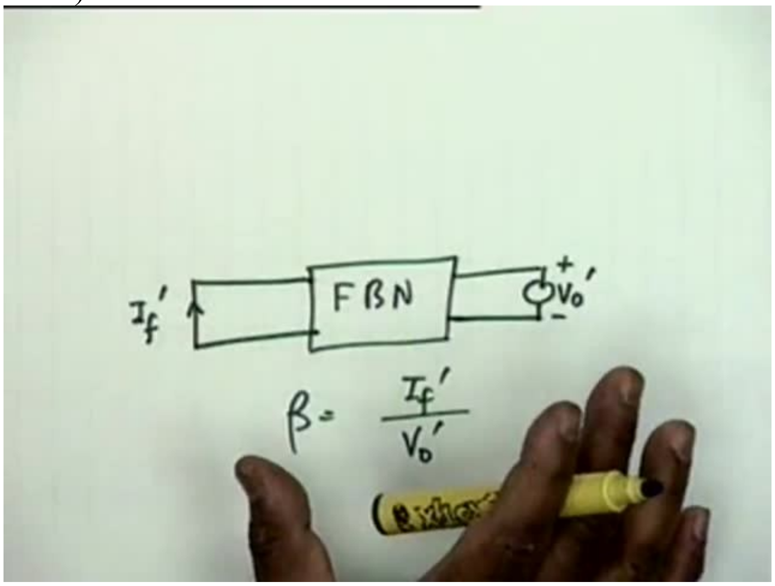

Professor: And what should I drive it with?

Student: A voltage.

Professor: A voltage source. So I drive it with V0 prime, I short this and find out the current, IF prime. Beta is IF prime divided by V0 prime. Okay. One check, is this point clear?

Student: no.

Professor: No. Let me to back.

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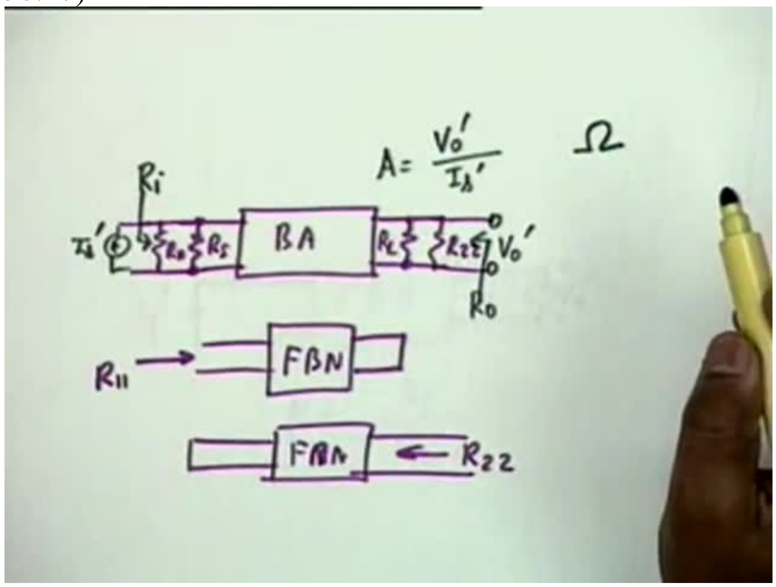

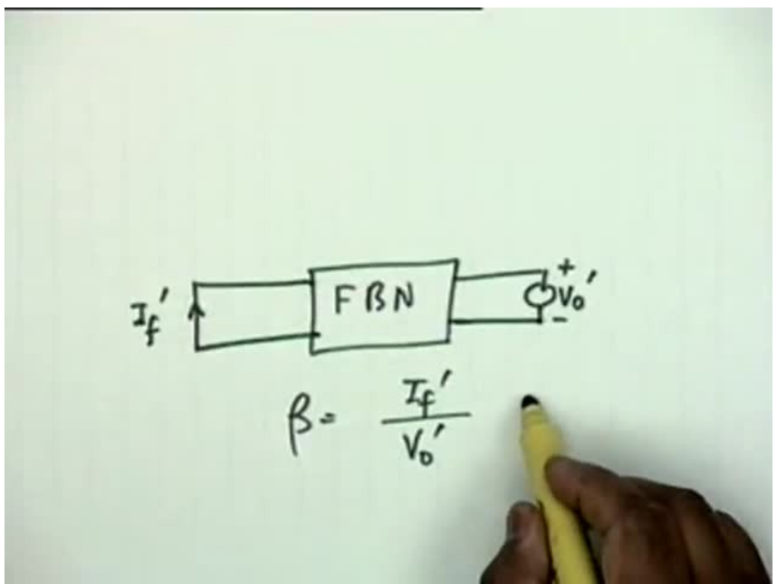

See what you are applying here is a voltage, the output voltage okay, V0 prime and what you are getting these are current. Now how do I find out beta? For beta, this has to be shorted and the short-circuit current is to be found. Shunt means short all right? All right. One checkin all this analysis which you must keep at the back of your mindis that the dimensions ofA and beta should be reciprocals of each other. Why? Because A beta is dimensionless. A beta adds to or subtracts from 1. 1 is dimensionless. Okay.

And therefore, does this check here? You see, A here is in ohms and beta is in mho. They have to be reciprocals of each other. If they do not, then you must have made a mistake. Thecritical point is the identification of the feedback. Once you identify the feedback, then nothing else is needed. Asimilarthe final configuration. Can youguess what parameters we used in short-circuited network?

Student: Inverse of z.

Professor: Pardon me.

Student: Inverse of z.

Professor: Inverse of z, that is small y parameters because it gives a shunt connection at both the input and output. Now the last configuration is and then we will take an example.

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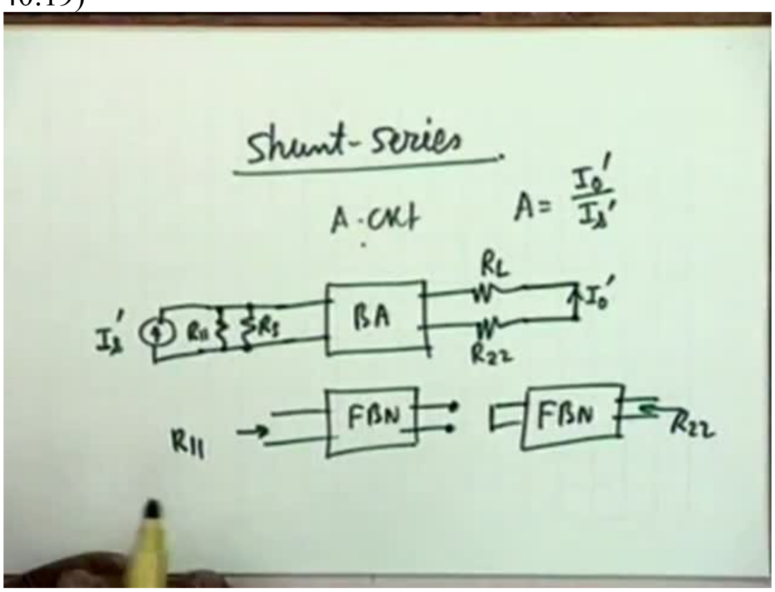

Last is ashunt-series.shunt-series which means that my A circuit, can I now draw the A circuit directly without drawing the practical circuit? Okay. A circuit. What shall it have? Basic amplifier. Since it isshunt-series, current and then what we shall have is RS in parallel. RS in parallel and it should be driven by current source. Let us say IS prime. If the original source was a voltage source, VS and RS, then you have to convert them into the equivalent Norton source. Now in the output it is a series connection, therefore what I want is?

Student: Current.

Student: Current.

Professor: A current. And therefore the load should come in?

Student: Series.

Student: Series.

Professor: Series, that is right. RL. Okay. In additionto this, I should have from the feedback network…

Student: R22.

Professor: R22. We will see how R22 is to be measured and from the feedback network here, an R11. Then what should I do with these 2 terminals? Short. And this is my I0 prime. And therefore the shunt-series, the appropriate A is a current transfer function, I0 prime by IS prime. Let us take the feedback network and identify R11 and R22. For R11, what do I do to these terminals?

Student: Open.

Professor: Open. And for R22, short. Right? We have identified the A circuit. We no longer bother about two port parameters and how the basic assumption of course is that the feedback network forward transmission is negligible compared to the forward transmission of the basic amplifier. And vice versa, reverse transmission of the feedback network is much larger compared to the reverse transmission of the basic amplifier. As long as that is obeyed, this circuit is valid.

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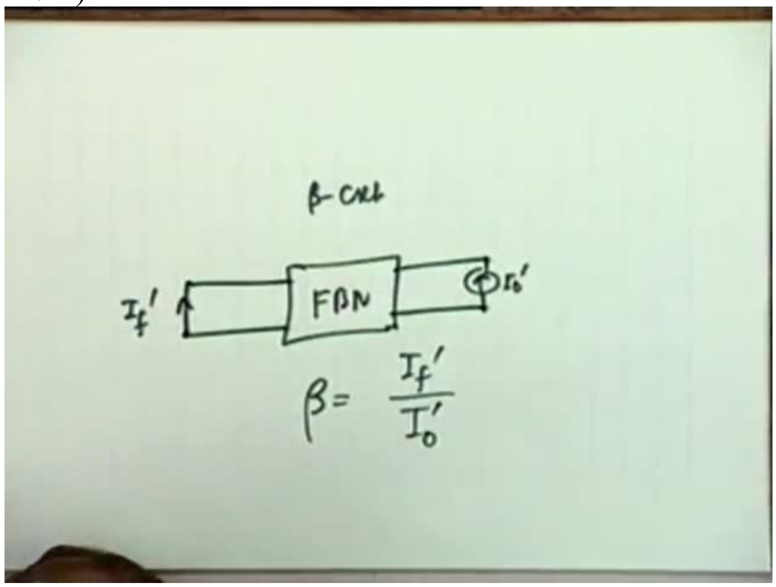

Finally the beta circuit. In the beta circuit, the feedback network, what should you drive it with? Obviously current source, I0 prime and what do you want here?

Student: current.

Professor: Current. It should be shorted and this is IF prime and beta is equal to IF prime divided by I0 prime. Okay, given any configuration, however complicated it may look, your ingenuity will lie in identifying what kind of feedback it is. Once you do that, then you can proceed blindly. Let me illustrate with one example. I will not calculate the full example. I will simply lost weight. Fairly elaborate .

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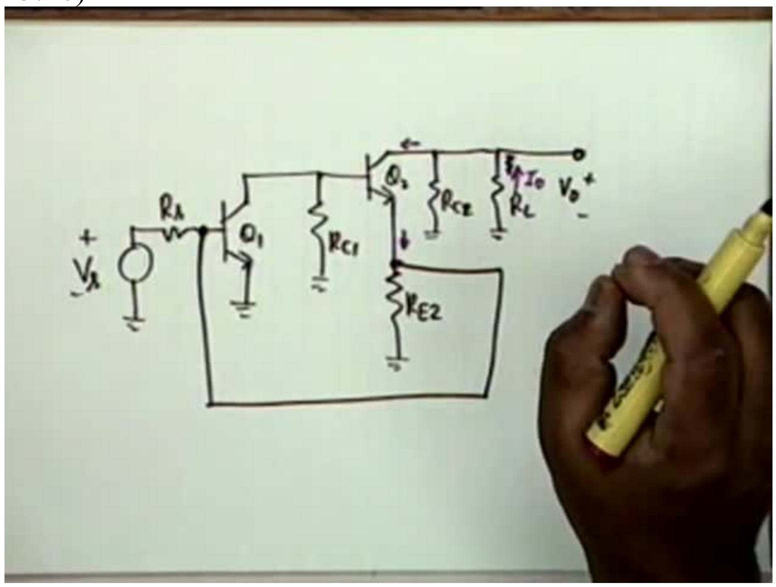

And I would omit the biasing circuit if you permit. I have a VS, RS, this is also a practical amplifier. This is shorted, Q1, this is RC 1 and then we have a Q2 which , RC 2, this is the biasing resistance and then you have an RL. This oh, I will not show the current yet because we want to identify. This is the RL and the voltage across this naturally we want a voltage at the output, okay fine. And the Q2 emitter, well that comes across that goes to a resistance RE2 and feedback is applied like this, from here to here. Okay. This is also a chip that is available, feedback is available like this. Now tell me, what kind of a circuit is this? Obviously, this is a shunt.

This is a shunt connection, is not that right? It comes in parallel, it draws away some current from the source. So it is a shunt connection. Noquarrelabout that. Now what about this? It is a series because it is the current which is being sampled. Now which current should we considered? Obviously RC 2 will be inside the chip. It is part of biasing. This is the current I0. Now it is not I0. Obviously I0 is being sampled because this current will be proportional to I0. Is not it right?

And this current would be approximately the same as this current. So whatever this current is, this current is proportional to I0 and any quantity proportional to the output is called a Sample quantity. Itmay not be the total output current, it may be a part of the total, part of the output current. So it isa shunt-series configuration stop is that okay? It is ashunt-series configuration.

Now let us see if we can draw the A circuit and thebeta circuit. If it is the shunt series, now what is the appropriate transfer function here? Before you apply those formulas, you mustdetermine what kind of transfer. What is the appropriate transfer function? Current to current or voltage to current?

Student: (())(46:48)

Professor: Current to current because there is a shunt here and therefore 1st thing you should do is to convert this into its Norton equivalent.

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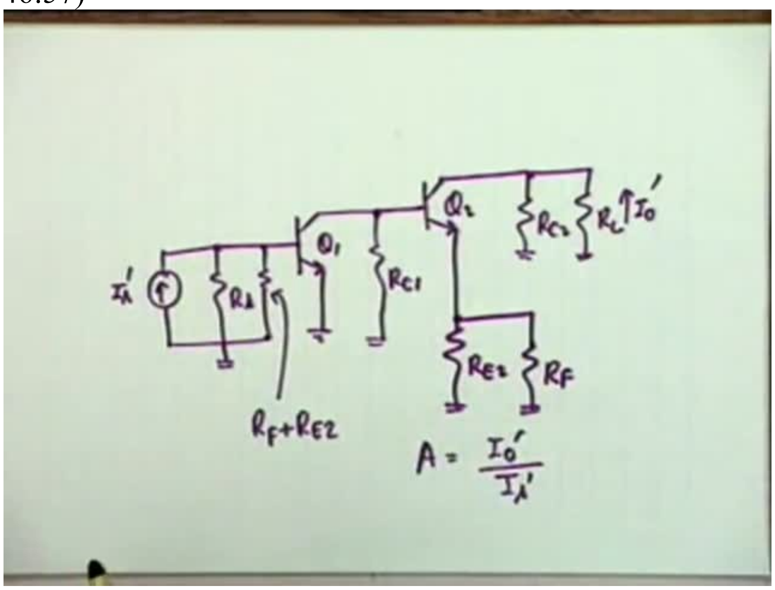

And so I have IS prime, RS, then you have the Q1, ground, R sub C1. What will come here from the feedback network?

Student: R11.

Professor: No.

Student: RE2.

Professor: RE2. No more parallel. You have to open this. Let us have another resistance here.

Usually, feedback is controlled by a resistance RF. Okay. So what will come in parallel is RF + RE 2. So there would be a 3rd resistance here, RF + RE2. Then we go ahead, we apply this to Q2 and we have a can we combine this? You better not because then you will lose I0. Is the point clear? Okay. So you keep RL and make this as I0. Then at the emitter, this is RE2 shall be parallelled by what? Simply RF because the input is to be port 1 of the feedback network has to be shorted. So it is simply RF. This is my A network and A is identifies as I0 prime divided by IS prime. Find out the A network, then find out the beta network. Let us look at the beta network.

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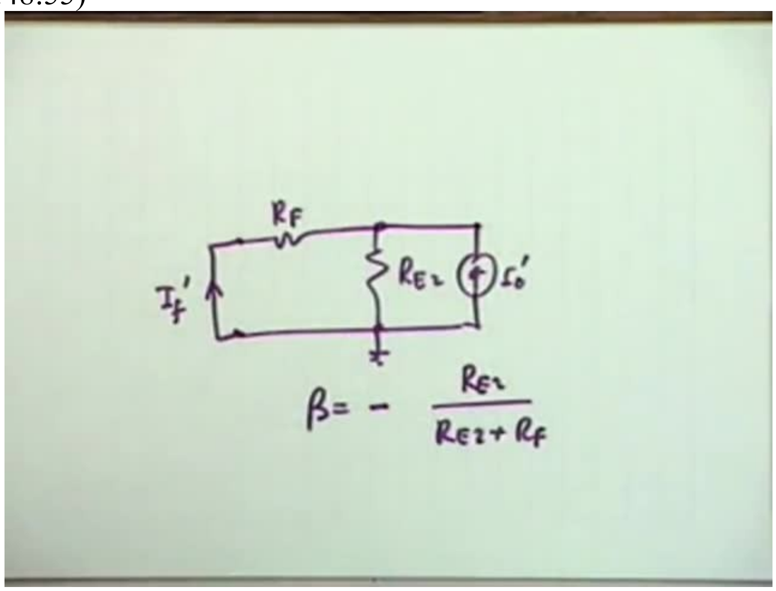

For the beta network, you have RE2 and RF. This is the beta network. Nothing else. What do you want to apply andwhat do you want to get? Apply a voltage or current?

Student: Current.

Professor: Current, I0 prime. And open or short?

Student: Short.

Professor: Short and you find out IF prime. Obviously, is it negative or positive? What is beta and how much is this? RE2 divided by RE2 + RF. Once you find this A and beta, everything else fits into place. On Thursday, we shall work out some examples of feedback amplifiers.