Basic Electrical Circuits
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Lecture - 103

Now, we have understood that for the op amp to have virtual short property, the op amp has to be in the negative feedback. Even with real op amps, when the op amps gain is finite it is only if you have negative feedback, that the difference voltage between it is inputs converges to a small value, with ideal op amps it converges to zero. In either case, whether you have finite gain or an infinite gain, if the op amp is in positive feedback, the difference diverges of to infinity.

So, now, it turns out that there is a very easy algorithm that you can use to check, whether the op amp is in negative feedback or positive feedback or if you come up with some circuit based on the virtual short concept, you can do that without assigning any signs to the op amp inputs, but after that work out which where the signs must be for the op amp to be in negative feedback.

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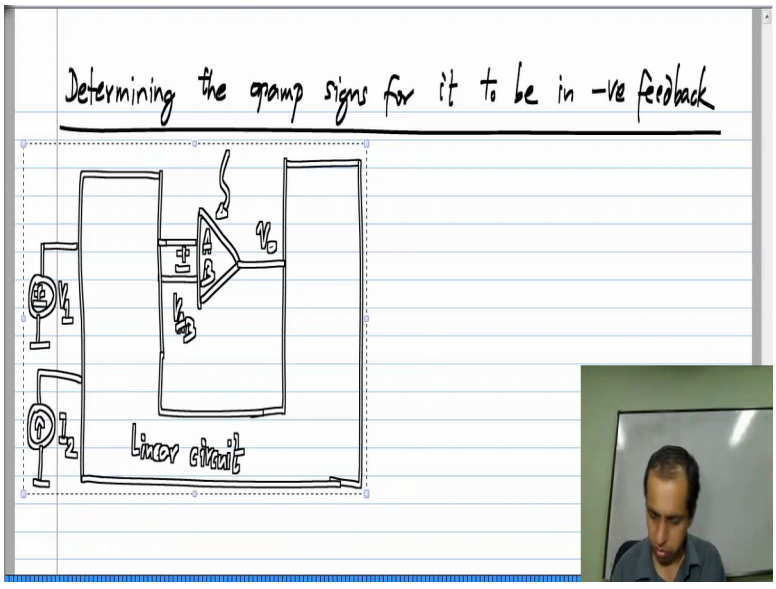

For this what I will do is, first show you what the algorithm is and then apply it to an op amp circuit. In fact, so far we know only one op amp circuit I will apply to that one. So, let us consider the op amp and let me label the terminals A and B instead of plus and minus and let say, the circuit has the number of inputs. I will show two inputs and there

could be any number of them and this is embedded in some circuit, this is the op amp for which we are trying to find the sign. So, there it is in negative feedback and of course, we will assume that the rest of it is a linear circuit.

So, this is the output of the op amp and this is the difference V A B of the op amp. So, now, feedback refers to what fraction of the op amps output comes to it is own input and that is what we have to determine.

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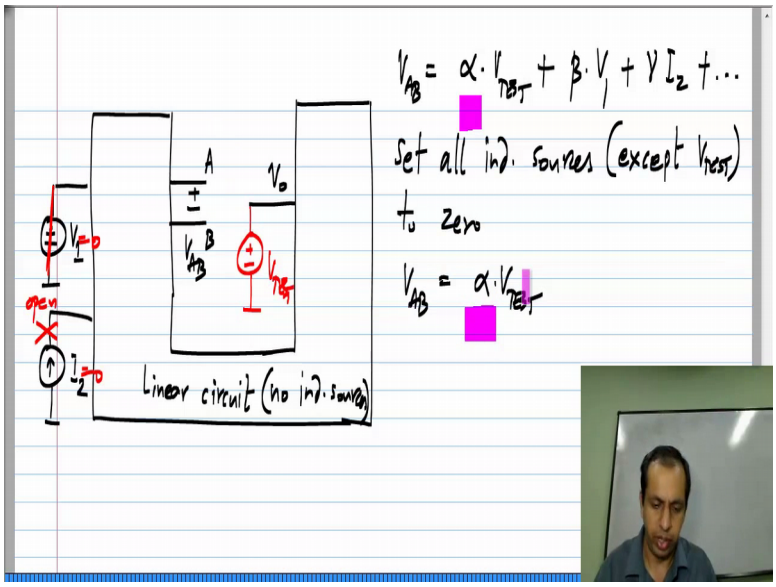

So, to do that let me do the following, I will remove the op amp. So, this was terminal A, this is terminal B, like I said we have to find out what fraction of voltage applied here comes back to it is inputs and let me apply some V tests, where the op amps output was, so this is the first step. So, if you look at the original circuit, the op amps output is here, now what I did was I removed the op amp and wherever the op amps output was I now drive it with some test voltage V test.

Now, what is this V A B going to be? This V A B, given what we know about linear circuits, it will be a linear combination of all the sources in the circuit, all the independent sources. Now, this circuit which is shown by this some odd shaped box, this is the linear circuit, so there are no independent sources inside. All the independent sources are shown outside, I have shown a case with two, but you can generalize it to any number.

So, this V A B will be some alpha times V test plus some beta times V 1 plus some gamma times I 2 and if you have more sources, the linear combination will continue. Now, as far as the op amp being in negative feedback is concerned, we have to only look at this particular number alpha; that is, what fraction of the op amp comes back to it is input; that is what is meant by feedback. It has nothing to do with what part of V 1 appears at V A B and what part of I 2 appears at V A B and so on, it is only what part of op amps own output comes back to it is input.

So, alpha is the proportionality constant between the output of the op amp and the input of the op amp and that is our only concern, we do not need to worry about this. Now, because we do not need to worry about these and the circuit is linear; which means superposition holds, this alpha is not affected by the values of V 1 and I 2. So, for instance one way to analyze this whole thing would be, I first said V 1 and I 2 to 0, see the effect of V test, then said V test and I 2 to 0, see the effect of V 1 and finally, set V test and V 1 to 0, see the effect of I 2.

Now, I am not interested in the contributions from V 1 and I 2, so I may as well set V 1 and I 2 to 0. So, I set all independent sources except V test of course, to 0 because I am not interested in this whole function, I am only interested in this value alpha. So, what do I do in this case? I have V 1 and I set V 1 equal to 0; which means, I replace it with the short circuit, I set I 2 equal to 0; which means, I replace it with an open circuit.

So, after doing this; obviously, this V A B will be just alpha times V test, because V 1 is 0, I 2 is 0 and if I have more independent sources, I will set them also to 0. So, all I have to do is linear circuit analysis with a single source V test and usually that is quite easy. Now, all I need to do to find out if the op amp is in negative feedback or to assign the signs of the op amp is to look at the sign of alpha.

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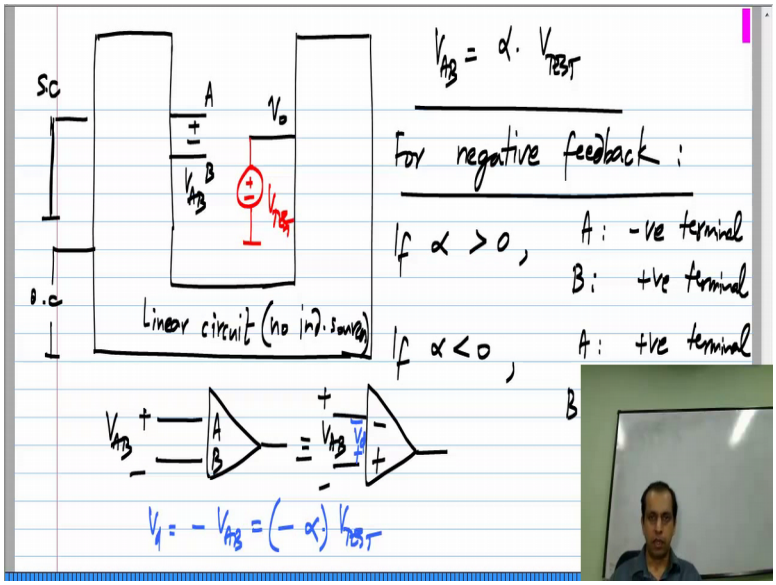

I have replaced the voltage source V 1 with the short circuit current source I 2 with an open circuit, I analyze the circuit with only V test stimulating it and I find that V A B is alpha times V test. Now, for negative feedback around the op amp what I need to do is the following, if alpha is more than 0 then I should assign A to the negative terminal and B to the positive terminal, because in that case this is how the op amp is and I say that A is the negative terminal and B is the positive terminal and this is V A B.

Now, V A B some positive number times V test, I assumed alpha is greater than 0, the way we have assign the signs of the op amp the difference input of the op amp is V d. So, V d is minus V A B which is minus alpha times V test, because alpha is positive I get some negative multiple of V test; that means, that whatever the op amps output is it will get multiplied by some negative number and will get apply it to the input of the op amp and that is the meaning of negative feedback.

So, the input voltage the input difference voltage V d of the op amp must be some negative number times the output of the op amp that is when the op amp is an negative feedback, if it is some passive number times the output of the op map it will be in positive feedback. So, I hope this is clear and it will become clearer after I do the example. Now, similarly if alpha is smaller than 0 then I have to assign A to the positive terminal and B to the negative terminal, my final goal is to have the input difference voltage V d of the op amp to be some negative multiple of the output voltage of the op

amp. Now, this voltage V test is a proxy for the output voltage of the op amp.

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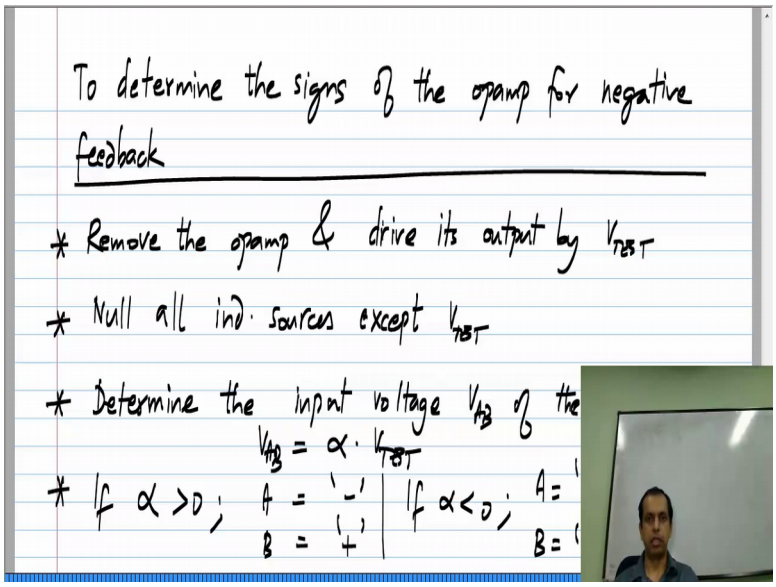

So, to summarize to determine the signs of the op amp for negative feedback these are the steps, you remove the op amp and drive it is output by an independent voltage source V test and null all independent sources other than V test, then determine the input voltage V A B of the op amp and it will be of the form V A B is alpha V test, it will just be proportional to V test, if alpha is greater than 0 then A is the negative terminal of the op amp, B is the positive terminal of the op amp, instead if alpha is smaller than 0 then A is the positive terminal of the op amp and B is the negative terminal of the op amp.

Now, you can ask what happens if alpha happens to be 0, if alpha happens to be 0; that means, that there is no feedback around the op amp at all, remember what is alpha the input voltage of the op amp is alpha times V test and V test is a proxy for the output voltage of the op amp, if alpha equal 0 it means that no part of the output of the op amp is coming back to it is input and this means that the op amp is not in feedback at all such a circuit cannot be used. So, this is how you determine the signs of the op amp for negative feedback.