Basic Electrical Circuits
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Lecture - 102

In this lesson we look at an extremely important aspect of op amp circuits; that is checking whether the op amp is really in negative feedback. Because, the crucial property of the virtual short between the input terminals of the op amp is valid, only when the op amp is in negative feedback.

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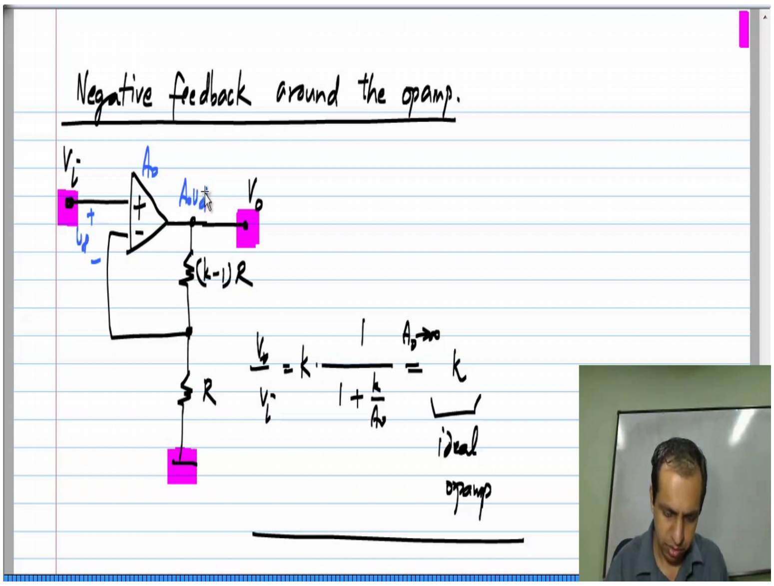

Now, let me take the circuit which we have seen earlier, this difference is term V d and the gain of the op amp is A naught, which means that the output is A naught V d. I apply V I here and I obtain V out there. By now it must be clear, that when I say I apply V I here, it means that it is between this point and ground. And similarly, when I say V out is available at this node, it really means between this point and the ground node.

The voltage is always measured between two points and only one point is specified, it means that there is some reference nodes somewhere, which forms the other point and you specify the voltage difference between some node and the reference node. We know by analysis that, if these resistors are k minus 1 R and R V naught by V I is k times 1 by 1 plus k by A naught and as A naught tends to infinity, it becomes equal to k, this is the value with an ideal op amp.

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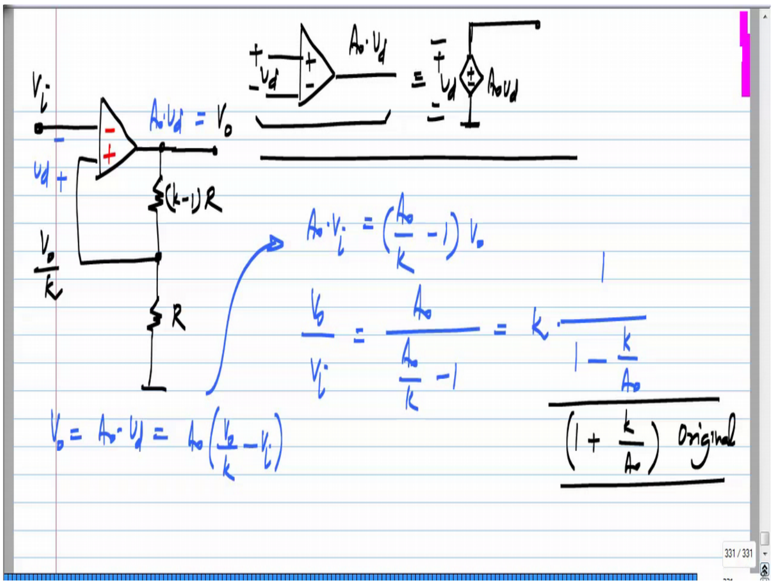

Now, let me make what may seem like a be very, very minor change to the circuit; that is, all I will do is reverse the terminals of the op amp; that is, V naught by k was earlier connected to the negative terminal now I connected to the positive terminal, V I was earlier connected to the positive terminal of the op amp. Now, V I gets connected to the negative terminal of the op amp. So, I simply flip the inputs, you can imagine that this is something that could easily happen, while wiring the circuits you interchange these two wires.

The definition of the op amp is still of course, the same; V d is defined from the positive to negative terminal of the op amp and the output will be A naught times V d, where A naught is the positive number. It is a large positive number and this will correspond to a control source which amplifies V d. Now, let me analyze this circuit which is the very, very minor modification of the previous circuit.

Now, my V d will be in this polarity, because it is defined from positive to the negative terminal of the op amp and V naught of course, will just be A naught times V d. So, what do you I have? V naught which is A naught times V d, which this time around will be this voltage minus that voltage, which is V naught by k minus V i. So, if I rearrange this I will get A naught times V i equal to A naught by k minus 1 times V naught. So, V naught by V i would be A naught by A naught by k minus 1.

Remember, earlier the only difference was we add a plus 1 there; this can also be rewritten as k 1 by 1 minus k by A naught and earlier, the denominator was 1 plus k by A naught. Now, this does not look very significantly different, because we are considering cases when k by A naught is very small, because the gain of the op amp A naught is very large. When k by A naught is very small, this expression as well as the earlier expression will be equal to k or will be approximately equal to k.

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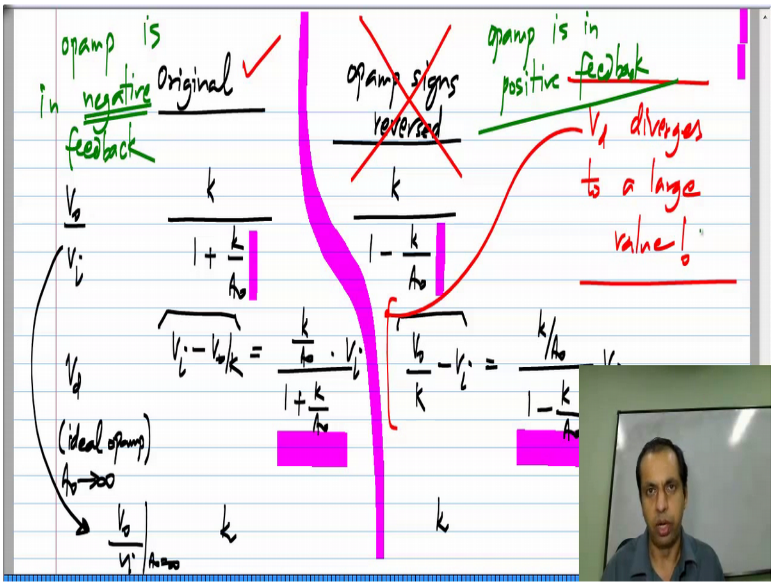

Let me put this down systematically, the expression for V naught by V I originally was k by 1 plus k by A naught and with the op amp signs reversed, it is k by 1 minus k by A naught and the difference voltage V d which is equal to V i minus V naught by k, which is basically k by A naught divided by 1 plus k by A naught times V i. This was the original case and with op amp signs reversed, the op amps input voltage V d is V naught by k minus V i, which is equal to k by A naught divided by 1 minus k by A naught times V i.

All I have done is, consider what V d is in each case, in the first case it was V i minus V naught by k, with the op amp signs reversed it was V naught by k minus V i. And in terms of V i that turns out to be either this one or that one, again it does not look like there is much difference over there. Because, this k by A naught is expected to be much smaller than 1 anywhere. And finally, this V naught by V i as A naught tends to infinity; that is as the op amp tends to being an ideal op amp, in both cases V naught by V i will be k, because this term here or this term there simply disappears, k by A naught will be 0, so V naught by V i will be k.

So, just by looking at this analysis, it looks like regardless of which where you have the op amp input signs the circuit will work in the same way. There is a very small difference here, if k by A naught is 1 by 1000, then this number will be slightly smaller than that number; that is all. Similarly, the difference voltage V d is very small in either case, because it is proportional to k by A naught and finally, as A naught tends to infinity both these tend to the ideal value of k, but this simply does not work that way.

So, the original circuit works as we intended and if you actually build the circuit with the op amp signs reversed, it will not work like this at all and in this case, this V d instead of being this V d diverges to a large value. So, you cannot use the op amp with it is signs reversed, although this algebra tells you that in both cases V d is very small and if A naught tends to infinity, V d will tend to 0, the op amp inputs will be still virtually shorted, that comes from this algebra.

In this expression, if A naught tends to infinity then this difference voltage V d will be 0, it looks like the op amp inputs are still virtually shorted, but they will not be. If you actually build it you will find that V d diverges to a very large value, if the op amp signs are reversed. I am exactly why they will diverge, we will not able to analyze here, because our model of the op amp which is just a control source is a simplified model, it does not include any of the dynamics of the op amp. If you do put in the dynamics of the op amp and analyze it, you will see that the difference voltage diverges to a very large value.

So, the crucial difference turns out to be that the way we originally derived the circuit, the op amp is in negative feedback and with the op amp sign reversed, the op amp is in positive feedback, it is only when the op amp is in negative feedback that the inputs are virtually shorted.

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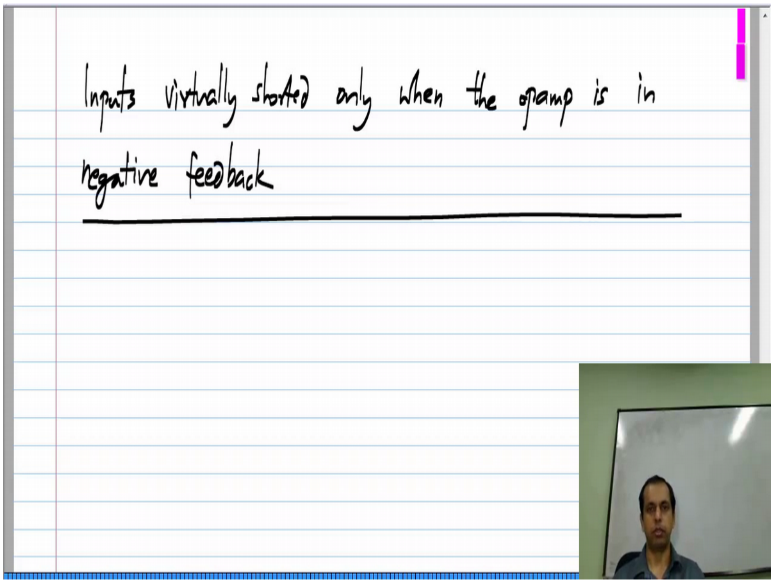

Extremely important concepts you have to be able to decide whether the op amp in a given circuit is a negative feedback or positive feedback, if it is a negative feedback the difference between it is input voltages will be very small, if the op amp gain is very large and will be 0 that is there will be virtual short between them, if the op amps gain goes to infinity. If the op amp is in positive feedback none of this is true, the difference between it is input voltage will be very large and as far as we are concerned it is a useless circuit.

There are some other circuits which make use of positive feedback in an op amp, but all the kind of circuits that we considered linear circuits like amplifiers and so on need negative feedback around all the op amps in a circuit. So, we no need to have a method of systematically checking if an op amp is in negative feedback or not. So, for now keep in mind that the input signs of the op amp are not arbitrary, even if you are told that the op amp is ideal.

Because, like I assured first of all even with the finite value of A naught, if A naught is very large it seems like a very small difference between the performance with the original signs and with the signs reversed also in both cases as A naught tends to infinity, the inputs are virtually shorted, but in reality this is not the case this appears. So, only because for inadequate modeling of the op amp, if you model all the dynamics of the op amp you will find that if the op amp is in positive feedback the difference voltage between it is input diverges to a very large value and we will simply not get all the nice circuit behavior that we had before.