Basic Electrical Circuits
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Lecture - 101

We have earlier derived the negative feedback amplifier circuit using an op amp, which has a very high gain and in this lesson, we will study this circuit in the limit of A naught tending to infinity.

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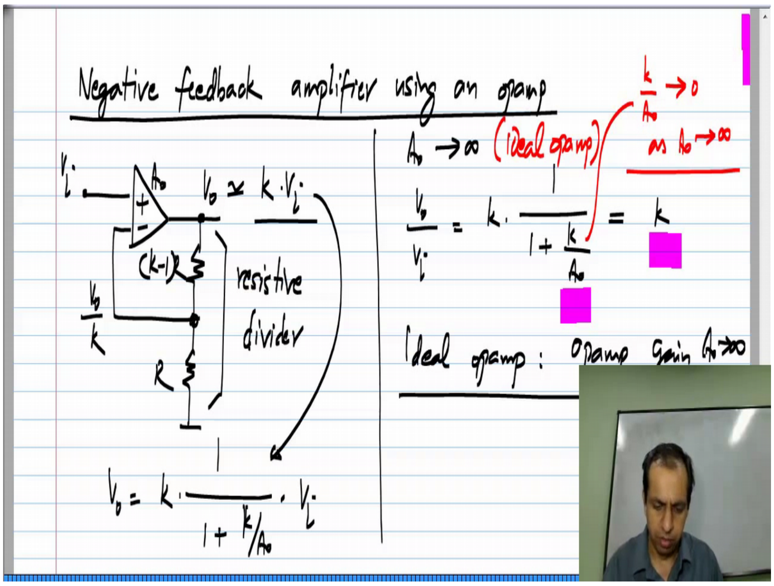

The circuit we derived was this, where we did void the output using a resistive divider with resistor k minus 1 R and R to get V naught by k and compare that to the input, that is we take the difference between V i and V naught by k, that is applied to the input of the op amp. So, the output is strongly driven by the difference between V i and V naught by k. If V naught is too small it is driven strongly positively, if V naught is too large it is driven strongly negatively.

So, finally, we saw that V naught is very close to being k times V i. So, if you add to be exact, V naught would be k 1 by 1 plus k by A naught, where A naught is often gain times V i. Now, if you take the limit of A naught tending to infinity, we see that V naught by V i, which is k 1 by 1 plus k by A naught is exactly equal to k. Because, as A naught tends to infinity, this term here goes to 0, k by A naught goes to 0 as A naught tends to infinity.

Now, if you recall to come up with the circuit, we had originally started with a goal of making an amplifier of gain k, that is we wanted V naught by V i equal to k and that is exactly what we get if A naught is infinity. So, we get exactly what we were looking for and op amp whose gain A naught is infinity is known as an ideal op amp. In other words, an ideal op amp is one where the op amp gain A naught tends to infinity. So, what happens in such a case, let us look at in some more detail.

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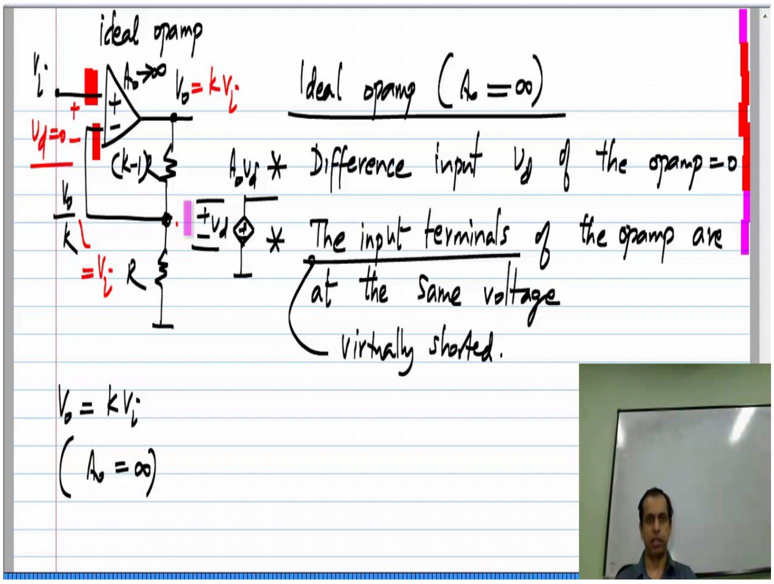

So, I will consider the case of an ideal op amp or A naught being infinite. So, what happens in this case is the following. In this case, V naught is exactly equal to k V i, this is because A naught is infinity. So, that means that, this value here V naught by k is exactly equal to V i and the difference voltage input of the op amp V d equals 0, so this is what we get if we set the gain of the op amp to infinity. So, in this case the difference input V d of the op amp is 0, another way of putting it is that the two input terminals of the op amp are at exactly the same voltage. Their difference is zero so; that means that this terminal and that terminal are at the same voltage.

Remember, this is the consequence of A naught being infinite. Now, when you have two nodes and they are shorted to each other, those two voltages will be exactly zero. So, if you have two nodes and you place a short between them, the difference between the two node voltages will be exactly zero. In this case the difference between this node voltage and that node voltage, that is the node to which the two inputs of the op amp are connected, that difference is zero.

It is not as they are connected by a wire, so there is no short circuit between them. But, because their difference is forced to be zero by a negative feedback, when A naught equals infinity, they are known as being virtually shorted. You may see this description in various forms, sometimes you say that the two inputs of the op amp are at the same voltage or that they are virtually shorted and sometimes it is also called as the virtual short at the input of the op amp and so on. They all mean the same thing.

What it means is that, the two input terminals of the op amp have the same voltage. So, that their difference is zero and this happens only when A naught equals infinity and it happens because of negative feedback. Now, because they have the same voltage, but are not actually shorted to each other, they are called as being virtually shorted to each other. Now, the op amp is a voltage control voltage source with a difference input V d and a control source, whose value is A naught times V d.

Now, if the input is zero you may think that the output is also zero, because it is proportional to the input, but remember this input difference is zero only if A naught equals to infinity. If A naught equals to infinity, this V d is 0, the output is A naught times V d which is infinity times 0. You cannot calculate what the output is by multiplying infinity and zero. So, you have to derive it based on other constrains, that I will consider while talking about analysis of circuits with ideal op amps.

But, do not make this mistake that, because the input difference voltage of the op amp is zero, it is output will be zero that is not the case. The input difference voltage of the op amp is zero, only if the op amps gain is infinite. Now, if the op amps gain is infinite, then as long as the output is finite the input will be zero, because the input is the output divided by infinity. So, do not get confused by that. When the gain of the op amp is infinity, the two inputs will be virtually shorted if they are in negative feedback. I will talk more about the op amp being in negative feedback in one of the later lessons.