Integrated Circuits, MOSFETs, OP-Amps and their Applications
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Lecture – 20
Operational Amplifier Configurations Contd.

Hi, welcome to this module. And in the last module, what we have seen, we have seen how we can use operational amplifier, how we can use operational amplifier as the inverting amplifier right, how we can use the opamp as inverting amplifier. Now, in this module, let us see how we can use opamp as non-inverting amplifier. So, Let us see how op amp can be used as a non-inverting amplifier.

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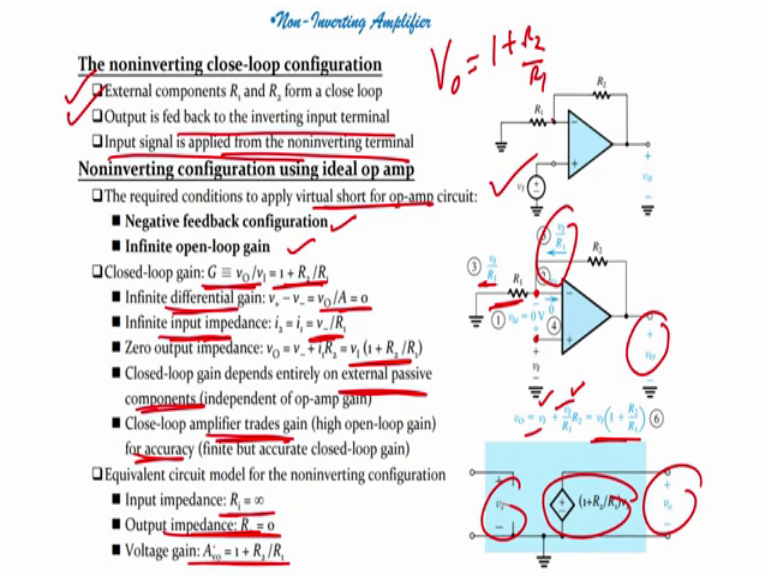

So, Let us come back on the screen and you will see the circuit. Here, what is the case, the case is that we have applied the input voltage or we applied the signal to the non-inverting terminal of the operational amplifier as you can see here right. We still have the feedback resistance R 1 and R 2, we still have feedback resistance R 1 and R 2, and here the inverting terminal is grounded, non-inverting terminal is given the signal. So, if I see the non-inverting close loop configuration, first is external components R 1 and R 2 forms a closed loop right, first point is that external components R 1 and R 2 forms the closed loop, the similar to the inverting amplifier. Second is output is feedback to the inverting input, output here is feedback to the inverting input correct.

Third, input signal is applied from the non-inverting terminal, input signal is applied from the non-inverting terminal right. All three things you understand very easy right super easy to understand. One is R 1 and R 2 forms a closed loop; second the inverting input is grounded and output is fed to the inverting input; third is the input signal is given to the non-inverting opamp.

Now, non-inverting op amp using ideal configurations, if it is ideal, then we have equal conditions to apply for virtual shot for op amp circuit is negative feedback and infinite open loop. Now, closed loop gain G is nothing but v o by v i is 1 plus R 2 by R 1 that is we already know it is a very basic. So, let us see R 1 is here which is grounded, R 2 is here. And then because of the virtual ground concept we have difference voltage zero. Whatever voltage is at this non-inverting terminal, same voltage, we will have at the inverting terminal because of the concept of virtual ground.

Now, if I see that then what will I find that is current here is nothing but v by R 1 here will be v by R 1, v that equals to zero volts. Or what we can further find it, when v o is nothing but v o will be v 1 plus v 1 by R 1 into R 2 right, v 1 by R 1 into R 2. This is nothing but if I have v 1 common then v 1 common 1 plus R 2 by R 1. So, my v o is nothing but 1 plus R 2 by R 1 all right. This is my output voltage, which is 1 plus R 2 by R 1 all right. So, this is what is closed loop gain inverse infinite differential gain we have seen it is nothing but it should be zero infinite input impedance is v minus divided by R 1 right, because R 1 is the input.

Zero output impedance will be output voltage. Closed loop gain independent are in the external passive components that is we have seen what does it mean by external passive components. Then we have seen closed loop amplifier trade is gain we have also seen this exactly similar concept in the inverting in the inverting amplifier. So, it equivalent circuit model if I want to draw, input impedance is infinite right, the gain is 1 plus R 2 by R 1 into v output voltage we have written here, output impedance is 0, gain is nothing but 1 plus R 2 by R, gain is nothing but 1 plus R 2 by R 1. So, you have to remember that the most of the things are similar to the inverting amplifier except that now since the input is applied to the non-inverting terminal my output signal would be in phase to the input signal.

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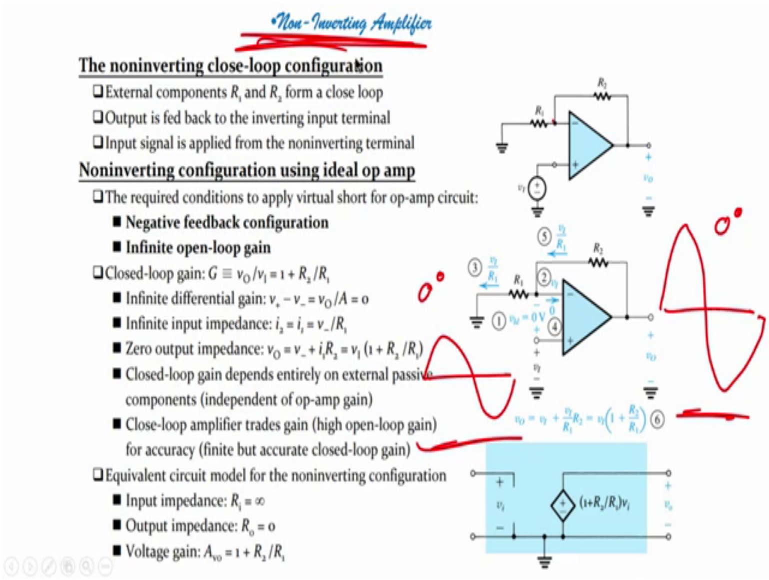

That means, if I apply a input signal at this particular terminal right my output will be amplified, but in phase right. So, this is zero degree, this is also zero degree. This is output, is in phase when you compare with the input signal all right that side is non-inverting, it is a non-inverting amplifier.

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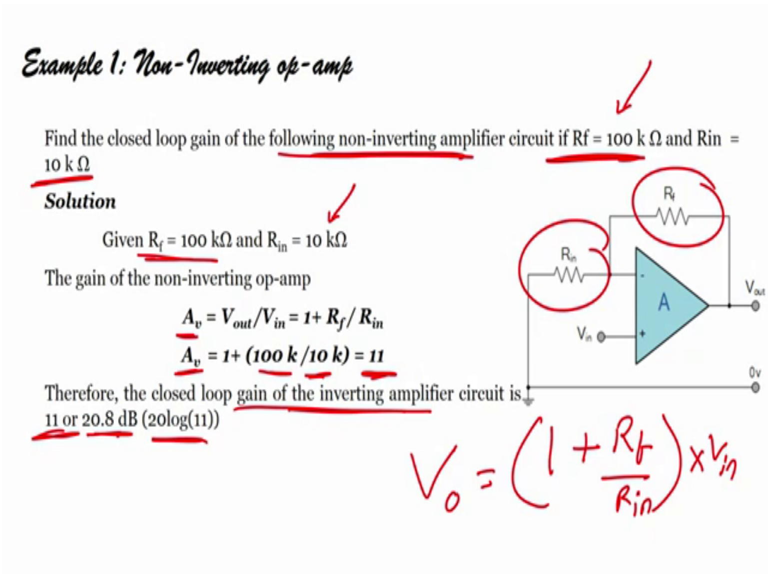

So, let us take an example of non-inverting opamp all right. So, find the closed loop gain of following non-inverting amplifier circuit if R f equals to 100 kilo ohms, R in equals to 10 kilo ohm. We have R f value; we have R in value right. Now, what is the formula for non-inverting amplifier is 1 plus R f by R in this is gain right. And if I have V o and V o will be nothing but 1 plus R f by R in into V in right this is my formula for non-inverting amplifier correct.

So, given R f equals to 100 kilo ohm which is given here R 1 is 10 kilo ohm, A v or V gain right is 1 plus R f by R in. So, if you put the value of R f and R in, I have A v equals to 1 plus 100 by 10, so 100 by 10 is what 10. So, 1 plus 10 is nothing but 11 plus 10 is nothing but 11. Therefore, the closed loop gain of the inverting amplifier circuit is 11 or 20.8 dB this you can get by substituting the value of by converting the value of gain into decibels by using 20 log of gain or 20 log of 11 which is equal to 20.8 decibel, easy super easy right. Because you have to just substitute the value of the resistors in the given equation.

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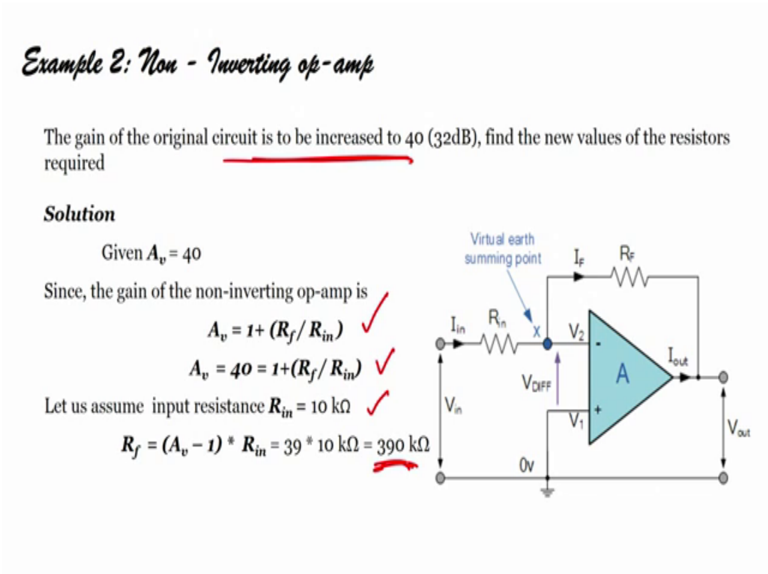

So, let us find another, let us solve another problem. So, this problem is that the gain of the original circuit is increased to be 40, you see similar example similar example right. Find the values of resistors required. So, given A v equals to 40 we know that a v the gain is nothing but 1 plus R f by R in or 40 equals to 1 plus R f by R in, R in is 10 kilo ohm, so R f can be 390 kilo ohm right R f can be 390 kilo ohm. So, this is super easy to understand, this is super easy to understand and that is why let us move to the next problem.

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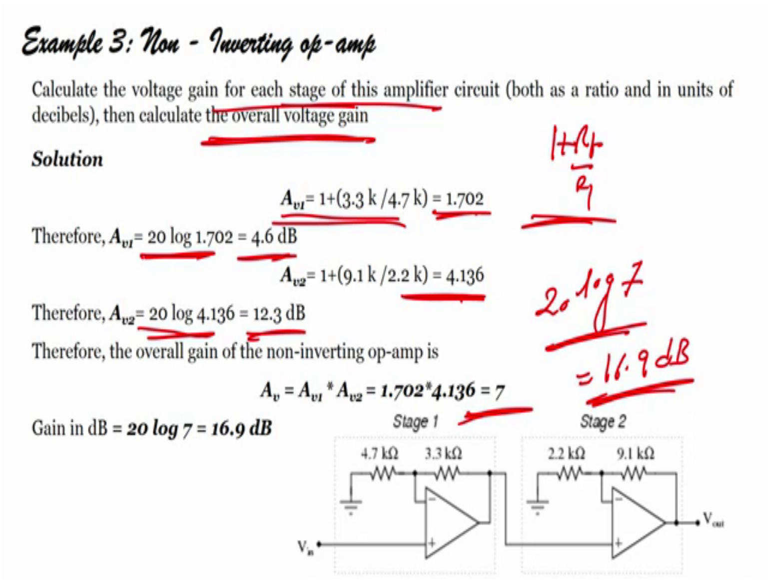

The next problem is calculate the voltage gain for each stage of this amplifier circuit both has ratio and in units of decibel, then calculate the overall voltage gain. So, you have given amplifier like this. You see there are two stages here; there are two stages here. We are applying the input at the non-inverting terminal, and the output is again applied to the another amplifier at the non-inverting input right. The output of the first amplifier is fed to the input of the non-inverting terminal of the second opamp right. Here what we are asked we are asked to find the value of A v, we have to find asked to find the value of overall voltage gain, and also the voltage gain for each stage.

So, you see a circuit may look complex, but the solution is very easy. Now, you see just stage one. Stage one is what, non-inverting amplifier, non-inverting amplifier what is the formula is 1 plus R f by R 1 right. So, what is R f - 3.3, R 1 - 4.7, so A v equals to 1 plus 3 by 3 divided by 4.7 is nothing but 1.702. Let us consider stage two. Stage two what is the formula, 1 plus R f by R 1, A v equals to 1 plus 9.1 divided by 2.2 equals to 4.136 because 9.1 divided by 2.2 will give us 3.136, 3.136 plus 1 will be 4.136. So, we now know A v 2 as well right.

So, if I convert my A v 1 into decibels it is 20 log 1.702 or it will be 4.6 decibels. If I convert my A v 2 into decibels, I will have 20 log 4.136 or 12.3 decibel correct. Therefore, the overall gain of the non-inverting amplifier is overall gain is A v 1 into A v 2 is 1.720 into 4.136 equal to 7. Now, again I want to convert my gain in decibels then I have to use 20 log 7 that will give me value of 16.9 decibels, that will give me value of 16.9 decibels right. This is how we can find the solution for the non-inverting amplifier given a problem to you.

So, in the next module, what we will see in the next module we will see how we can solve the differential amplifier right. What we have seen earlier inverting, then we have seen summing, then we have seen non-inverting amplifier right. Now, let us see in the next module what exactly a differential amplifier means. Till then you just look at this module understand how the non- inverting amplifier works, or how you can design the opamp as a non-inverting amplifier circuit, how you can design opamp as a inverting amplifier circuit, how you can design opamp as a summing amplifier all right.

Till then you take care, I will see you in the next class, bye.