Electronic System for Cancer Diagnosis
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Lecture - 28

Basic Building Blocks of Electronics System: Amplifiers

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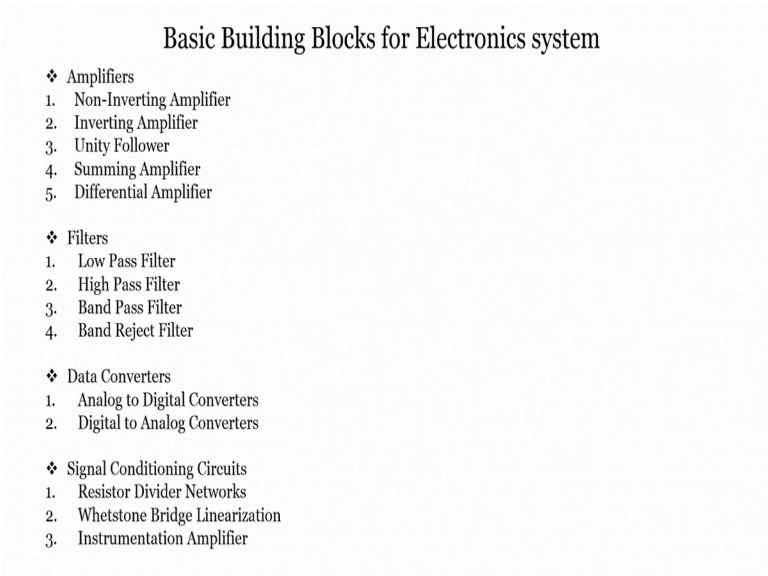

Hi, welcome to this lecture. In this lecture, we will be talking about how can we design several electronic modules that can be used in single conditioning systems and there can be interfaced with sensors and transducers of our interest, so as to get the electronic side of the system a realization of the electronic side of the system. So, to start with we will look at several you know components or you can say several circuits and their respective videos and I will discuss with you, so that you can understand in detail what are those circuits.

So, if you see the slide we will be looking at the basic building blocks that finally, we will be integrating together to form a entire single conditioning unit, right. To start with we will go and understand how we can use the op amps as a amplifiers and we will talk about several kind of amplifiers starting from non-inverting, inverting, unity amplifier, summing amplifier, differential amplifier. Why exactly you use this? Because you have to integrate your sensor to this kind of amplifiers to amplify your signal.

Then we look at the filter. Several now filters, low pass, high pass, band pass, band reject. Again, the use of filters is to filter out the all necessary components, that is your noise from the signal. Then we will go for data convertors, and we look at how the ADCs and DACs work. This is to convert your analog data to digital domain. So, they can interface with the micro (Refer Time: 01:53) and display. Finally, you have signal conditioning circuits which is resistor divider network whetstone bridge network and instrumentation amplifier.

This circuits can be used at the at the starting of the you know stages as a first block of the stage where you can interface your sensor directly on the whetstone bridge or you can use a potential divider network which is a resistor divider network or you can and then final followed by that instrumentation amplifier circuit.

So, let us see the videos of each of those in detail and in fact, then not really videos that I will show you the things in detail one by one in the following slides and then we will continue in understanding how we can bring all things in together to form a entire electronic module, all right. So, till then let us see the first block which is your amplifiers.

Now, in this module let us see how we can use; how we can use op amp as non-inverting amplifier ok. So, let us see how op amp can be used as a non-inverting amplifier. So, let us come back on the screen and you will see the circuit.

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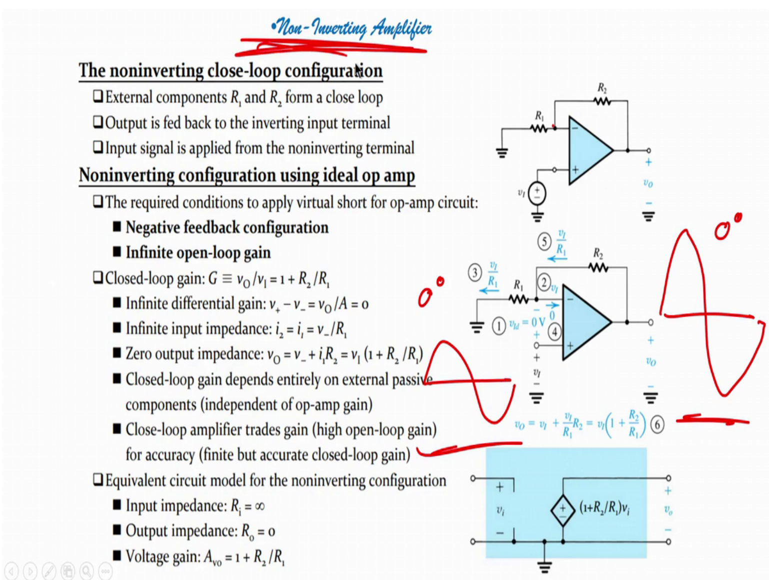

Here, what is the case? The case is that we have applied the input voltage or we applied the signal to the non-inverting terminal of the operation amplifier, as you can see here, right. We still have the feedback resistance R 1 and R 2, we still have feedback resistance R 1 and R 2 and here the inverting the terminal is grounded non-inverting terminal is given the signal ok.

So, if I see the non-inverting closed 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 close loop, this similar to the inverting amplifier. Second is output is fed back 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 3 things we have listed very easy, right, simple, easy to understand. One is R 1 and R 2 forms a close 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 op amp.

Now, non-inverting op amp using ideal configuration, if it is a ideal then we have require conditions applied for virtual short 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 this we already know its a very basic. So, let us see R 1 is here which is grounded, right, R 2 is here and then because of the virtual ground concept we have difference voltage 0, whatever voltage is at this non-inverting terminal same voltage will have a deep inverting terminal because with the concept of virtual ground.

Now, if I see that then what will I find that is current here even in that v by R 1 here will be v by R 1, v r equals to 0 volt or what we can further find it that v o is nothing but v o will be; 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 very common then v 1 common 1 plus R 2 by R 1, right 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 one is closed loop gain, inverse infinite differential gain we have seen it is nothing, but it should be 0. Infinite input impedance is v 1 minus R v 1 v minus divided by R 1 and because R 1 is the input; 0 output impedance will be the output voltage. Closed loop gain depends entirely on external passive components that is we have seen, what does it mean by external passive components, then we have seen closed loop amplifier trades gain. We have also seen this exactly similar concept in the inverting in the inverting amplifier.

So, equivalent circuit model if I want to draw the input impedance using finite, right output will be 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 3, gain is nothing but 1 plus R 2 by R 1. So, you have to remember; 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; my output signal would be in phase in phase to the input signal.

That means, if I apply a input signal at this particular terminal, right my output; my output will be readily amplified, but in phase, right. So, this is 0 degree, this is also 0 degree. It 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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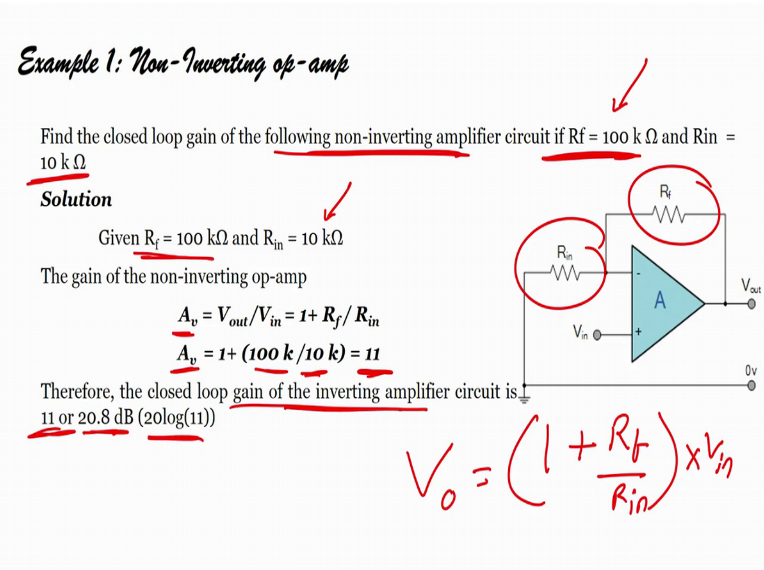

So, let us take an example; let us take an example of non-inverting op amp, all right. So, find a closed loop gain of following non-inverting amplifier circuit if R f equals to 100 kilo ohm R in equals 10 kilo, ohm we have R f value, we have R in value, right. Then what is the formula? Formula for non-inverting 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 v 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 this is given here R 1 is 10 kilo Av or v gain, right is 1 plus R f by R in. So, if I value put the value of R f and R in, I have Av equals to 1 plus 100 by 10. So, 100 by 10 is what? 10. So, 1 plus 10 is nothing but 11, 1 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 value of a by converting the value of gain into decibels by using 20 log of gain; 20 log of gain, a 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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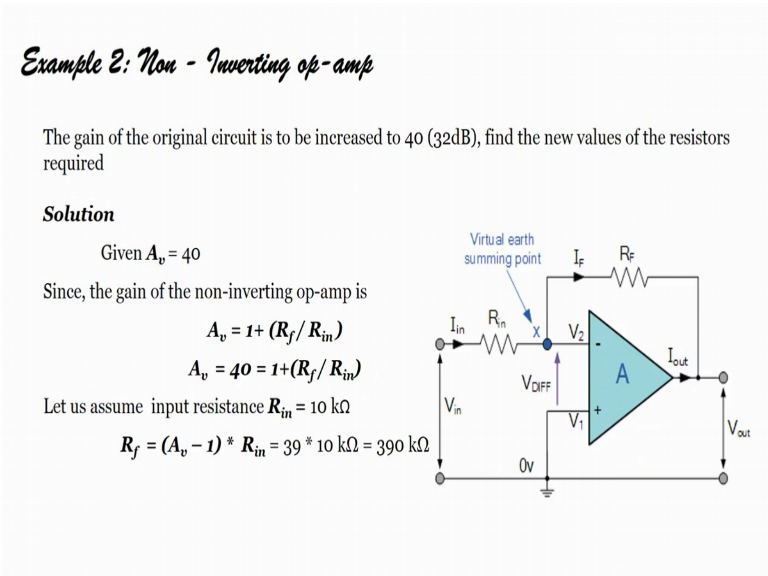

So, let us find another let us follow in that problem ok. So, this problem is; this problem is that the gain of the original circuit is increased to be 40. You see similar example; similar example, right. Find the values of resistors; find the values of resistors ah required. So, given A v equals to 40, we know that Av 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. 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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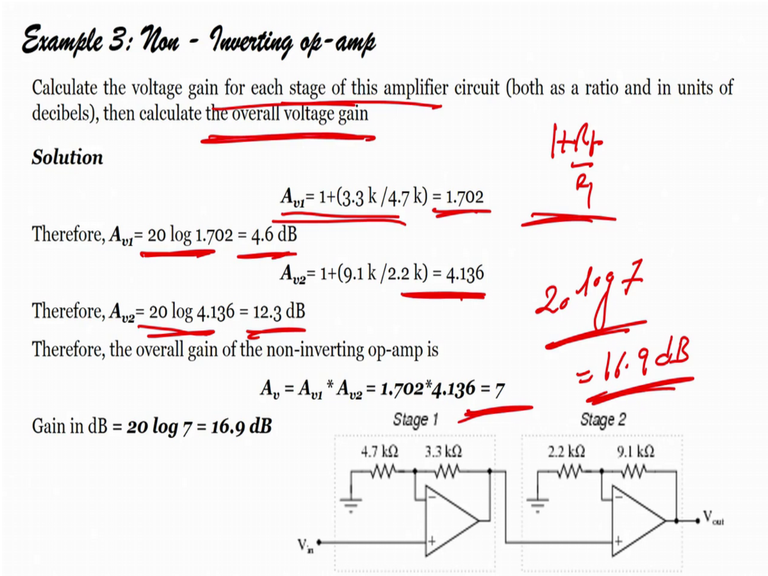

Next problem is, calculate the voltage gain of for each stage of this amplifier circuit both as ratio and in units of decibels, then calculate the overall voltage gain. So, you have given amplifier like this. You see, there are two stages here; there are two stages here when applying the input at the 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 op amp, right.

Here what we are asked? We are asked to find the value of Av, we have to find asked to find the value of overall voltage gain and also the voltage gain for each stage; voltage gain for each stage ok. So, you see a circuit may look complex, but the solution is very easy. Now, you see jus stage 1; stage 1 is what? Non-inverting amplifier. Non-inverting amplifier what is the formula? Formula is 1 plus R f by R 1. 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 this is nothing but 1.702.

Let us consider stage 2; stage 2, what is 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 decibles 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, right. Then, for the overall gain of the non-inverting amplifier is, overall gain is A v 1 into A v 2 is 1.702 into 4.136 equal to 7; equal to 7.

Now, again I can want to convert my gain in decibels then I have to use 20 log 7, 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; given a problem to you, all right.

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