Integrated Circuits, MOSFETs, OP-Amps and their Applications
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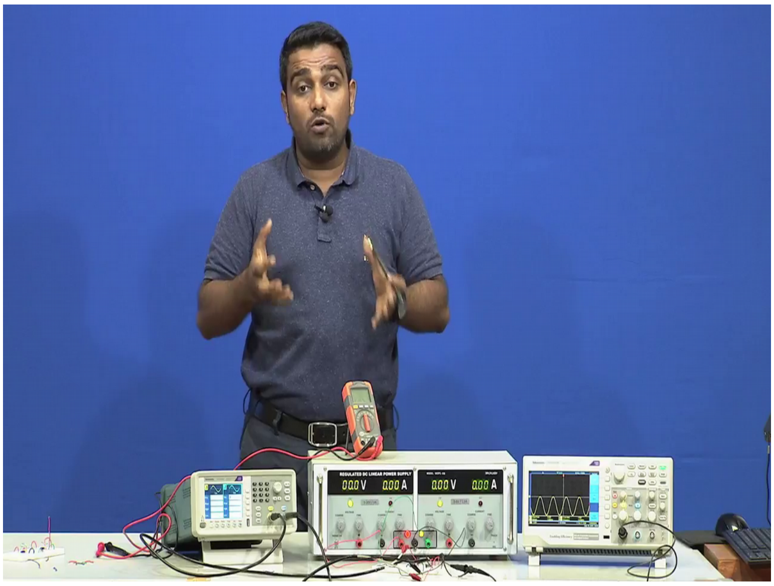
Lecture- 49
Experiment: Summing amplifier using op-amp



Welcome back. So, this particular module like I said in the last module if you have seen the inverting, non inverting amplifier, and then voltage follower input output voltage ranges this particular model is focused on important function of an operational amplifier and that is summing. So, like I said operational right there several operations can be performed by this operational amplifier that is your op-amp right.

You can use this op-amp to do addition, you can use this op-amp to do subtraction, you can use this op-amp to integrate. So, integrator you can use this op-amp to differentiate differentiator; that means, it can perform mathematical functions right and that is why it is operational amplifier. So, we have seen this again in the theory, but let us quickly recall what exactly summing amplifier is and how we can perform an experiment using a summing amplifier right.

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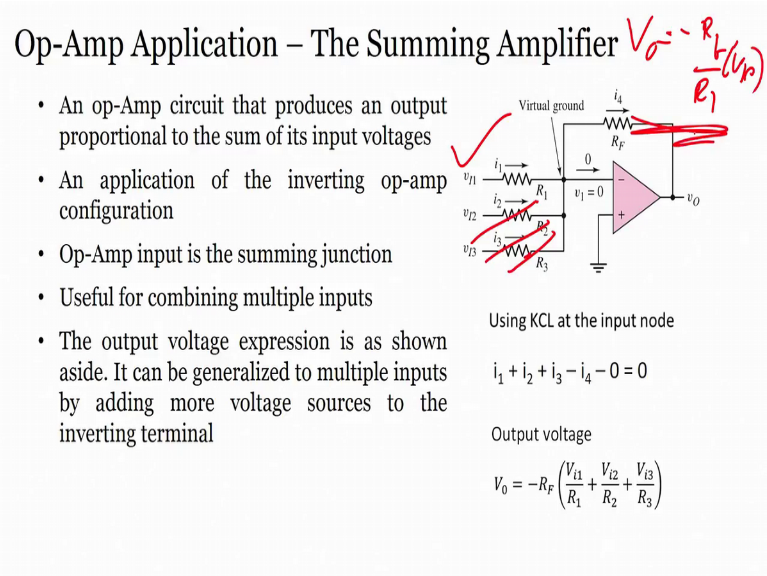

So, let us go on the screen let us see what is the summing amplifier. So, if you see this particular circuit right the circuit it is if I remove this thing which I remove only one if I just keep one signal which is here and if I remove this thing what will be it will be an inverting amplifier right inverting amplifier is.

So, I do not consider this thing right if I do not consider this then what will I have input and I have feedback resistor R in R F. So, we are would be V 0 will be minus R F upon R 1 in to v in this is the formula for your inverting amplifier correct

Now, if I give inputs like this right and if I use Kirchhoff's current law right all of you should learn; What is Kirchhoff's voltage law? What is Kirchhoff's current law? So, easy when I use this terminology Kirchhoff current law all right I have told you the same thing in theory class also that you do learn to Kirchhoff current law, Kirchhoff voltage law.

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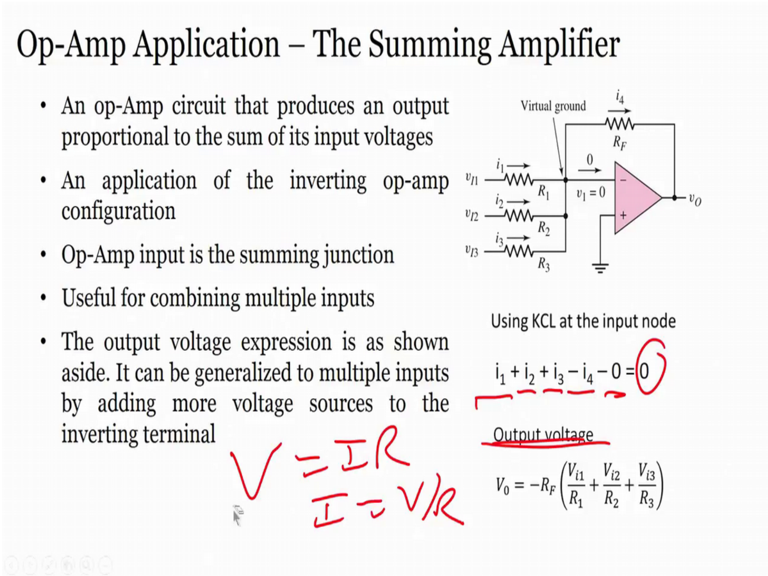

So, you if we I apply this Kirchhoff current law or KCL what we will get will get i 1 plus i 2 plus i 3; here minus i 4 minus 0 equals to 0 correct if you see this i 1 plus i 2 plus i 3 minus i 4 minus 0 equals to 0.

So, output voltage right i is what i equals to so we know right V equals to I R. So, what will be I, I equals to V by R right we all know ohms law right our favorite; so it will be very few people who will say I do not know ohms law. So, using the ohms law what we have instead of i 1 we can write V 1 by R 1.

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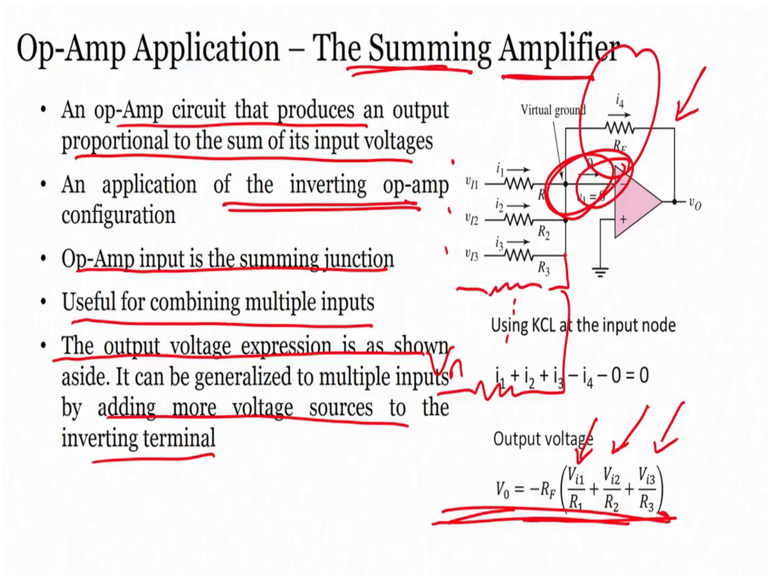

So, you see the first term V 1 by R 1 i 2 V 2 by i 2 i 3 V 3 by R 3 right. The output voltage if I convert like this we will have V 0 equals to minus R F V 1 by R 1; R V 1 V 2 by R 2 V 3 by R 3, and the addition of this. This we have already seen in the summer amplifier or summing amplifier right or it is also called summer and short form it is called summer.

So, an operational amplifier circuit which is shown here right it produces an output proportional to the sum of input voltages an application of inverting amplifier right inverting we have already seen, op op-amp input is the summing junction right this is the input terminal right summing junction useful for combining multiple inputs.

We can see there are 1, 2, 3, 3 different inputs we can combine the multiple inputs and we can use it. The output voltage expression is as shown aside which is here this is the output voltage expression right and it can be generalized to multiple inputs by adding more voltage sources to the inverting terminal. If I keep on adding this I can keep on adding until particular voltage which is called v n right n times then you can add n number of input signals to this summer.

These are all of a summing amplifier in short the summing amplifier is used to sum this signal some of the input voltages and it also depends on the feedback resistor you see that is the feedback resistor; that means, it is not just summer it summing your input voltage, but it is also amplifying it right that is why we do not only say it is a summing it we also call it summing amplifier alright. So, this is the use of the operational amplifier as an summer.

So, let us see in an experiment how we can use this summer and how you can see the changes how we can understand when we apply input signal; how the output signal would be obtained using the oscilloscope.

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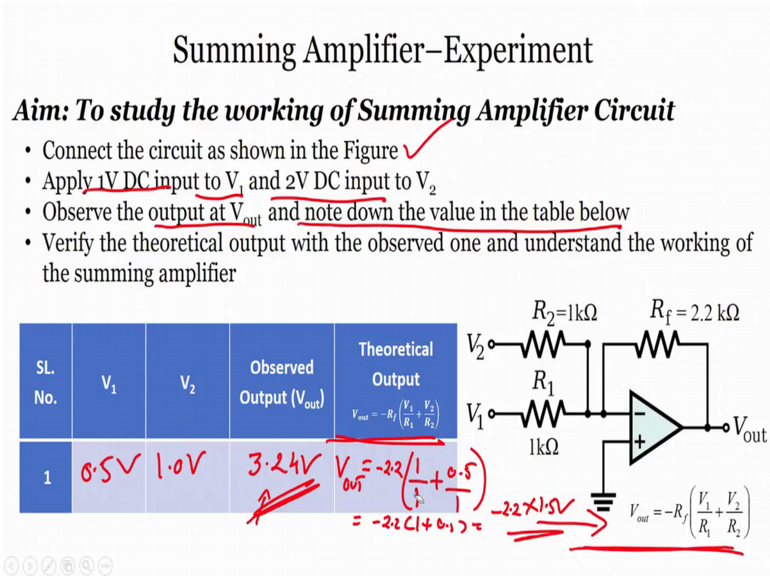

So, for performing this summing amplifier or performing the summing operation right we have taken here an example of 2 voltages right there we have seen in the in the last slide 3 voltages here we are take an example of 2 voltages.

Now, we have gain you see gain both volt both resistance are same 1 kilo ohm, 1 kilo ohm gain will be about 2.2 kilo ohms right because it is R F by R 1 around 2.2 kilo ohms. Now, you have voltage here v out equals 2 formula is very easy minus R F right and here is i 1, i 2; i 1 is V 1 by R 1 i 2 is V 2 by R 2. So, v R equals to minus R F in the bracket V 1 plus R 1 plus V 2 by R 2 this is so simple right.

So, what we have to do if you want to perform summing amplification we have to first connect the circuit as shown in figure right second is we apply 1 volt DC to V 2 volts V DC to V 2 means we have to signal will apply 1 volts or 2 volts or 0.5 volts and 1 volt does not matter right whatever signals we are applying corresponding to that we have to edit and we have to amplify it de depending on the amplification factor that is how the summing amplifier would work.

So, observe the output and note down the value in the table is here we have value V 1, voltage V 1, voltage V 2, output voltage formula is here which is your theoretical output. So, we calculate theoretical output theoretical output formula is same which is given here write V out equals to minus R F into V 1 by R 1 plus V 2 by R 2. We will see what is the actual output and that that will be the end of the understanding this summing amplifier. So, let us see how summing amplifier we can perform this particular operation.

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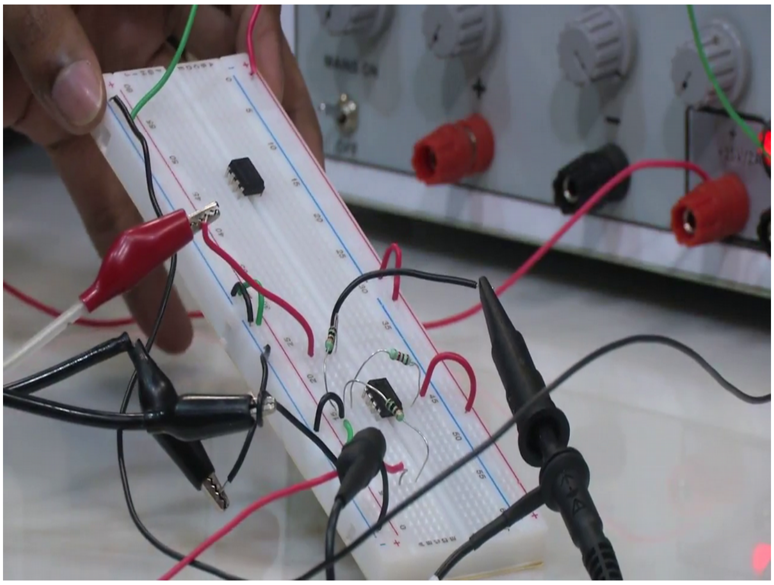

If you see the circuit again which is the breadboard here on the table and again someone is with us to help us so this is a breadboard right and we have this summing amplifier already connected somewhere here. So, if you can see here right this is the summing amplifier; this is summing amplifier which is connected here alright.

Now, if I am yes this is better even so what do we have seen we can see there are 3 register 1, 2 and 3 right 1, 2, 3, 3 registers are there and 1 register is a feedback register; 2 register at the input registers and we are applying this signal to the individual input. So, let us let us use the let us give a signal 1 by 1.

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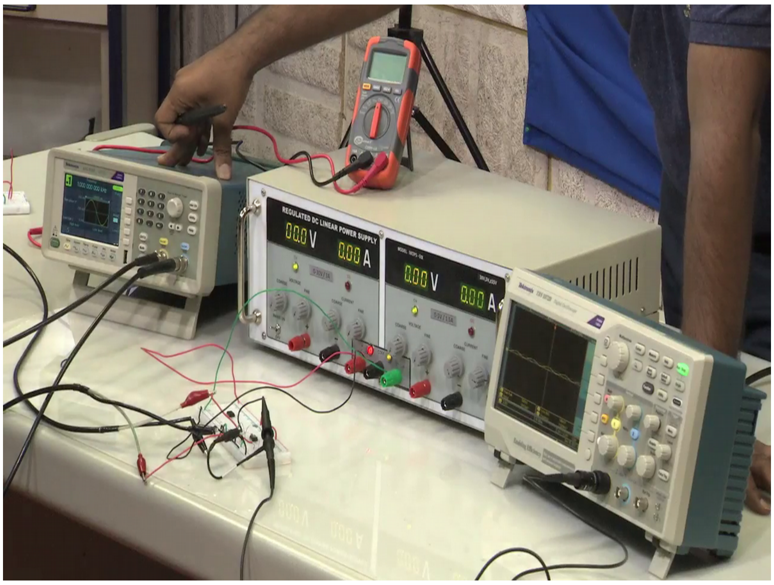

We can see here the first signal the frequency generator.

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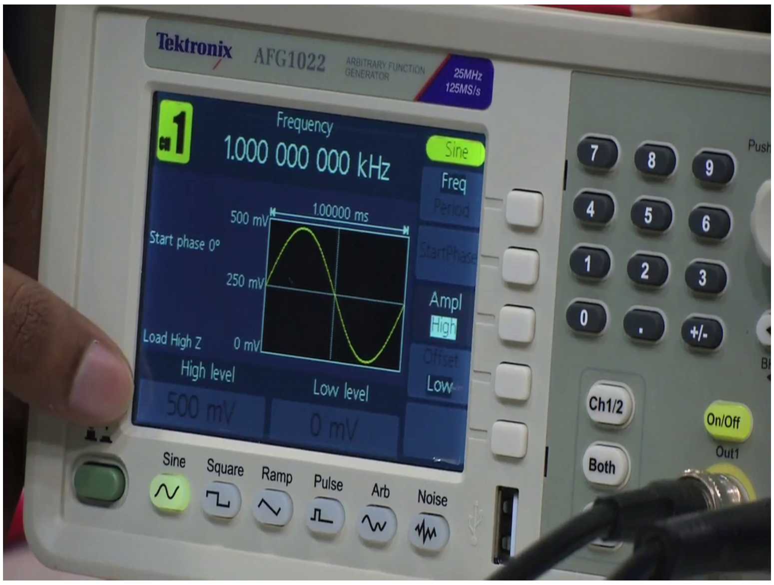

We can see the signal that is given is how much voltage about 0.5 volts; 0.5 volts is first signal to the summing amplifier alright.

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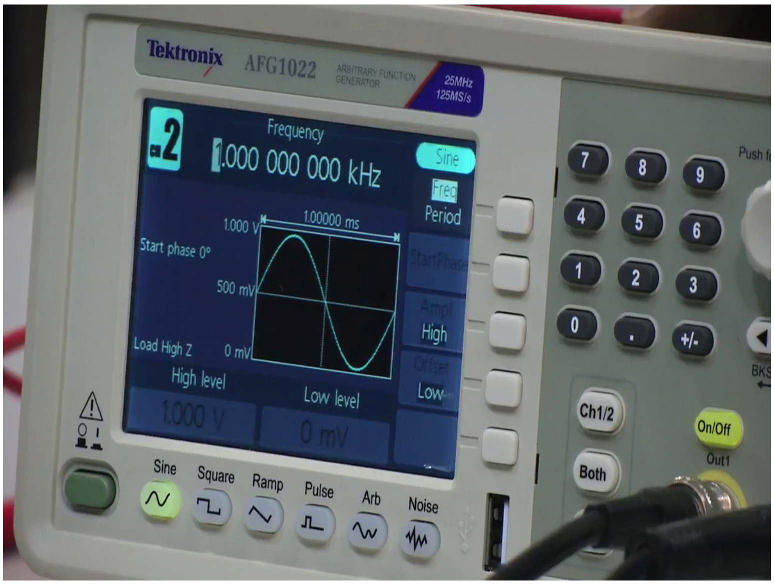

What is the second signal that we are giving second signal we are giving is 1 volt right. So, and then what is a gain, gain is about 2.2 volts gain is about 2.2 volts.

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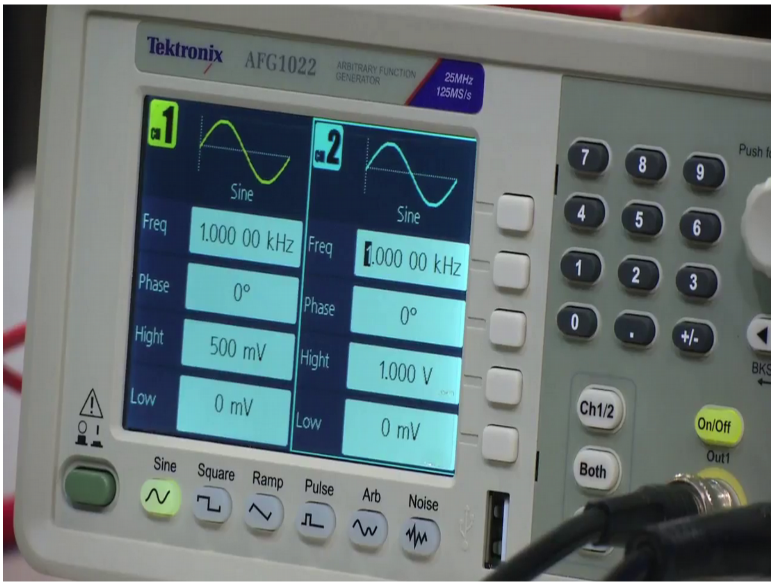

Now, we are applying 1 volts we are applying 0.5 volts, frequency is constant 1 kilohertz, phase is 0 degree, right then we what will be the output will be 1 volts right plus 0.5 volts right into the gain so whatever the gain is; so, if you see the output, output will be the sum of this plus amplification. So, let us see the output in the oscilloscope.

So, if we connect the oscilloscope to the output of the summing amplifier let us see what is output?

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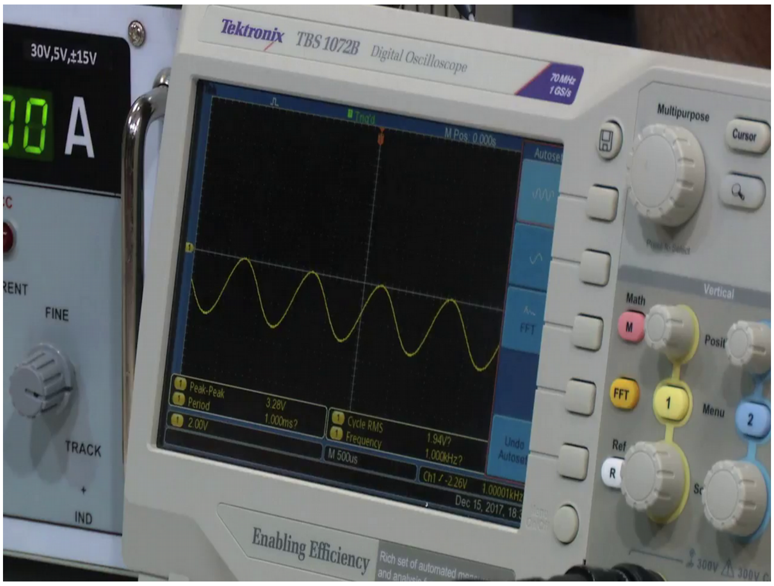

So, here if you see in the oscilloscope you will be able to see the output, output is about 3.28 volts right. You can see yellow color peak to peak voltage can please so here so it is easy 3.28 volts peak to peak right so that is because we I have added 1 volts plus 0.5 volts plus into the gain, gain is about 2.2.

So, yeah so that is fine now we can also see if you want to see the input and corresponding output so the sum of the inputs and corresponding output that is also possible. So, if you see just what is the input voltage right. So, we will be able to see the input voltage what is the input voltage we can we can cal we can we can measure the input voltage using the oscilloscope.

Again when you focus oscilloscope you will be able to see input voltage is about 0.5 volts that is from 1; 1 channel and what is the input voltage to another from the another channel that is through the function generator, another channel the input voltage is about 1 volts.

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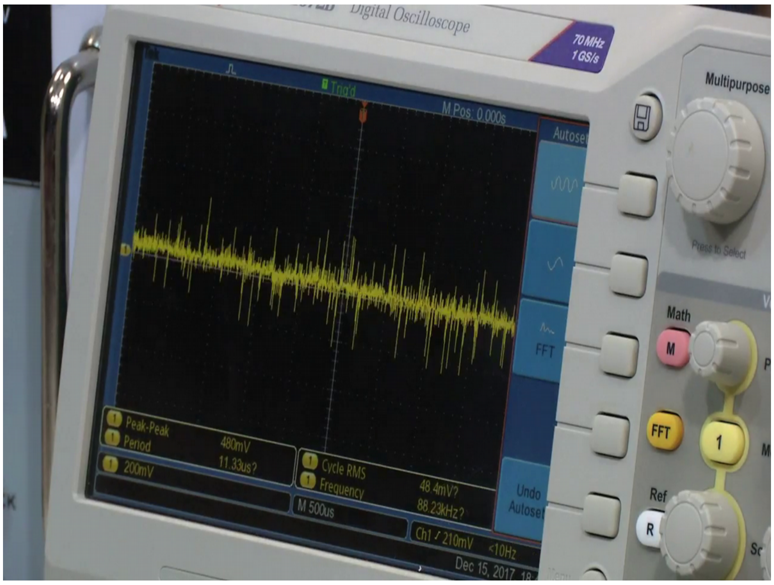

So, we will see input of about 1 volts. So, we have given 2 input voltages V 1 and V 2 to the summing amplifier 1 volt and 0.5 volt and the output we were able to see about 3.28 volts about 3.28 volts which you can see again here around 2 point 3.28 volts and if you again focus you will see the same value 3.24, 3.28 volts; that means, that what is what is my calculation.

Let us come on the screen my input voltage V 1 was 0.5, V 2 was 1 volt, v output was 3.24 volts. Here theoretical evaluation alright theory V out equals to R F 2.2 2.2 into V 1. What is V 1 1 volt by R 1 1 plus V 2 0.5 by R 2 1 volts right. So, this will be what if I calculate this will be 2.2 into 1 plus 0.5 or 1.5 or minus 2.2 into 1.5 volts this is correct.

So, this will be close to you are the 3. 24 volts right this will be close to your 3.24 volts you calculate this minus 2.2 into 1.5 volts and this is how you can calculate theoretically. So, this is theoretical way of measuring the output of this summing amplifier, this is the actual way or practical way of measuring the output of the summing amplifier.

Now, you guys now you know how to use a summing amplifier; that means, how to use operational amplifier as a summer right it is so simple whatever input signals you are giving it will edit it will sum it right V 1, V 2, V 1 plus V 2 ,V 1, V 2, V 3, V 1 plus V 2 plus V 3 right but it is amplifier also; that means, it will amplify with the set gain that you have set; that means, that if your gain is about 2 volts or about 2 sorry it should not never be volts gain is about 2 then 2 into your sum of the input signal very easy right.

This is how you can operate or you can use an operational amplifier as a summing circuit the same way in the following modules we will be looking at different application of the op-amp like I said we will see how the integrator is, we will see how the differentiator is, we will see how separator is if you can sum it you can also separate it is not it.

So, I hope that in this particular module you are able to understand how you can use operational amplifier if you have the minimum number of equipment in your lab right. So, you just require a DC source you require a multi meter and it is very easy it is a cheap multimeter it is not so costly as well as many as you say again this is all relative terms for one person it may be extremely costly for second person it can be super cheap.

So, we can never say cheaper costly, but the point is that most of the laboratories would have the multimeter, most of the laboratories would have the function generator, most of the laboratories would have DC power supply, most of laboratories would have oscilloscope right.

So, it is it is easy if you cannot see the signal let the output in the oscilloscope you can measure the output using multimeter right. You are you are understanding does not really depend on you should have a oscilloscope if you do not have it do not worry you have a multimeter right.

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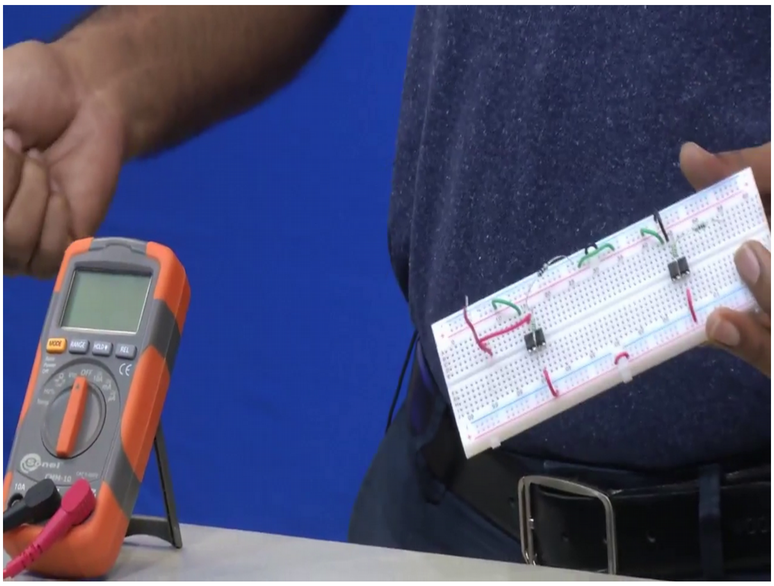

So, with a minimum number of equipment that we have in front of us with a breadboard that we have right with a breadboard that we have correct then with a IC and few passive components which are registers right with IC and few components which are resistors and with some connectors you can always test different operational amplifier circuits right.

So, this is the idea that is why I am pressing more on the experiments even it looks very simple when you really work on it you will find a few of the things that you never expected that it will happen right. One thing that you have seen in earlier modules that we gave square wave and we were expecting a sin wave.

So, you cannot get that when you apply sin wave you will get sin it again you can convert the signal using ampler again op-amp so that is a another part and I will cover it that if you apply sin wave can you obtain a triangle wave, or can you obtain a square wave or if they apply square wave can you change it to some other waves wave form. So, you can do that you can do that that is not a problem, but the point is right.

Now, we were not working on the conversion we were working on the input signal and the output signal input signal and output signal waveform would be same only there will be change in the phase shifts. So, one there was phase shift change of 0 degree, in non inverting one it was phase shift of 180 degree inverting, we have seen input voltage ranges and now we have seen the summing amplifier we also see in the voltage follower or buffer or unity gain amplifier right.

So, this is a this a end for this particular module and I hope that I see you in the next class where I will be teaching more on the another application of the operational amplifier and how to operate it all right you have a nice day and I will see you in the next class bye.