Op-Amp Practical Applications: Design, Simulation and Implementation
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Lecture - 12
Op-amp Circuits using Diodes: Clamper

Welcome to this particular module and as we discussed in the last module that in this module, we will focus on the application of the Operation Amplifier and that is your clamper, right. So, what is the use of clamper and how you can use the clamper and you may also know that clamper is also called the restorer. It also called the restorer or as a DC inserter. So, clampers are also called restorers, clampers are also called DC restorers or inserters and let us see it what is the quickly receiver is the theory of the clamper and then, we move to the actual experiments, so that we can we can see how the signal changes when we apply some signal at the input, what is the change in the output, alright.

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So, if you come in the screen and look at the screen, what is clamper as I said is also known as DC inserter or restorer or restorer. Now, these are used to add a desired DC level, desired DC level to the output voltage. These are used to at the desired DC level to the output voltage, right. So, if the clamped DC level is positive, if the clamped DC level is positive, it is called a positive clamper and the clamped DC level is negative, it is

called a negative clamper, right. So, first is that it will add a desired DC level to the output voltage. Whatever the output voltage is there, you want to add DC level to it. It can add it and it will give us the new output voltage with the desired level added to the output voltage which desired level DC voltage.

So, that is why it is also called DC inserter. That is why it is called DC inserter, right. Now, if the DC level is positive, it is called positive clamper and the clamp DC level is negative, negative clamper third Next one is a clamper with a variable positive DC voltage applied at the non-inverting terminal is shown in figure 5. So, if you see here, here this figure, right the clamper with variable DC voltage here you can generate you see this connected to plus V cc.

So, you can generate a DC voltage and you can vary it with the help of this potentiometer, with the help of this potentiometer and that voltage you are applying to the non-inverting terminal of the operation amplifier of the operation amplifier. Now, the circuit clamps the peaks of the input, it will climb the peak of the input and hence, it is also called the peak clamper. It will peaks the peaks the or clamps the peaks of the input, right. It will clamp the peak of the input and that is why it is also called peak clamper. What hap, how it will operate? How it will work?

So, let us see, right let us see now we have we have if the V reference is greater than 0, the output V o A is positive. Output voltage V o A across the terminal is positive. So, what we are looking at if the V reference voltage which is the reference voltage across this potentiometer is greater than 0, the voltage across here across here right is positive and so, diode d is forward bias. So, we can write here V reference we write here V, o A we write here V o A, right. So, if the diode d is in forwards bias, why because if this is more than the inverting, is more than the inverting, then you have a higher voltage across the anode and lower voltage across the cathode.

So, the diode will become forward bias. Diode will become forward bias, the circuit operates as a voltage follower, the circuits will operate as a voltage follower because now we are connecting with as to this one and therefore, the output voltage V o is nothing, but your V reference. So, when is forward bias the output voltage V o is nothing, but your reference voltage V reference, right.

Now, when a sine wave input voltage with amplitude a, with amplitude a is applied, so here you see. So, what is very important to understand that we are applying some DC voltage, DC voltage at the non-inverting terminal, but we are applying some sine voltage at the inverting terminal. Sine voltage is applied to the terminal; the diode d conducts during negative half cycle, right. So, diode d will conduct only during negative half cycle. Positive half cycle, this will be higher. So, negative half cycle, it will conduct and positive half cycle will not. There is a capacitor C charges to the diode do the negative peak voltage, correct. So, the capacitor will charge to the diode to the negative peak because is the only negative half cycle.

So, capacitor cannot charge to the positive half cycle. It could only be charged in the negative half cycle and this we charge through the d diode. That is why because diode is conducting, right. So, there is a minimum thing that I am expecting from you guys that you know how a capacitor functions, how the diode functions, alright. So, I am assuming that when you know and apply the peak signal, if the positive is conduct is not allowed, negative is allowed, right. That means, in negative half cycle if diode conducts, then only the capacitor can charge, right otherwise you cannot charge.

So, these are prerequisites that you need to understand. So, I hope that now at least now you all know what is capacitor, you all know what is diode because to understand complex circuit such as this or at least a little bit complex circuits, you need to understand the basic components in the role of and the application of basic components to the working of the basic components.

So, in this case like we have seen capacitor charges through diode during the negative voltage when the input is positive half cycle, the diode stops conducting as it is in reverse bias, right because if it is in positive half cycle, diode will not conduct because this will be higher, this will be less compared to this and that is why the diode will not conduct or it is in the reverse bias condition and holds the previous voltage, which was the earlier voltage. There is nothing, but here V reference plus V a, however where V reference is negative, a negative peak clamping can be observed.

So, if a V reference voltage if you make it negative, then a negative clamping can also be same. The resistor r is used to protecting the op-amp against excessive discharge currents from capacitor. Now, you see whenever we use LED, we use a current limiting of the

register, right that if we use capacitor, we have to use the register between a capacitor and the inverting terminal, where you have avoid any discharging, sudden discharge of the capacitor voltage and it will destroy your op-amp, it will destroy your op amp. So, as you protect the op-amp against excessive discharge currents from capacitor. When DC supply is switched off, right we have to use the resistor; we have to use the resistor.

So, like I said if the V reference voltage is positive, it can be worked as of positive clamping circuits. You can see here if I want to design this clamper if I want to design this clamper, right using this operation amplifier, using the operation amplifier, using the simulation and see how the circuit will operate, then we have to again use the multisi. We have to again use a multisim.

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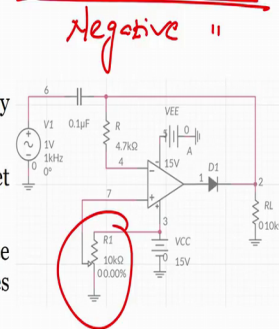

Now, before we use the multisim, let us first understand, what is the experiment. The experiment is the experiment is that how we can understand or study the working of an operation amplifier based positive, clamper based positive clamper.

So, if I see I can make a positive clamper, but I can also make a negative clamper, I can also make a negative clamper. So, we will see how the positive clamper works, we will also see how a negative clamper works, we also see how a negative clamper works. So, we will not only see positive, it will also see negative. Since we have seen in the last slide how the clamper positive negative works, let us now also do the simulation in which both this circuit will work, positive clamping and negative clamping, right.

So, to understand the positive and negative clamping, to understand the positive and negative clamping, first thing that we have to do is to connect the circuit as shown in figure.
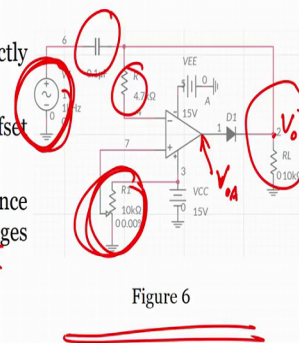
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Figure 6

This is the same figure that we use previously. There is a capacitor, there is the resister that will protect the op-amp from the sudden discharge of capacitor or search as the capacitor here. We will apply the same input signal here, we have reference voltage here is our V o V o A and here is our output voltage V o, right and then, we have seen how the op, how these circuit will operate. So, we had to apply one volt to peak, one volt peak to peak at this particular input and at V1 and then, we observe the output voltage V o at this particular point and note down the offset voltage, ok.

Now, we will adjust the potentiometer, will adjust this particular potentiometer and we will change the reference voltage is and see how the output waveforms would change. Finally, we can comment and the signal is what we always do at the end. We comment on the signal. So, to design the circuit design, the circuit using multisim again we will ask our friend Seetharam who will show us how to perform the experiment using multisim.

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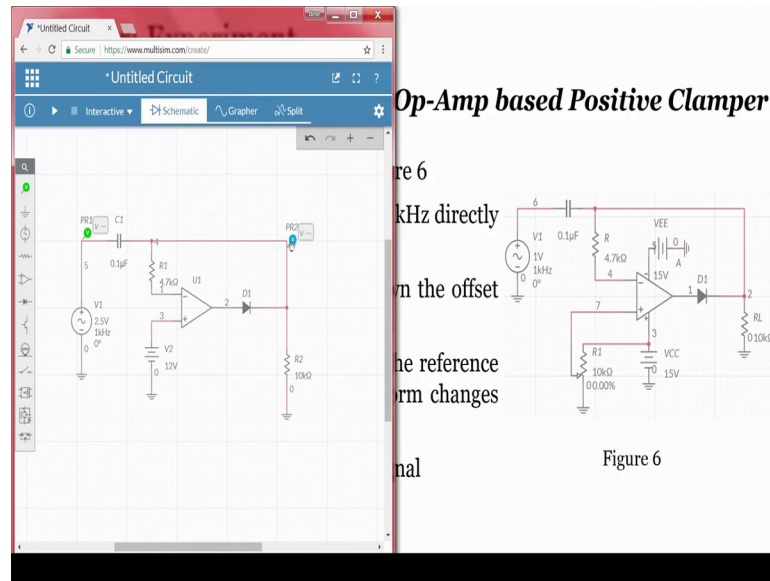
Now, we will see the working of a clamper circuit using multisim. So, what I will be doing is that this particular positive clamper I will be designing using multisim. So, let me open multisim. Now, let me keep aside. So, now I will take all the components one by one. So, I will take an op-amp first. So, this is an op-amp that that will be using. Let me flip, right. So, what I will be doing is that I will take capacitor point 1 micro farad and resistor of 4.7 kilo. So, this is the resistor. So, I am using it. So, I am changing to 4.7 kilo.

So, one terminal will be connected to the negative, right and the capacitor I will be taking and the value of this is 0.1 micro farad, right and since it is also clamper, so we have to take a diode even in this case that since we are constructing a positive clamper, the anode of diode has to be connected to the output of the operation amplifier, right. So, I will take a load resistance to just looking to the input signal with the very high resistance value, so that this will not load your circuit connecting in this way and the other terminal, I will be connecting in to the ground.

Let me make full connections. So, we have to connect input, sig input voltage to the capacitor C1. So, what I will be doing is the, I will be taking a peak to peak value of 5 volts. So, that is why the peak value I will be selecting it as 2.5 volts and other terminal of power supply has connected to the ground. I will take it to the ground and I will connect it now. Now, if you clearly see that, we in this case we have to provide a

reference signal to the non-inverting terminal, right and we should always have a negative feedback. So, what I will be doing is that this I will be connecting it to this terminal and to this to this ha.

So, if you look in to the circuit carefully, we are providing the reference voltage using a potentiometer. So, the positive terminal is connected to the potentiometer and by using the wiper were giving as an input to the non-waiting terminal. So, rather than using the potentiometer even in this case what we will be doing is that I will take DC voltage, I will be connecting the input DC voltage to the non-inverting terminal.

So, as a result it is nothing, but some particular reference we are providing. So, it will act as a reference to the circuit. In order to analyze this particular circuit, what I will be doing is I will take a probes one at the input side and I will take another sorry let me connect it another probe at the output side. So, the input represents green whereas, the sky blue represents are output voltage.

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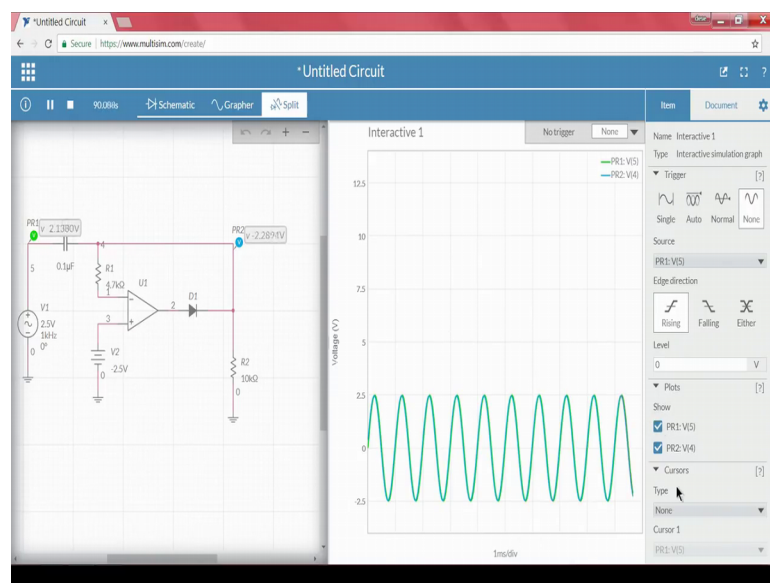
To understand to understand the circuit, let me run the circuit in the multisim.

Now, if you see the circuit, let me change V 2 to 2.5, right. Now, if you clearly observe in this case, the green represents are input, right. So, let me enable one by one and disable one by one. So, if you see PR1 is nothing, but in this case the input and PR2 is nothing, but the output. So, I am disabling PR2, so that we can see only PR1. Now, that this green

represents your input, the peak value that we are applying is 2.5 volts, a peak value of 2.5 volts. So, peak to peak is 5 volts, right.

So, it looks similar to that of what we have applied? Now, what about the negative? I will disable the input and when you see the output signal, this is also showing the same peak to peak because when you see the reference, the reference is minus 2.5. That means, I do not need any lift, right. So, if you recall what professor has discussed in this particular lecture, right which all portion that you want to clamp whichever you know whichever voltage to be clamped that particular voltage has to be provided to the input.

So, it depends upon whether you are applying a positive input or negative input that particular input signal will be clamped to that particular value, right. Since in this case we are provided input as minus 2.5, so since the signal the negative peak is also starting from minus 2.5. So, it is not clamping it.

Now, if I slowly increase, so I will start with zero. So, since it is 0, right so the complete signal is you know starting from 0. So, that means it is shifted by 2.5 times shifted to 0. So, let me change it to 1 volt. So, here we can see, so the starting point is 1 volt. Now, if I make it as what I will do is that, I will start from minus 2.5, right. So, I will also enable input to here and this is my input the maximum minimum I will make it as 8 and 8, right.

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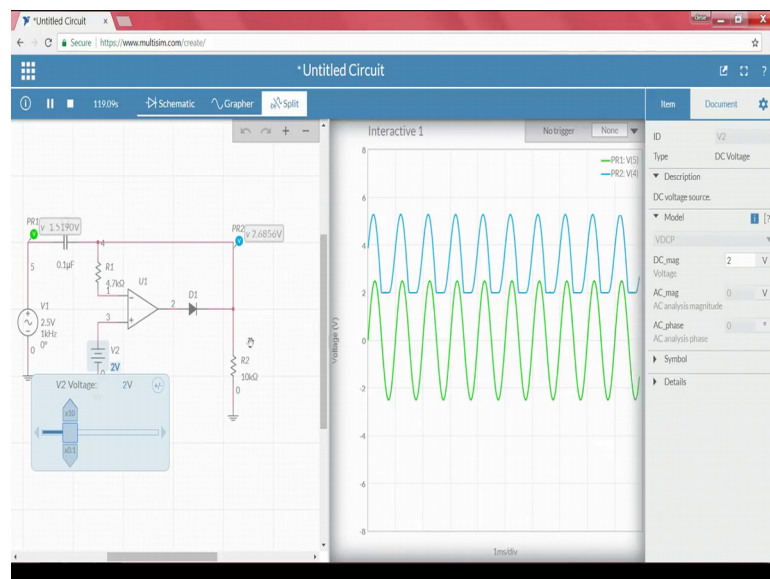
Now, let me make it as minus 1.5, right. Now, it has shifted let me make it as minus 1, right. Here we can see minus 1 let me make it as 0. So, the reference value is 0. So, it is completely shifting from here to top. So, it is starting from 0. So, that means we can see that depends upon what is the reference value, that we are applying the input whatever we have connected is slowly moving towards the positive side. So, that is why this is called positive clamper right. So, if I make it one two right. So, here we can clearly understand the working of you know use of a diode as well as the working of the circuit using multisim you will also understand the working of the negative clipper the.

So, in case of a negative clipper what we have to do is that the diode has to be reversed. So, let me construct the circuit using multisim.
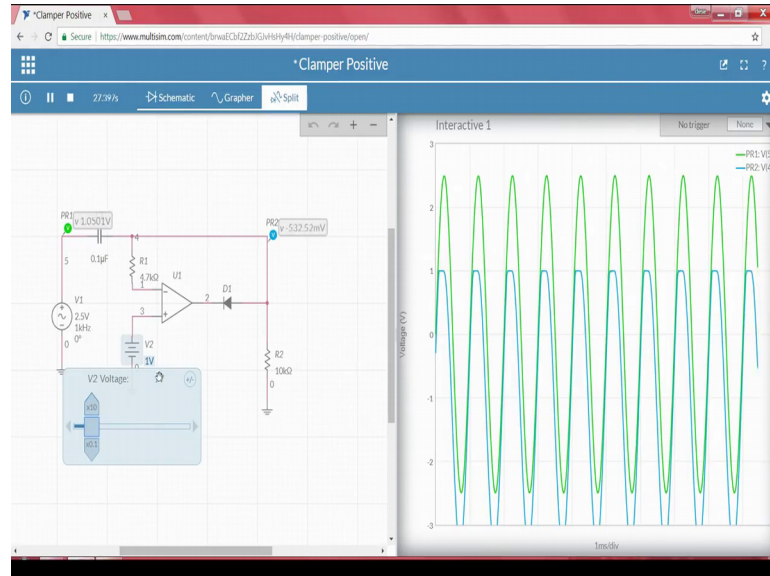
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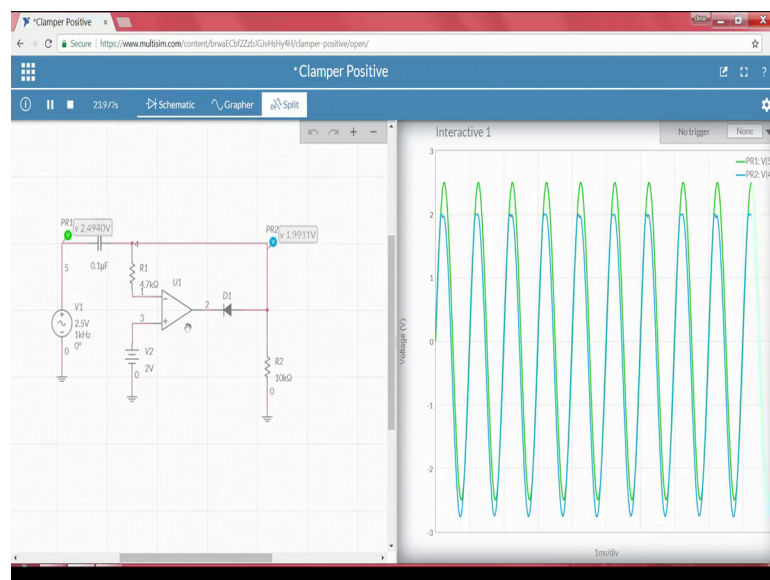
So, what I will be doing is in case of our positive clamper the diode has to be reversed. That means, the anode has to be connected to the output whereas, the cathode has to be connected to the output of the operation amplifier. Now, if I recall if I see the circuit, if I run the circuit, now we can see that depends upon what is the input voltage that we are applying. The complete signal has been shifted to the negative side, right. So, let me change to 3, ok. Let me change from 2.5, right. Since it is starting from the peak is of 2.5, we cannot see any shift. So, above greater 2.5, we can see any shift in the output towards the negative side, right.
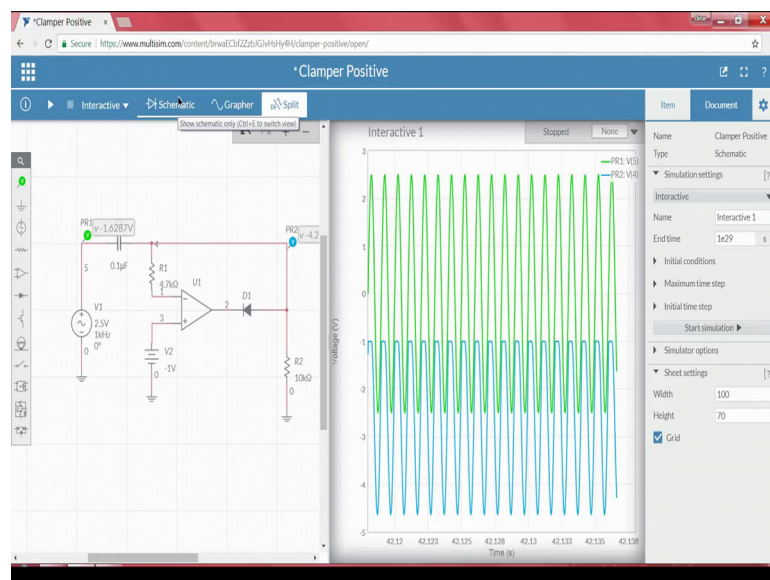
So, let me change it to 2. So, we can see that the input signal is started from 2 and going to starting from 2. So, it means that it has op-amp at 2.

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Now, change it to 1 volt. We can see slowly shifting of the input signal towards the negative side. That is why this is called negative clamper. Let me change to 0.

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It starts from 0. For case of understanding what I will do that I will take the voltage rule and I will make it as a negative. So, it will shift from negative, right. So, simply by

changing the diode, we can understand the working of both the positive as well as the negative clamper.

So, what matters here is what is the reference that we have providing is an input to the non-converting terminal as well as what type of how exactly the diode is been connected to, connected to the operational amplifier that complete results whether you are, you are using a negative clamper or a positive clamper.

So, now we have seen the simulation in, we will compare the same simulation designs with our experiment. So, in order to understand how exactly this clamper circuit works, positive clamper circuit, right so you will construct the same circuit using TI board.

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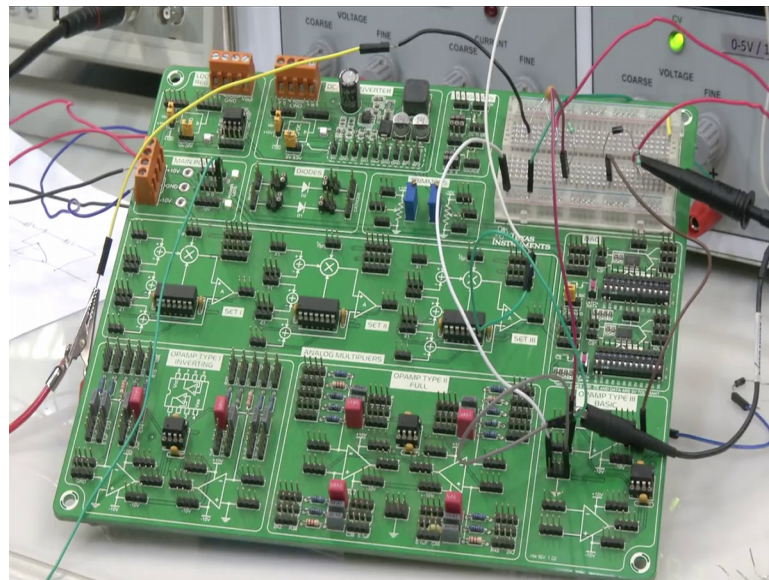
So, in this case the circuit whatever we have seen the positive clamper has been connected using this particular part, this is an op-amp that we are using. Only in this case we are using single op-amp. So, one side op-amp TL 0 to and this is the diode we have seen and the capacitor and the resistance, right. So, if you recall we of connected to the positive terminal using voltage source, right. So, here this point to the non- inverting terminal, so this is we have connected the input whereas, in this case what we are doing is rather than using a potentiometer by using this particular channel, right to 5 volts channel. We have connected a input to non-inverting terminal of your operational amplifier.

So, as a result we have connected in such a way that negative terminal of the second channel, the negative terminal of the input voltage is connected to the input of non-inverting terminal whereas, the positive terminal of this channel is connected to the ground.

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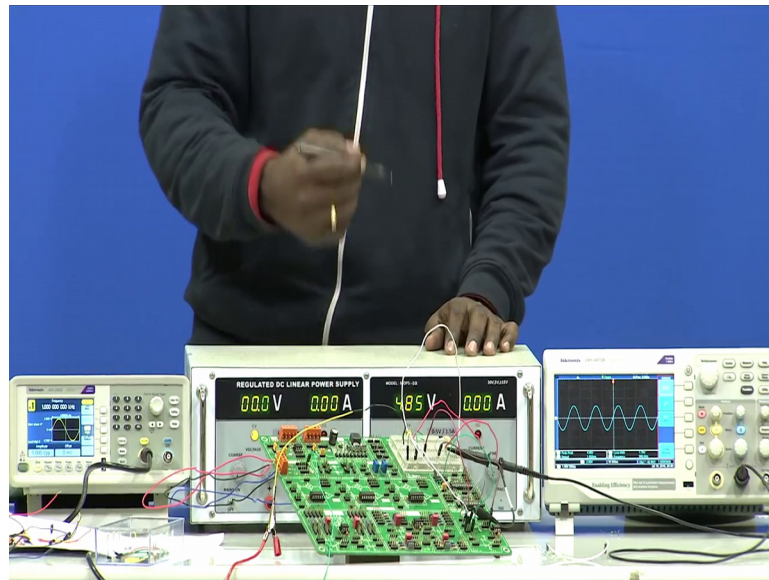
So, that means that when it shows, it shows the input as 4.25, actually the input that the reference input that we have connected is minus 4.85. Now, when you look into the function generator, here we can see that the input we are applied is of 5 volts peak to peak. So, that means the negative peak of peak is of minus 2.5, the positive peak is also plus 2.5. Now, what I will be doing is that. So, this is acting as a reference to s, right and we can see using the cro; when I slowly decrease the value from 2.5 volts to 0, we can see the shift of the shift of the signal from 2.5 to 0, right. Now, if I see the peak, the each value is of 2 volts, each block is of 2 volts.

Now, what I will be doing is since it is 4.85 and the peak the negative peak is of 2.5, we cannot see any shift. So, that means it is not clamping because the reference value is higher. So, I will slowly decrease. So, it shows a positive which is nothing, but a negative that we are applying it. So, I am slowly decreasing. So, till 2.5 we cannot, we will not see any shift of your output signal. So, when we come close to that of 2.5, I will use a fine knob, right. So, this is 2.5, right. I have applied 2.5.

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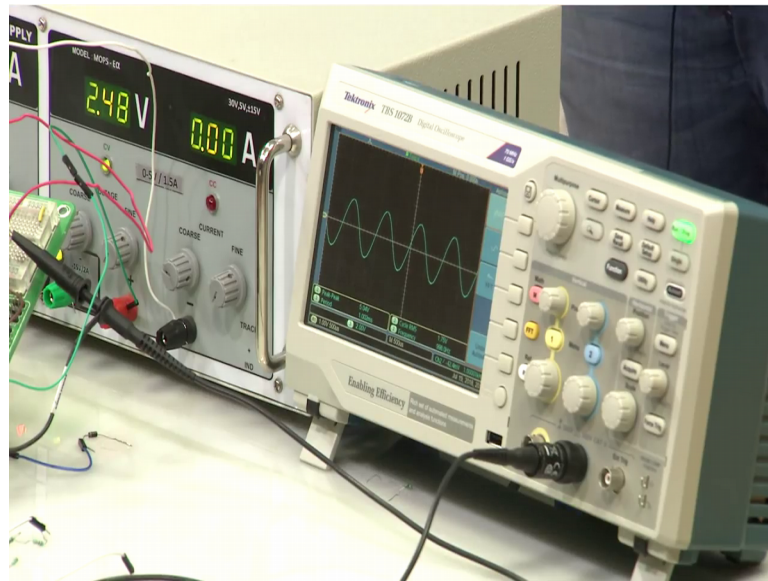
Now, I will slowly decrease in the signal. In the cro, if we see that when I slowly decrease right, the value started you know clamping towards the positive side, right. By looking into this particular point, we can clearly see that it is started plan the positive. The positive is of two higher and compared to the negative. Now, let me decrease it. So, you will understand if I decrease I mean if I increase the value actually speaking you are decreasing it, right. Here you can see it was moving towards the upside, right.

So, if I would have connected to the negative side, so if I connect the positive terminal of a of this particular channel input of a non-inverting terminal of an operation amplifier, you would have seen the clamping of the signal towards the positive side, right. Now, we will show you the working of the negative clamper. So, in case of understanding about the working of a negative clamper, what we have to do is that, you have to simply reverse the connections of the diode.

So, this is the diode. So, what I will be doing is that, I will be simply reversing the connections. So, let me switch off the circuit and this value this value I am reversing the diode and connecting the output probes. So, since we are discussing about the negative clamper, I will also change the reference value, the positive to the positive input and negative to ground. So, this is the positive input.

This will be connecting it to the non-inverting terminal, non inverting terminal of operational amplifier whereas, the white one is ground I will be connecting to the

ground, ok. Let me switch on supply, right. So, if I see that by input peak to peak in this case is of 5 volts right, so that means the peak value of 2.5. So, since the input voltage is greater than 2.5 volts, we cannot see any shifting of your, that means clamping; clamping of your input signal towards the negative signal.

Now, if I slowly decrease, if I slowly decrease the value from 2.5, if you observe that it will start shifting towards a negative side, right here we can see this shifting of shifting towards a negative side. So, the point is what I was discussing is that you can perform the positive clamping, you can perform the negative clamping. The only thing is when you perform the positive and negative clamping circuit, you need to understand what reference voltage is you are given and whether the reference voltage you are giving to the non-inverting terminal of the operation amplifier connect or not.

If you do not apply a correct voltage or if you do not connect a correct load register to the circuit, you will not get the output as desired. You can make positive clamper, you can make negative clamper just by changing the reference voltage at the non-inverting terminal. So, I hope that you understood the role of the clamper and how the positive and negative clampers can be designed and can be used using multisim. So, I will see you in the next class. Till then you take care. Bye.