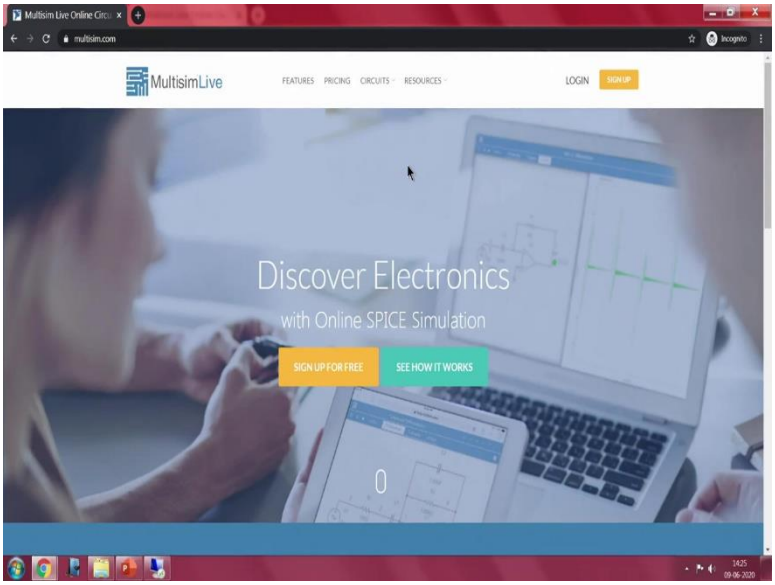
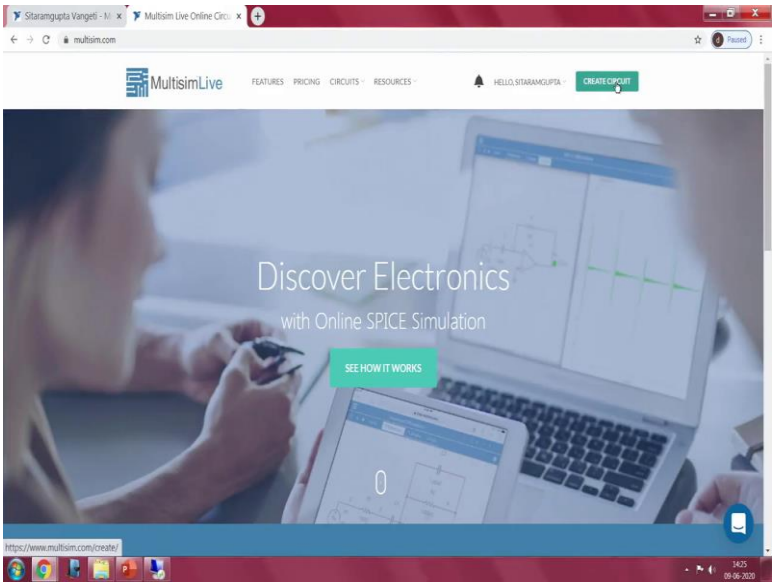
Introductory Neuroscience and Neuro Instrumentation
Indian Institute of Science, Bangalore
Lecture 40
Basics of Instrumentation Amplifier and Online Simulation

(Refer Slide Time: 00:20)





Hello all, welcome to the module. So, today we will see how to use the online version of NA multisim. So, professor Hardik has already discussed about the circuit in the last module, especially for the acquisition of EEG you know signals from the human. So, in order to understand the working of the circuit it is better to do a circuit simulation, so that we will understand and we can also analyse the design you know performed on the circuit is as per the requirement or not.

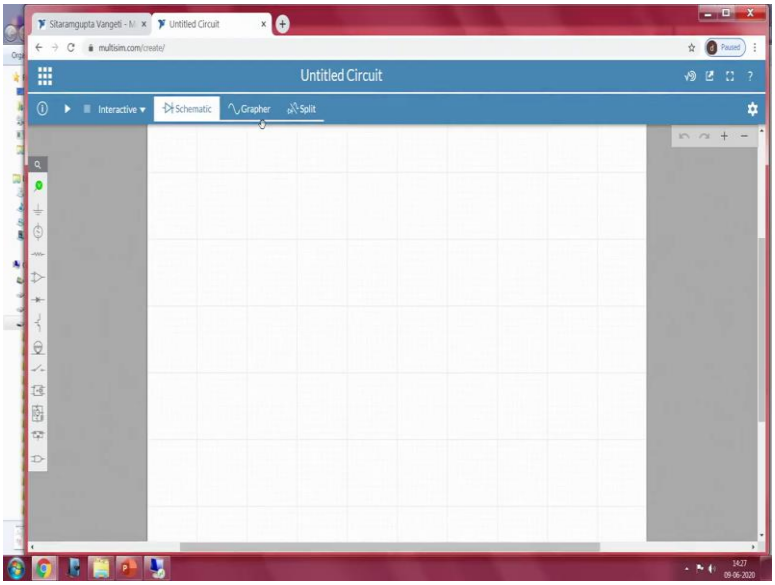
So, one particular way of understanding is either by building it on a breadboard, first we will always go with a theoretical design and based upon the theoretical design after optimizing it we will go with the you know hardware, but prior to the hardware if you use a simulation it will always be helpful in order to rectify the designs within lesser time.

So, in this I will show you, how can we use online simulation software which is a circuit builder software, how can we make use of that, simulation circuits simulation software in order to analyse different circuits. So, the complete circuit I will be dividing into different subsystems, each subsystem I will be looking about its requirements and whether it is matching our requirements or not.

So, in order to built first we have to get flexible first we have to get you know used to the features of online multisim. So, in this module I will try to get use to the online multisim in order to work with this circuits simulation software, online circuits simulation software you just go to multisim.com, so I have already open the page a multisim.com.

So, in case if you do not have an account just create using sign up, if the account is already existing just log in using your existing credentials. So, right now I have already logged into my account so you can have a look here, my account. So, now in order to create a circuit on the top right you know on the top right side you can see a green colour tab, which indicates a create circuit.

(Refer Slide Time: 03:01)



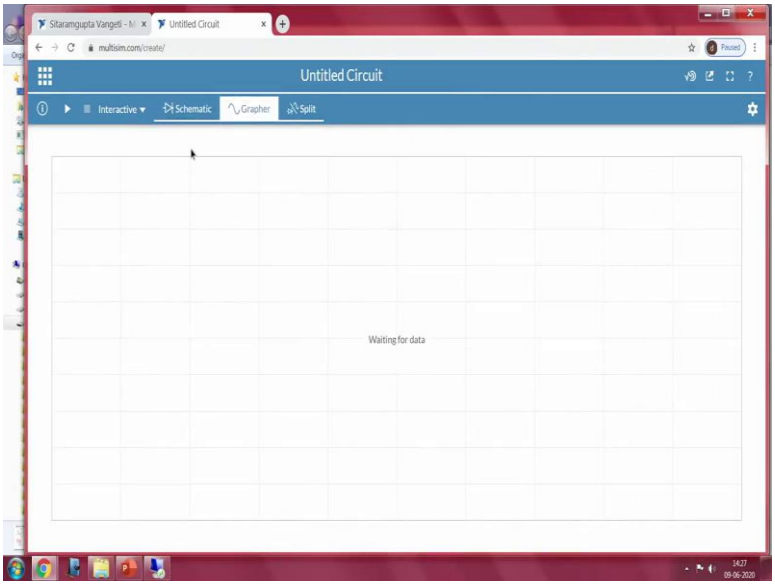
So, just to create a circuit just click on this create circuit button, it initializes the interface for circuit building, this is the interface for circuit building, so where you can see a different

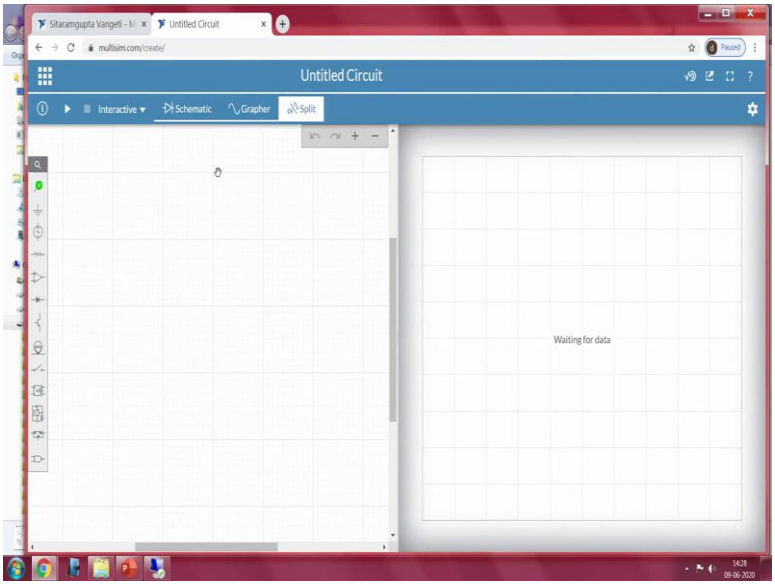
options available, so on the top we can see the options something like schematic, grapher split, the idea of the schematic is to built the circuit for analysing it, so whatever the circuit we planned to understand what we to plan to analyse that can be built in this particular tab.

So, during this tap we can see a page a white colour page where the all the blocks required has to be dragged in place at this point and do the connections, that means we are what are the designs we trying to understand or analyse we will be putting on this graph. Whereas there is another tab called grapher, the idea of this grapher is to visualize the output wave forms at the selected point.

So, which is nothing but in case if you want to provide a function generator to the circuit at the same time to analyse an output. So, all the responses from the function generator the responses from the circuit will be looked or will be visualised the output waveforms from each of these things will be visualised using this particular tab.

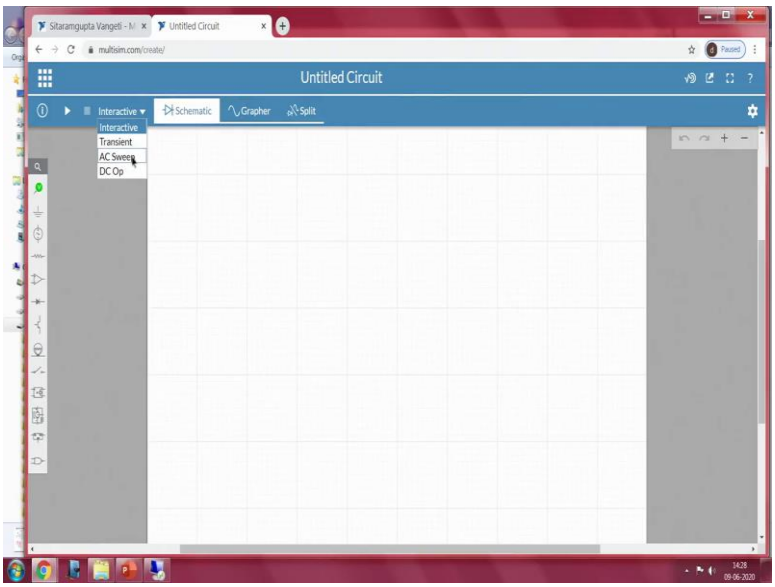
(Refer Slide Time: 04:32)





So, this particular tab is only meant for visualisation purposes, provided we should have to mention at which point of the circuit the visualization needs to be you know plotted. We also have another menu here called split where you can see both schematic as well as a grapher windows side by side. So, however in this case we were not able to see anything here because we have not built any circuit at present at the same time we are not executing or we are not running the software, so that is why it always shows waiting for the data.

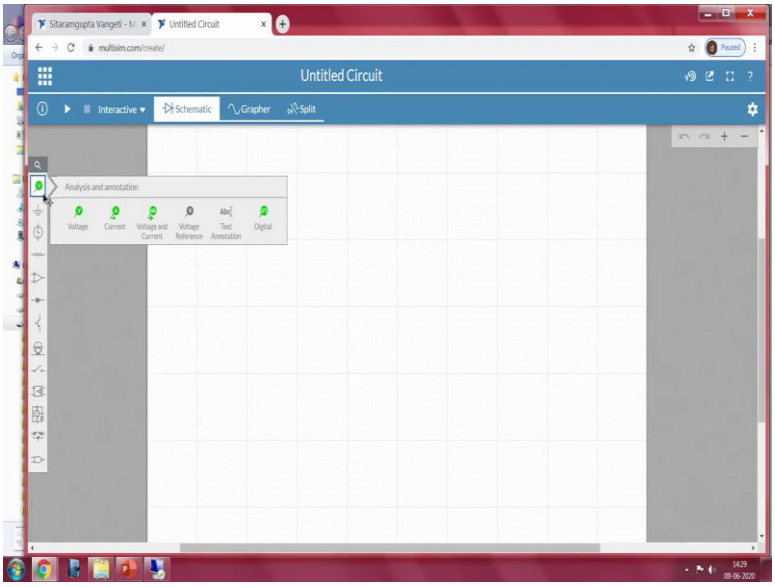
(Refer Slide Time: 05:16)



So, this are the main basic functions which we will be always using it in order to build it. So, in our practice application when we designing a filters or when we are understanding the functionality we may opt for different simulations we may perform different simulations or different analysis on the circuit. So, those analysis we can further verify at this point we have

a four different analysis available interactive, transient, AC sweep, DC operating point. On the left hand side it contain all the circuit components required to build it.

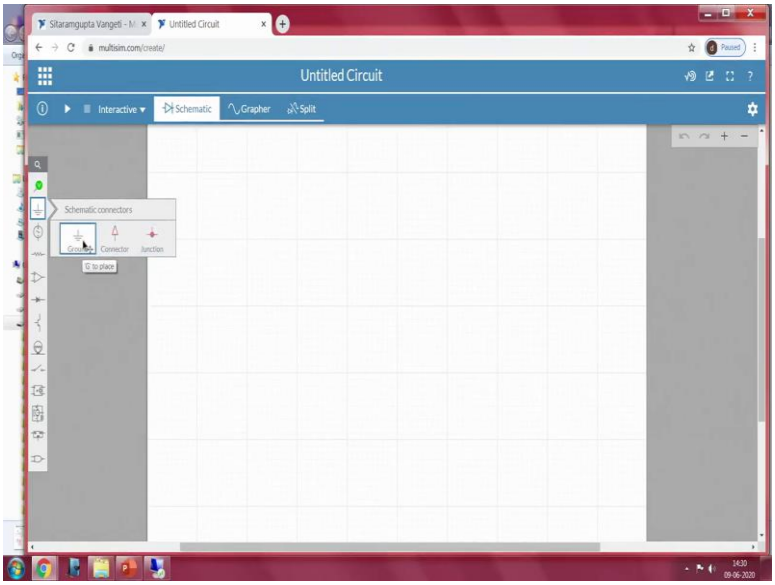
(Refer Slide Time: 06:04)



So, for example if we want to understand the voltage at one particular point and the same has to be visualize we may have to go with a voltage you know probe, this is something looks like a voltage probe, so which will be available in analysis and annotation toolboxes. So, voltage, current in case if you want to see what is a current flowing through that particular wire or a cable can be visualizes using this.

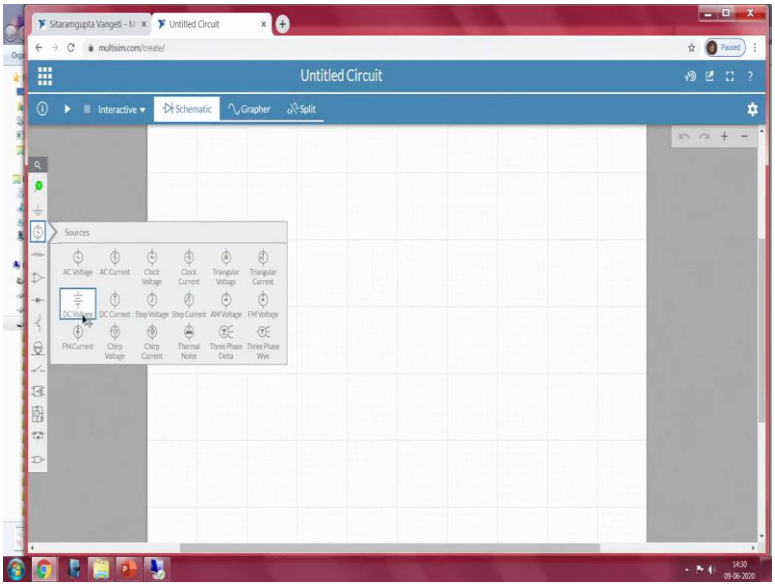
So, digital voltage and digital current probes both together we can verify with and this act as when we are considering voltage reference instead of ground some other voltage reference we can put this particular probe as one of the reference another probe where we are measuring it. So, it measures the voltage with respect to this reference rather than with respect to the ground. If this reference is does not exist the whatever the voltage it measures is with respect to the common ground.

(Refer Slide Time: 06:58)



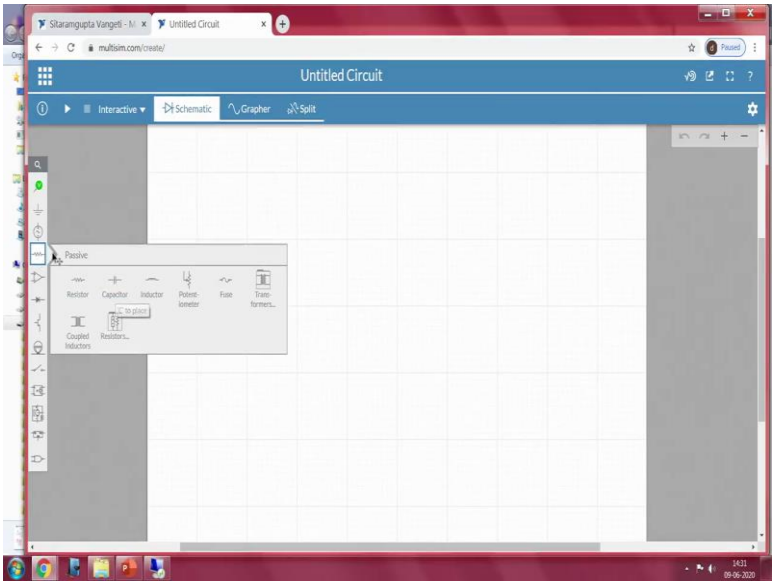
So, this are the different ground, different schematic connectors like a ground common reference point a connector and a junction if you want to have a multiple connections at one single point which is in the junction.

(Refer Slide Time: 07:14)



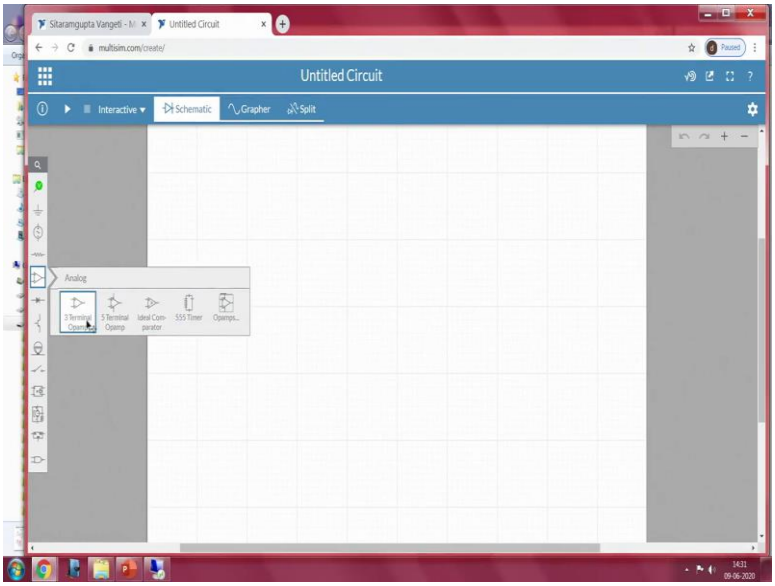
Similarly, on the third palette you can see different sources, starting form AC voltage, AC current, clock voltage, Clock current triangular wave DC voltage, so irrespective of, so if we want to perform any analysis using AC you can see any clock related you can apply any triangular voltages DC voltages everything is available at this particular toolbox or palette.

(Refer Slide Time: 07:43)



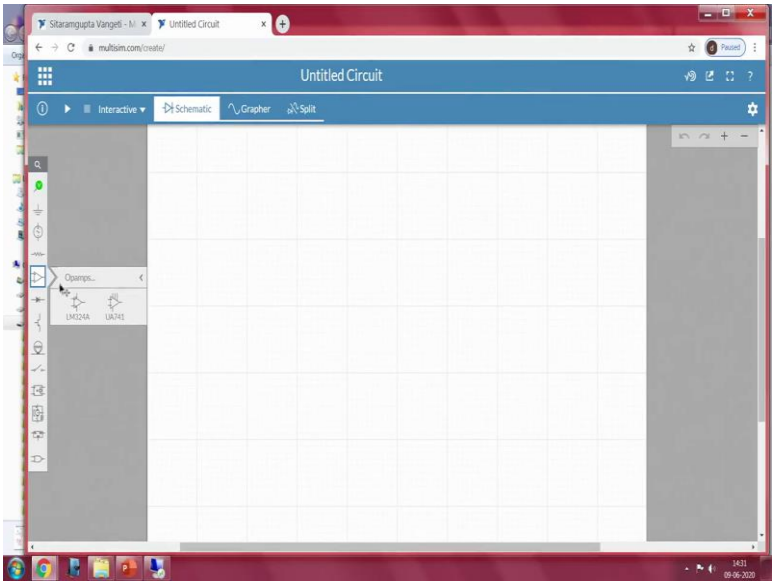
So, most of the our electronics circuit uses a passive elements like inductor capacitor and resistor, especially pots too. so all different passive elements are available at one particular tab passive tab where you can see all resistors, capacitors.

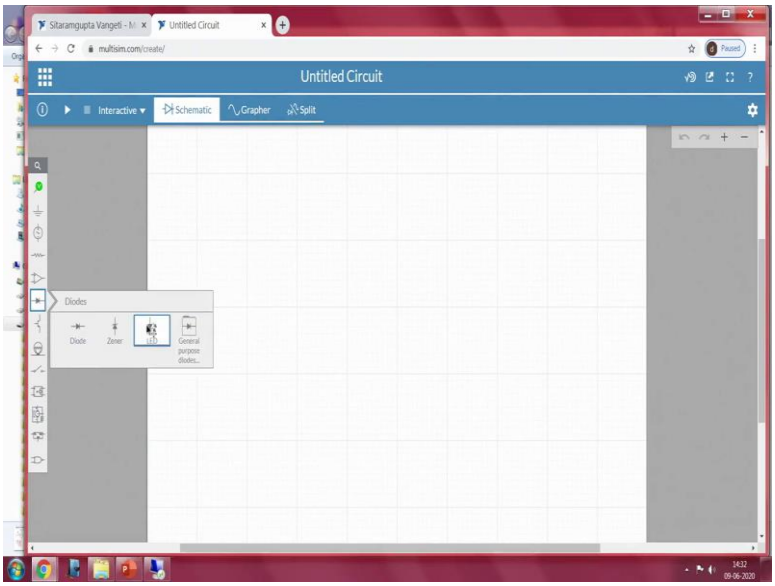
(Refer Slide Time: 08:04)



And the next tab we can see different, different operation amplifiers, so this are all generic operational amplifiers 3 terminal op amp 5 terminal op amp, ideal comparator and this are the existing operational amplifiers in the market 555 op amps, the features or the specifications of these op amps when you select will be closely matched with respect to the specifications available, specifications given in the data sheet.

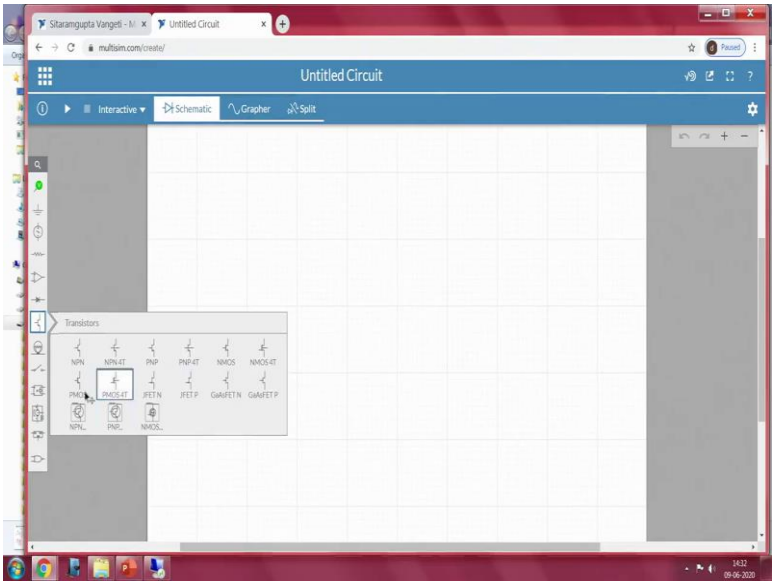
(Refer Slide Time: 08:40)

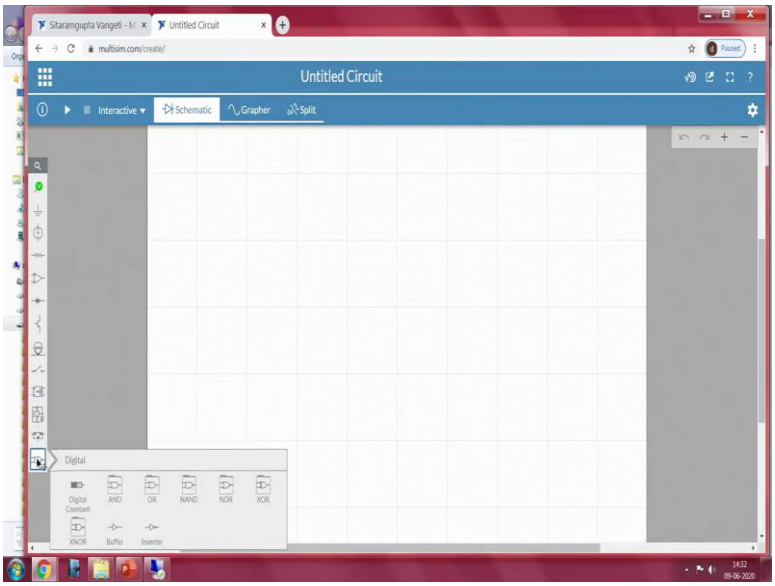




At the same time with these op-amps, we can also change the specifications default specifications provided in order to make use of you know, make use similar to the existing component available in the market. Similarly, we have a diodes different diodes rectifying diodes, Zener diodes, LEDs and general purpose diodes which are commercially available.

(Refer Slide Time: 09:07)



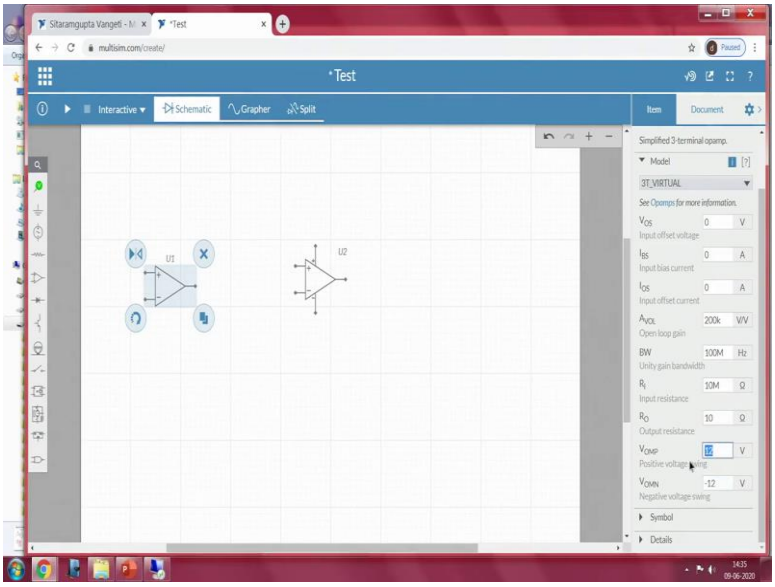


And transistors T channel, N channel, NPN, PNP, MOSFETs everything, indicators, switches, analog blocks sorry digital, analog blocks we have already seen here and we have also have a digital blocks too. So, this particular I hope now these things whatever we have seen or anything working with simulation packages or similar builder softwares is a basically completely like intuitive.

We will always have all the dedicated blocks available in the database you may have to pick and drag and drop to the circuit builder part and you have to connect a circuit accordingly. So, once the circuit is done we can simply place a button here run simulation button, so in order to visualize the outputs or in order to visualize the input and output waveforms. So, in

order to make you clear I will just show you an example of using this particular multisim software and analysing using that.

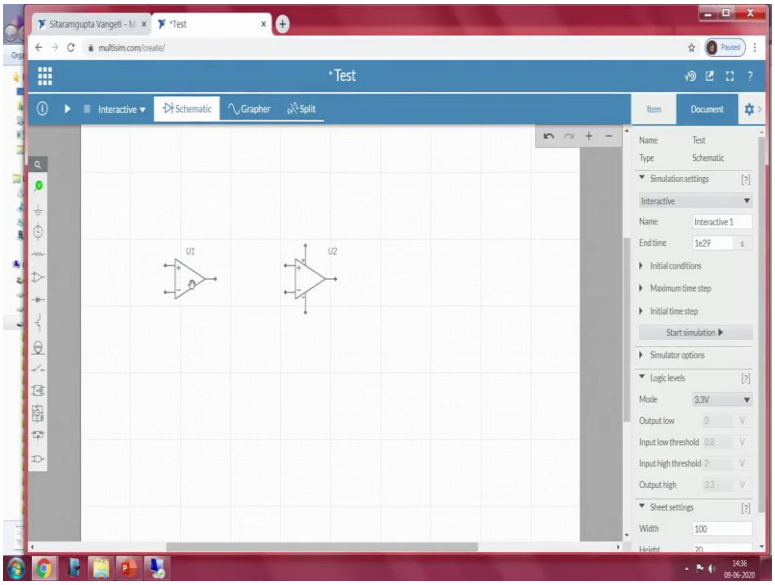
(Refer Slide Time: 10:19)



So, I will name it as test circuit, I will try to build an inverting amplifier. So, either you can go with three op amp based inverting amplifier or 5 terminal op amp base, the only difference between 3 terminal and 5 terminal is in case of 5 terminal it contains a external to other 2 terminals apart from 2 input and 1 output terminal.

Those are plus VCC and minus VCC, whereas in case of 3 terminal op-amp the plus VCC and minus VCC is fixed in the specification, it does not mean that it cannot be changed it can also be varied, in the settings parameter however he default will be 12 volts, whereas in case of 5 terminal volt it has to be provided using volt resources. I will show you the difference between those two.

(Refer Slide Time: 11:10)



So, I will consider 3 terminal at the same time I will also consider the 5 terminal, so these 2 are one is noninverting input terminal, inverting input terminal similar to what you have seen the U2 which is the 5 terminal op amp and this is an output terminal. So, the only difference between these 2 is that you have you have extra 2 terminals to provide plus VCC as well minus VCC. So, this has to be provided using external volt resources but whereas in this case when we clicking to the when we click on to the configuration pane located on the left side of the top left side.

When we click here, here we can see the virtual modal parameters which has been a default parameter. So, in order to map with respect to the existing operational amplifier you can change the these you know parameter modal parameters to act according to the commercial operational amplifiers. Similarly, there are two more terminals or properties available, so which is nothing but VOMP, VOMN which represents the positive voltage swing and negative voltage swing.

So, the default positive or negative voltage swing is 12 and minus 12. In case if you want to replace you can change to 12 and 15 to minus 15. So, as we are already aware when the operational amplifier are working in you know amplification mode in a negative feedback mode, the maximum output voltage it can provide.

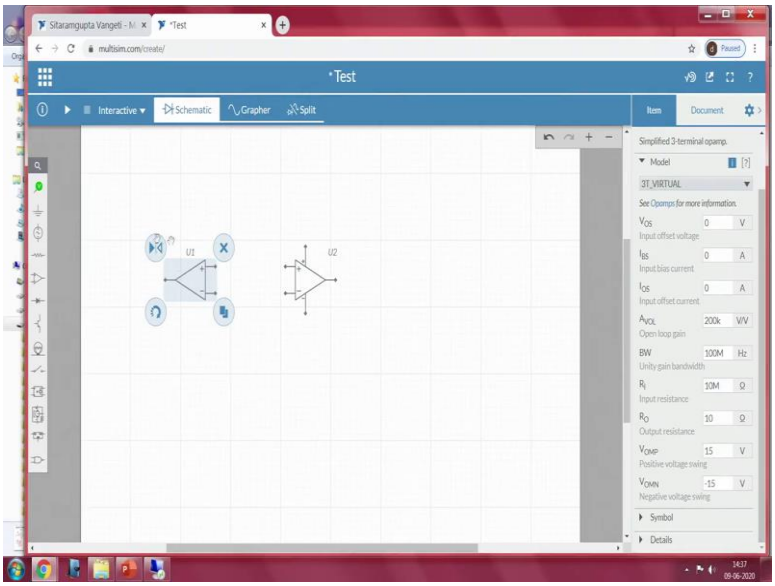
Irrespective of whether it is inverting amplifier or noninverting amplifier mode or a comparator mode the output of these operation amplifiers will be equal to or lesser than the plus VCC and minus VCC, so that reaches to the saturation as well output is goes close to the

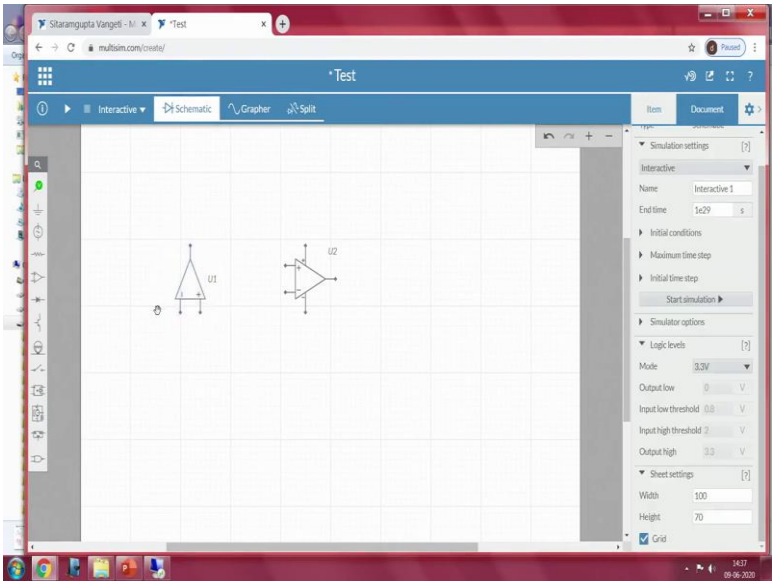
plus VCC and minus VCC, so the plus VCC and minus VCC is very much important when in order to design the circuit or to decide the saturation voltages.

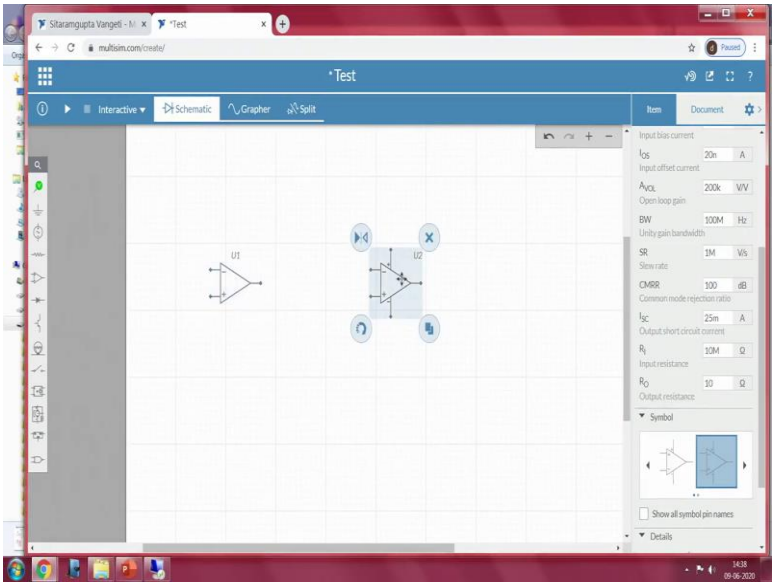
Now, in case if we want to further you know understand about the building of simulation software understanding about NA multisim you can further look into the internet multisim tutorials are also available where you can understand each and every property which has been given mentioned in this particular multisim. You can go to multisim.com and there exist a few tutorials you can have a look.

Now, I will show you the how to build it. So, when you click on it you can see 4 options available. This option tent is use for flipping or mirroring of the operational amplifier you can see that. So, in the previous case if you observe the positive on the top and negative on the bottom but it is always easy or it is our we have come across a different circuit where negative terminal will be on the top and positive terminal will be bottom, so you can easy to recognize the inverting amplifier configuration as well as non-inverting amplifier configuration.

(Refer Slide Time: 14:35)





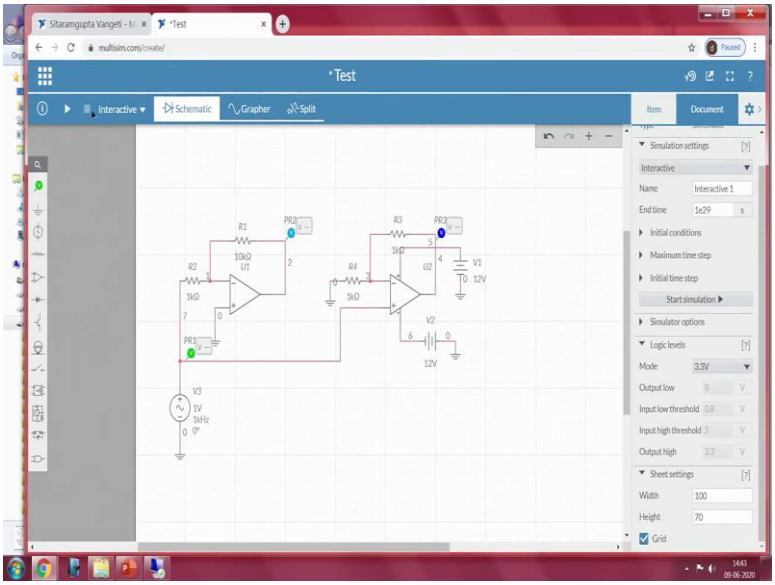


So, that is why in order to have that I will mirror it, I will rotate it so that the negative will is on top and the positive will be on the bottom, similarly the same thing you can do, of course it can also be done at this point to so go to this symbol, just go to the other particular part that is all, it will automatically flap accordingly.

So, the second option which is available on the top right side of the U1 is a delete button in case if you do not want to use it, this is a duplicate button where you can duplicate the same component and this is a rotator which you have already seen. So, in this case we may not have to provide with external power supplies in case of U1, whereas U2 we have to provide with external power supplies.

So, now in order to construct inverting and non inviting amplifier configuration I will use U1 as an inverting amplifier configuration and U2 as a noninverting amplifier configuration. So, to do that so we require passive elements as well as power supply units.

(Refer Slide Time: 15:41)



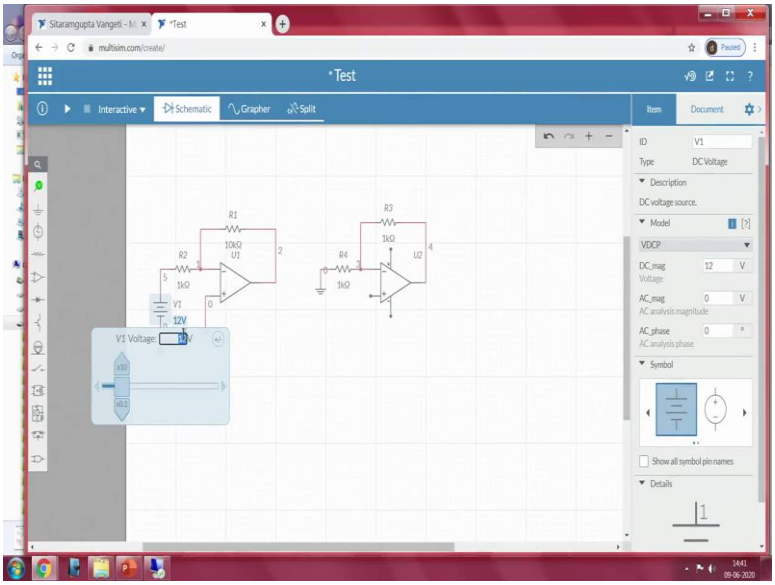
So, what I will do? I will take passive elements. So, in order to once you take a passive element, so R1 being the feedback R2 being the input resistor and R3 being the feedback in case of U2 and R4 being the input resistor I am considering it. So, in order to make the connections between the resistor and to the operational amplifiers when you place the curser at present it is in the hand tool. When you place the curser close to the edge of any edge of any terminal or edge of this particular component it will automatically change to wiring tool.

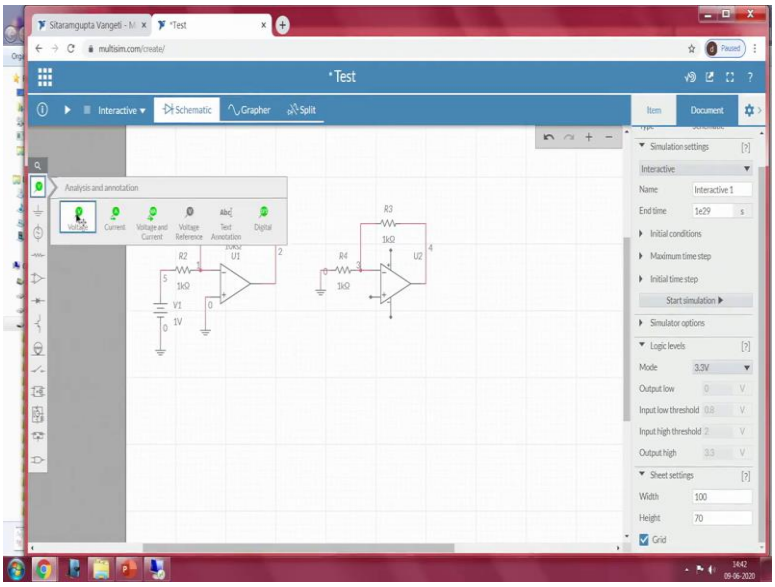
Just click on at that part and again click, so similarly here I am doing it, so wherever the junction is forming wherever the connection is forming we can clearly observe a circle assuming out circle, so which indicates it at this particular point you can make a connection. Once you click on it just left-clicking it, left clicking it will automatically make a junction, similarly even on the other side.

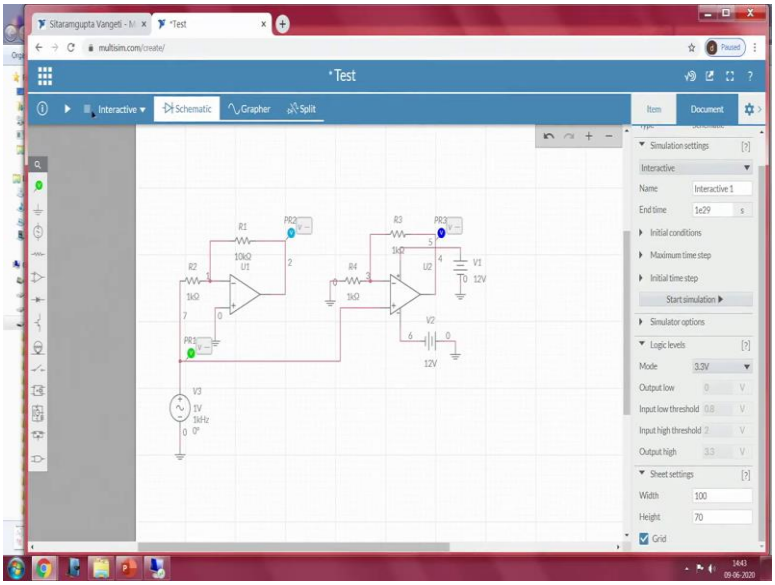
The same way I am even doing at U2 part, but in this case we may have to provide positive VCC and negative VCC, so we require ground terminal as well as positive negative, in order to make the ground terminal in the second tab, in the second tool box we can see the ground, so since it is in inverting amplifier configuration so the positive terminal has to be connected with a ground and I am duplicating it connecting at this point, sorry this is a non-inverting amplifier configuration so this terminal will be connected at this point.

So, we also have to apply positive and negative. I will go to the third tab sources where it contains all different types of sources, I will go to DC voltage I can connect at this point, I am duplicating the ground and then connecting it. So, now if I want to change any resistance while uses something just click on the number or just click on to R2 you can go to the settings pane, configuration pane.

(Refer Slide Time: 18:06)







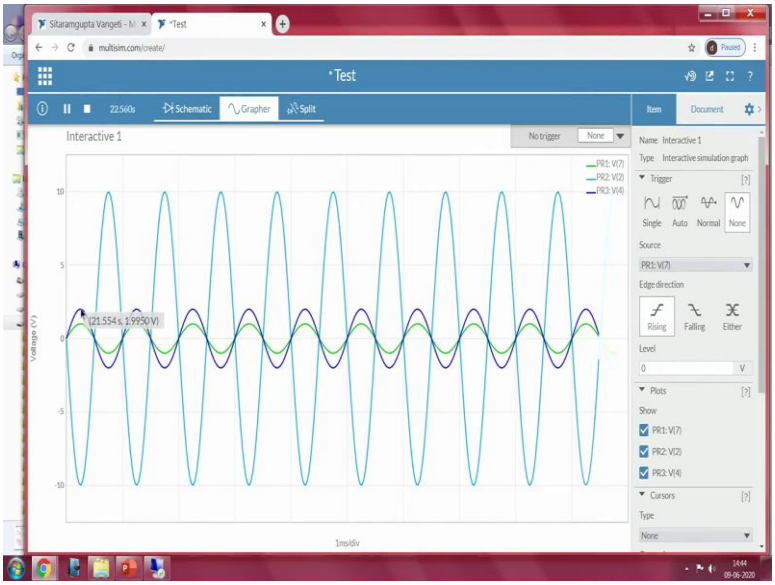
Here we can see the resistance, either we can change at this point or during the simulation industriously we can vary. So, in this case I am going with 1k and whereas I am changing to the 10k so the gain is 10. So, since is op amp is powered with plus or minus 15 the maximum voltage that you can see close to 14.3 something you can refer to the datasheet, it depends on the op amp that you are considering.

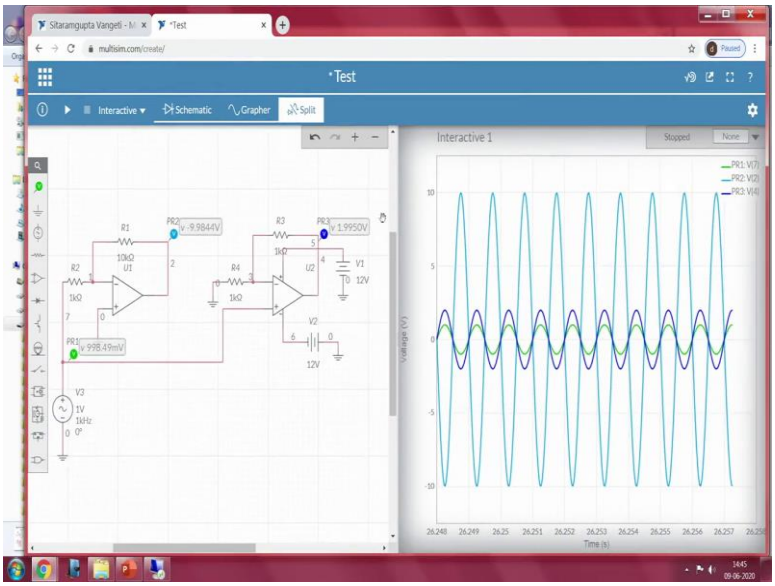
But it will the saturation voltage will be close to lesser than 15 volts, lesser than plus or minus 15, so if is apply 12 since the gain is 10 the output will be 120 volts theoretically ideally. But because of the positive and negative volt it cannot go more than plus or minus VCC. So, as a result I am changing it to 1 volt, so since it is a negative amplifier, we know that theoretical output voltage should be minus 10, we will verify that.

So, in order to verify what I will do I will put a voltage probe by the output terminal. Similarly, so instead of voltage I will go with simple AC signal, so whereas in case of 5 terminal we may externally have to connect the voltage sources, so this I am going with a 12 and I need to take one more voltage source for the negative terminal connection I am rotating it and then connecting it to the negative terminal with same ground.

Whereas input I will go with AC voltage, connecting with the same input terminal even here to, in this case the gain is 1, 1 plus 1 2. So, since it is a non-inverting amplifier configuration whereas in this case it is 10. So, the ground, so to in order to visualize the input output and everything. So, green colour represents the input sorry, green colour represents the input, blue colour PR2 represents output whereas PR3 dark blue, sky blue and dark blue represents the output from the non-inverting amplifier configuration.

(Refer Slide Time: 20:52)





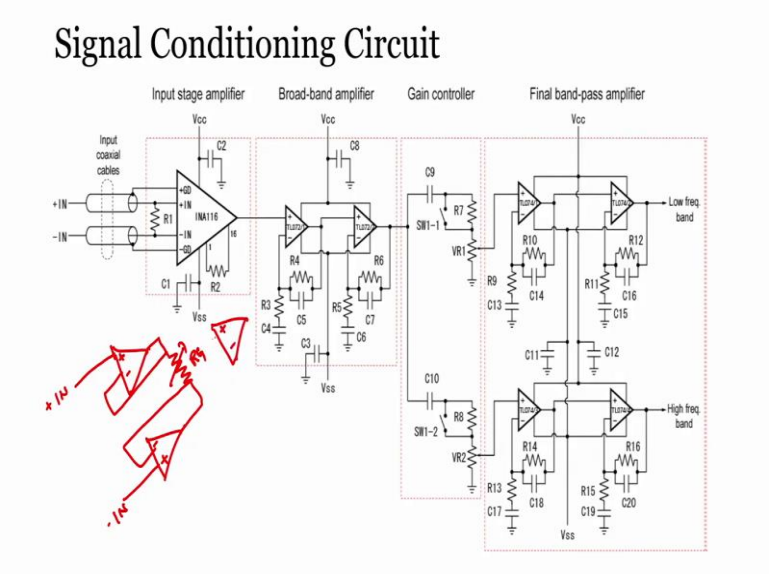
So, right now I am going with the interacting mode, whenever we go to the grapher we can see. So, we know the PR1 is input so the green colour represents the input which is 1 volt and PR2 is a output from the inverting amplifier configuration with a gain of 10. So, since the input is 1 the output is of 10.

And since it is in inverting configuration inverting amplifier configuration there will be phase shift of 180 degree as a result whenever it is a positive we are getting a negative output voltage. Whereas PR3 is a output from non-inverting amplifier we can have a look on to the PR3 which is of dark blue.

Where the phase is almost same equal to the phase of it is same as input phase but since the gain is 2, so the amplitude is somewhere around close to 2 volts. So, this way we can

understand the analysis of any circuit using circuit simulation software. Now, we will see the actual circuit which we would like to analyse which professor Hardik would have already discuss in the last class.

(Refer Slide Time: 22:10)



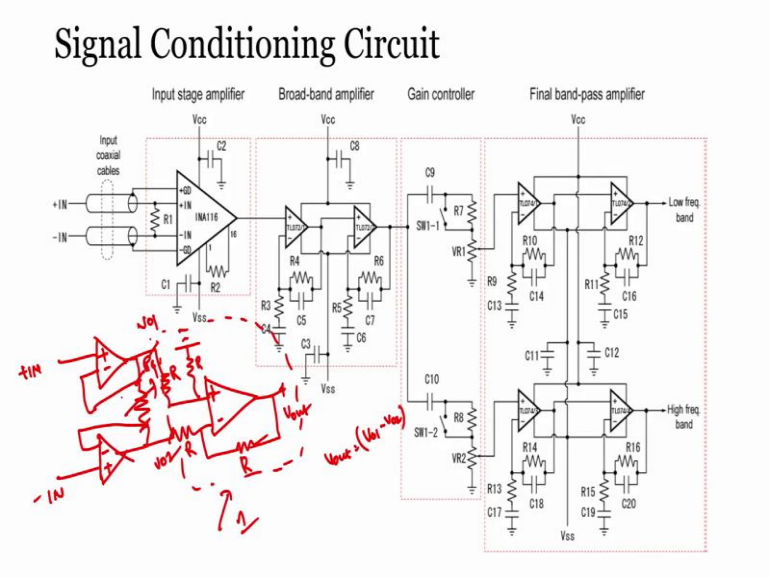
So, this is a signal conditioning circuit, so in the first stage, we have input stage amplifier where instrumentational amplifier, so now I will show you how to construct this instrumentational amplifier as we are all already discussed the use of instrumentation amplifier at this point and the use of INA116 and since we do not have the commercial we do not have the exact you know 116 in circuit simulation software.

As well as we do not have INA instrumentation amplifier configuration itself in the online database, we can in order to understand the functionality of instrumentation amplifier we can construct an instrumentation amplifier itself using a normal operational amplifier. So, general most of these instrumentational amplifiers are 3 terminal base instrumentation amplifier, sorry 3 op amp base instrumentation amplifier, where the first op amp the second op amp is used for the gain application to provide the gain to the instrumentation amplifier. Whereas a third op amp which measures the difference between the both the outputs.

So, let me draw the instrumentational amplifier, 3 terminal instrumentational amplifier configuration. So, this is 1 input so I can say it as IN plus and whereas this is another input IN minus. As most of people know the configuration of an instrumentational amplifier I am not discussing much about this, but I will draw the circuit and I will try to construct the same in order to visualize the functionality as same as not. So, the negative terminal be connecting at this point this negative terminal so, I am connecting at this point, this constitutes as again.

Whereas a third operational amplifier is used as a differential amplifier, I will draw it properly.

(Refer Slide Time: 24:25)



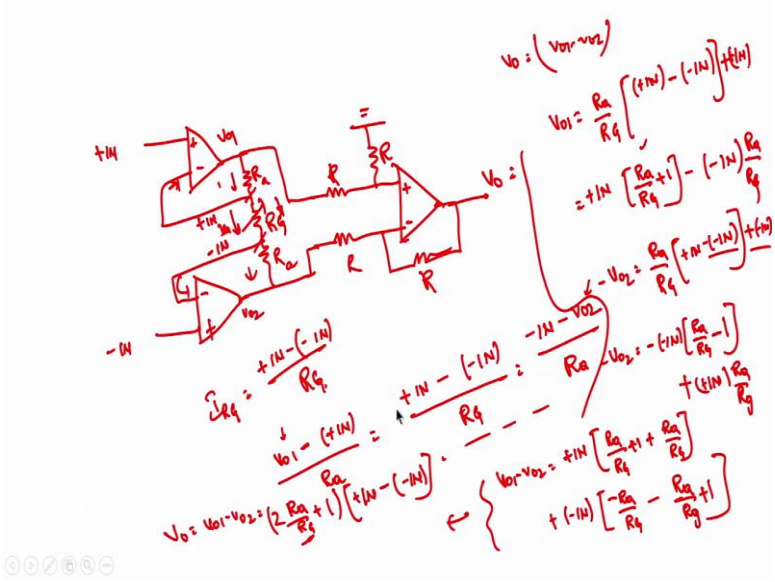
1, 2 a resistor in between, this is minus this is plus this is IN minus, this is IN plus. So, the negative terminal since we always require a negative feedback so this will be connected at this point whereas this will be connected at this point this act as gain, whereas it contains another operational amplifier, in differential amplifier configuration with a gain of 1.

So, this is 3 terminal operational instrumentational amplifier configuration. So, since these gains are almost or same the gain of this the third operational amplifier which is in differential amplifier configuration is 1, so this is the output. So, in order to understand the relation between input and output we can have a look.

So, I am dividing this as VO1 and I am saying as VO2. So, we know that V out is nothing but since a gain is 1, in this case VO1-VO2. So, if you can find the relation between VO1 and VO2 and IN+ and IN- the complete operation amplifier instrumentational amplifier gain we can understand it or we can derive the relation between input and output terminal too.

So, in order to understand first if we observe this particular point as we already know what are the input applied the positive terminal the same input at this point, as well as the at this point. So, as a result, this terminal is nothing but IN plus and this terminal is IN minus, so the current flowing through this.

(Refer Slide Time: 26:54)



I will take the new page so that it will be easy to further discuss on this. I will construct an 3 terminal operational amplifier since we do not have INA116 in the online database of NA multisim. So, even it does not have an operation instrumentation amplifier configuration a 3 op amp base instrumentation amplifier I will show.

So, it contains 3 op amps minus plus. So, these two op amps are used to provide a gain to the operational amplifier, whereas the third op amp will be in differential amplifier configuration with a gain of 1. So, plus minus I am considering, so this is an differential amplifier configuration, so where this terminal is also grounded.

So, since the gain is 1 all the resistance should be the same, so differential amplifier configuration should be in inverting amplifier configuration this is R and this is R, this is V naught. So, we need to derive a relationship between V naught and IN plus and IN minus. So, if I consider the output of this op amp is VO1 and the output of this op amp is VO2 and since we will be connecting VO1 at this point and VO2 at this point, so we need to find out the relationship between and we know that the relation between V0 and V1 VO2 so V0 is equal to gain, gain is 1 in this case VO1 - VO2.

If we once finds the relation between VO1 and VO2 and IN plus and IN 1 our problem is solved, but however this is not a complete circuit still I have to build a complete circuit here, this negative terminal be connected at this point this negative terminal be connected at this point, this Ra I can consider and this is nothing but RG.

So, this RG is responsible to have a gain that is required for the instrumentation amplifier, since both the terminals IN plus and IN minus are the input voltages are being connected at positive terminal of operational amplifiers the input impedance will be very very higher. So, once we derive a relationship between VO1 and VO2 and IN plus and IN minus will be very easy.

So, as we know the property of any op-amp in a negative feedback configuration virtual short, so whatever the terminal whatever the voltage at the positive terminal the same voltage will be at the negative terminal to, so this is IN minus and this is IN plus at this terminal. So, as a result so the current flowing through IRG is nothing but, right?

So, this is the current flowing through but if you observe the input terminal at since this directly connected into the negative terminal even this is directly connected to the op amp terminal there would not be ideally speaking there would be any current flow through this terminals and as a result what are the current flowing through here IRG is same as a current flow even in IRA.

So, now we can say VO1- IN + / Ra = IN+ - IN - / RG = IN- VO2 / RA. So in order to get a relationship first, I will consider these two then I will consider these two to solve it, so when I try to solve it so since we know, since we need to get a relationship between V naught and IN plus and IN minus first I will try to eliminate VO1 I will get a relation between VO1 and IN plus and IN minus and I will get later on I will get relation between VO2 and these two input terminal.

So, when we see this VO1 is nothing but Ra /RG * IN+ - IN- + IN+. So, when I take IN plus as a common I can consider it as Ra /RG + 1. And similarly, IN- * Ra / RG. So, similarly in other case if I consider these two, so minus VO2 I would say Ra / RG * IN+ - IN- + IN-.

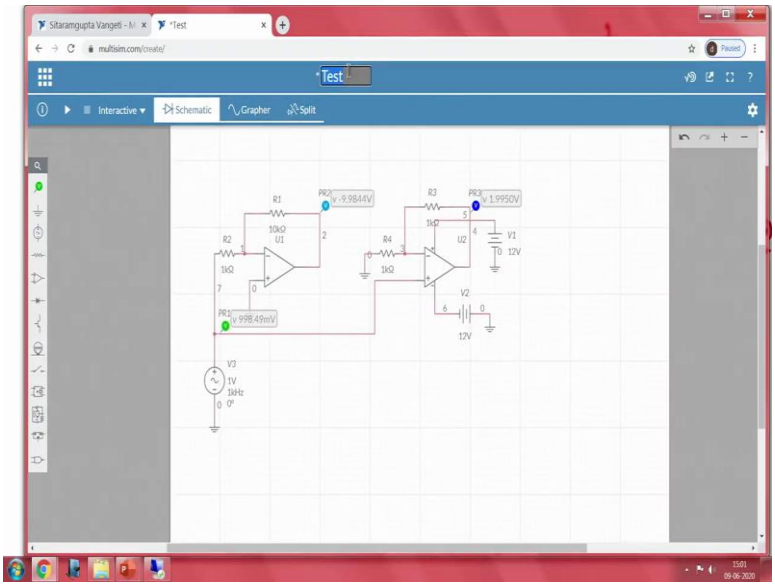
So, when I take VO2 this is nothing but okay let it be minus VO2, so I will take IN plus as common so now I will get so in this case I have to take IN minus as a common because I have two IN minus. So, if I take IN minus as a common I will get Ra by RG minus. So, what I will do? I will take minus of minus VO2 minus of IN minus, so which is nothing but Ra by RG minus 1 plus IN plus into Ra by Rg.

So, now we got relation between VO1 and VO2 now if I want to subtract VO1 and VO2 what I can get I will take Ra by, I will take IN plus between these two so here it will be Ra by RG plus 1 from here and in this case it is nothing but plus Ra by RG and I will take again IN

minus as a common, again I will take IN minus as common when I take IN minus as a common from here it is minus Ra / RG and this will become minus Ra / Rg + 1.

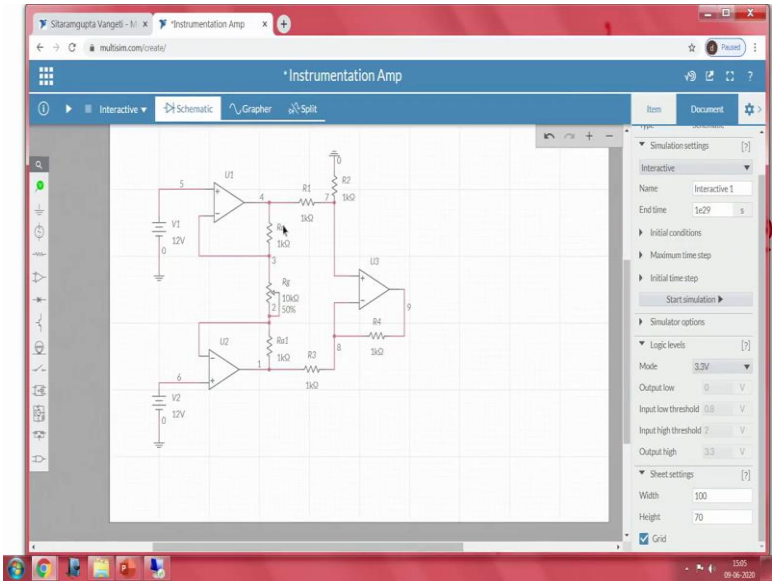
So, when I see this rewriting this one I can write it down as VO1 minus VO2 is equal to Ra by RG, 2 Ra by RG plus 1 if I take a common this is nothing but IN plus minus IN minus, so we know that VO1 minus VO2 is nothing but V naught so we get 2 Ra / RG + 1 * IN plus minus IN minus. So, if we fix Ra as particular constant so the gain of this op amp mentally depends upon RG, so that is it was. Now, we will see how to construct this and how to analysis the instrumentational amplifier configuration using multisim.

(Refer Slide Time: 35:27)



So, what I will do, go to the schematic, now we have to use the 3 op amp base instrumentation amplifier, since we do not have. So, here I will make it as instrumentation amplifier.

(Refer Slide Time: 35:50)



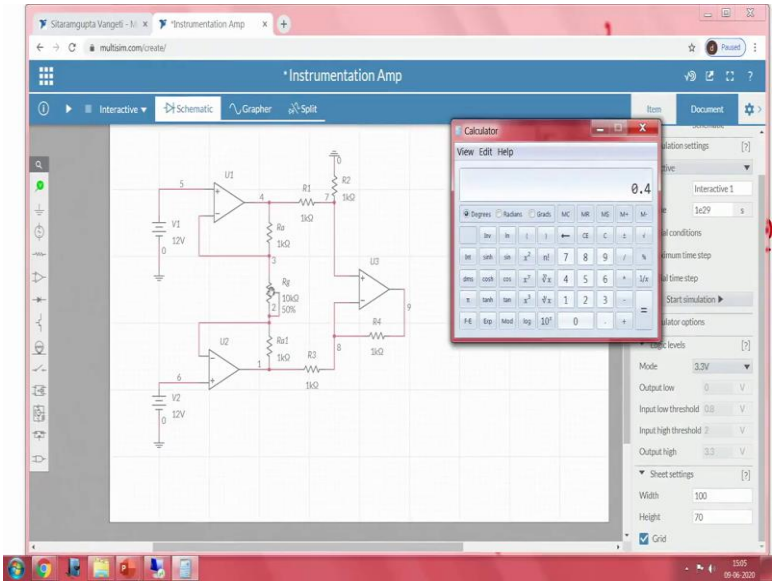
So, I will delete the previous circuit I need 3 op amps in this configuration I will take a 3 op amp base itself but 1, 2 but whereas this one I have to flip, two way of flipping it either we can go to the sitting and directly use it configuration pane or we can use the duplicate, we can use a mirroring and rotation method.

And we also need a passive component I will rotate it, so I am taking Ra as 1k similarly this is also Ra, since a same name is not possible to create Ra1 and whereas RaG I will take a potentiometer here I will connect the negative terminal has to be connected at this point, whereas this negative terminal has to be connected at this point.

So, the first configuration is done this is I will name it as RG, so this is IN plus and IN minus, so I will take two voltage sources to verify it, it I will take a DC voltage one more DC voltage at this point, whereas other terminal has to be connected with a ground, so whereas other this particular configuration we have to use a differential amplifier, so I require a few more resisters I will take this resister the output of the first op amp has to be connected with it.

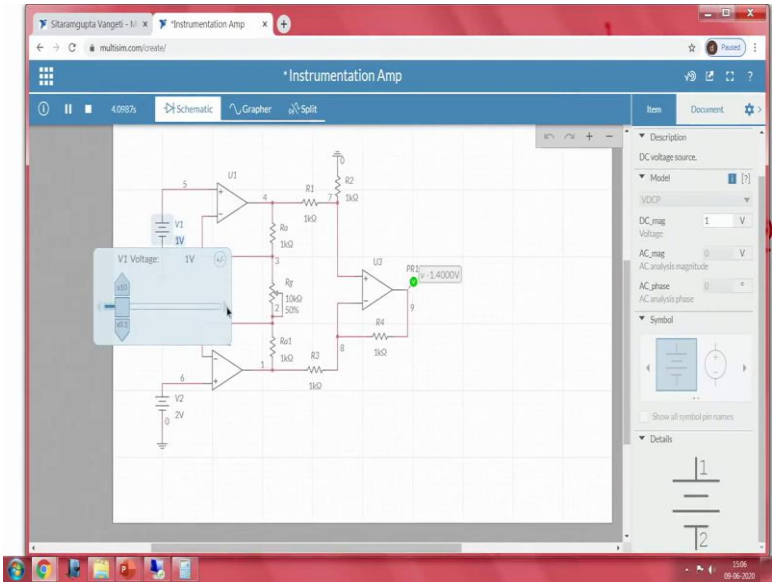
So, I made the complete circuit here, so the gain of this op amp is 1 now in this difference amplifier is 1 that is the gain of this is nothing but 1 plus 2 Ra / RG, so since it is 50 percent this is 5K, so Ra is 1 so 2 * 1 / 5, 1 + 2 / 5.

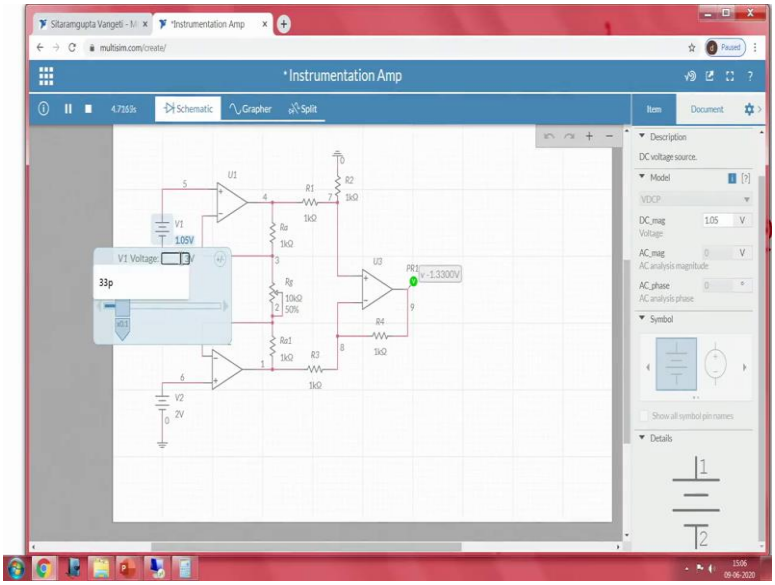
(Refer Slide Time: 39:17)

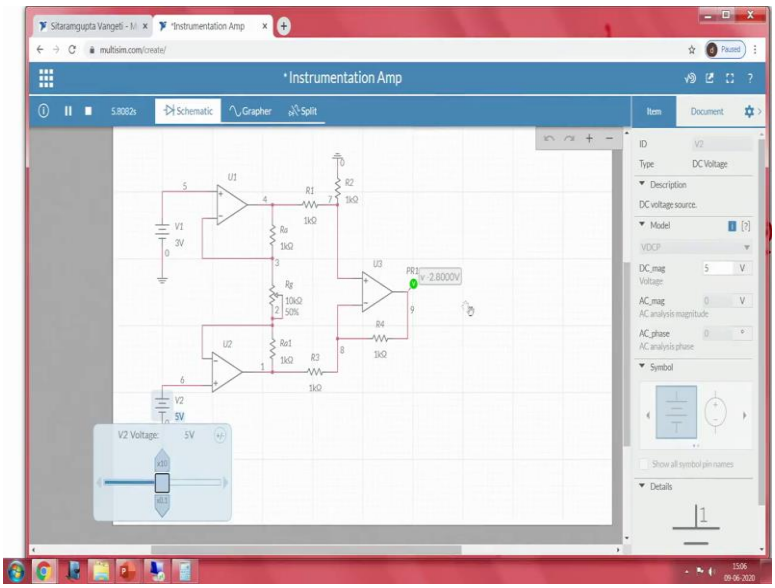


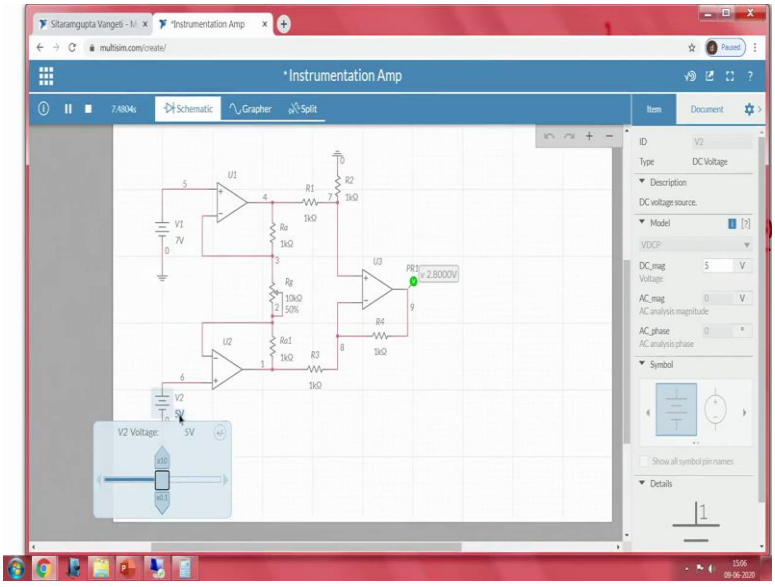
So, the value of 1 + 2 / 5 =1.4. So, the output voltage will be the difference between these two into 1.4, so if I set the V1 as 1 V2 as 2 them I should get so the positive terminal IN plus is having a lower voltage one compare to IN minus. So, this will be minus 1 into 1.4 which is nothing but minus sorry minus 1 into 1.4 into minus 1 which is 1.4. So, now I will connect a voltage probes at this point to visualize since it is not an analog we may not have to go into the grapher view, even if we go into the grapher it will be a like constant DC so we get 1.4 when we have simulated it so it's a completely DC 1.4.

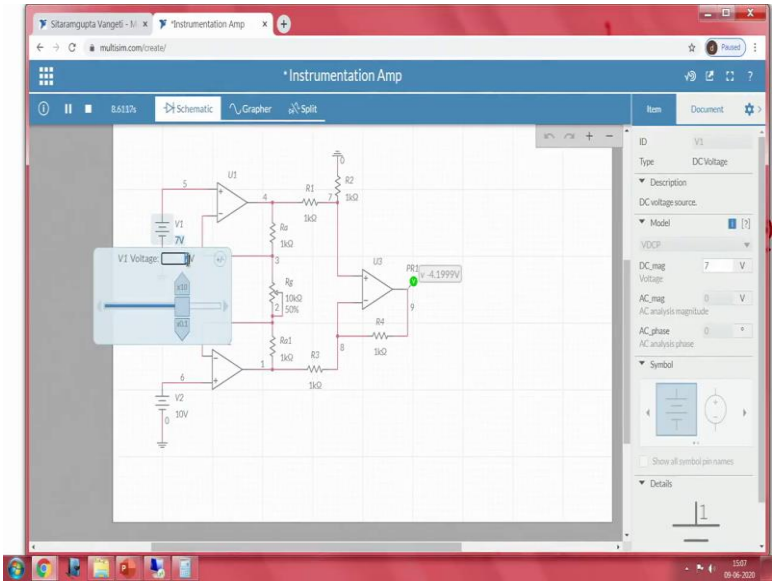
(Refer Slide Time: 40:27)

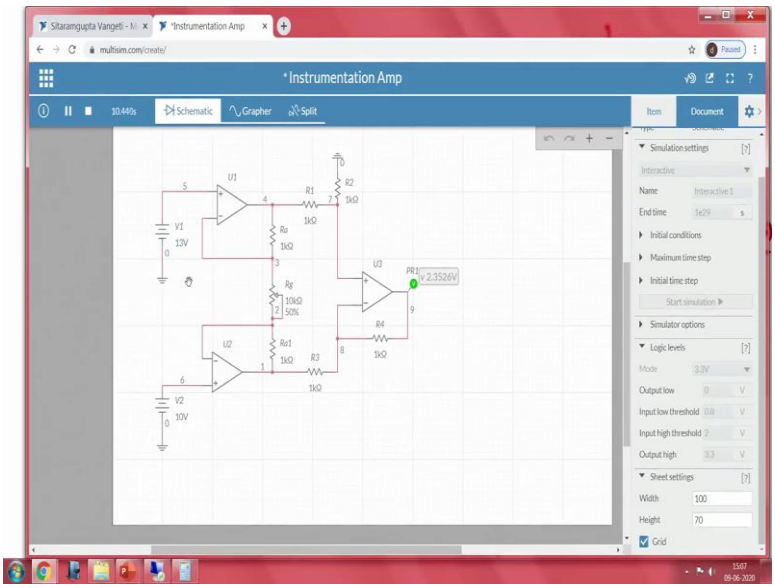


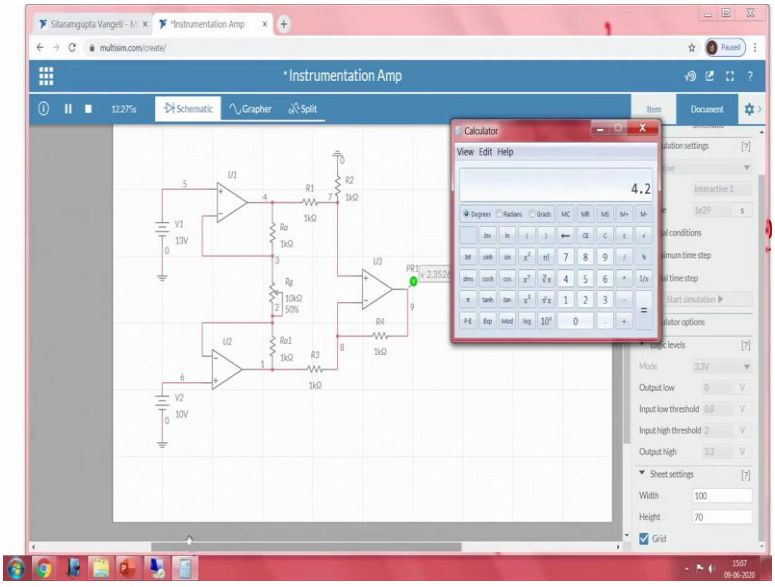

*Instrumentation Amp
Schematic
Grapher
Split
U1
R1
1kΩ
R2
1kΩ
Ra
1kΩ
V1
1.05V
V1 Voltage:
33p
Rg
10kΩ
50%
Ra1
1kΩ
R3
1kΩ
U3
PR1
v -1.3300V
R4
1kΩ
V2
2V
Item
Document
Description
DC voltage source.
Model
VDCP
DC_mag
1.05
V
Voltage
AC_mag
AC analysis magnitude
AC_phase
AC analysis phase
Symbol
Show all symbol pin names
Details

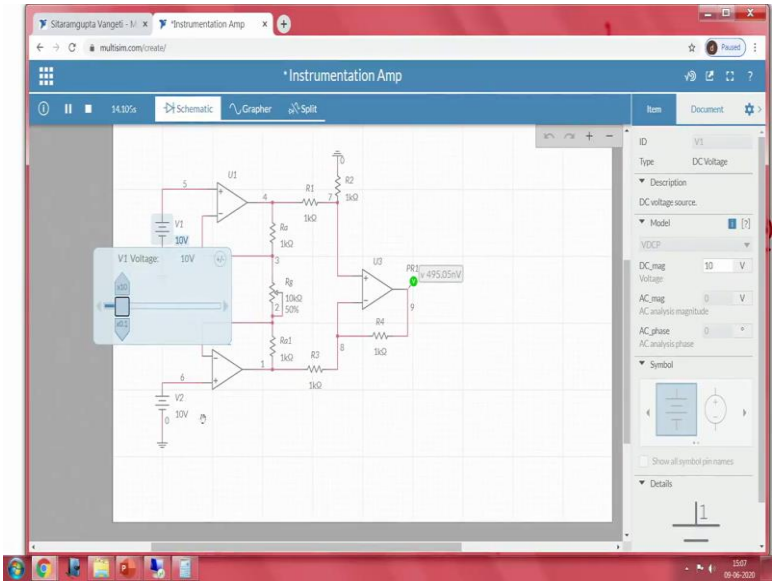

*Instrumentation Amp
Schematic
Grapher
Split
U1
R1
1kΩ
R2
1kΩ
Ra
1kΩ
V1
3V
Rg
10kΩ
50%
Ra1
1kΩ
U2
R3
1kΩ
U3
PR1
v -2.8000V
R4
1kΩ
V2
5V
V2 Voltage:
5V
ID
V2
Type
DC Voltage
Description
DC voltage source.
Model
VDCP
DC_mag
5
V
Voltage
AC_mag
AC analysis magnitude
AC_phase
AC analysis phase
Symbol
Show all symbol pin names
Details

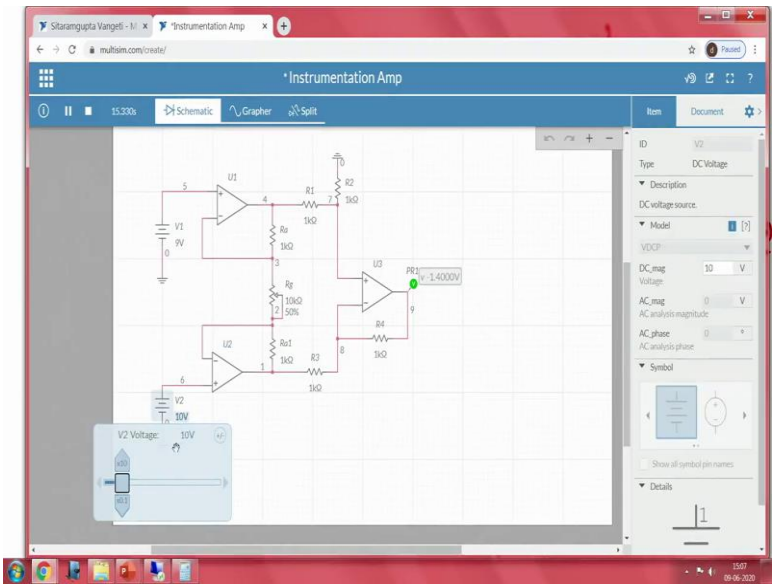

*Instrumentation Amp
Schematic
Grapher
Split
U1
R1
1kΩ
R2
1kΩ
Ra
1kΩ
V1
7V
Rg
10kΩ
50%
Ra1
1kΩ
U2
R3
1kΩ
U3
PR1
v 2.8000V
R4
1kΩ
V2
5V
V2 Voltage:
5V
ID
V2
Type
DC Voltage
Description
DC voltage source.
Model
VDCP
DC_mag
5
V
Voltage
AC_mag
AC analysis magnitude
AC_phase
AC analysis phase
Symbol
Show all symbol pin names
Details

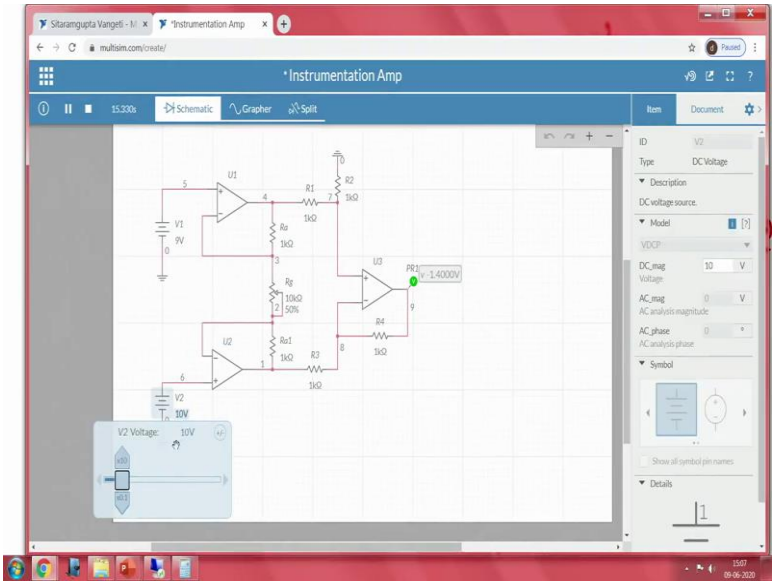

Instrumentation Amp
Schematic
Grapher
Split
V1 Voltage:
7V
10V
PR1
v -4.1999V
Item
Document

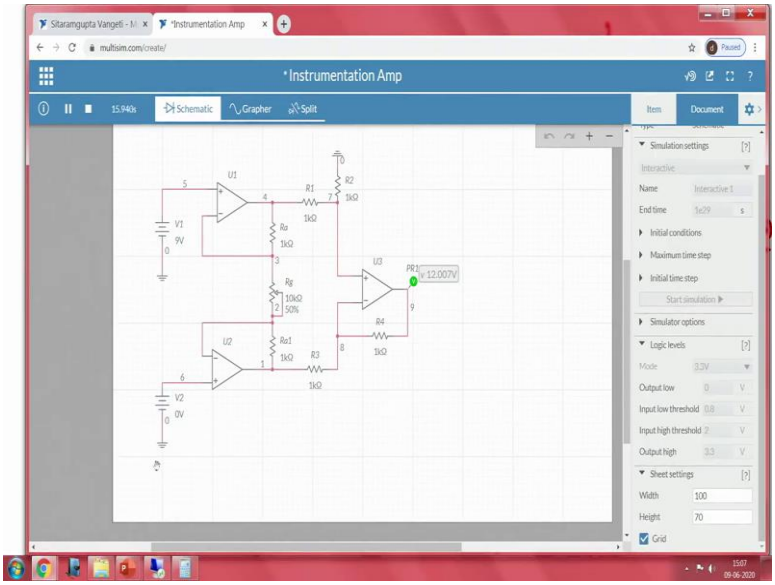

Instrumentation Amp
Schematic
Grapher
Split
13V
10V
PR1
v 2.3526V
Item
Document


Instrumentation Amp
Schematic
Grapher
Split
Calculator
View Edit Help
4.2
13V
10V
Item
Document


Instrumentation Amp
Schematic
Grapher
Split
V1 Voltage: 10V
V: 495.05nV


Instrumentation Amp
Schematic
Grapher
Split
V2 Voltage: 10V
V: -1.4000V


Instrumentation Amp
Schematic
Grapher
Split
V2 Voltage: 10V
V: -1.4000V

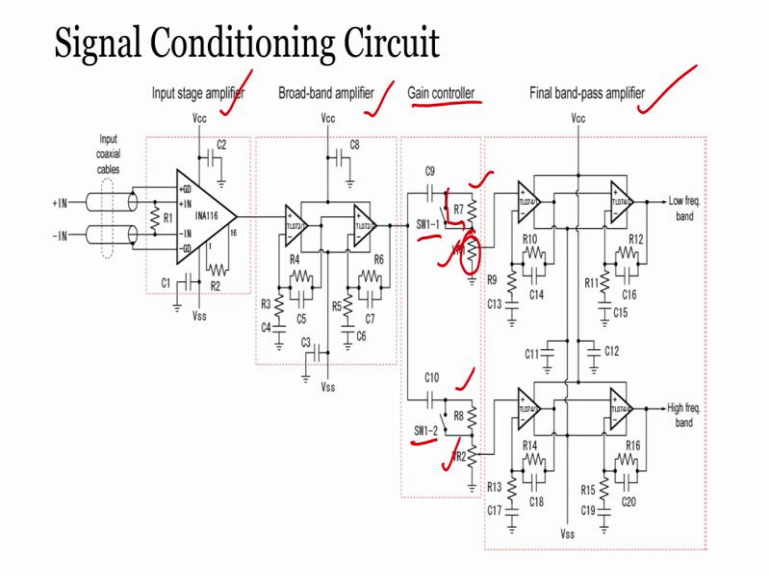


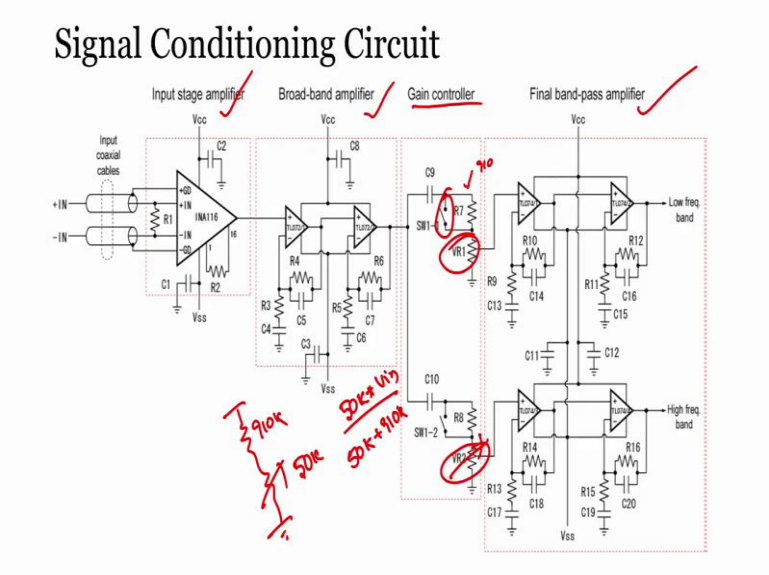
So, in the real time we can also for the change values of V1 V2 so, V1 let us say 2 volts I will change it to 3 volts this will be positive 1.4 this let me make it as 5. 5 - 3 2, 2 into 1.4 2.8 this I will change it to somewhere around 7 positive 2.8 this I will change it as 10 4.19 this also I will change it to 13, so 13 minus 3 into 1.4 4.2 here already it is a saturation.

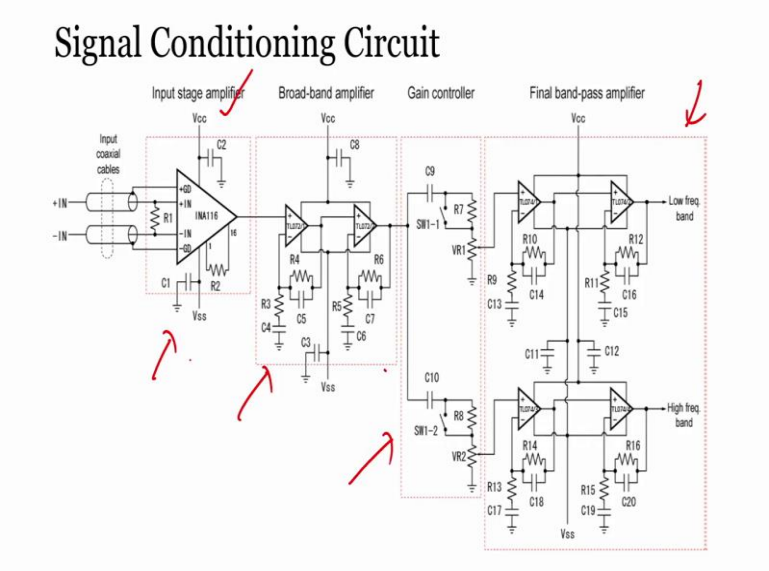
So, 9 minus 0, 9 into minus 1.4 the value is of 12.6 since the plus or minus VCC is 12 volts and it can only show the maximum, maximum 12 volts at this point. If I further increase the saturation voltages or by changing the op amp positive input voltages, plus VCC and minus VCC we can see the change to 12.6.

So, this is how we can understand about this is how we can analyse any kind of a circuit using circuit simulation software provided the data base relevant to the component that we have selected in the you know in the circuit is available. However, this are the some of the generic you know op amp configuration it will be inside the 3 terminal which will be inside any instrumentational amplifier.

(Refer Slide Time: 42:40)







So, now when we come back to our slide. So, we finished about the input stage amplifier configuration the working of instrumentational amplifier we have also finished about we have also seen about a broad band amplifier and final pass amplifier and since we know about the gain controller part, so the idea of this gain controller is to act as a attenuator aware, it has been provided with SPSC switches two SPSC switches and R7 and VR1.

VR1 and VR2 are the pots 100k pots and R8 it is a 19 kilo ohms resistance R8 and R7 so the idea is that whenever the switch is closed that means whatever the output voltage at this point will be directly connect to this terminal because current will always flow through the short circuit path, so low impedance path which is short circuit path at this point as a result the attenuation factor will be smaller one compare to as a result the attenuation will be based upon the VR1 even similarly in this case it depends upon the VR2.

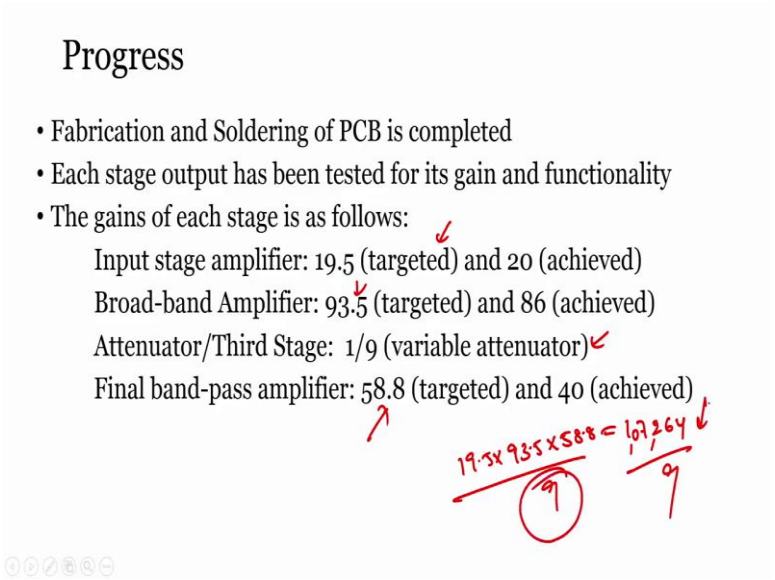
Whenever the switch is open, whenever the switch is open again when the switch is open these 9 10 kilo ohms will become in series this with the pot, so now it will become something like this. This will be 9 10 kilo and whereas this is the pot so I say we are the pot value is of 50k now the output will be 50k * Vin / 50k + 9 10 k.

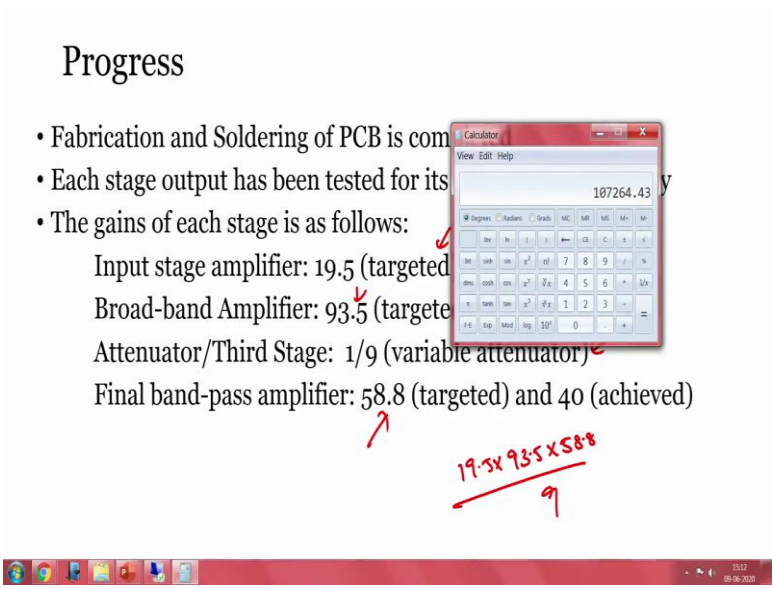
The factor of attenuation will automatically change according to the selection of switches and according to the VR1 and VR2 pots. Of course, it is not only the way that the gain setting has to be done we can also further use an another operation amplifier in order to have a different gain settings probe by changing the pot itself.

So, the idea of having a different stages is to a filter out different signals and to collect only particular frequency range of a signals at the output side, at the same time each stage will be

have its own gain as a result the total gain of this particular circuit will be the gain of this chase. The gain at this stage, the multiplication of all the gains will be the total gain of the circuit.

(Refer Slide Time: 45:08)





Progress

- Fabrication and Soldering of PCB is com
- Each stage output has been tested for its y
- The gains of each stage is as follows:
  - Input stage amplifier: 19.5 (targeted
  - Broad-band Amplifier: 93.5 (targete
  - Attenuator/Third Stage: 1/9 (variable attenuator)
  - Final band-pass amplifier: 58.8 (targeted) and 40 (achieved)

19.5x93.5x58.8 / 9

Progress

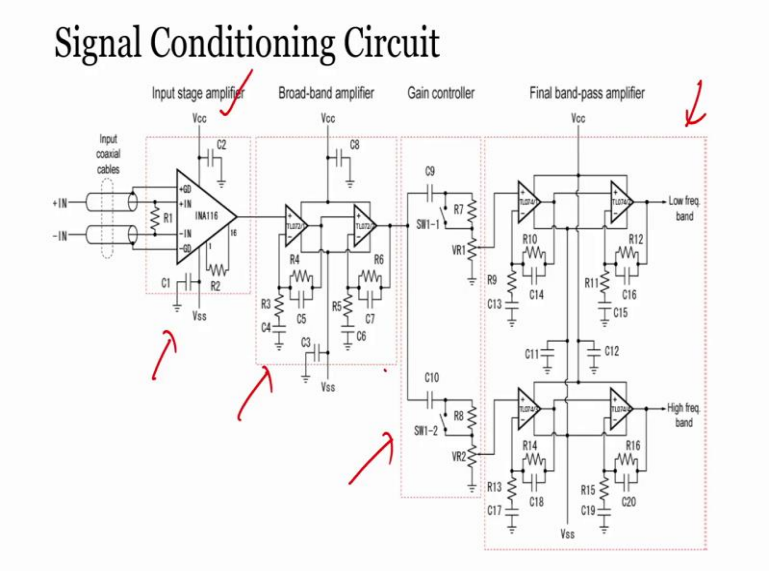
- Fabrication and Soldering of PCB is com
- Each stage output has been tested for its y
- The gains of each stage is as follows:
  - Input stage amplifier: 19.5 (targeted
  - Broad-band Amplifier: 93.5 (targete
  - Attenuator/Third Stage: 1/9 (variable attenuator)
  - Final band-pass amplifier: 58.8 (targeted) and 40 (achieved)

19.5x93.5x58.8 / 9

Progress

- Fabrication and Soldering of PCB is com
- Each stage output has been tested for its y
- The gains of each stage is as follows:
  - Input stage amplifier: 19.5 (targeted
  - Broad-band Amplifier: 93.5 (targete
  - Attenuator/Third Stage: 1/9 (variable attenuator)
  - Final band-pass amplifier: 58.8 (targeted) and 40 (achieved)

19.5x93.5x58.8 / 9



So, when we look into the gains of each stages when we consider input… based upon the design, based upon the resistor value that we have selected the targeted input stage amplifier is of 19.5 the target broad band amplifier stages of 93.5 and the attenuator third stage which act as an attenuator in this case is of factor of 9 and the final band pass filter is of 58.8.

So, when you multiply all the factors. So, 19.5 * 93.5 * 58.8 / 9 is the total gain of the operational… of the stage. So, the value of this is so somewhere around

19.5 93.5 into 58.8 divided by 9. So, if we do not consider the attenuator factor the gain of this stage is 107264 without this 264 / 9.

So, this attenuation factor will decrease a gain of the overall circuit, so this is the idea of this is the analysis that we can understand from the circuit that we have used for acquiring EEG signal and conditioning the EEG signal, thank you.