Electronic Systems for Cancer Diagnosis
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Lecture – 42
Experiment on Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computing BPM

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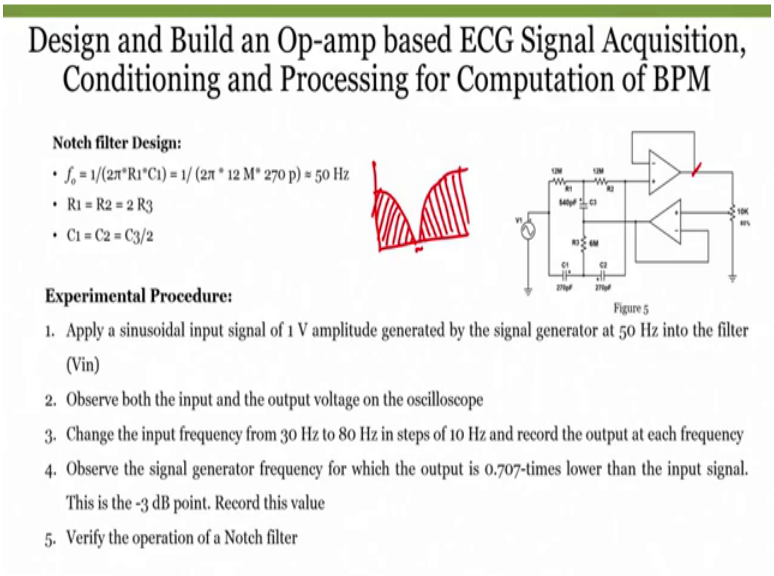

Now, we will see other step in our signal conditioning and processing unit. So, if we recall our block diagram if you go back to and visualize a block diagram we will see the ECG amplification sometime later by the end of the experiment.

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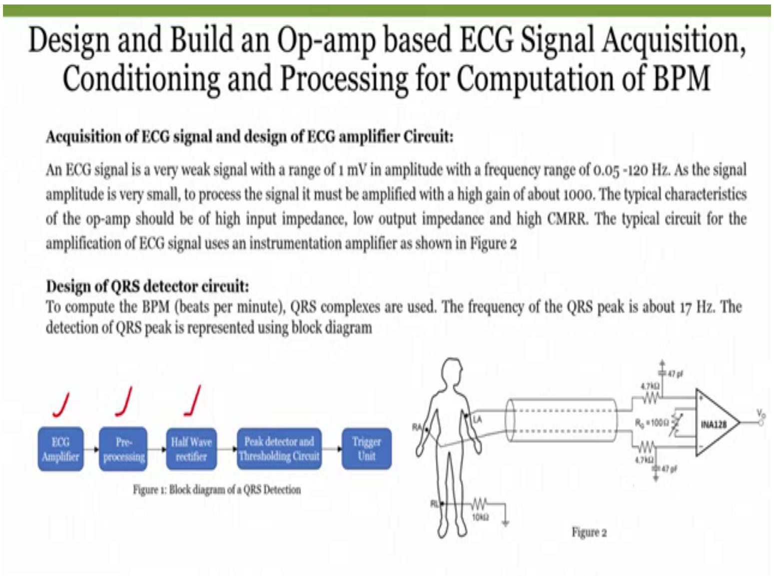

And we have done the filtering part which is nothing but a preprocessing part which are we require especially like low pass filtering, high pass filtering as well as notch filtering. Now next step is what? If we recall our previous session we require in order to find out our BPM we require to know the QRS peaks.

How many number of QRS peaks obtained within a minute gives the measurement of our BPM. So, in order to find out the PPM value how do we determine this is our peak QRS peak and we when we see that peaks can be either a positive peak or negative peaks; generally, negative peaks are called valleys, but when we design a circuit no matter what either it may give the positive peak or a negative peak and since we are interested only in a positive peak values, if we can pass through an half wave rectifier the negative peaks will be completely removed off.

So, that is a reason we are interested in or we have to design a half wave rectifier, but it is not mandatory to have an half wave rectifier, even simply we can go with a positive peak detector and a thresholding circuit and we can implement that too without having a half wave rectifier too. But if you have a half wave rectifier, we do not even have to worry about the negative peaks at all. So, now, how do we do an half wave rectification, half wave rectification using an op amps?

If you remember op amp generally in case of any rectification, the first and the important passive element the important active element that we take is nothing but a diodes; diode place and measure role, diode place active role, even in case of our filtering from AC to DC. So, one step is a rectification, where half wave you know by using a diodes we will convert our AC signal into pulsating DC right.

So, the problem with simple element is impedance matching, so that is a reason. If you want to at a if you want to have some gain as well as some kind of an you know impedance matching rather than having a simple you know of diodes if you can go with an diodes with an operational amplifier it will always have a better advantage.

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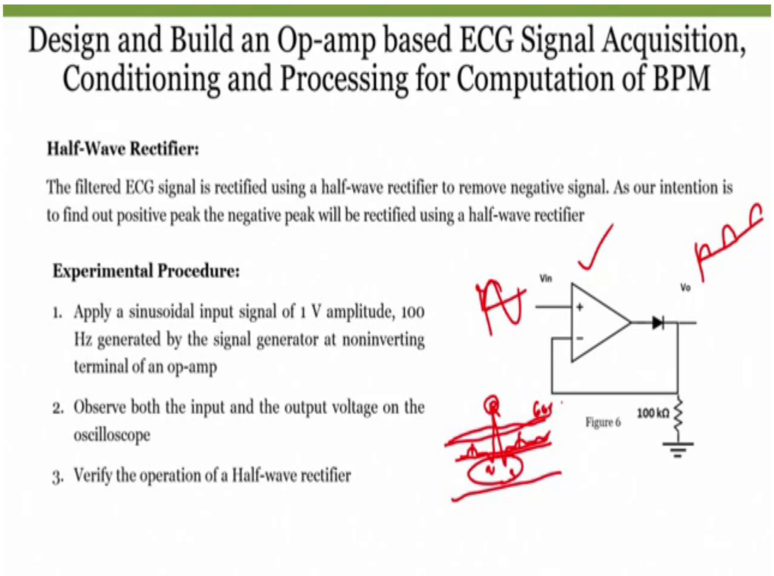

Now, if you see here you know half wave rectifier, so since we require to remove our negative remove negative signal right, as our intension is to find our positive peak the negative peak will be rectified using this half wave rectifier. Now how does it work? If you clearly see that right, the input is connected to the positive terminal and forget about the diode right now, how does it if this diode is not that.

How does it look like? It is nothing but our half wave rectifier; sorry it is nothing but our voltage follower. Now how does an voltage follower works? What are the input that you give output will also be the same. So, and the gain of the voltage follower is 1. So, what are the input amplitude, the output will also have the same amplitude with us not having any change in the shift phase shift. The reason is the output is applied with the positive terminal, but now in this case if you clearly observe there is a diode, only one particular amplitudes will be allowed and the amplitudes below and the negative amplitudes cannot be allowed right.

So, when the diode is in a forward bias condition it will allow the input signal. When the diode is in reverse bias condition it will not allow it right. So, to understand about the circuit what we do is that, we can understand; for example, like say if the input is a positive peak, what suppose to be the output? It should also be positive peak right. Now because of this positive peak that diode will be in forward bias condition so that we will get a positive peak. Now during a negative peak since it is voltage follower right we will get a negative and diode will be in a reverse bias condition. So, we will not get anything right, but diode will have some cut off ok.

Ideally speaking we will not get any negative and similarly another positive peak. So, as a result when we pass through the circuit we will get only a positive peaks right. Why do we have to go with the circuit? Because when we see our ECG signal, ECG signal will also looks like something like this. Since our interest is only this QRS peak right and we do not have to consider the negative and this is nothing but our unwanted signal.

So, what we can do is that we can remove this particular the signals which are lower than this value right. So that means, the negative values can be completely eliminated removed by using this our half wave rectifier. So, to understand that we will do you know simulation. Now what we require? We require a diode. Let me take op amp as well as diode, let me take op amp as well as diode then we require a resistor.

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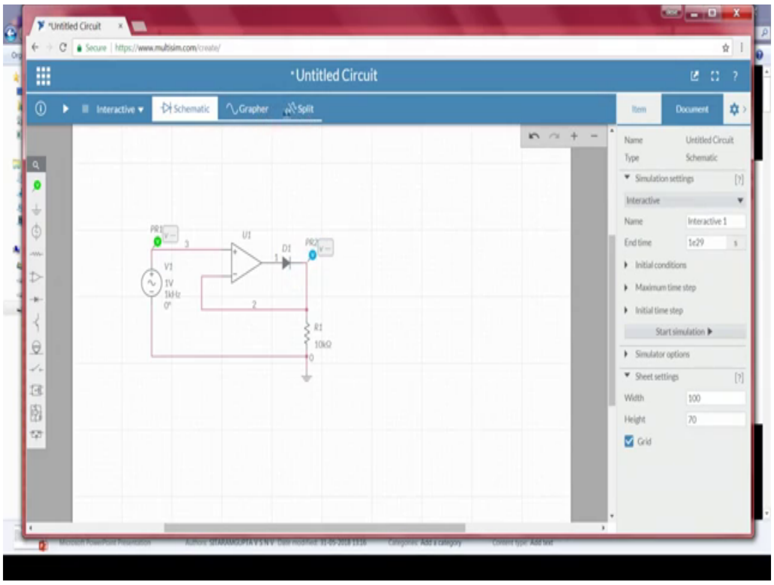

So, negative terminal should be connected here and this is Rl, the resistance value is more than that of this point, even we can go with a 10 k it should not load the input, so let me take it as 10 k resistor. Now to understand the working of the diode working of our half wave rectifier what we do is that we will connect a sinusoidal input free signal working of the circuit, connect a sinusoidal input signal right.

And the peak to peak values 2 volts because this signal is generally used to represent a peak voltage itself. Since, so since we require the positive peak a negative peak as an input signal so that easily to understand whether it is passing only the positive peaks or positive as well as negative peaks. So, we can take peak to peak as 2 volts then to visualize both the input and output I am connecting green; green represents are input signal and other one blue represents our output voltage.

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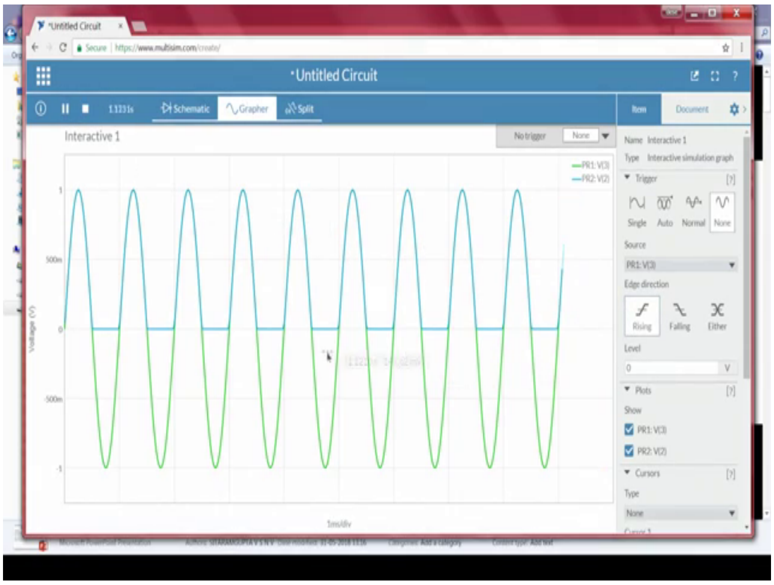

Now when we go to the grapher and run the circuit right, if we observe the green is nothing but our input and blue is nothing but our output. When we see that the green is completely right full wave with a peak to peak of 2 volts right peak to peak value as 2 volts, but whereas, an output if we observe it was only allowing a positive peaks to flow whereas, a negative peaks is completely removed off.

So, even if you consider the ECG signal in the same way only the positive portion of the ECG signal will be allowed and the negative portion of the ECG signal will be removed. So, that now it is easy to understand the positive peak from the data from the signal and we can set a threshold. Now here comes our the thinking. Why? The reason is, when we recall what we had discussed about our ECG signal till this part is ok, but how do we find out this particular voltage is a peak and how do we set a threshold to the system right. So, as we know that if we keep a capacitor, capacitor will charge to what value? To whatever the output we receive.

So, from that we can understand that if we use a capacitor if the voltage is increasing capacitor starts slowly right. So, it will since if we do not create any discharging path whichever the voltage that we get highest voltage that we get capacitor will be charged to the highest voltage value that is good enough. So, it is easy to understand the highest peak in a ECG signal. What I mean is that suppose if I pass the signal to a capacitor, so, if I if the complete signal is passing through this since the maximum voltage is at this particular value right and if I do not create any discharging path the capacitor will always at this particular point. But how do we set a threshold right?

The idea is that if I can set a threshold if we recall what we have discussed in our first session of our experiment, if you recall, if I can set a threshold and if I can find the peaks how many number of peaks above this particular threshold points that completely gives our the number of peaks in particular duration of time. But why do we have to consider? The reason is when we see the peak, this also will be considered as a peak this also considered as a peak right.

So, if I do not consider the threshold even these things can also be considered as a peak and it is very hard to understand the BPM correctly and accurately. So, that is a reason as we all already know that the QRS peaks is very very long or having a very high amplitude compared to other peaks, if we can detect this particular peak our problem is solved.

So, in order to detect that we are using capacitor which shows you know the complete highest voltage. But how do we created threshold right? And if I can create a threshold, if I compare the output signal from the input signal, so, when you do the comparison whichever is the highest that I can decide it right.

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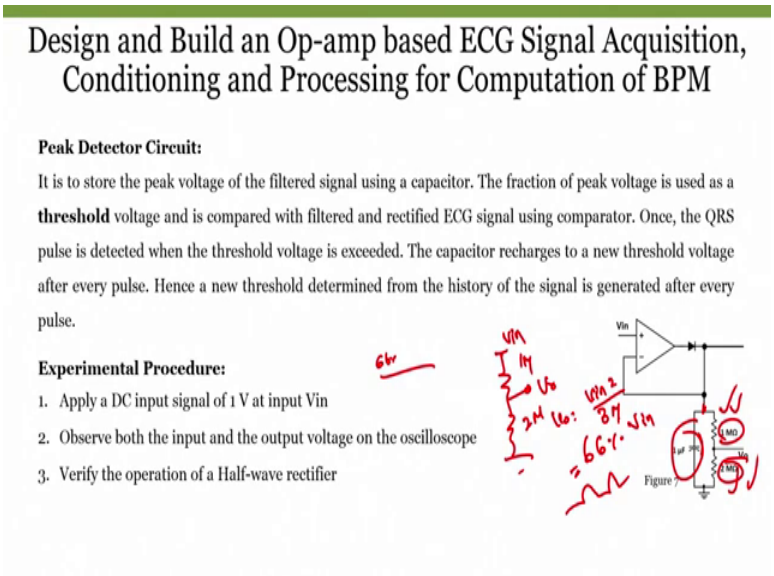

So, if we see the logic to implement it, so this particular capacitor part will charge and the purpose of this 1 mega and 2 mega is to provide is to provide threshold, but what percentage of threshold we are doing here? So, if you observe suppose if I say this is nothing but voltage divider circuit 1 mega 2 mega; if I say this is Vin, so this is what V out. Vin is that the charge across our capacitor right the capacitor will be charged to the r voltage value let us consider that Vin.

So, V out is nothing but Vin into 2 mega divided by 3 mega. So, 2 by 3 is how much? 66 percent right, 2 by 3 is 66 percent of Vin. So, that means, V r setting a threshold at 66 percent. If you want to set at 75 percent or if you want to set at 50 percent even we can change the resistance value, such a way that it will always gives 70 percent or 65 percent whatever the percentage that threshold in that we required for.

Now, why do we are choosing 1 mega and 2 mega resistance, why not 1 kilo, 2 kilo, 100 ohms, 200 ohms? The reason is that the input signal should not see it should not create any loading of our input signal when we choose a lower resistance value, this resistance require from current to operate right. So, because of that; because of that the we cannot it creates an loading on our input signal.

So, in order to not to have any effect on our input signal what we do is that if I can take very high input resistance it will not load our the input signal. So, rather than going with 1 kilo or 100 ohms if I go with a mega ohms, the you know the loading effect will be good, so that is why we are using 1 mega and 2 mega. So, then whatever we get is nothing but the signal which is greater than this threshold; this threshold is 66.6 percentage, so it will you will get a signal like this right. We will see what we do is that in a simulation, we will pass sinusoidal signal and we will look at this point without this particular, we will see whether the capacitor is charging to the peak value or not.

Now we will take even this particular portion this portion to attach to that and we will see whether it is setting a threshold and it is passing only the values greater than that particular threshold or not right and we will also compare with experimental results. Now we will see how to implement the circuit using a simulation, once we verify in a simulation we will see in actual way and we will do the experiment on that. So, just open multisim, if you recall the circuit what we have discussed? Just recall the circuit, so we need this particular part.

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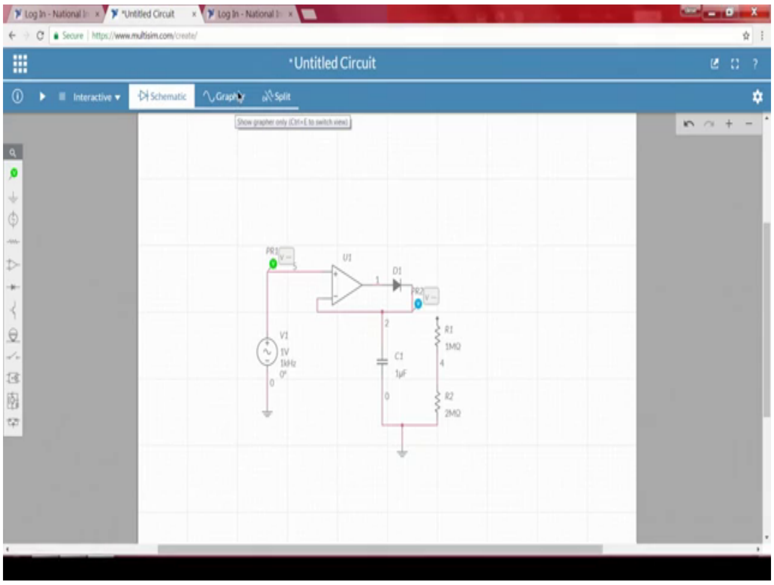

So, I will take an op amp; I will take op amp right and I need to have a diode, so I will take a diode. Then we will take resistors as well as a capacitor. I am taking a resistor, one more resistor and the capacitor to so capacitor is also there then this resistor right, so this 2 has to be connected together. Now if you remember the purpose of a capacitor is to charge to a peak value, so which are the value that we are that ECG signal peak value is there that will be charge inside the capacitor.

Now the purpose of this resistors are to provide a threshold, now we are setting a threshold using 1 mega ohm resistor and 2 mega ohm resistor. So, when we calculate if you recall it is somewhere around 66 percentage right. So, I am taking 1 mega as R1 resistor and 2 mega as R2 resistor, now we have to connect this terminal to this one right. So, this is the input signal. So in order to takes the circuit what we use? We generally go with AC voltage.

So, let me connect the AC voltage here connecting here and we also need a ground, so I am taking ground connecting here from here to here and even this part should be ground. So, what we have to do in using the circuit? What we have to measure? We will see what is the output voltage at this whether when I change the voltage of the input whether the capacitor output. So, in order to understand what I do is that let me remove this part this particular terminal.

So, that there is no connections here, so we can easily see whether it is following the peak or not, then we will make this connection and at this particular terminal at this particular junction or at this particular node right we connect another voltage output nothing but our we will connected to a probe and we will see what how the output signal looks like right. So, whether it is giving that threshold of our requirement or not.

Now, I will take 2 probes one at the input, so which measures the input voltage or whatever the input that we are connecting to the op amp positive terminal and the other one at this particular point right. So, the green represents are input and the blue represents are output of the op amp. Now to understand the circuit, let me go to the grapher and run it.

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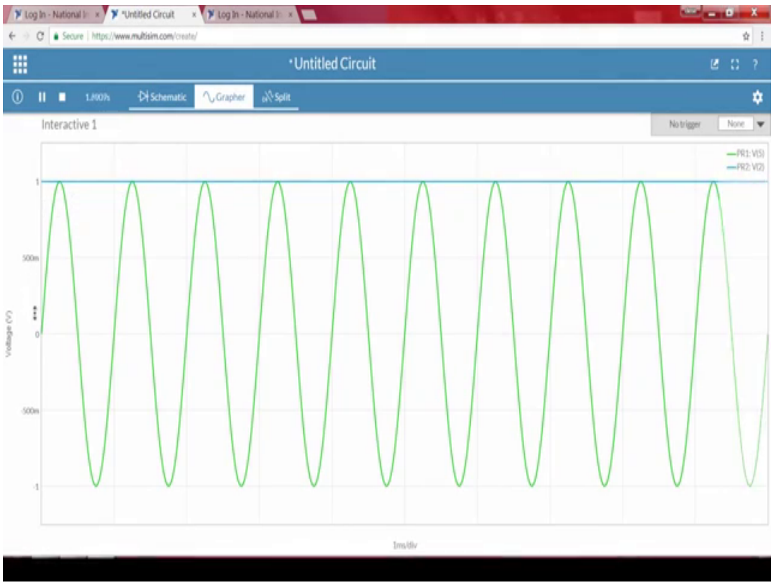

See what we can see? The green is completely input right the blue is output; output is always showing it as 1 right, let me stop it. So, if it is showing the 1, what how do we understand it?

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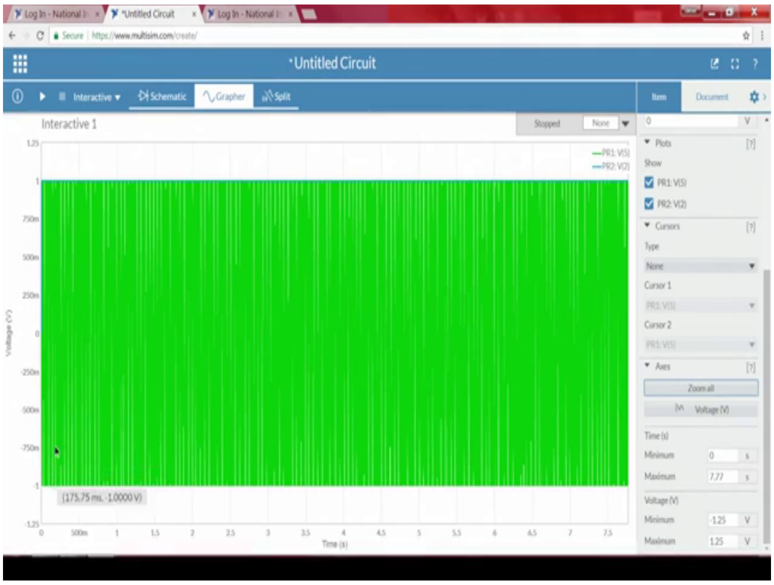

Now if I zoom completely zoom all and let me zoom only to this particular portion somewhere around 159 milliseconds right and even to 10 milliseconds I will zoom right, if you observe the output initially it is keep on increasing; keep on increasing meaning it is charging the capacitors charge charging; charging; charging and it's charge to value of 1. Why only to 1? Because the input voltage the peak voltage that we applied is only 1 volt.

And since we do not have any discharging path, since it is a maximum voltage that the output is providing it is the capacitor is always at this particular point. What if I will change in my output? Right if I change sorry what if I change my input? If my input voltage change, if the input voltage is 2 volts slowly again the capacitor charge charging to the 2 volts value why do not we see that? So, the whole idea of the circuit is to find out the peak value and the purpose whether it is the purpose is solving or not let me check. So, let me run continuously and I am running it continuously.

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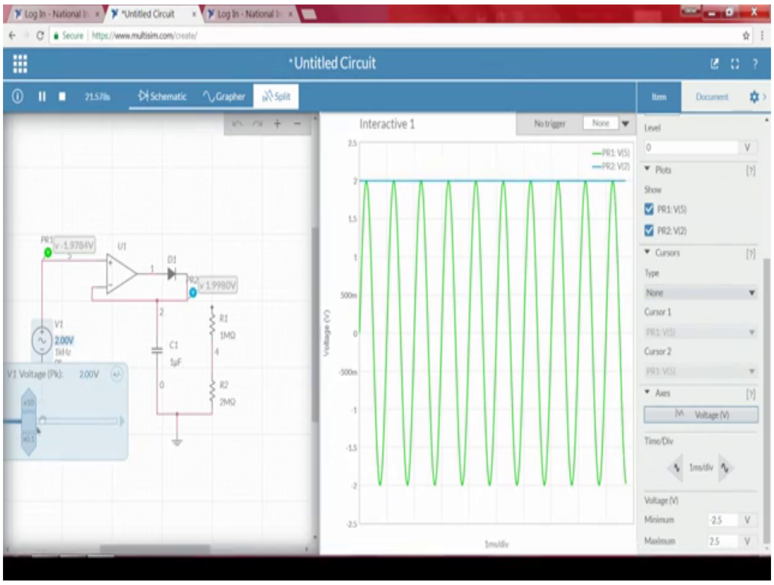

Now, this voltage I will change it to 2 1.05 2 slowly to 2 value 2 volts now it is a 2 volts. Now, let me change the settings of the graph 2 voltage if we observe now this capacitor started increasing to a value of input peak value right is not it. Now what if I decrease? Let me decrease right. Now the capacitor started slowly decreasing because the input voltage now is very smaller and the capacitor will also take some time to discharge, so because that until depends upon the discharging rate. So, that is why started discharging and again continuously maintaining the value of the peak. So, that means, one part it is clear that whatever the peak voltage that we are getting, the capacitor can the capacitor will charge to that peak value right.

Now, what is other purpose? We have to see whether it is providing the threshold of our requirement or not. So, in order to understand whether it is providing or not what we do we will connect this R1 resistor and we will take another output voltage connected this point.

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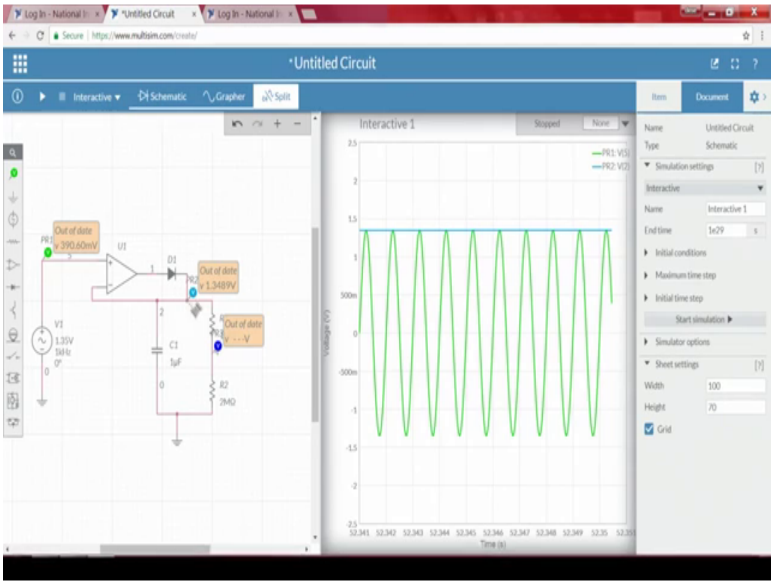

Now, this particular terminal I am not interested in I do not have to. So, what I will do is that let me run and even if it is a no problem for us this right, so this indicates our the output voltage at this particular point and the violet colour indicates the threshold; that means, the output voltage at the threshold, at the junction or note point of both the resistors 1 mega and 2 mega. Now based upon our calculation; based upon our calculation what is the threshold value? So, as we if we recall the potential divider circuit it is nothing, but Vin into R2 by R1 plus R2.

So, in this case Vin is for example, like say Vin is 1 volt and R1 is R2 is 2 mega R1 is one mega 2 by 3 2 by 3 is 66.6 right. So, that; that means, if the input voltage is 1 volt the output, the threshold point is somewhere around 0.66 millivolt 60 660 are 0.66 millivolts right. Now, so to understand that let me change the input voltage to 1 volt, now observe right 664 millivolt; that means, it is it is properly following the required or whatever the threshold point that we set right.

If the input voltage is changing even the threshold value we will change and how fast it changes everything depends upon the capacitor value that we choose that we have chosen there. So, in this case we have chosen one micro one micro farad capacitor right. So, another requirement in order to do the signal conditioning circuit or signal processing circuit of our ECG is completely full field using this circuit right.

Now, what is other part; what is other part? Now once we detect, once we understand which are all but which are all voltages are which are all the input signal is greater than this particular threshold only those output signal has to be passed right. Now, we have said this now, what we have to do? The input signal should be compared with this particular threshold value and whenever the input value is greater than the threshold value only that particular value has to be pumped out. So, in order to do that what we have to use? We have to go with a comparator simple comparator is enough we do not have to go with any (Refer Time: 22:45) or anything.

The reason is we are not setting any 2 thresholds here we are using only single threshold, if the input value is greater than this particular value only that particular signal has to be passed and that has to be detected and that has to be counted. So, depends upon how many number of such a pulses are we are getting and if you use a counter there then we can automatically see the number of pulses we are getting per second or per minute anything. Now in order to do that we will implement other part of our circuit, when we look into our presentation right this particular part we have seen.

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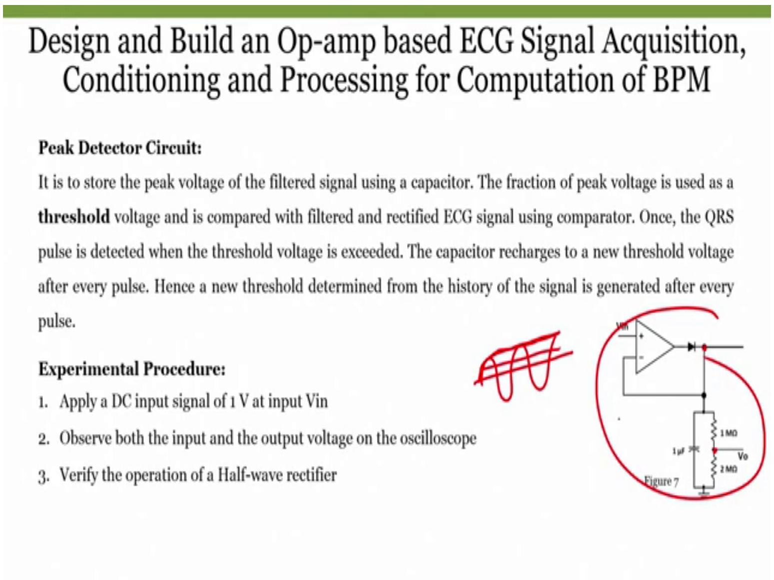

And if the input signal is sine wave; if the input signal is sine wave right then at this particular point the output will be completely because of the capacitor because of the capacitor the output is charge to the particular value that is nothing, but the peak value.

So; that means, we could able to see the peak value, now this particular point we can also created threshold.

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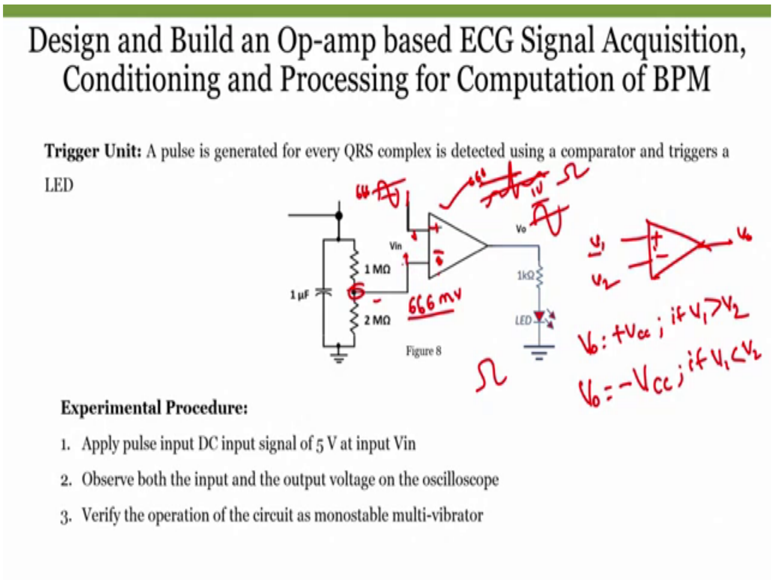

Now, next part is identifying; identifying and generating a triggering pulses, if the input voltage is greater than the particular threshold value. So, in order to do that what will be using? We will be using a comparator. We will compare the input signal sorry the input signal with this particular threshold right. So, how a comparator works if you recall the working of a comparator and if I observe this let us see this is plus or minus this is V 1 and this is V 2 and this is V naught, if you recall. So, the V naught will be equal to plus V cc if V 1 is greater than V 2 right and V naught will be equal to minus V cc if V 1 is less than V 2.

Now, in this case if I see V 1 is nothing, but our threshold right, so positive terminal is v 1 and in this case positive we have connected to V 1; that means, the threshold values 666 millivolt and V naught is what V sorry and our V 2 is nothing, but the input signal or the positive PQRS wave right only this particular part. Now when we are passing that we will get a peak only when this particular input right input is greater than this value right.

So, when the input signal is greater than 666 millivolt, so say this is 666 millivolt then we will get a peak value pulse. Now, we will see whether we are getting it or not. So, what I will do is that will implement the same circuit. So, if you remember so this particular portion will implement now right.

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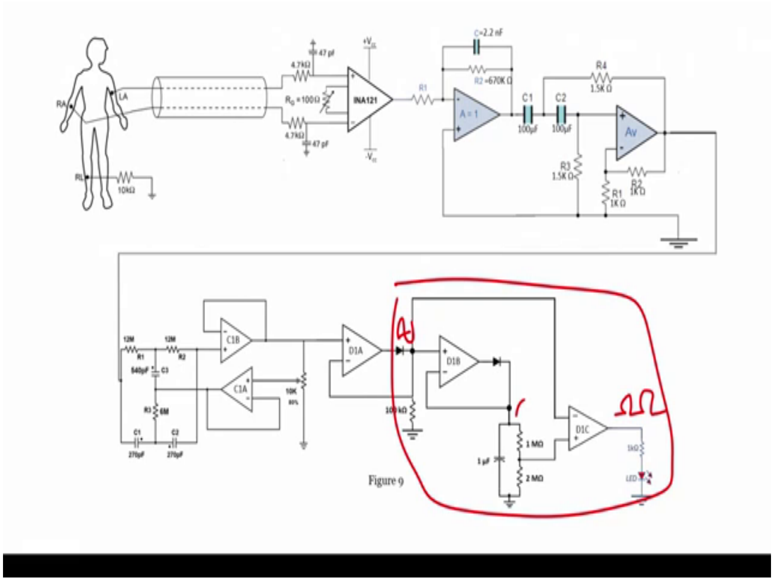

So, here we will apply the input actual input signal right, this input signal we are applying and here it detects a peak and it generates a threshold that we will compare with the input signal and whether we will get pulses only when the input is greater than that or not we will observe that ok. So, I will go to multisim once again let me save the circuit right.

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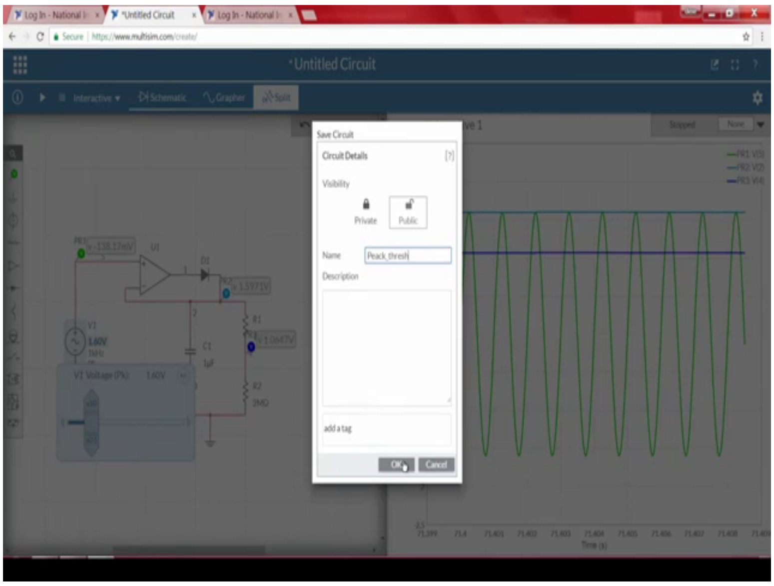

And opening a new file or to this itself we can create extinction of it by using another comparator. So, I will go with schematic and I will take one more op amp right.

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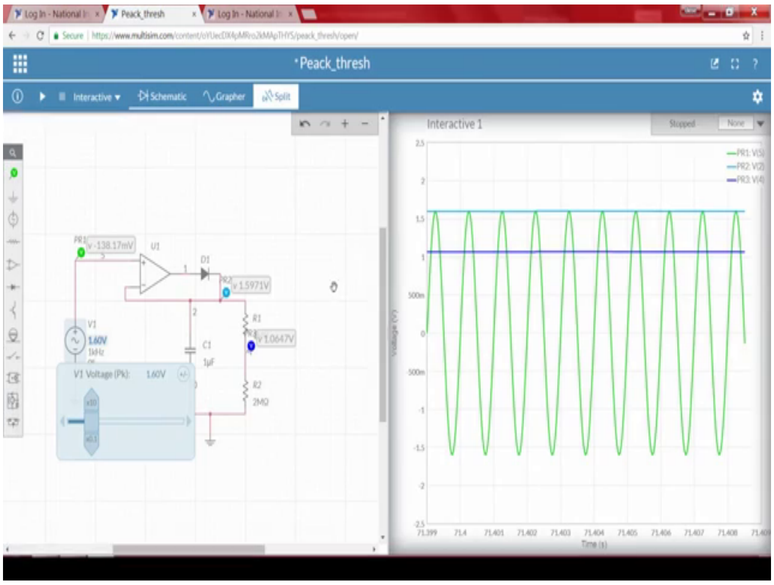

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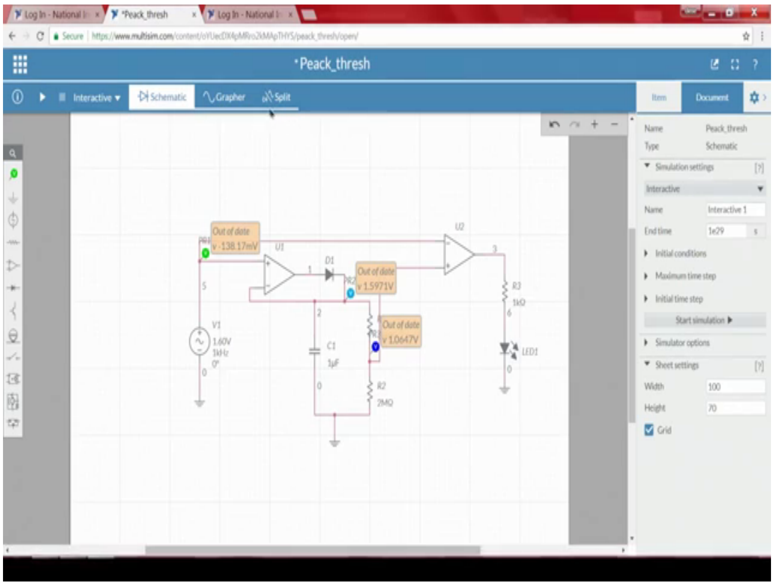

So, let me flip it and the negative terminal when you look into our circuit if we see the to the positive terminal we are connecting we are connecting the threshold value and to the negative terminal we are getting connecting the input signal. Now, so just to identify what I will do is that I will take one more resistor some rough 1 k value and other terminal I will be connecting it to the ground or you can connected to we will take the same circuit itself, we will take LED.

So, I will take an LED connected here and one more ground let me connected here. So, color is red that is cool, now when I see let me run it.

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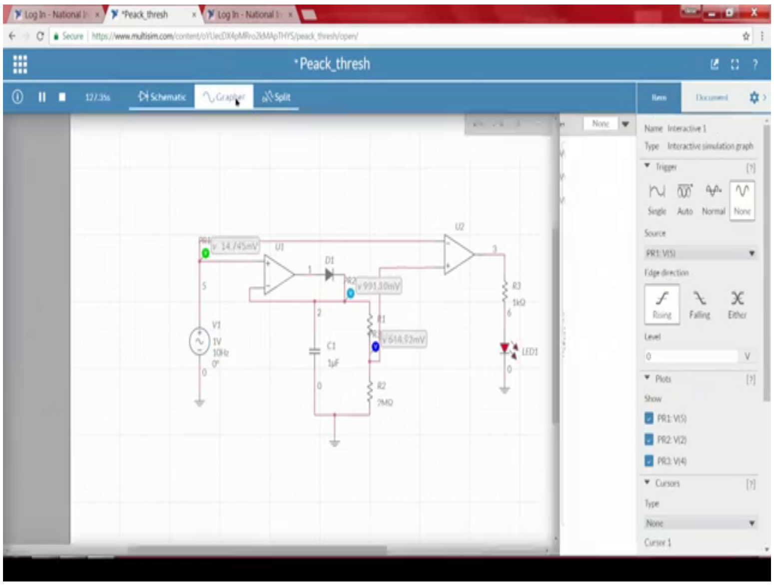

So, since the frequency is very high we can see it continuously glowing. So, make it as frequency sorry 1 volt I will say 1 volt right, then this one let me decrease. So, we have to one like, so 100 hertz this is also really higher to understand, so let me make it as 50 even that is too much 30 go to graph.

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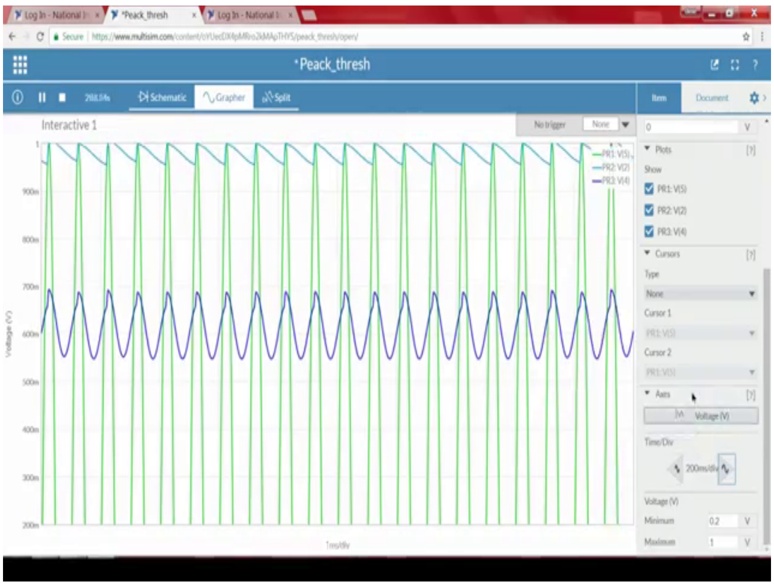

And here let me change, let me increase the time division these to understand, so what is happening here that we have to understand. Now so we have not connected voltage source here. So, let me remove everything right, so I will take one more voltage source connected this point I will take one more voltage source connected this point, now let me go to the split voltage right.

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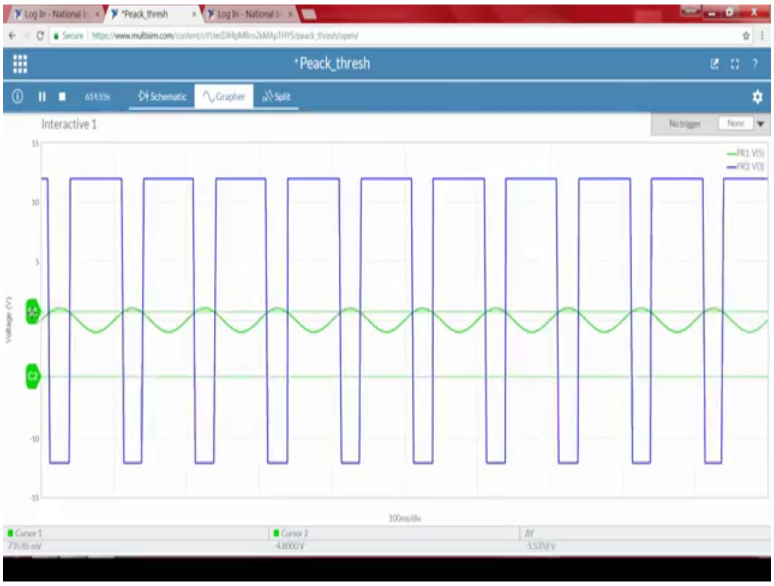

So, zoom it, so to understand this how do we understand? If I want to understand this, what I have to do is that I have to create a cursor the input voltage is 1 volt. So, the cursor is I will take y axis cursor and I will keep somewhere around if you observe the cursor value it should be somewhere around 600 and 66 millivolt ok. Somewhere around roughly 6079 and let me zoom little bit, so that easy to understand for us make it as auto or single yes.

Now what to understand? One thing is clear that the C1 represents are threshold and the green color represents are input signal, what about the blue color blue is nothing, but our output. Now what is happening when r whenever the input signal is greater than that; whenever the input signal is greater than the threshold value what is happening? It is going to minus V cc right and whenever the input signal is lower than that it is going to plus V cc.

The reason why because we have used positive input here if you observe the negative terminal is connected to here where the positive terminal is connected to the threshold.

Now when we recall our comparator working one thing we are sure that the e output will be higher only when only; when the input signal is greater than this particular value right that is what that is what we even we have seen in the calculation.

Now to quickly understand that why do not we take some values? So take a sine wave I am taking a sine wave. So, let us say the value is 1 volt, so I am applying a sine wave 1 of 1 volt and the threshold value is 660 millivolt, now this is positive right. So, in order to become plus V cc V naught to be plus V cc when it will become only if the input is lower than the threshold in this case right.

Suppose if the input is 0.5 volts V, so we are taking V 1 as positive V 1 will be higher and this value will be lower as a result v out will be plus V cc. So, that is a reason, but we require in a volt away so; that means, if I make this is a positive and this as a negative righ. Then what happens? Since it is 666 and this is the sinusoidal wave till when the input, so this is a threshold in order to become V naught as a higher the input voltage should be greater than the negative value only then it will become higher.

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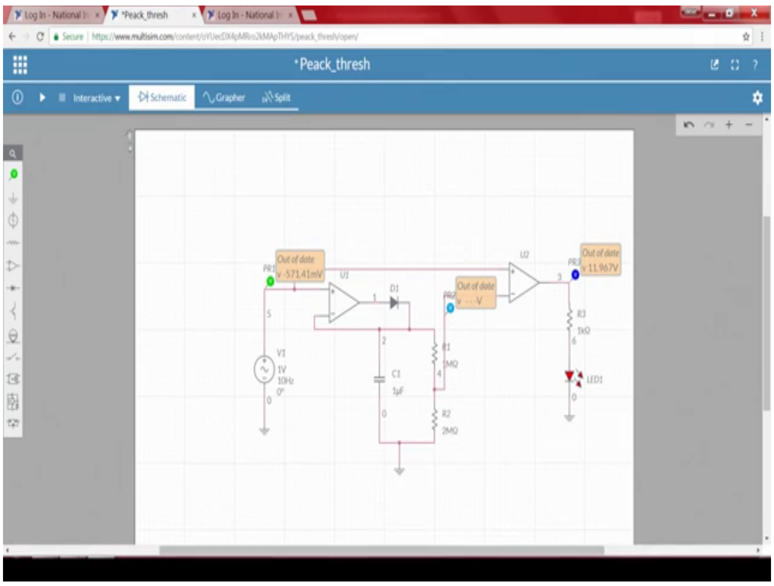

Now let me go to schematic just stop the circuit, I will change I will swap the terminals this particular terminal should be connected to here and this is here and this particular terminal should be connected here right there is a input. And here I am going to measure the threshold value and this is now let me run it, so graph a.

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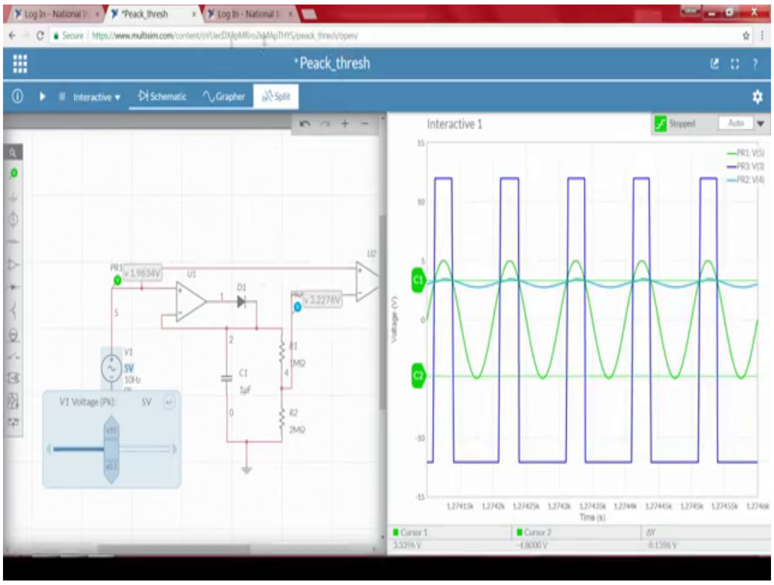

Now, see what is happening yes when we observe C 1; C1 is at it what point? C1 is a 679 79 millivolt, so we require 666. Now when we see the output is becoming a higher only when the input is greater than this particular threshold. Now what is other colour behind that value behind the C1? That is our blue colour that is for the threshold. So, here if you remember the schematic we have used one at this point other one is at this point light blue sky blue and dark blue. So, here if you see this is the output and sky blue colour is somewhere here, so that is our threshold right.

Now, whenever the input is greater than the value we can also see the LED is keep on blinking it right, if I change the input voltage even thresholds everything will change. So, let me make it as 5 and change this to auto right we can see threshold is also changed and even right this is the input and this is the threshold and this is the output that we are getting it. So, that means, that the thresholding part everything is working fine for our application. Now we will see experimentally right we will see experimentally of complete circuit.

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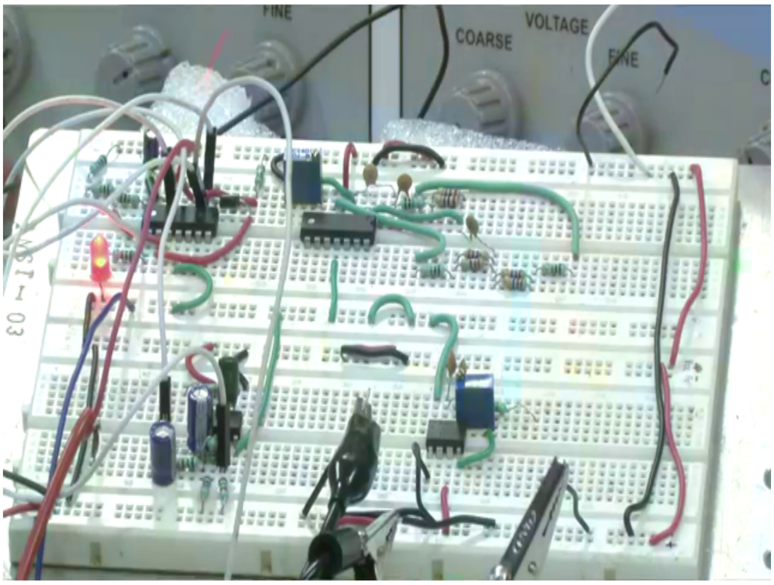

Now, if you see the next part of this particular portion, so we are using a diode right and we are also using a resistor right, this the diode and the first quadrant portion of the op amp is using that you know the half wave rectifier portion. So, in order to verify that the circuit what we do is that? Now the input we will connected to the input signal we will connected to the input of operational amplifier that is at the pin number 3. So, what I will do is that I will take the input sinusoidal signal to 3 volts to the third pin. So, the third pin is somewhere here and this is the output and which is the output in this case the output is after the diode.

So, there is somewhere around when you recall the circuit the output is the cathode terminal of the diode right. So, the cathode terminal of the diode is connecting it to the second pin; second pin is are nothing, but a inverting terminal of our op amp. Now if you see that in this case I will take one more wire or I will take the second CRO probe and I will connect the second CRO probe to the third pin the second pin.

So, third pin is input, so I am connecting it to the third pin of the input signal and the second pin is the output I am connecting it there right. Now so let me auto said it, so, we can keep it keep it at any frequency there is a no problem.

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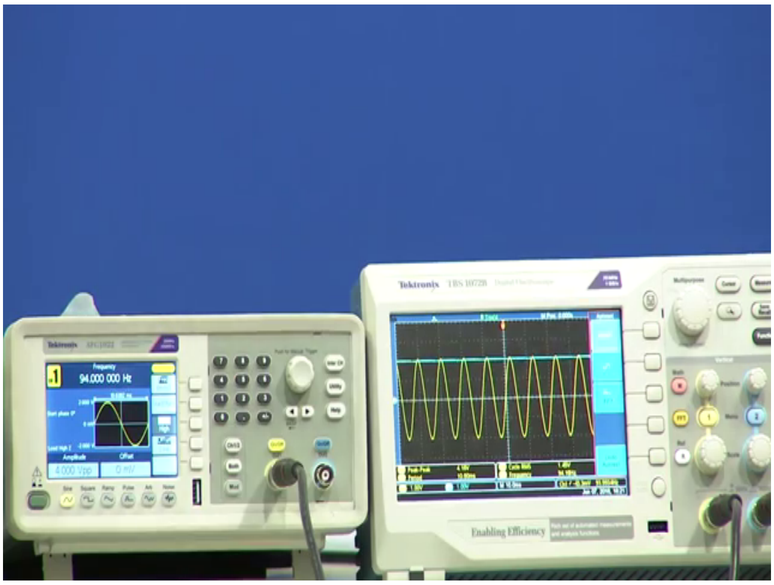

When we look into the oscilloscope so what I will do is that, I will change a little bit down to the same value, from the signals it is clear that right only 1 peak we can see in the output; only 1 peak we can see in the output and other peak we cannot see that there is because of a rectifying. So, we are we are removing complete negative peak signals of our input signal by using a simple diode why? The reason is that we have to find out only the positive peak we do not need negative signal processing in this case.

So, that is the reason we are going with the removal of a negative signal. Now if I observe, so there is no negative signal when are there is a negative signal in the input the output is 0 and positive signal it is passing through output is 0, when there is a negative again. So; that means, it is completely removing our negative part negative peak of our signals negative signals at all. So, even if I change the frequencies no matter what frequency that you are at.

So, it can only pass positive frequencies not the negative frequencies sorry pass 2 input signal not the negative input signal right. So; that means, that particular portion whatever we have seen in the simulation and what we are seeing in our experimental the peak then the half wave rectification is completely done. Now what is an expert that we have to see after passing through the half wave rectifier we have to find out the peak. So, in order to the finding out the peak we if you remember we are using a capacitor.

Now in this case, if you see here the other part of the operational amplifiers in the board right when we look into the board, right. So, this part we are using a capacitor and we are using the resistors of 1 mega and 2 mega right. This combination this particular combination we will give us the peak the you know the peak detection as well as the thresholding. So, now, what I will do is that, so since we have already connected to this terminal and the output of this is connected to the next portion of our circuit it is nothing, but the peak detection.

So, it's already connected using the white colour wire here the output of this and now what I will do is that the output of CRO, we will take the output of CRO . So, we will connect this particular point to the cathode or the 6th terminal in this case. So, this is my output right when we see that when we look into the oscilloscope, the input is yellow color input is are yellow and the output is the sky blue in colour right, we can clearly see that.

Now the output is very the output is completely at the peak value of our input signal. Now what if I change the frequency? It remains the same. What if I change my amplitude? right. So, now, let me increase the amplitude value, so right now it is the peak value of 1 volt, if you see that the peak value of 1 volt because we are applying a amplitude of 2 volts peak to peak 1 volt on the positive can 1 volt in the negative peak.

So, the 2 volts peak to peak value and increasing the voltage, so I will go to the amplitude I will change it to 3 volts; that means, 1.5. Now see the capacitor because of one microfarad capacitor it's quickly charged and it has gone to the that particular peak value. Now if I slowly increase even then we can see, so it is always, but whereas, when I am decreasing it we can observe that the capacitor is slowly discharging and, but whereas, when I am increasing it, we get see quick rapid change of going to the peak value.

So; that means, we can understand that with this circuit we can easily find out the peak value of the input signal right, so the peak detection part is done, then the next part is once a peak detection is done we have to create a threshold. Now if you recall our circuit we are creating the threshold by using 2 resistance that is of 1 mega and 2 mega resistor. Why we are using such a high resistance value? Again the reason is that not to have any loading effect into the system. So, what I will do is that, now this particular output terminal the blue connection I will connected to you know the junction the resistor junction.

So, when we see that we have connected output at this point right which is the combination of 1 mega and 2 mega resistor. So, what we are using it at the node of 1 mega and 2 mega we have connected the output, so here if you can see we have applied input frequency of 100 right amplitude peak to peak value of 2; that means, peak value of 1 volt. Now when we see the output this is this is the yellow represents our input and we can see that the output is in blue colour right the peak value is of 1 volt 1 box and the blue colour if I see it is 2 2 points, so somewhere around 400 486 millivolts we are getting it. The reason why there is difference in the at the actual calculated value and the experimental value it maybe because of some loading due to the previous stages or maybe because of the tolerances that we have that since we have used 1 mega 2 mega resistances.

The tolerance is 5 percent tolerance is enough to change the complete resistance value of that 2 different other value. So, because of that tolerances and because of some previous loading stages it is changing some other to it is going to show some other threshold value, but as long as long as even though my input voltage is changing if that is maintained constantly my problem would be or I can replace some other resistance value and we can see whether it is you know you know whether it is having the required threshold or not.

But where we apply DC input voltage and we do the experimental and we can see the complete like theoretically we can see that 666 millivolts it can be achieved and even in the simulation we have seen. Now what I will do is that I will change the amplitude to somewhere around 4 volts, so if it is a 4 volts it should be, so previously it was 400, now it should be 800 right.

Now, if I see previously it was it was in 2.2 levels now it has moved to the 4 levels. So, closely towards 1 volt, so somewhere around 800millivolts. So that means, when the input is keep on increasing the, the threshold value is also increasing let me change to some other value 6 so it is 1.2, right. So, either may be because of the previous loading or because of you know the tolerance is due to the resistance value the threshold value expected and the actual are little different, but by put by putting some pot some potentiometer we can even you know set it to the required threshold value in this case.

Now what is the other stage that we have seen? Other stages we have to pass through the comparator. So, we have to connect the negative input to negative input of an op amp to this particular point and the positive input to the input signal. So, that when we do in that connection we can see the output of an op amp to plus cc state right whenever the input is greater than the threshold. So, so what we do is that when we look into the board, what we do is that we will connect the positive terminal to input terminal. So positive in this case is 10th terminal, so 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10. So, this terminal I am connecting it to the input right whereas, other terminal I should connected to the output I will remove this wire.

So, this is our threshold all right to this threshold point I am taking one more wire I am connecting it to this point. Now I have to measure the output, so this is my output let me auto set it when I look into oscilloscope right. So, let me keep both the things to the same point, so easy for us to understand and this point to this is changing the offset value all right and the input also I will change to the same 2 volts peak to peak, so easy to understand.

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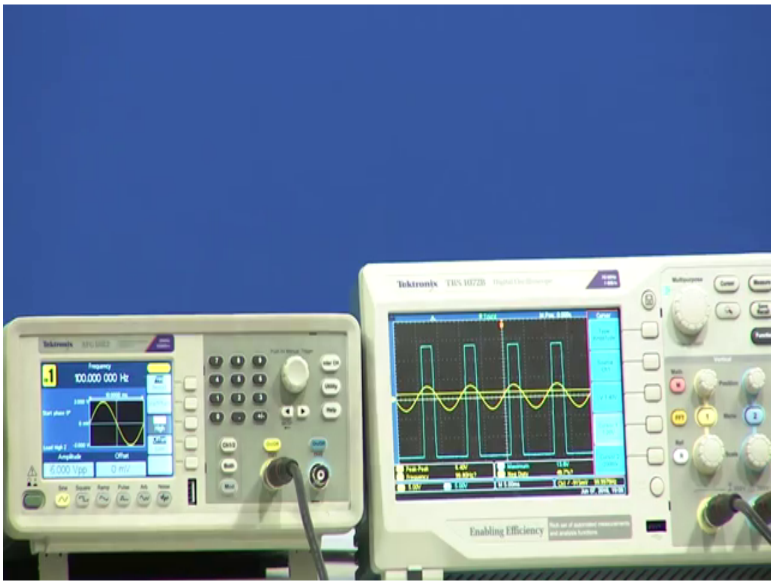

And let me change the input range to 5 volts all right so both are at the same point. So, since it is a difficult to understand what I will do is that I will change the input amplitude itself to somewhere around 6 volts peak to peak so; that means, 3 volts, so here it is clear. Now if you remember the threshold the theoretical threshold for 3 volts would be 666 millivolt into 3, but practical we are getting 1.2 volts right. So practically we are getting somewhere around to 1.2.

Now when we observe that one thing is clear that when I say if I take a cursor I will take a cursor of a amplitude type, I will just keep somewhere at 1.2 there is what theoretically when we measure we are getting sorry the practical when we measure we are getting at that point, now a place a cursor at that point it is clear that.

So, when we look into that it is clear that when the input, so the cursor yellow one when we look into the CRO this particular cursor consider it as a threshold for ours whatever we have calculated practically. Now when the input is greater than the particular threshold we can see there is a high value. High in this case is fifteen volts because the V cc and minus V cc that we are applying is plus 15 and minus 15 it’s close to plus 15.

It is slightly below plus 15 because of the saturation the output saturation will be lesser than the V cc that you are replying to that and when the input is lower than that particular value it is again going back to the minus Vv cc stage, but when we look into the board we can see the LED is continuously going glowing we cannot see any flickering of an led like on off on off the reason is there frequency when we see the frequency the frequency that we applied is 100 hertz; 100 hertz it’s a very hard to understand with our eyes.

So, what I will do is that I will change the frequency to somewhere around human understandable value. So, somewhere around 30 or 20 hertz’s, so where we can easily visualize it when I see that right since the frequency when you look into the oscilloscope.

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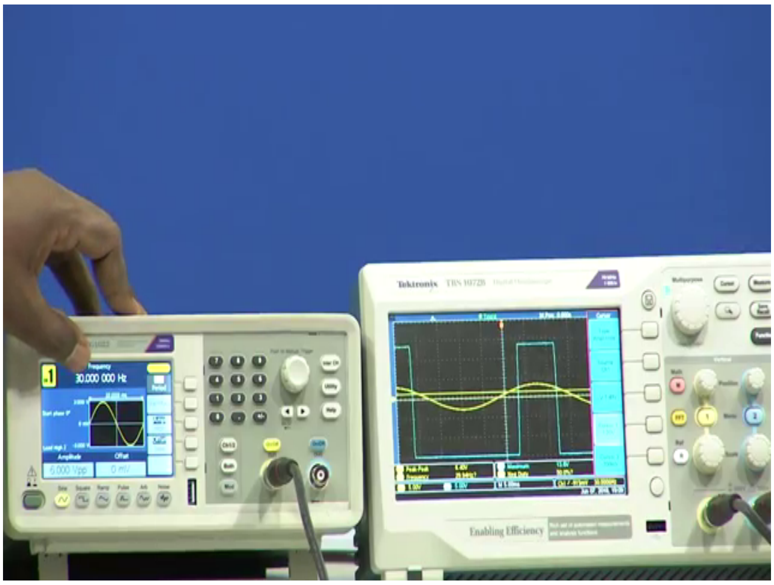

So, we can see we have kept somewhere around 30 and even the oscilloscope, so we can see the input is thirty hertz frequency oscilloscope we can see the high value and when you look into the breadboard right. So, whenever it is higher the LED is starting glowing. So, when we look into the breadboard we can see because of the smaller frequency right we can see the on and off on and off of our LED 2.

Now if we connect to a digital counter the output of this to a digital counter one thing is clear that we can easily count how many number of pulses we are getting it right and if you create a some clock cycle for different for this particular time period how many number of frequency that we are getting right that gives us how many BPM beats per minute. So, we have seen individual subsystem point of you how whether it is working as per our requirement or not. Now what we have to do? We have to take a subject or we have to connect particular person we will connect the ECG electrodes. So, these are the ECG electrodes connected to the person.

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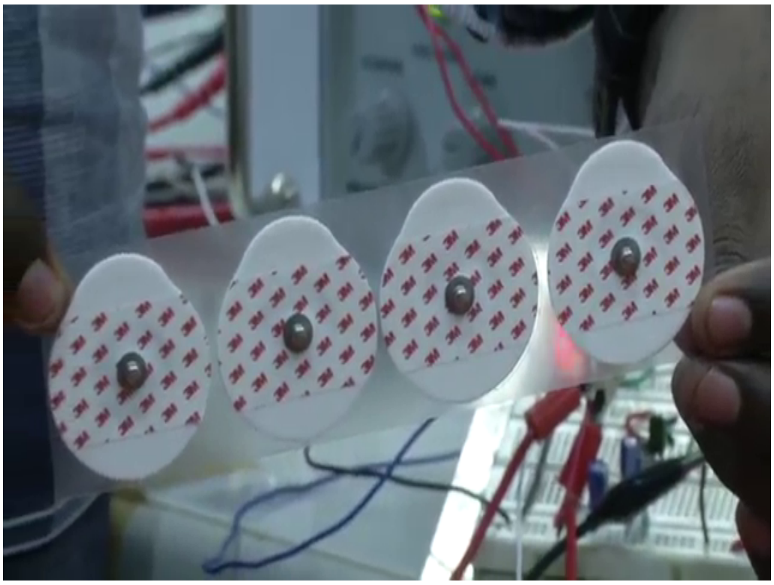

So, one at right hand other one at right left hand and other on the ground is at right leg that we have discussed in the starting of our experiment right and here we will be connecting to this metal pins, we will connect the electrodes and we will see whether we are getting ECG signal or not in a oscilloscope.

Then what we do is that we will pass through amplifier for amplification of an ECG signal until unless we do the amplification it is very difficult very hard to detect using our normal DA source because the magnitude of the actually signal is very poor right. So, in order to improve our signal ratio we are go passing through the instrumentation amplifier when we will pass through filtering, so that we can easily visualize whether the signal has been filtered or not.