Biomedical Signal Processing
Prof. Sudipta Mukhopadhyay
Department of Electrical and Electronics Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture – 04
Biomedical Signal Origin and Dynamics (Contd.)

In the last day we have started with the E C G signal, now E C G signal even for a the same person if we take it that it may be different acquisition, it is not just that we are taking the signal at different time. So, the signal would be different, but if different people acquired that signal it could be different as well, the reason is there a number of configurations through which the signal can be collected. So, today we will know about the lead configurations which also determine that how the E C G signal will look like.

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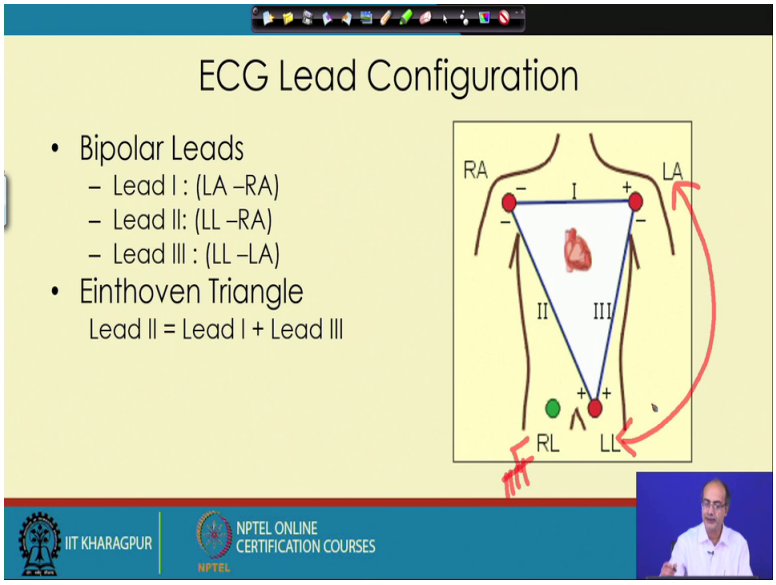

So, now let us look at that first the bipolar lead it is the simple 2 lead connection we know that for any electrical potential we need two leads to measure that. So, that is called bipolar lead, and here we have 3 such configurations now to know that that lead 1 lead 2 lead 3 configurations first we need to look at that how actually it is acquired it is taken from first of all the left arm one point, then right arm and the left leg and the right leg these point actually it is permanently grounded. So, that is a way that the configurations are done these leads area use for the bipolar lead configuration. And that the connection is not done in the shoulder or in the (Refer Time: 02:20) as it is shown in

the picture it is taken from the periphery or in other words for the two hands it is taken near the leads. So, that it becomes easy to collect the data.

So, you can take that instead of here it may be taken from the right wrist and the left wrist, the two connection will be there and near the ankle of the leg the connections are done for the leg. So, that these are the points now let us look at that what is lead 1, lead 1 means that the left arm and right arm in between these two points the connections are made. So, the connections are made between these two points for the lead 1 and all the time the, that right leg is grounded that is something permanent. So, that gives us to a waveform we call that lead 1 configuration E C G.

Next comes that the lead 2 configuration where we take it from left leg to right arm. So, you can take diagonally opposite actually these two electrodes from there it is taken and lead 2 configuration is the one that what we have used earlier for the explanation. In fact, the lead 2 configuration gives the highest level of signal and it is more known than the other configuration signals.

So, that is what the lead 2 the third one is, that if we take the left leg and the left arm in between these two that we if you have and the right arm sorry right leg is grounded all the time. So, then we get the lead 3 configuration signal. Now as we get actually these signals they are forming a triangle the signal vectors also acts in that way. In fact, the heart what we see here first thing to notice, that the heart axis is not vertical it is making an angle with the vertical axis and the signal generator that is the electrical signal that actually forms a rotating electric field you can take that this is rotating electric field.

So, at different times you will find the different configuration they there the value will pick. So, under this influence of this rotating electric field, all these leads can give some signal and if we vectorically add them then what we find that lead 1 plus lead 2, lead 1 plus lead 2 means the signals are from left arm to right arm one side and sorry lead 1 plus lead 3. So, left arm to right arm and left arm to left leg. So, if we add them together now it becomes the configurations like lead 2. So, that if we vectorically add that we can also see that in the graph. So, now this one as it forms a triangle that has been given in the name of the inventor of the E C G signal Einthoven and this triangle is known as Einthoven triangle.

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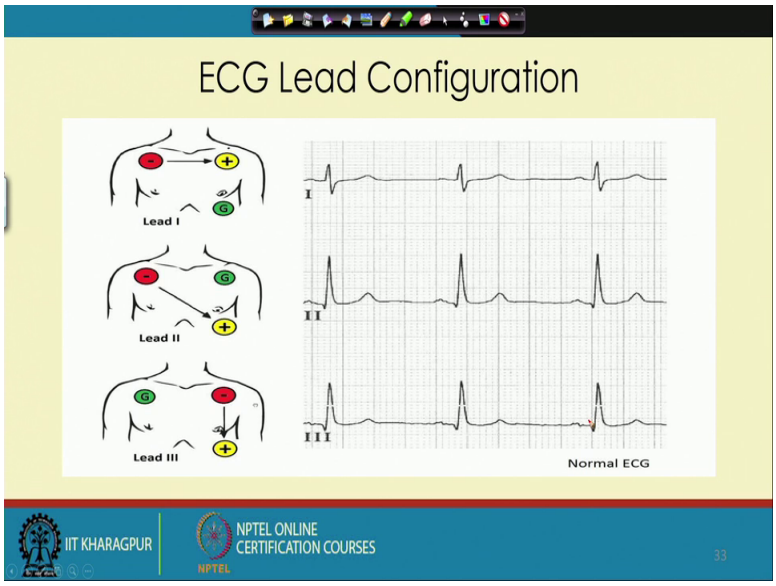

So, now here in this graph we show that how the E C G signal will look like for different that configurations. We see at the top the lead 1, then followed by lead 2, and then the lead 3 configuration and that vectorical addition what we told we can check that in that way.

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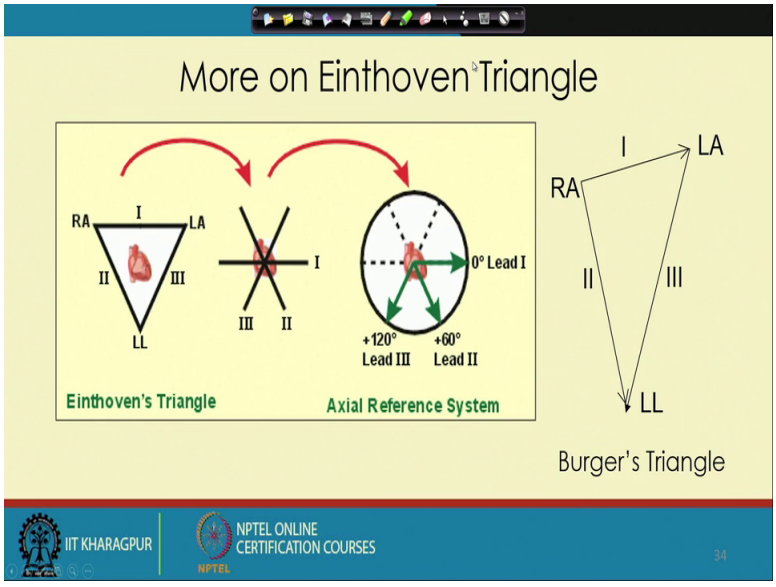

And initial idea was that this triangle it would be an equilateral triangle, the Einthoven triangle it was postulated as that a equilateral triangle all the three sides would be the same because it is coming out of a rotating magnetic field, and each one of them they are

actually making say 120 degree angle with the 0 access. So, depending on the configuration they are making lead 1 is making 0 degree with the horizontal axis, lead 2 is making 60 degree the opposite would have been 120 here. So, 60 degree in this side clockwise and 120 degree clockwise by the lead 3, so that was the initial assumption but here something actually went wrong in this calculation primarily because that the human body is not homogeneous specially for the (Refer Time: 08:37) region, that what we get that we have the lung which is filled with air, then spine is there in the moving towards the vertical direction. So, the assumptions of uniformity within the body that is not actually maintained, and that is why this electrical fields are not actually just a simple rotating magnetic sorry electric field with uniform strength.

So, when the people tried to actually add them vectorically they got a triangle like this, where that lead 1 and lead 2 their magnitude is smaller than the that the that this one that lead 3 configuration now this thing that this is known as burgers triangle. So, that it is given in the name of the inventor who has corrected this error. So, this is known as the burgers triangle. So, now instead of the Einthoven triangle we refer to the burgers triangle.

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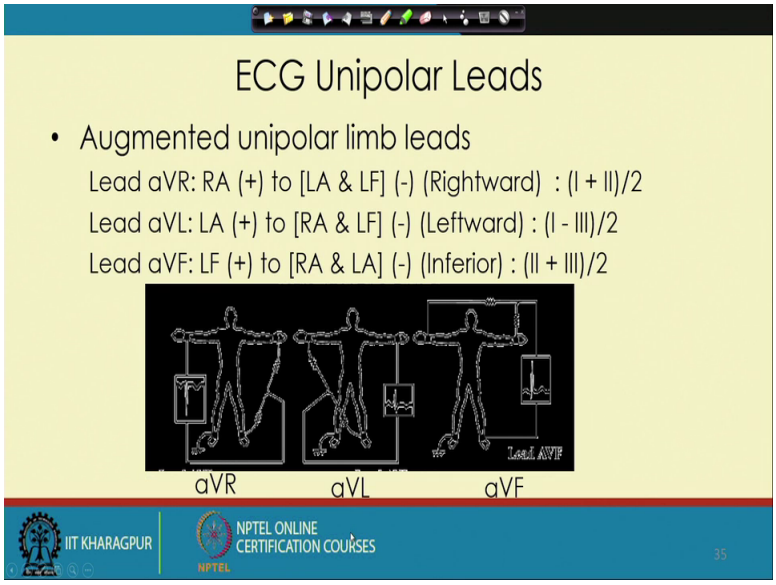

Next we come for more leads now first thing we should note here, that here we are talking about the unipolar leads now how is it possible with 1 lead we can measure a potential now here the catch is that there is always a reference lead, however the

reference lead is not a simple lead it is a composite lead and how that it is done, that if we have multiple actually leads and if we add them up that can provide us a reference in all the three pictures you can see that 2 leads are there connected through 2 resistance now in between that that it centre tap that resistance is centre tapped and we take the reference here.

In a next case here is the reference point. So, that is why because there is no single point as a reference which is connected to the body it is called unipolar lead connection and with that we can have again three configuration one is lead a V R that means, in this case that right arm that is the unipolar lead is connected and references is the in between the two potentials of the left arm and left leg. So, in this configuration the first thing we should note that, the primary points from where the potentials are checked they have not changed, only thing we change that that how we are connecting them.

So, we get first one is lead a V R, this can be you can say it is somewhere comparable with lead 1 that where the one point was with the right arm the second one is a V L. So, here it is from left arm is the single lead is connected the other two that is the right arm and the that left leg, the midway potential between them provides as the reference and for the third case a V F. So, a V F in this case that the left feet is the point from where we are taking the connection and the midpoint potential of the 2 arms that is serving as a reference.

So, let us look at first that how the nomenclature is done. a V R stands for the connection where that unipolar lead is connected to right arm. So, R is taken the next one that a V L that unipolar lead is connected to left arm and we know out of the 2 legs only the connection is taken or E C G is taken from the left leg. So, it is marked with F, that unipolar lead is connected to the feet and all the time that we have that this right leg that is grounded just like the bipolar lead configuration.

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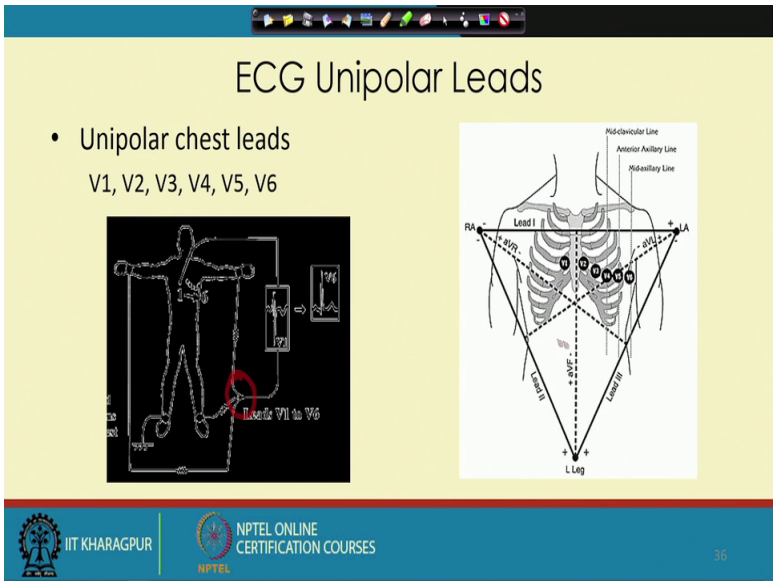

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Now, we go for another kind of unipolar leads these are called that unipolar chest leads, now when you have that the bipolar leads or the that a V L or a V R this kind of unipolar leads, we are taking the E C G signal from far away of the that our heart. Now if we take the signal from far away from the heart it is very difficult to get that which part of the heart is contributing how much there we get actually the resultant of the full heart there.

So, that though it can suggest that there is some problem there and that can be depicted as a change in the morphology by looking at that the bipolar signal you will not be able to find out that what is the origin of that problem, if we have to find that thing more carefully then you need to come closer to the heart and in this case what is done that this unipolar lead configuration or the chest lead configuration the right feet is grounded like previous one the other three points that is left leg, left arm and that right arm that the leads are connected with that and the potential we get here after some equal resistance they are connected to equal resistance and these points are was a that this point is having as a reference here.

Now, taking that as a reference we take different points V 1, V 2, V 3, V 4, V 5, V 6 different points from there the potential is actually recorded, and if you look carefully you will find it is starting from the that other side of the sternum that right side of the sternum and moving away going to completely the opposite side slowly and this points

they are actually in between the 2 ribs all this points they are marked, and they are surrounding the heart and because of that that they can get actually the influence of different part of the that heart in different leads in a better way.

So, this chest lead configuration it can tell you the problem is in which chamber of the heart. So, that is that is the unique feature of that and when the standard E C G signal is taken. So, these chest leads are also connected and they are monitored to find out if there is any abnormality in the heart. So, this is very important points and nowadays that you get that number of channels they are connected and you get all of them and some of the machines they come with automated features where the machine itself can suggest that which signals are not probably normal.

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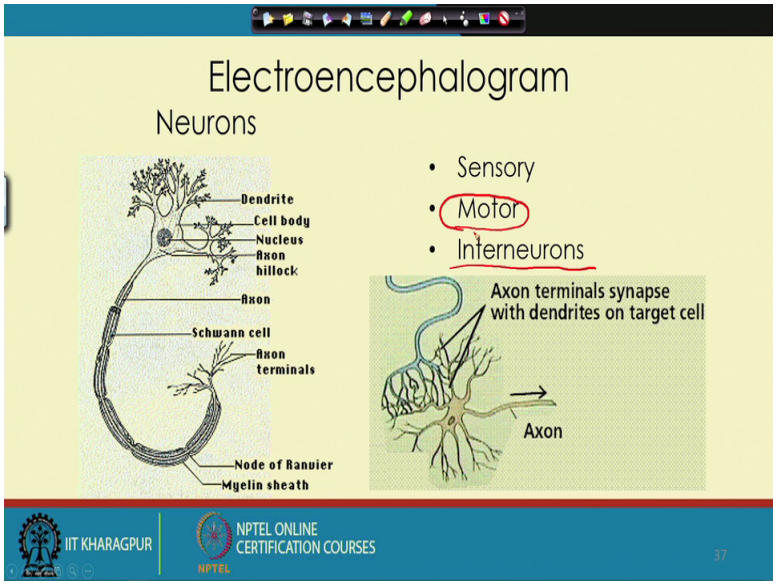

So, now let us move forward, let us go for the second signal that is electroencephalogram or in short we call it as E E G. Now to know that first we need to know the origin of it here we see in the left hand side the picture of a neurone, the neurone here is the cell body that this is the cell body and at the top of it just like the branches of the tree we get some of shoots that is called dendrite, we get the dendrite they the dendrites acts as a receiver to the this nerve cell and the signal that comes here it passes it on through the this pipe kind of structure that is called action and at the end of it we get some actually the divided the points or branches it looks like the roots of the tree they are called the axon terminals.

So, axon terminals acts as an actually transmitter it gives the signal to the next part, now how that happens when ever we look at the neurones that usually that the axons and the dendrones they couple with each other.

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So, that is call the synapse.

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And depending on the strength of connection that we can get that how much coupling is there or what would be the strength of the signal transmitted to the, that the dendrone of the next neuron. And here there are few more peculiarities of the neuron that we should look at like any other animal cell it has a neuron that is there in the cell body, but apart from that we if we look at the construction of the action what we get that it is covered with some lipid layer or lipid profile and this lipid profile act as a insulation.

So, wherever the lipid profile is there that there would not be any electrical activity, that means when we have told about that axon potential through the transfer of ions from the cell to outside and in the reverse way that is not possible in that, those region where the lipid layer is there. So, to have the action potential or to allow the reaction there is a gap in that and we mark them they are called as load of ranvier, in between the that in the continuous this myelin sheath there are some gaps where there is no sheathing is there and that is called node of ranvier.

So, when the signal passes what happens that from that cell body the next electrical connection can happen in the next node of ranvier. So, electrical connections or signal jump from one point to the other and that is how that the signal can actually pass at much higher speed in the neurone. And how the circuit is completed one part that ions are flowing through the within the cell here in the through the axon and through the interstitial fluid which is outside the cell that the circuit is getting completed.

So, that is how the signal flows and the neurons can be divided into three classes the first class is the sensory one the sensory neuron sensory neurons are actually their dendrites are connected to our sense organs. So, for example, through the skin we get the sensation of touch. So, there are number of actually that neurons whose dendrites are terminated on

the skin. So, whenever someone touches are or we touch some other object. So, that sensation comes to the dendrite and passed on to the neuron and that signal goes to the central nervous system.

In central nervous system there are number of actually signals, or number of neurons they are connected with each other and those neurons are called inter neurons. So, they help in making the decision, now once the decision is made that comment comes sometimes it could be autonomous kind of decision for example, if we touch a hot body immediately our hand and leg will recoil will take it back. So, that is an autonomous action or it could be a conscious choice, that we have touch the wall we want to step back. So, all such signals come to the motor neuron. So, motor neurons are giving back the signal or giving the command to the muscles and inter neurons are taking the decision.

Thank you.