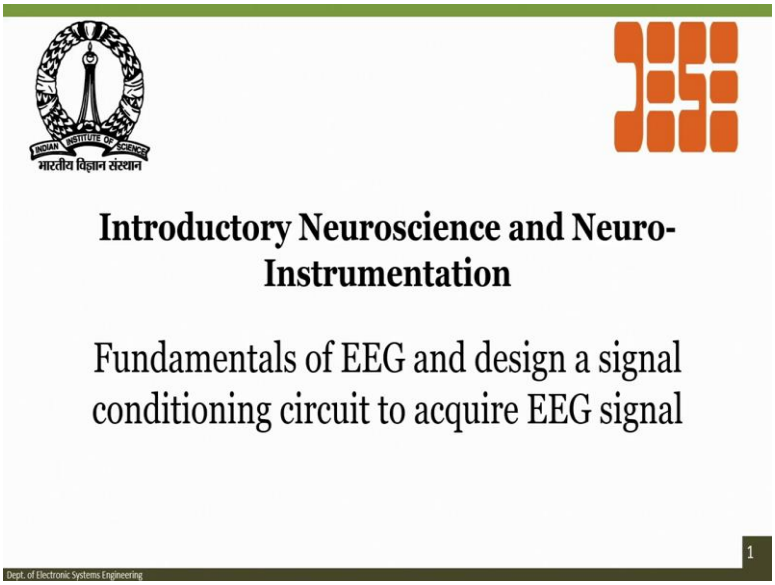
Introductory Neuroscience and Neuro-Instrumentation
Indian Institute of Science, Bengaluru
Lecture 09: Fundamentals of Biopotentials and Applications

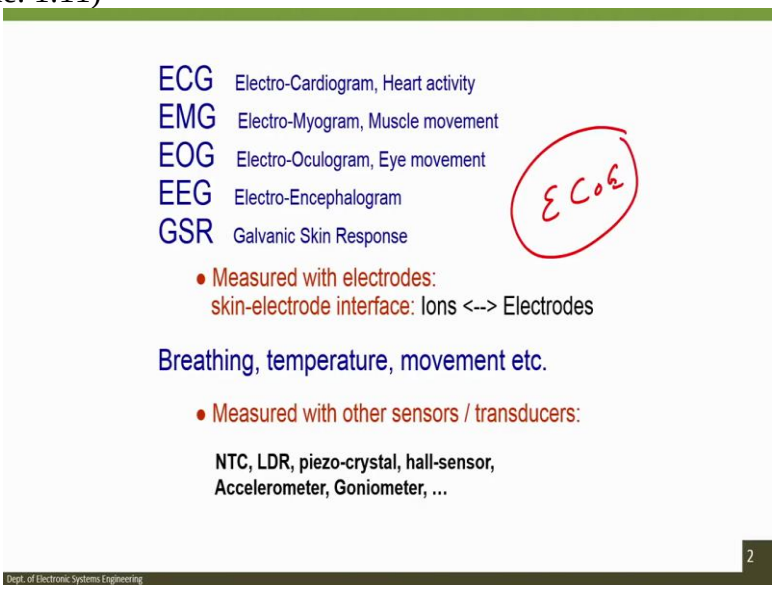
(Refer Slide Time: 0:29)



Hi, welcome to this module. In this module, what we are looking at? We are looking at the fundamentals of EEG, which is electroencephalogram and how to design an electronic signal conditioning module for acquiring this EEG signal. Now, acquiring of course, we can say that electrodes are used to acquire it. But to process the signal and to convert in a readable form we require an electronic module.

So, before we before we jump to EEG and the details regarding that and the signal conditioning circuit, let us also focus on, a bit on ECG, EMG and EEG, they are kind of like I said related terms and sometimes it is confusing.

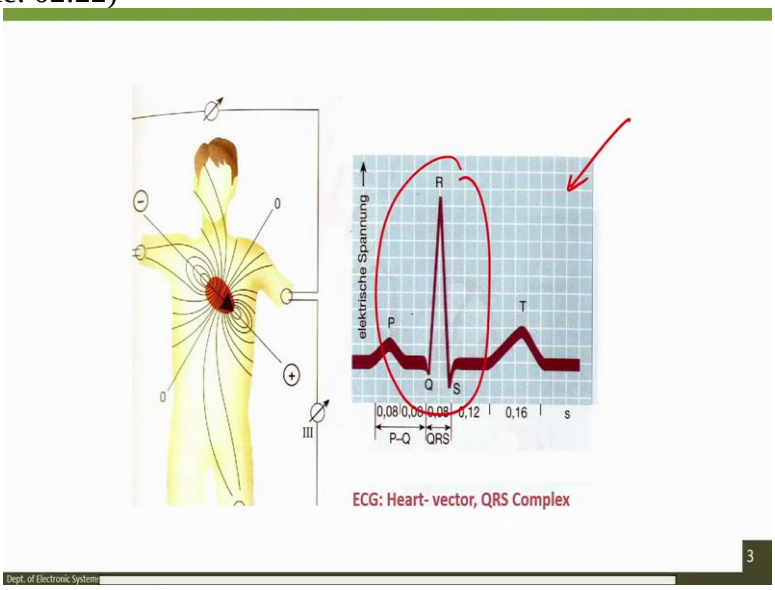
(Refer Slide Time: 1:11)

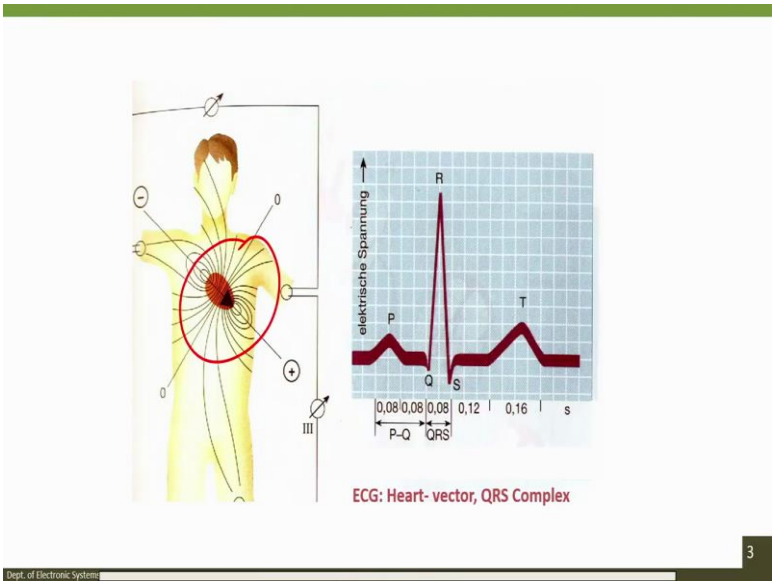


So, if you see the slide, these are the terms that you will come across, ECG, EMG, EOG, EEG, GSR, ok. So, ECG, electrocardiogram, it measures the heart activity. EMG, electromyogram, muscle movement. EOG, electrooculogram, eye movement. EEG, electroencephalogram, brain signals. GSR, galvanic skin response. We also have a term called EECoG, electrocardiogram.

And this also measures the brain signals or neurological signals from the brain. While the EEG is on the scalp, ECoG is directly on the brain, signals from the brain. The use is for breathing, if you know how the breathing is working, temperature, movement, etcetera, and what are the measured with other sensors, transducers? Some sensors available on NTC, LDR, piezoelectric, hall-sensor, accelerometer, goniometer, and a lot of sensors are available that we can use for this application.

(Refer Slide Time: 02:22)

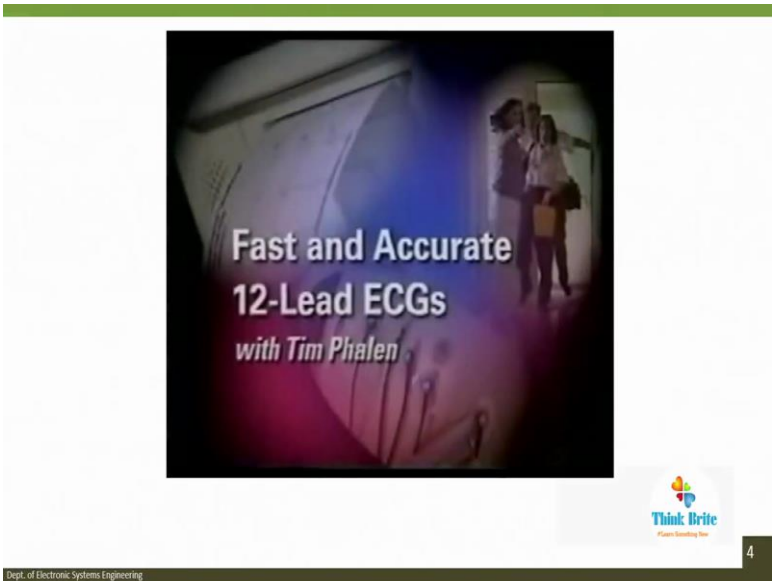


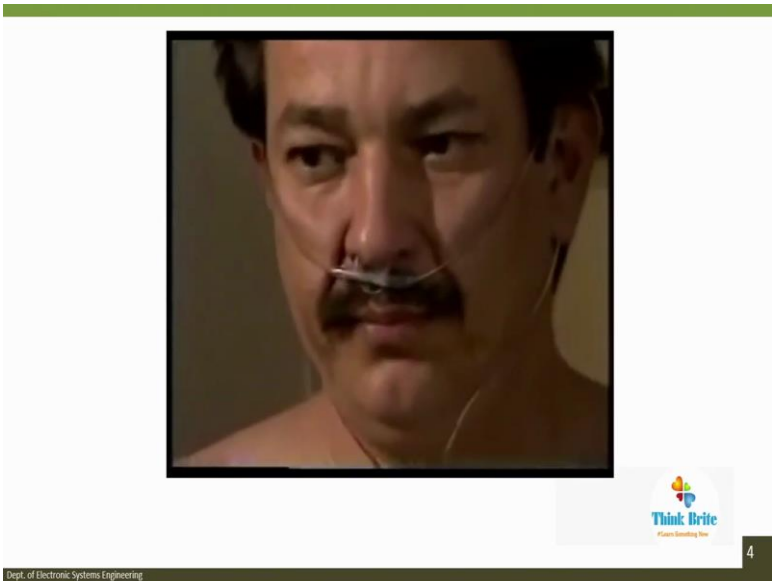


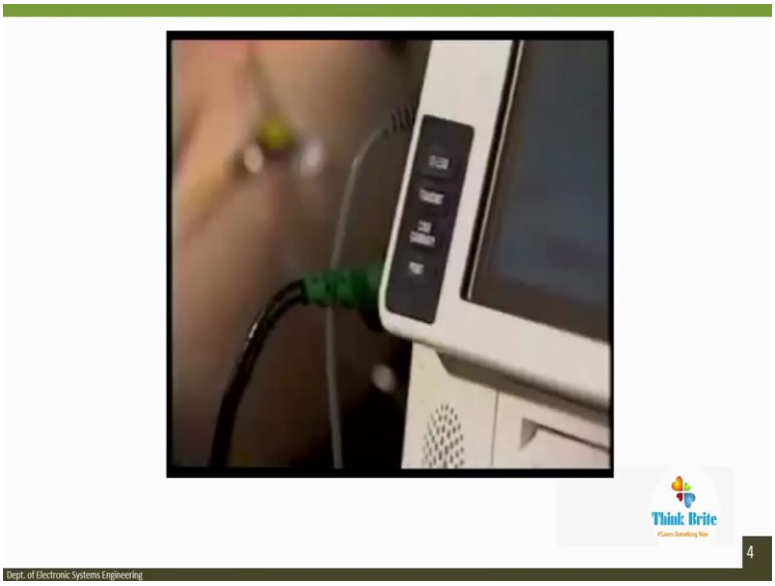
ECG as we already know, it is generally you have seen the ECG monitor whenever the patient is in the hospital and it shows the performance of the heart or the quality of the signals that is generated from the heart.

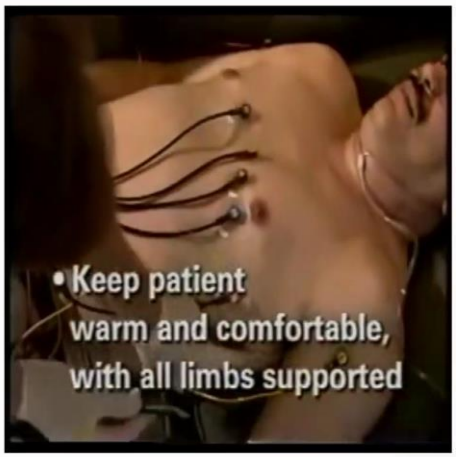
And generally, we are understanding the PQRS signal. Or QRS signal and PQ signal, which shows the heart, the quality of the heart response. And, if you see, it is a heart when we measure the signal, it is a vector signal. So, the idea here is if I want to measure the ECG, what, how we can measure this ECG signal? What kind of electrodes are there? How to connect this electrode? Say the 12 lead ECG electrodes, how to connect it to the heart to measure the ECG is shown in the next video.

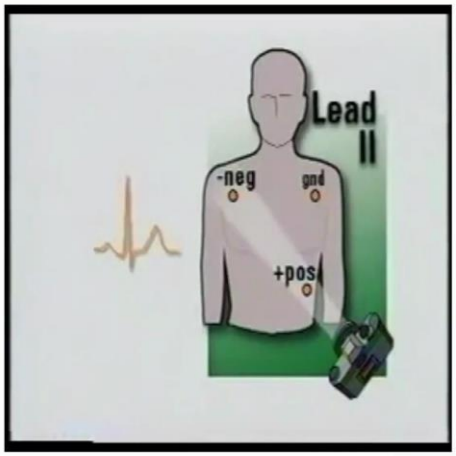
(Refer Slide Time: 03:18)

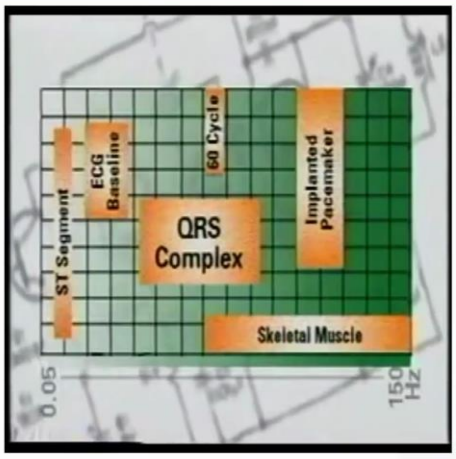


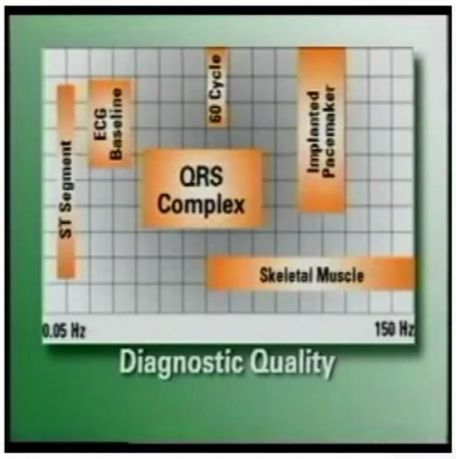


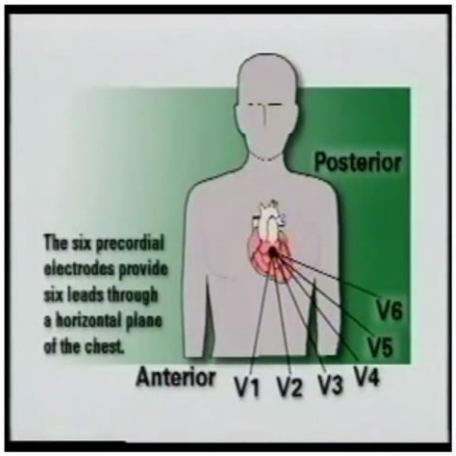


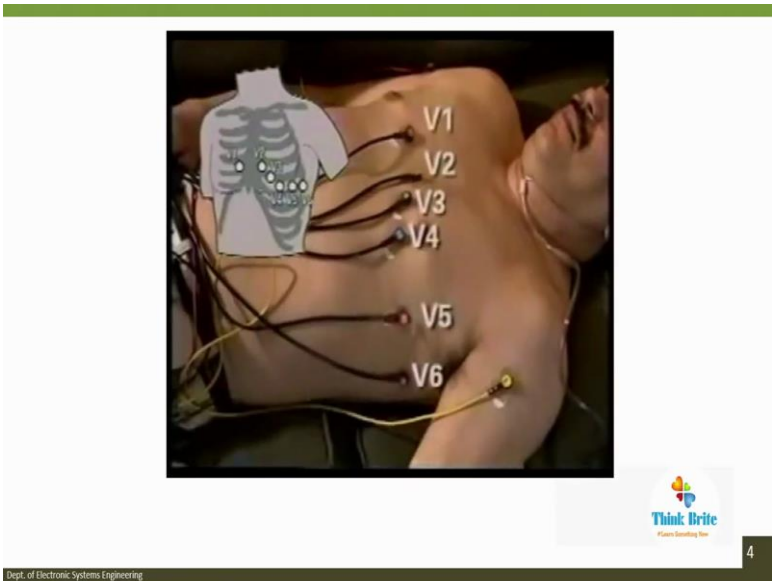

• Keep patient
warm and comfortable,
with all limbs supported

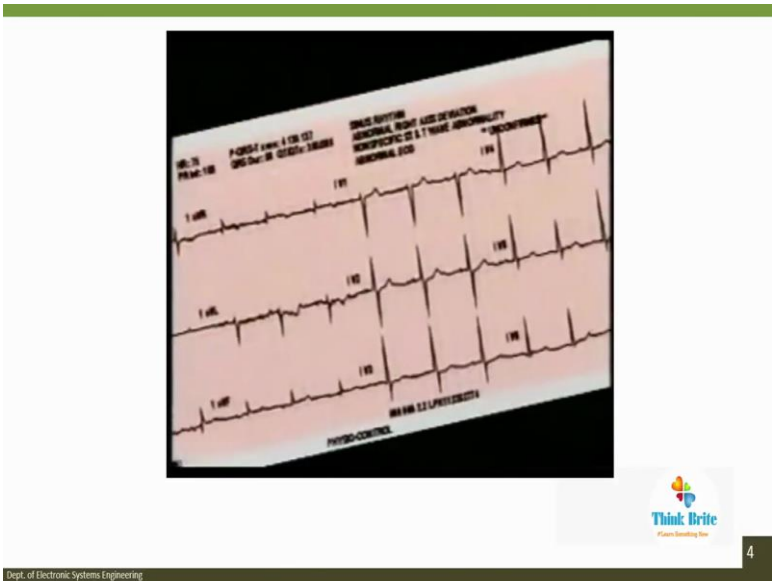

Lead
II
-neg
gnd
+pos


ST Segment
ECG Baseline
60 Cycle
Implanted Pacemaker
QRS Complex
Skeletal Muscle
0.05
150 Hz


ST Segment
ECG Baseline
60 Cycle
Implanted Pacemaker
QRS Complex
Skeletal Muscle
0.05 Hz
150 Hz
Diagnostic Quality


Posterior
The six precordial electrodes provide six leads through a horizontal plane of the chest.
V6
V5
Anterior
V1
V2
V3
V4





I will just play the video. [Video being played from 03:26 to 11:57]

“Video: Fast, accurate 12 lead ECGs with Tim Phalen. Oh hi, alright now, Keymon is a 45-year-old male complaining of some heartburn, maybe some chest pain. Wife says he started to feel a little sicker. Anything from indigestion, there are lot of things in between.

But this is it and I am doing it. So it is a pretty safe bet. This poor guy is going to be having an acute myocardial infarction, once come along with us and we will show you how to do a 12-lead ECG. Ready? Let us go. Tim Phalen is a seasoned paramedic with more than 18 years in EMFs, and internationally known author and educator. He has trained more than 25,000 paramedics and nurses on diagnostic 12-lead ECGs.

Thanks for the nice intro. The American Heart Association in chapter 9 of their new textbook talks about the acute coronary syndromes, including myocardial infarction, and it makes some bold statements. It says that emergency care providers that you and I need to be familiar with the core principles of diagnosis and treatment of these acute coronary syndromes.

It also says that the 12-lead ECG stands at the center of decision making for these acute coronary syndromes. 12-lead ECG is a routine part of the assessment of a patient with possible ACS. Included with the history symptoms and vital signs the 12-lead ECG is critical to the diagnosis and treatment of the cardiac patient.

Explain the procedure and reassure the patient. Remove the clothing on the upper body. Wipe the electrode sites with a brisk dry rub. Oily, dirty, or diaphoretic skin should be quickly cleaned with an alcohol wipe. Routine standards though. Allow the skin to dry before placing the electrodes. If necessary, shave or clip hair on electrode sites, there you go. The ECG is best obtained with the patient resting in the supine position lying as still as possible for the 10 to 15 seconds required for the ECG device to acquire all the information.

The patient must be relaxed, warm and as comfortable as possible with all limb supported. If the patient is uncomfortable or having difficulty lying flat, place him in a low sitting position and make a note on the ECG printout. Well, you get the basic idea. But I would like to take a minute to go over a couple of key points. First, seen time; studies and experience have shown that getting a 12-lead ECG does not prolong seen time.

So do not be concerned about that. Second thing, getting a 12 lead really is easy. Once you have done a few of these, you will see for yourself. The truth is the skills you have learned already are far more difficult than 12-lead acquisition. And remember getting a 12-lead makes a difference on scene, in route and arrival at the hospital. Of course, to be valid, it absolutely must be done correctly.

So let us talk about ECG monitoring in general, everyone is familiar with leads 1, 2 and 3. You learned about them in school, you have been using for years on your job. And when you have used it, you did it for the purpose of identifying cardiac rate and rhythm. Now, each one of those leads is a view of the heart. Each one of those three leads has a single positive, a single negative electrode and a ground.

The actual view of the heart is seen from the positive electrode toward the negative electrode. That is why each of the complexes have a slightly different configuration. The ground electrode helps to reduce electrical interference and helps produce a clear tracing. To get a 12-lead ECG we must isolate only the heart's electrical signal.

The human body and external environment have many sources of electrical signals. The electrocardiograph can detect and reproduce the various electrical signals of cardiac conduction, the monitoring frequency response mode provides a 0.5 to 40 hertz view of cardiac conduction while the diagnostic frequency response mode provides a 0.05 to 150 hertz window. This broader frequency bandwidth accurately reproduces cardiac electrical data necessary for diagnostic interpretation of the status of the myocardial muscle, which may be reflected in the ST segment of the cardiac ECG complex.

The ST segment is found in the lower end of this electrical frequency window and accelerated way to play is assumed to be eligible receiver quite a complicated. Whoa, timeout. That is the textbook version of frequency response. Here is the real-world version. You see the difference between 3-lead monitoring and 12-lead monitoring is not the number of wires coming out of the machine.

The difference is frequency response. In monitor quality, the machine is not attempting to reproduce the full spectrum of cardiac electrical activity. Instead, it is just focusing in on the center portion. So you can see the QRS complex, so you can do rate and rhythm. In the process it is filtering out some artifact, which makes the ECG clear. That is terrific. But you cannot do this for ST segment analysis because in monitor quality, you cannot see the ST segment properly.

That is why the 12-lead must be done in diagnostic quality. In diagnostic quality, the machine can see the full spectrum of cardiac electrical activity, not only the QRS complex, but the ST segment as well. You notice that the artifact is seen a little more clearly as well. But because we need to see the ST segment, all 12 leads must be done in diagnostic quality. The 12 views of the heart are taken with 10 electrodes.

The 4 limb lead electrodes do not require precise anatomical placement. However, it is best to avoid sites that have a lot of hair, large muscles, or bony prominences. The upper limb electrodes can be attached anywhere along the arms from the wrist to shoulders, if they are

off of the torso. The lower limb electrodes may be attached anywhere from the ankles to the thighs. The 4-limb electrodes provide a total of six leads, leads 1, 2, 3, aVR, aVL and aVF.

All limb leads provide a view on the vertical or frontal plane of the body. The 12-lead ECG and 6 views through electrodes placed on specific points on the chest wall. These chest leads also called precordial or V leads provided you on the horizontal plane of the heart. The international standard for 12-lead placement requires that the limb leads be positioned on the limbs and not the torso.

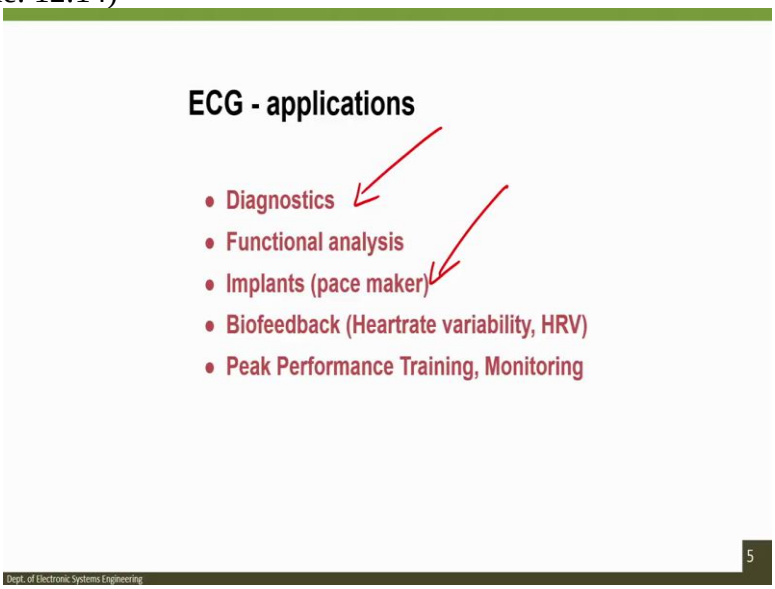
However, some emergency departments obtain the limb leads from the patient's torso. In that case, you may opt to do the same for the sake of consistency. So while there may be some variation in limb lead placement, there can be no variation in chest lead placement. The chest lead electrodes must be obtained from their specific anatomic landmarks. Let me show you. Find the clavicle and position your finger just below it, move your finger until it contacts the sternal border here in the first intercostal.

Find the second, third and fourth intercostal space, position the electrode for V1 just to the right of the sternum in the fourth intercostal space. V2 goes in the corresponding intercostal to the left of the sternum. Skip V3 for the moment, V4 goes in the mid clavicular line, fifth intercostal space. V3 is positioned between V2 and V4. The V5 electrode is horizontally level with V4 in the anterior axillary line.

V6 also horizontally level with V4 in the mid axillary line. Notice we did the 12-lead ECG on the scene. This was very intentional. For a variety of reasons, the ECG may change quickly, and the early tracing may provide very valuable information. Let us look at some tracings. The first shows gross and obvious changes. The second tracing was obtained from the same patient only a few minutes later, and the changes have all but disappeared. That is why it is important to get the first ECG with the initial set of vital signs. Get a repeat ECG every 5 to 10 minutes or at least with each change in patient condition.”

Professor: So, you have seen in the video that how these electrodes are connected to measure the ECG signal. Now, let us see what the applications of this ECG are.

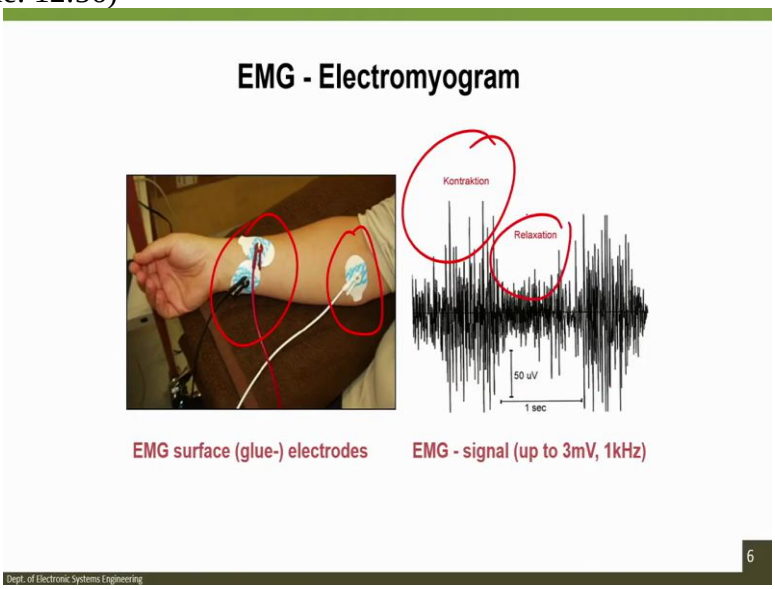
(Refer Slide Time: 12:14)



If you see the ECG applications are many, from the diagnostics that is the heart performance, function analysis. If there is an implant, then implant is working properly or not? We want to know the heart variability, which is HRV. And we also want to know peak performance training and monitoring. That means that if a person is let us say performing an exercise, at what rate the heart shoots up? What was the maximum heart activity? How it is shooting back down or how it is coming back to its normal beating mode or rhythmic mode?

There is everything we can measure if we know the ECG signals. There are a lot of companies working on the variables to understand the ECG.

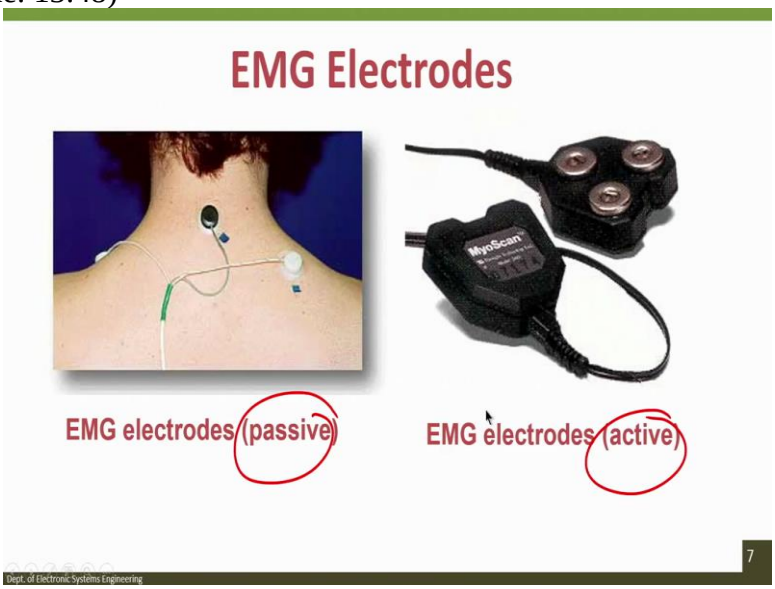
(Refer Slide Time: 12:56)



Now, let us go to the second; see, we will not spend too much time on ECG and EMG, we will spend more time on the EEG signals. So EMG when you talk, EMG is the signals obtained from the muscles and generally the EMG signals are around 3 millivolts, which is a huge signal similar to your heart signals which are of few millivolts.

The electrodes are placed and if it is a wet electrode again, you must use a glue to attach these electrodes. There is a gel also which is required to be attached, to be used with electrodes to reduce the impedance. And you can see here that you will see when the muscle contract, the signals would change. When you relax the muscle, the signals will change back.

(Refer Slide Time: 13:48)



So EMG electrodes, EMG electrodes are passive in nature. And there are other electrodes which are active in nature. So two types, passive and active. This MyoScan is a company which makes the active electrodes. Now if I want to see how the EMG signals are generated, let us see this video and then we will take it forward.

(Refer Slide Time: 14:11)

GVB - geliMED

8

Dept. of Electronic Systems Engineering

GVB - geliMED

8

Dept. of Electronic Systems Engineering

GVB - geliMED

8

Dept. of Electronic Systems Engineering

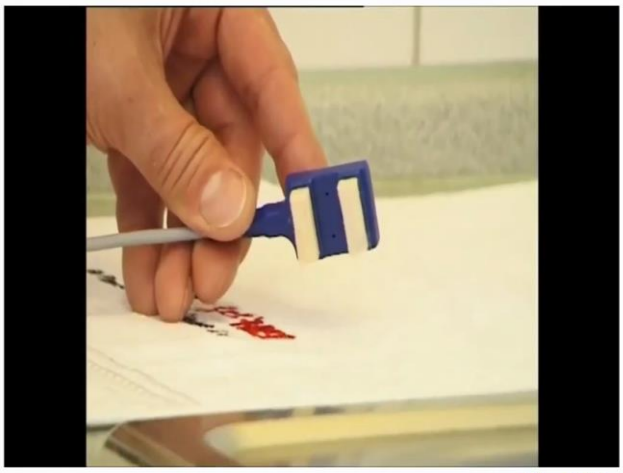
GVB - geliMED

GVB - geliMED

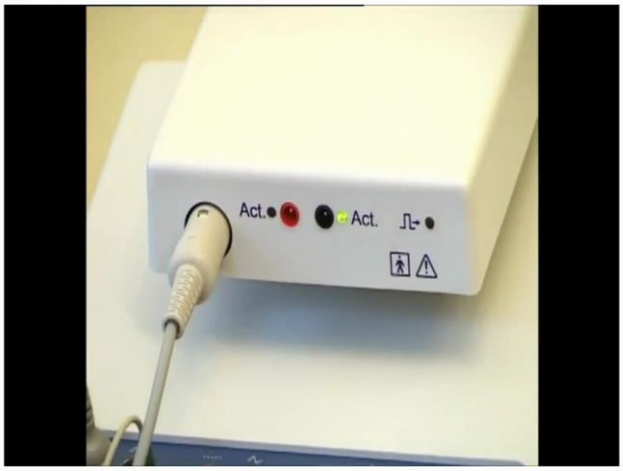
GVB - geliMED

GVB - geliMED

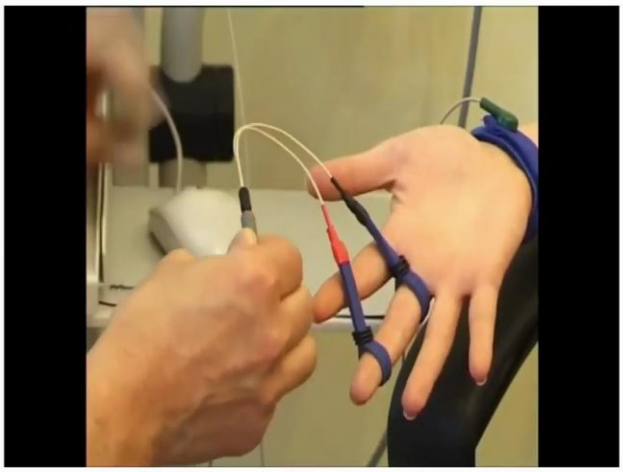
GVB - geliMED



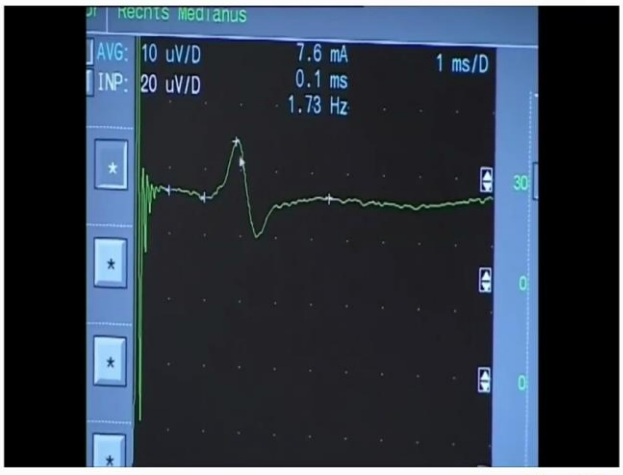
GVB - geliMED



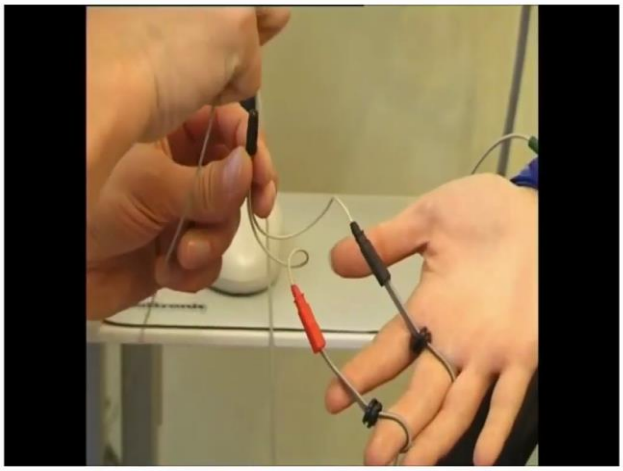
GVB - geliMED



GVB - geliMED

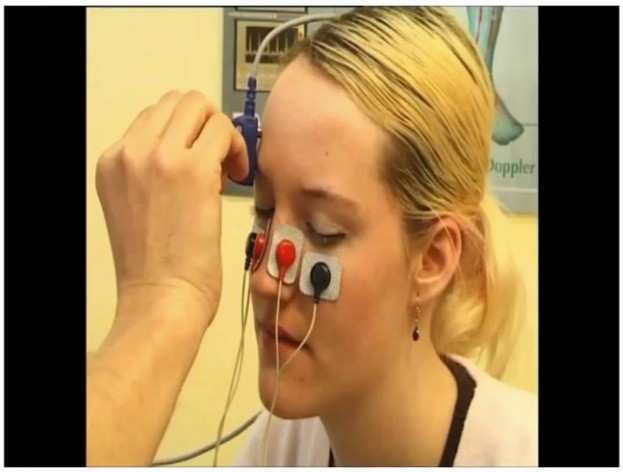


GVB - geliMED

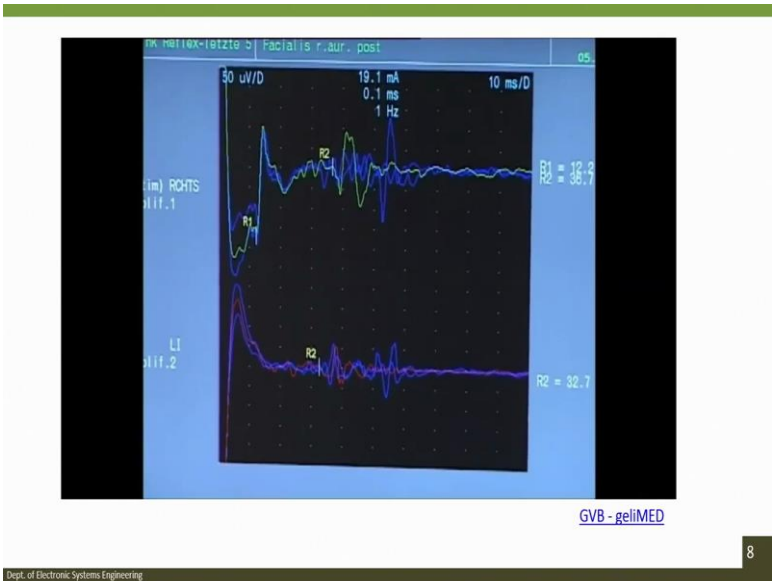


GVB - geliMED

GVB - geliMED



GVB - geliMED



“Video: NCV EMG derivations comprise a multitude of investigatory measurements as well as their electrodes and accessories. GVB geliMED will supply you with the electrodes required for stimulation and derivation including the appropriate accessories ranging from cable connectors through paces and creams. These will be of optimum quality permitting you to carry out derivations with no complications and to receive stable results. Now you see a standard NCV EMG investigation using different stimulation and derivation measurements as well as a special form of neurography with the blink reflex.

Prior to the neurographic investigation the ground electrode is placed over the wrist between the recording electrode that has yet to be positioned and the stimulation area. Finally, this is connected to the EMG instrument by a snap cable. In modern neurography, the recording and stimulation areas should be decreased before the recording electrodes are attached. Following this and using the belly tamping technique, the active electrode should be positioned on the muscle belly and the reference electrode above the attachment of the 10.

In this case, tap adhesive electrodes with crocodile clip lead wires are used and connected to the EMG instrument using a multifunctional cable. Various types of multifunctional system electrodes can be connected to this multifunctional cable. However, snap cables that fit the multifunctional system and snap adhesive electrodes can be used as an alternative to the crocodile clip cables and tap electrodes.

Waffle electrodes are a further alternative. However, electrode drill should be applied prior to use to guarantee a good electrode resistance. The electrode itself is attached using a piece of tape. Plate electrodes that are employed in the same way and disc electrodes that also have

electrode gel applied to them and are fixed using a piece of tape form part of the multifunctional system electrode program and can be used as alternatives.

The stimulation electrodes should be ready prepared for use for this switch to stimulation balls into the electrode appliance. If you are using stimulation electrodes with felts, soak these in NaCl liquid prior to inserting them into the appliance to guarantee good skin contact, adequate resistance too. However, the felt must be dried well to avoid wetting the skin. The next step is the connection of the stimulation electrode to the EMG instrument.

The stimulation electrode is placed over the nerve and stimulus is increased following a predetermined sequence until maximum amplitude is reached. The user observes motor reaction as a control. The stimulus is increased until the supra maximum stimulation is attained recognizable by the fact that there is no further increase in amplitude. The cursor is set exactly to the initial negative potential output.

The highest and lowest points in the curve determine the amplitude's magnitude. The electrodes must also be moistened with NaCl when stimulating with finger toe stimulation electrodes, however, the electrode should not be wet. Therefore, dry the electrodes with the cloth. A ground electrode is also placed over the wrist between the stimulation electrode and stimulation area prior to connections EMG instrument when using stimulation insensitive neurography with finger toe stimulation electrodes.

First, the kettle is attached proximally to the finger base joined and the anode is then attached distally to the fingertip, there should be no liquid glitch between the two loops, which can however, be injured the prior drying to the electrodes. Finger toe stimulation electrodes are also a part of the multifunctional system and can now be connected to the EMG instrument by the multifunctional cable.

The sensitive recording electrode is positioned directly over the nerve impulsive wrist attached using velcro tape and then connected to the EMG instrument. This stimulation and recording electrode have already been used as a stimulation electrode in the previous section. The orthodrome method shows the first variations of sensitive neurography. During stimulation with this method stimulation is carried out supra maximally, an example until the amplitude increases no further.

This is similar to the approach taken in motor stimulation. Then the sinal is averaged online. The sensitive nerve action to potential free of noise is obtained after averaging approximately 20 to 50 times. The anti-drone method shows the second variation of sensitive neurography. In this case, digital ring electrodes are used as recording electrodes. The active electrode is attached proximally, and the reference electrode attached distally in this method.

These electrodes that are also parts of the multifunctional system can be connected to the EMG instrument by the multifunctional cable. Contact gel must be applied to the contact surfaces on the metal loops once the ring electrodes have been connected to the EMG instrument. This guarantees an optimum contact resistance. An anti-drone sensitive neurography recording occurs from the skin and the respective paraffin are stimulated, anti-drone stimulation is advantageous as it is rapid method with high response amplitude.

However, motor overlaps can influence this method. Our Myogram needle programming supplies EMG needle electrodes of different lines and diameters for the pain free investigation of superficial muscles, deep muscles and small hand and facial supplied muscles. These needles can also be connected to the EMG instrument using the multifunctional cable. Specialized forms of neurography like the F wave are as shown in our example, the blink reflex can be applied extremely well using disposable adhesive electrodes or disposable adhesive snap electrodes.

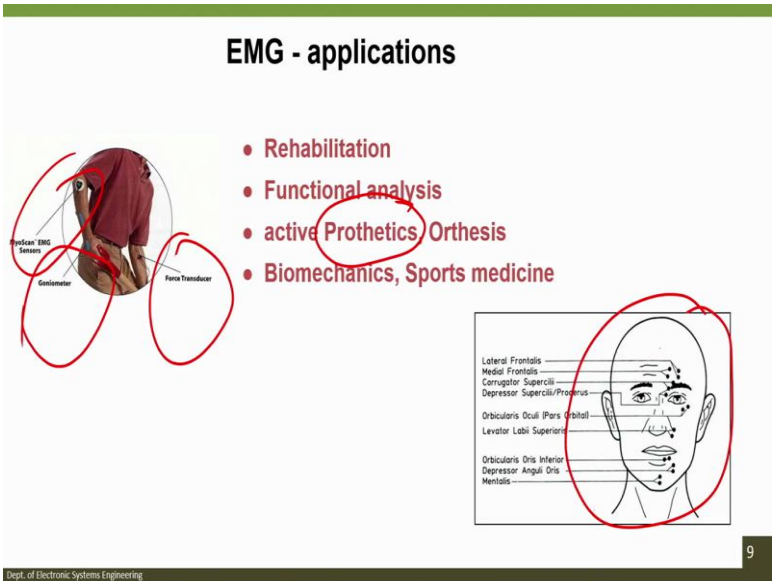
The respective reference electrodes are attached to both the nasal wings and the active electrodes are attached to both the respective orbicularis oculi. These electrodes can then be connected to the EMG instrument using a multifunctional cable. To prevent an ACL liquid from being released from the felts and running into the eye for the stimulation, it was used to stimulation electrode with stimulation balls.

The blink reflex can thereby be derived free of add effects. Similar curves must be overlaid and the R1 and R2 components on the stimulatory side and the R2 component on the contralateral side are determined. Alternatively, disposable adhesive electrodes can be used. In this case, the ground electrode is first placed on point N and then connected to the EMG instrument. The adhesive electrodes are then attached to the respective orbicularis oculi as done previously in the reference electrodes and subsequently connected to the EMG instrument with 1.5-millimeter safety connectors.

To prevent liquid spills, a stimulation electrode with stimulation balls is also used in this blink reflex recording."

Professor: So, you understood how this video, in the video how the EMG electrodes can be placed and how the signals are generated. Now, let us, like ECG what are the application? Let us see EMG and its application.

(Refer Slide Time: 23:55)



EMG can be used for several applications including rehabilitation, functional analysis, active prosthetics, orthesis, biomechanics, sports medicine. Also, recently the face muscles give lot of information about the vitals of the body. So it can be, we can also use MyoScan ECG sensor which is shown here. Then we can use goniometer, we can use forced transducer to help the person to balance, which is generally used in the rehabilitation application.

Also, for prosthetics also, if it is a prosthetic then person must get acquainted with the prosthetics and that is why EMG signal feedback is extremely important. So, till then you take care. I will see you next class. Bye.