Lecture - 44
Fundamentals of Electrophysiological signals

Hi, welcome to this module. What we are discussing in this module is very interesting,

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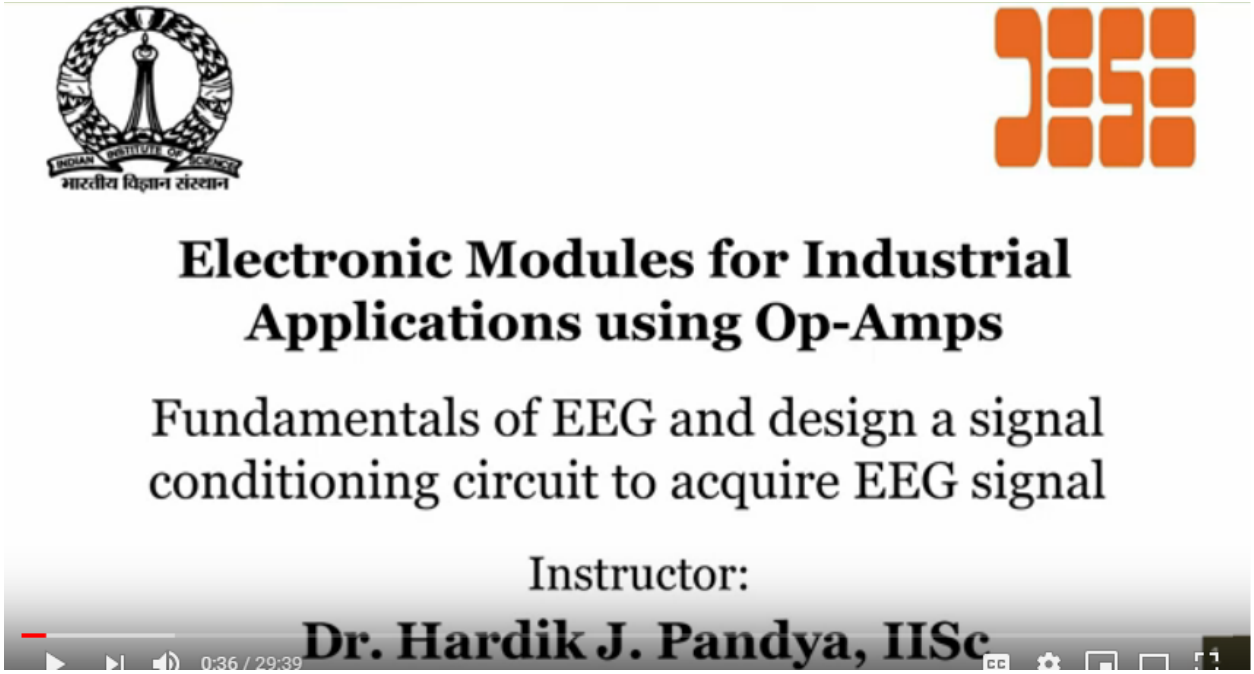

we want to understand, different signals starting from ECG; we'd understand what kind of bio potentials are there, particularly when we talk about ECG, we talk about EMG, we talk about EEG. And then, we will be focusing on, what are the fundamentals of EG and how can we design, a signal conditioning circuit, to acquire the EEG signal. Okay? So, we will also see, a detail on, how can you design a circuit and how can you understand different signals coming out of the, EEG. How can you how can you do this in the condition of those signals. In the experiment part, one of my tears will show it to you, how the dry lector looks like and what exactly are the advantages of dry electrode or wet electrode. So, I'll come to that point, before that let us see, what are the bio potentials? That we can jervey that is generally measured right,

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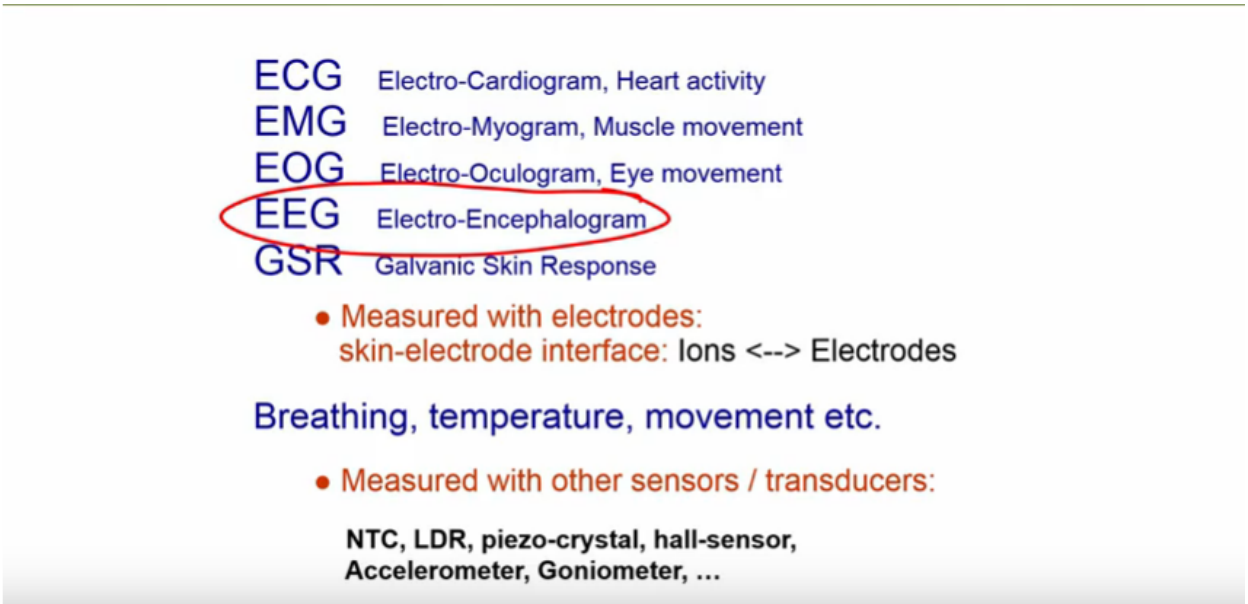

from the human body, to start we will talk about, ECG. ECG stands for, electrocardiogram and as, most of us those, if you see our fan of movies, you always see in fact in the serials also you will see that, there is a ECG measurement in the hospital right, whenever somebody has a, heart problem, we need to record the ECG signals and that's why, ECGs are mostly used for understanding the heart activity. Same thing goes for, measured moment. When we want to understand how the signals are generating when we are moving our measures, there is a named for that, which is called EMG and it stands for electro-Myogram, same thing when we had to understand our eye moment, how we are bringing our eyes and what kind of signals are generating from that blinking of the eyes, then we can have, electro -Oculogram. And finally when we are understanding the brain waves and the signals, coming out of there, out of our brain, we rely on EG which sends for, electro encephalogram, where we can understand a lot of things including scissors, including epilepsy and dyslexia. So, a lot of problems we can understand, if we know how to analyze EG signal. Okay? Right now, what we are interested is to develop a system that can be used for measuring, EEG in particular our focus is more on developing a system, which can measure EG. Finally there is another bio potential, which generates from the skin and that's a resistance is called, 'Galvanic Skin Response'. And the, the things are measured generally with the electrodes, with the use of skin electro interface and because, of the eye exchange of ions between electrodes, same thing we can also understand reading temperature movement etc, we can also measure, this thing with other sensors or transducers, to name a few we have piezo electric crystal, we have Hall sensors, accelerometers, we have LDR, etc,.

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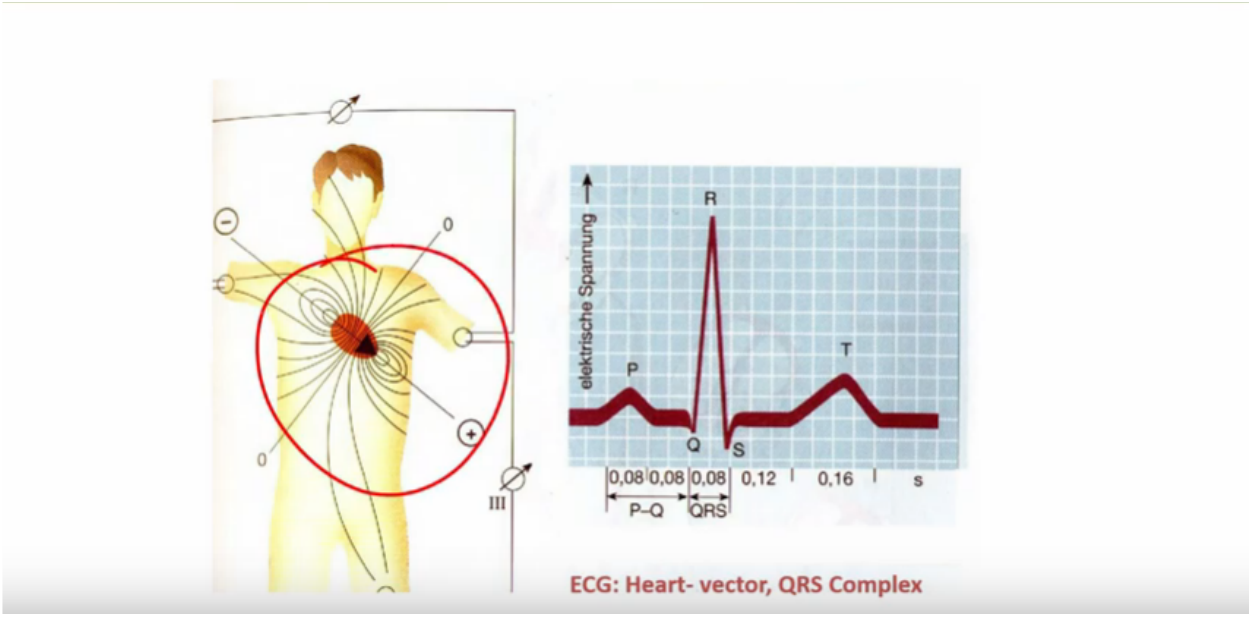

So, I'll start with the ECG. And we will not discuss too much detail about ECG; I'll just quickly run the slide through, because we have to concentrate more on EEG. So, when you talk about ECG in particular, you generally see this kind of waveform, right. And generally we had to interested in QRS wave forms and but, but to understand the complete, the understand the functioning of the heart, we generally see at P Q and QRS signal. So, again you when you go in detail is a, systolic and diastolic pressure that you don't understand. And why many opening of heart and closing of heart, the valves in the heart, causes the change needed to call signal, this is the ECG that you can see here, mostly what we are interested is in PQ signals and QRS signals. So, QRS complex is where the, very important physiology lies. And this is how the vector is formed; there are ways of measuring the ECG signals.

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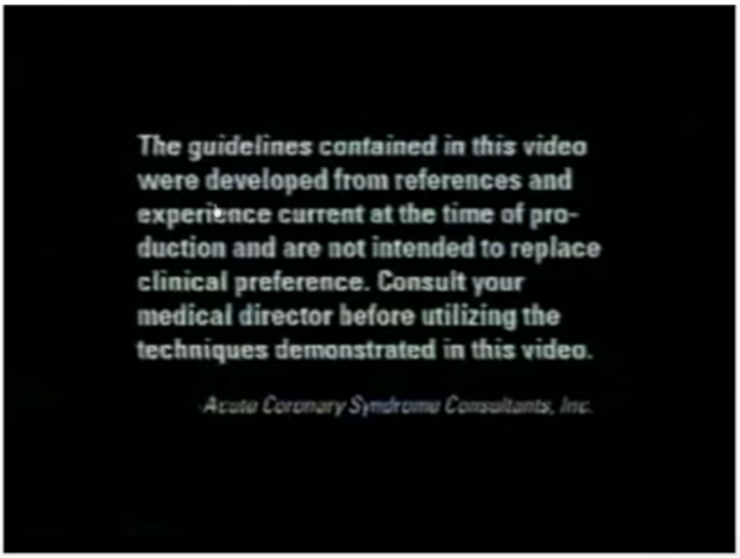

And some of the ways, of how to connect the ECG electrode is shown in this particular video. So, I'll play the video for you and then, we will, we'll continue with the measurement. Okay? So, let me play the video for you.

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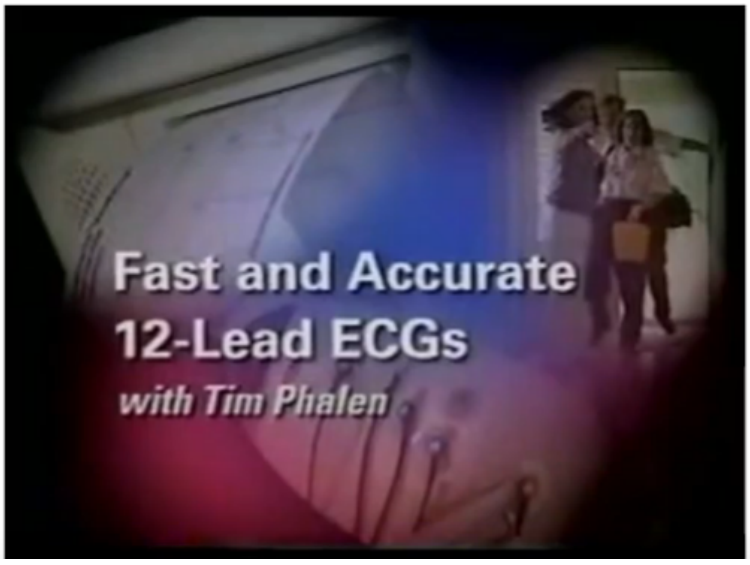

Fast and Accurate 12-Lead ECGs, with, 'Tim Phalen'. All right, all right now, key man is a, 45 year old male, complaining of some, some heartburn, maybe some chest pain; wife says he started to feel a little sicker, anything from indigestion to high fortune or a lot of things in between. But you know, this is though and I'm doing it, so it's a pretty safe that, this poor guy is gonna be having an acute myocardial infarction. Once come along with us and we'll show you

how to do a 12-lead EKG. Great? Let's go. Tim Phelan is a seasoned paramedic, with more than 18 years in EMS, an internationally known author and educator, he has trained more than 25 thousand paramedics and nurses, on diagnostic 12 lead ECGs. ‘Thanks for the nice intro’, you know, the American Heart Association, in chapter 9 when you learn in your textbook, talks about the acute coronary syndromes, including myocardial infarction. And they make some pretty bold statements; it says that, emergency care providers that you and I, need them 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. Okay? 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. Allow the skin to dry, before placing the electrodes. If necessary shave or the 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 of the information, the patient must be relaxed, warm and as comfortable as possible, with all them supported. If the patient is uncomfortable are 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 scene time. So, don't be concerned about that. Second thing; getting a 12-lead really is pretty easy, once you've done a few of these, you'll see for yourself. The truth is, the skills you learnt already, are far more difficult to 12-lead acquisition. And remember, getting a 12-lead makes a difference, on scene and route and arrival at the hospital. Of course, to be valid, it absolutely has to be done correctly. So, let's talk about ECG monitoring in general. Everyone is familiar with Leads one, two and three. You learned about them in school, you've been using them for years on your job.

And when you've used them, 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's why; each of the complexes has a slightly different configuration. The ground electrode helps to reduce electrical interference and helps produce a clearer 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 band width 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 rate of play is assumed to be eligible receiver cords

across Decatur County. ‘Whoa, timeout, that's the textbook version, of frequency response’. Here’s, the real-world version. You see the difference between freely 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, is just focusing in, on the center portion. So, can see the QRS complex, so you can do rate and rhythm. In the process it's filtering out some artifact, which makes the ECG clearer, that's terrific. But, you cannot do this, for ST segment analysis. Because, in monitor quality, you can't see the ST segment properly, that's why the 12-lead has to be done in diagnostic quality. In diagnostic quality, the Machine is able to 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 forelimb 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, as long as they are off of the torso. The lower limb electrodes may be attached anywhere from the ankles to the thighs. The four live electrodes provide a total of six leads. Leads one, two, three, AVR, AVO and AVF. All the leads provide a view on the vertical or frontal plane of the body, the 12 lead ECG, adds six views through electrodes, placed on specific points on the chest wall, these chest leads also called, ‘Precordial’. Or ‘V leads’. Provide a view 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.

In reality 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 could be no variation, in chest lead placement. The chests 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 sterna border. You’re in the first intercostals. Find the second, third and fourth intercostals space, position the electrode for v1, just to the right of the sternum, in the fourth intercostals space. V2, goes in the corresponding intercostals, to the left of the sternum, skip v3 for the moment, v4 goes in the midclavicular line, fifth intercostals space, v3 is positioned between v2 and v4. The v5 electrode is horizontally level with v4, in the anterior, axillary line, v6 also horizontally leveled 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's take a look at some tracings. The first shows gross an obvious changes. The second tracing was obtained from the same patient, only a few minutes later and the changes have all that disappeared. That's why it's important; to get the first ECG with the initial set of vital signs. Get a repeat ECG every five to ten minutes or at least, with each change in patient condition. Okay?

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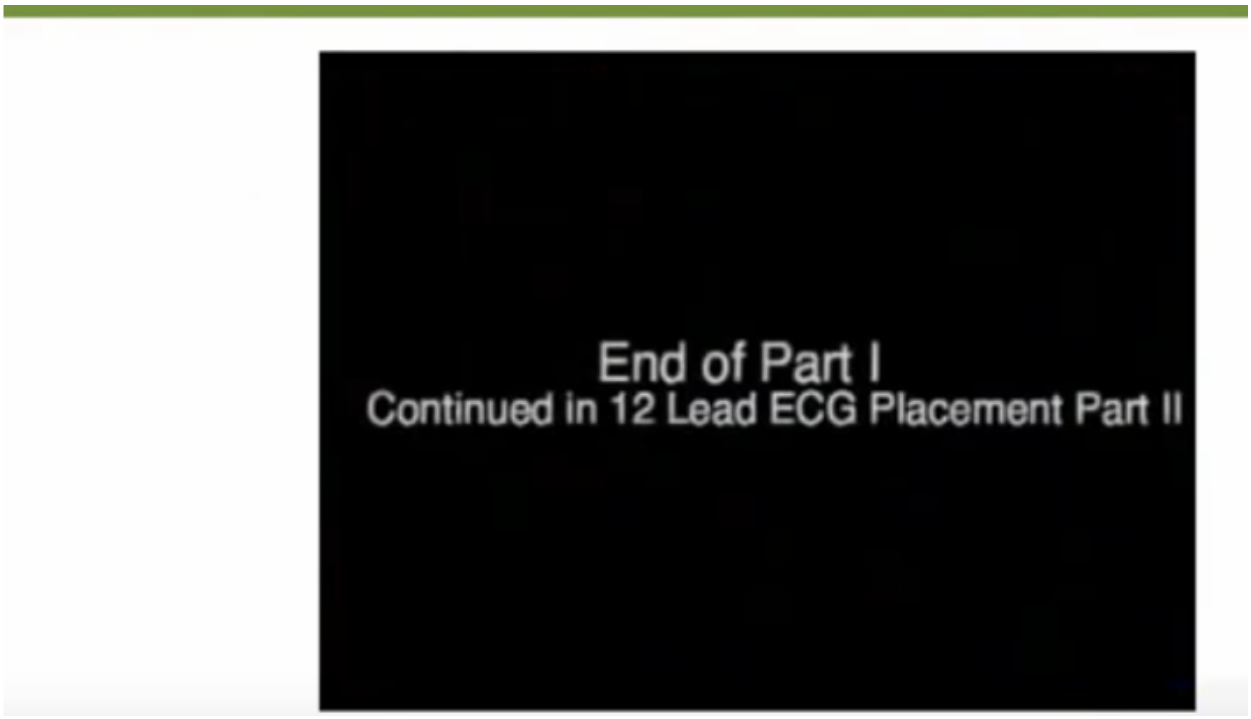

So, you have seen in the video, how the ECG electrodes can be placed and how can get these signals from the ECG lectors. Now, let us like I said our focus is more on eg cell just running through slide and so that you can have, you understand that, if your effect and design a signal conditioning module, for eg we can also design signal conditioning model for ECG as well and EMG as well and other, other bio potential.

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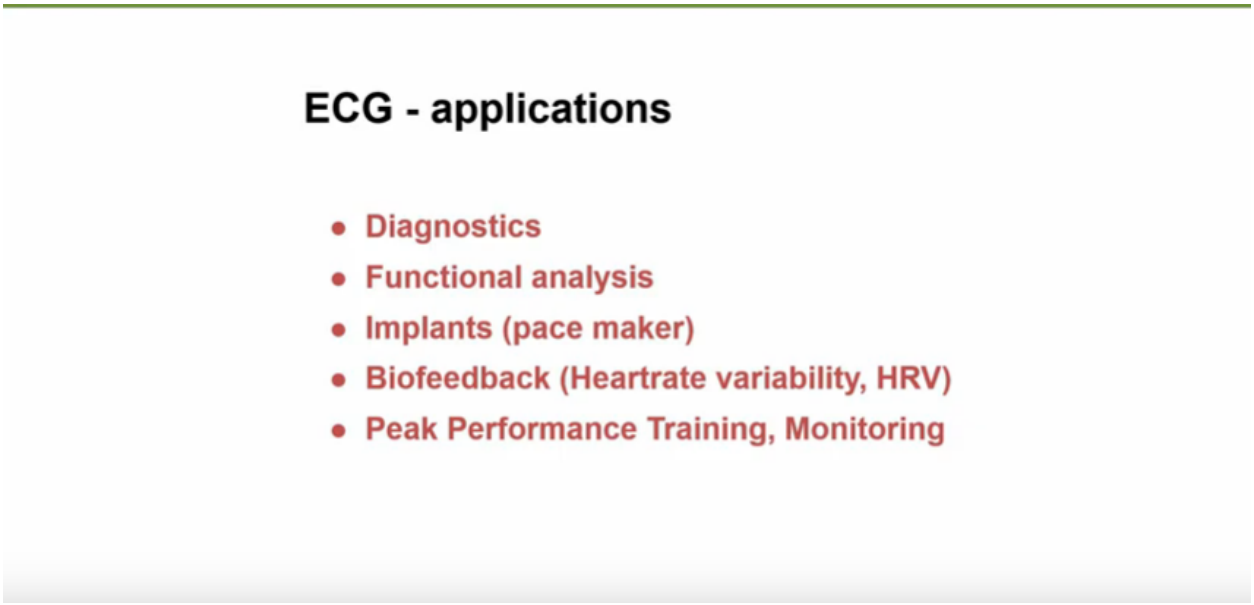

So, the if I consider the applications or if I look at the applications of ECG. The applications of ECG in Diagnostics, we understand the heart rate, the, the health of heart, we also need it for functional analysis, sometimes we are when do you implant the pacemaker, then we need to understand how these signals are behaving, we also want to understand, if you want to understand the heart rate variability, then we require this ECG applications, ECG signals again we want to understand peak performance training and monitoring, we again acquire the ECG. So, the applications of ECG are enormous and we had to rely, on ECG signals right now for understanding the health of a heart.

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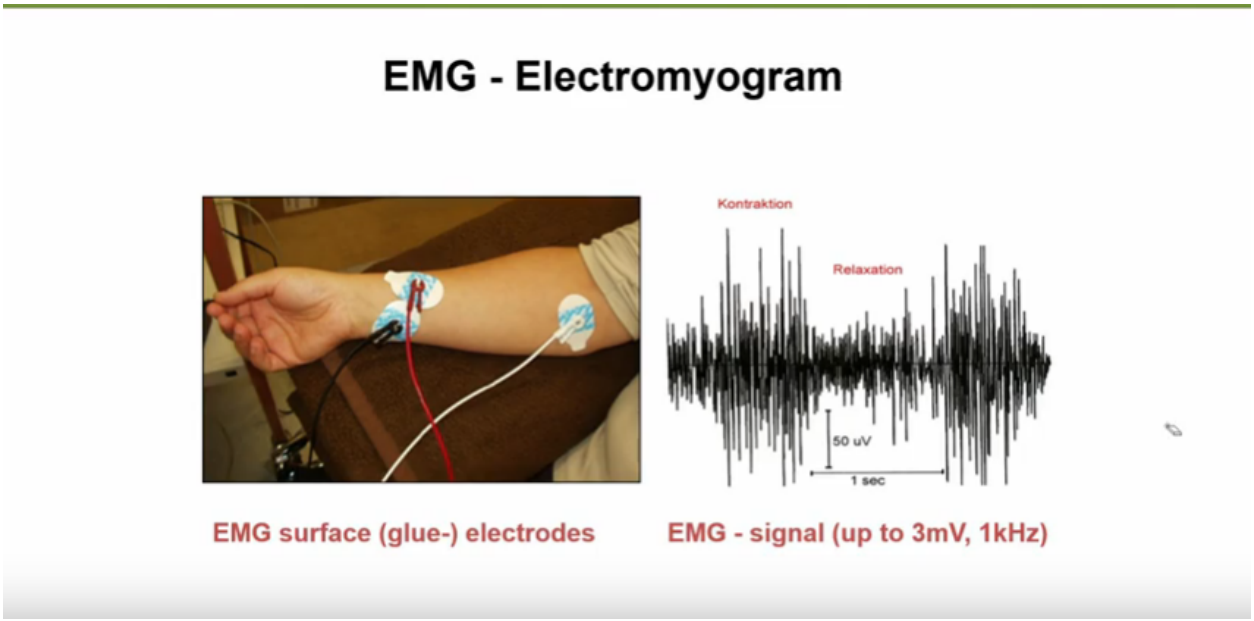

So, let us move to the next way of understanding these signals and that is from the muscles. So, as you see here right, this electrodes are placed with the help of glue, see the, the reason of using glue is to reduce the impedance. Now, when you relax it and when you expand it, you can see the change in the EMG signal. EMG signals are close to 3 milli volts at 1 kilowatts and you can see the change in the signals, when it is relaxed compared to when it is expanded, right. So, again this is another way of measuring the muscle moment and people have used this particular signals to help, you know moody arm of a patient, who has lost his motor skills. So, let me show you, let me give you, let me show you in my hand, what exactly I mean, by motor skills. Okay?
There are some motor skills, when I say, if let's say, if I say fold, fold your hair, fold your pump, this is what I am doing. Right? So, the to make a fist right, so when the signals is, signals are sent from the brain to my hand, to fold it to make a fist right, then this is the motor skills. Same way had to hold a pen. Right? Same way to hold a mobile right, so or to wave at you, so this all moments are because of the synchronization, between the signals that is sent to your from your brain, to your muscles to operate. Now, if somebody has lost a motor skill that means that, either a part of that, or hand or there that part of the body, it's not working as the signals are not getting

translated to that particular organ. Right? So, how to use EMG signals, to control the muscle movement of a person who has lost, motor skills. So, people are doing research on that, how can you understand this? And how can you control it? First thing is you need to understand, have what are the signals coming from your muscles, when I move my muscles right, this momentum of muscles causes the change in the origin it's the signal. And this signal was, as you can see otherwise we have seen is about 3 millivolt at one kilohertz frequency. Now, water Delta of EMG electrodes are there that we will see and like I said, again I'm reiterating it that we are more focused on EMG in this particular module. And not ECG, EMG. But, I'm just giving you an idea that if you know, EEG you can also understand, ECG girls understand, EMG.

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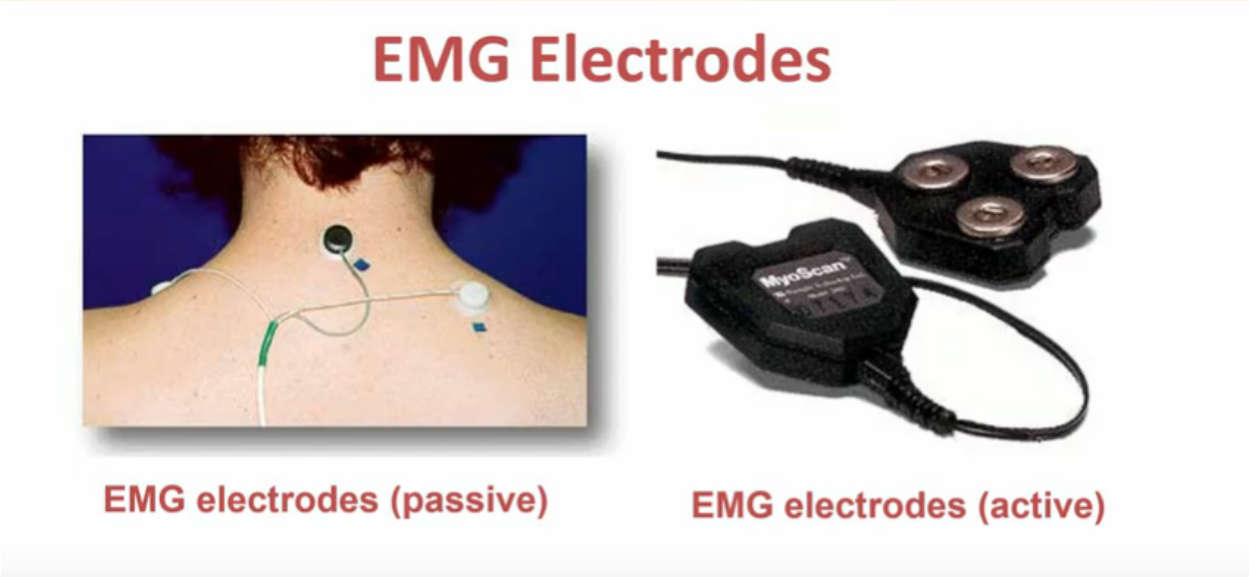

So, if you see the slide, this is how the EMG passive electrodes looks like, where it takes the signal from the muscle moment, where there are other electrodes called, ‘EMG’ active electrodes there's a company called Mayo scan which sells this active electors, for measuring the EMG signals. Let me play the video for you, so understand how the EMG electrodes are placed.

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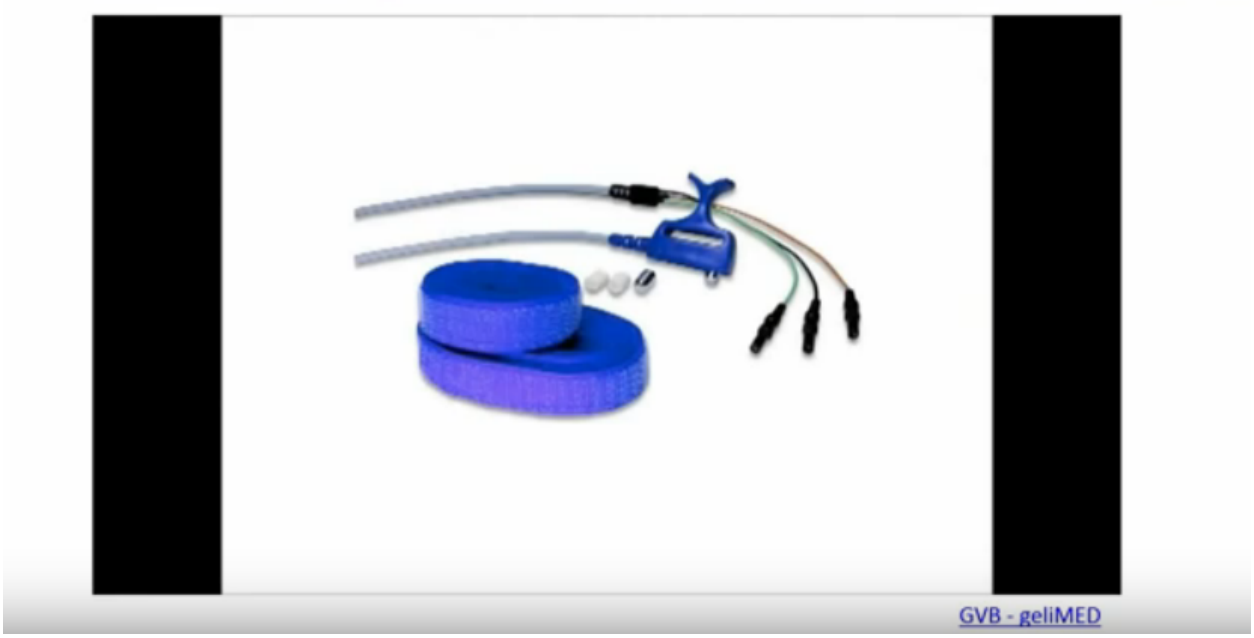

NCV, EMG teruvation, comprise a multitude of investigatory, measurements, as well, as their electrodes and accessories. GVB – geliMED will supply you, with the electrodes, required for bio stimulation and teruvation, including the appropriate accessories, ranging from cable connectors, through paces 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, is a blink reflex. Through paces and dreams 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, enter evasion measurements, as well as a special form of geography the blink reflex, Raya to the new graphic investigation the ground electrode is placed over the wrists 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 motor oil graphic, the recording and stimulation areas, should be decreased before the recording electrodes are attached, following this, technique the active electrode should be positioned on the maskel 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 cavers of that fit the multifunctional system and snap adhesive electrodes, can be used as an alternative to the crocodile clip cables and tablet rows, waffle electrodes are a further alternative. However an accrued reel should be applied prior to use, to guarantee a good electrode resistance. The electrode itself is attached using adhesive tape, plate electrodes that are employed in the same way and disc electrodes that also have electrode rail applied to them and are fixed using adhesive tape, form part of the multifunctional system electrode program and can be used, as alternatives. The stimulation electrode, should be ready prepared for use, for this suite the stimulation balls,

into the electrode appliance, if you are using stimulation electrodes with felts, soak these in NSEL liquid prior to inserting them, into the appliance in order to guarantee good skin contact and a good resistance to, 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 the stimulus is increased following a predetermined sequence, until maximum amplitude is reached, the user observe motor reaction, as a control. The stimulus is increased, until the super 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 amplitudes magnitude, the electrodes must also be moistened with NaCl, when stimulating with finger toe stimulation electrodes. However, the electrode should not be wet. Therefore, Piezo electrodes were the clothes, the ground electrode is also placed over the first, between the stimulation electrode and the stimulation area prior to a connection the EMG instrument, when using stimulation insensitive neurography, with finger toes stimulation electrodes. First the cathode is attached proximally to the finger base joined and their node is then attached just to lead to the fingertip, there should be no liquid ridge, between the two loops which can however, be enjoyed the prior trying 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, the post the wrist, attached using Velcro tape and then, connected to the EMG instrument, this stimulation and recording electrode, has already been used as a stimulation electrode, in the previous section. The autotrol method, shows the first variations of sensitive Neurography, during stimulation with this method, stimulation is carry it out Supra maximally, an example, until the amplitude increases no further, this is similar to the approach taken in motor stimulation, then the Seidel is averaged online, a sensitive nerve action 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 to, to, to arrange 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 part 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 of the ring electrodes, have been connected to the EMG instrument.

This routine is an optimum contact resistance. An anti drum sensitive Neurography, recording cures from the skin and the respective peripheral nerve or stimulated. Anti drum stimulation is advantageous, as it is a rapid method, with a high response amplitude. However, motor overlaps, can have an effect on this method. Our mayolin needle program, supplies EMG, needles electrons of different lengths and diameters, for the pain-free investigation of superficial muscles, deep muscles and also 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 waves or 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 electrode, 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 the multifunctional cable. To prevent an IC a 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. Several curves must be overlaid and the R 1 and R 2 components, on the stimulatory side and the R2 component of the contra lateral 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, with 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. GVB-geliMED, in cooperation with Best Medica, always wants to offer you all stimulation electrodes and accessories, which suffice the newest technical requests. GVB-geliMED electrodes enable stable and comfortable recordings, for you and the patient. If you need further information's, to find the right electrodes or accessories for your request, please call us. The team of GVB-geliMED, will be happy, to answer your call. Okay?

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So, you have seen the video right. Now, if I talk about the applications of EMG. So what are the different applications of EMV?

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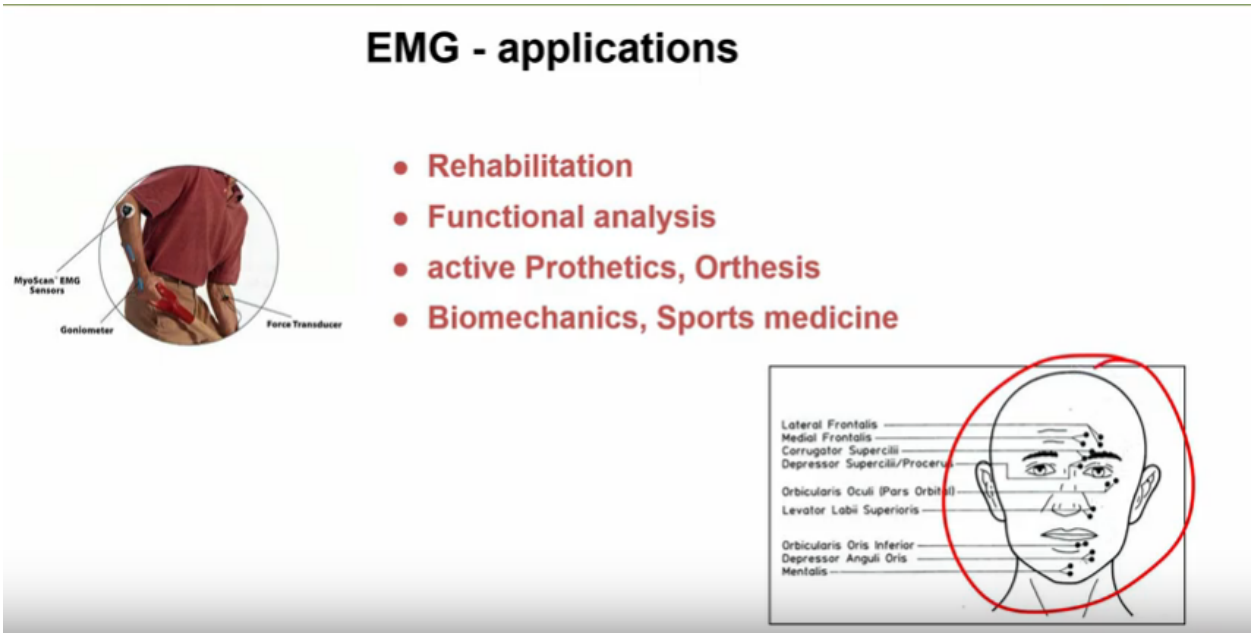

So if you see the screen, the EMG applications can be in rehabilitation, right? Rehabilitation like, I was telling you that is a company Bio scan, you can see the EMG sensor over here, there is a Goniometer over here, while there is a force transducer over here, this also helps to understand how the functional analysis is done, it is also used in sports medicine, it is also used in active orthotics, it can also be used for rehabilitation like what, I already said and same thing you see here that for the moment of the eyelids right, you can see here, lateral frontalis, medial frontalis right, depressor supercili, levator lobii superioris , orpicunaris oris inferior , as well as the mentolis everything that we have, on our face right, when we move the muscles that muscle, moment will cause change in the voltage. And that voltage is nothing but, we can measure with the help of EMG, alright. This is called electro Bio.