Lecture 45
Fundamentals of EEG Signal

Now, let us focus on the topic that is of our interest for today's lecture which is easy, now this earlier one was like, like a trailer Right? when you understand further how the ECG signals are open if you also have seen the earlier part we have discussed about ECG in detail. Right? It's all only about EMG further, so I give it to you as an exercise of how can you design EMG from the EMG signal, how can you design a circuit, that can help to move the, the muscles of a next person. If I, if I connect EMG signals over here if I if I take the EMG signals from my muscle moment and there is a person next to me, if I do this particular moment can he or she can also perform the same moment because of my moment of my arm moment. Right? So, this is a circuit that you need to design how can you transfer the signals to the next person's hand and how it can be connected, is it's not so easy, it's as a detailed research problem, so the best way is if you see the TED Talks you can understand how it can be it can be applied. Okay? But, but the point is you, you should get into the research domain and this is only way, that you can understand that you can use the, the basic understanding of your op amps and your analog circuits to develop electronic module for such applications. Okay? like signal conditioning circuits for ECG for EMG and now we are talking about EEG. Okay?

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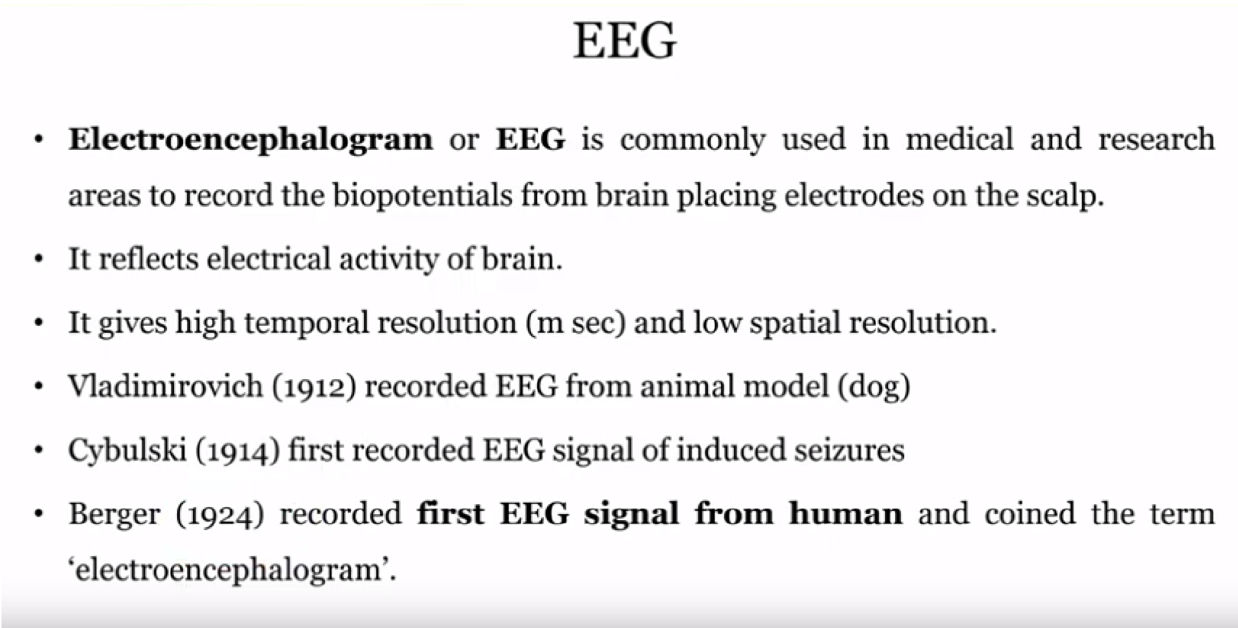

So, let me go to the slide and we are talking about EEG, so EEG stands for electro encephalogram is commonly used in medical and research areas to record the bio potentials, and variations are occurring from they occurred from brain placing electrodes on the scalp. So, What exactly EEG do? EEG reflects the electrical activity of brain. That is the use of EEG, next one, it gives high temporal resolution some milliseconds and low special resolution, so if you see the in 1912, Vladimirovich which recorded EEG from animal model, which was a dog and then further 1914 first EEG was accorded of induced seizures, and then Berger In 1924 recorded first EEG signal from human and coined the term 'electroencephalogram', so that's how the name came from 1924 one was lot of research is going on it's an interesting field for all of us to work on because it's related to brain.

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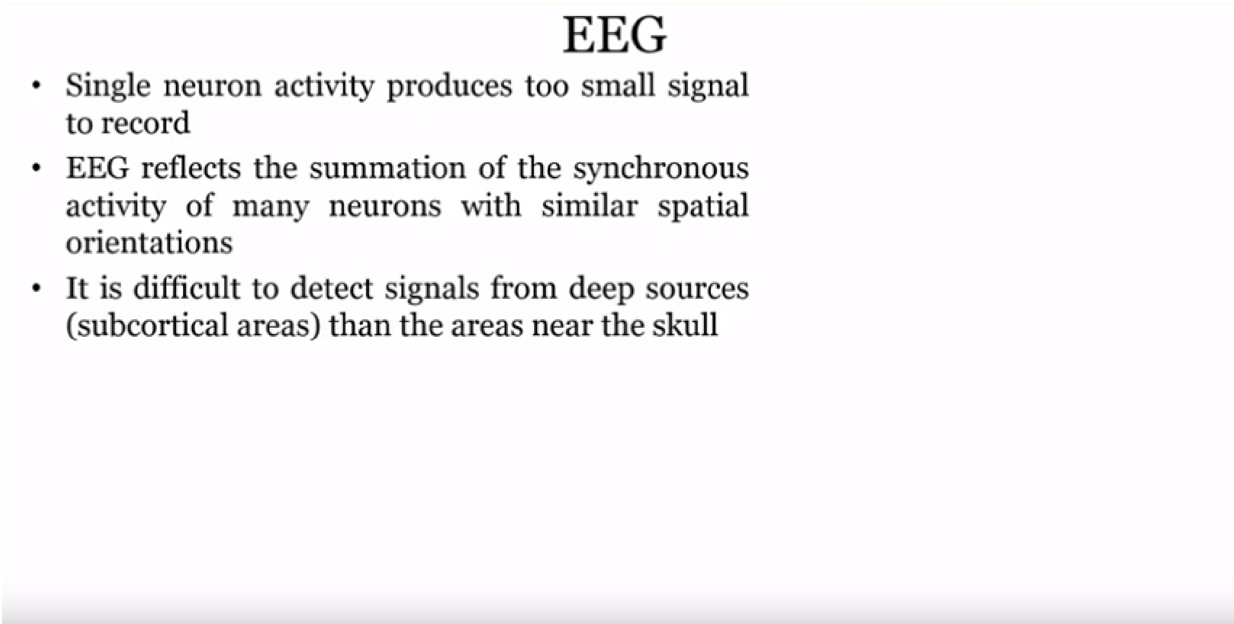

And, unfortunately we had not explored the early part of the brain, it's very difficult it's extremely complex you know in terms of electronics if you want to say brain is the most complex electronic circuit, and we are yet to identify why, what exactly is the role of each and every part in the brain. When you see a brain, it looks like a it looks like, it is called gray matter by the way, and you don't really have a separate columns where, it is responsible for that particular action. So, so, so if you see the EEG, it is not just a signal coming from one single neuron. It is activity produced by several groups of neurons, that's what is written over here. When we talk about EEG signal Neuron activity produces two small signal to record EEG reflects the summation of synchronous activity of many neurons with similar spatial orientations, It is difficult to detect signals from deep sources for example subcortical areas than the areas near the skull for determining the deep sources we had to rely on micro needles way to rely on the e-cog and that is a different topic we will not talk about that in this particular module.

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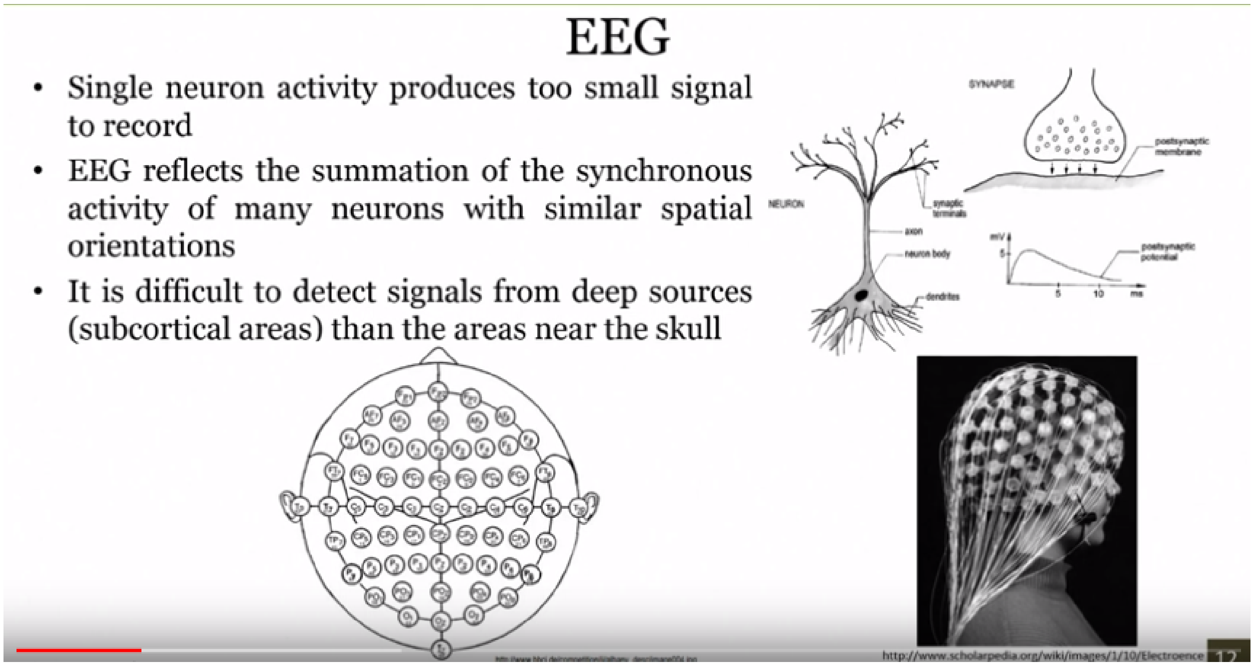

I want to show it to you how the electrodes are placed onto the, onto the scalp to get the easy signal out Okay? That is my point of showing you this particular slide we can see that there are ways you know placing the electrodes on to the on to the head.

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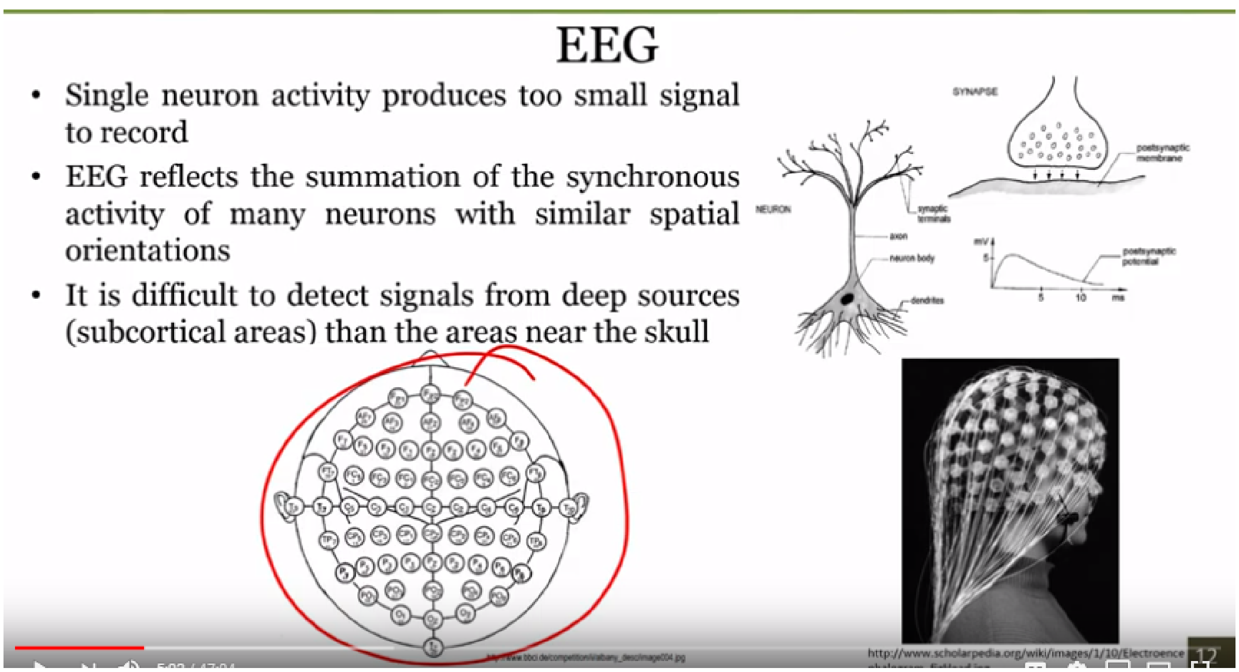

And, this is the one such diagram, where you are understanding the frontal portion, the center portion, the posterior portions. Right? and then the temporal portions, so that's one for T,C,F and then P. Okay? So, when you talk about neurons. Right? Then there are dendrites and there is a neuron body axon which connects to other sympathetic terminals and then you have some few millivolts of micro volts of signal that is generated.

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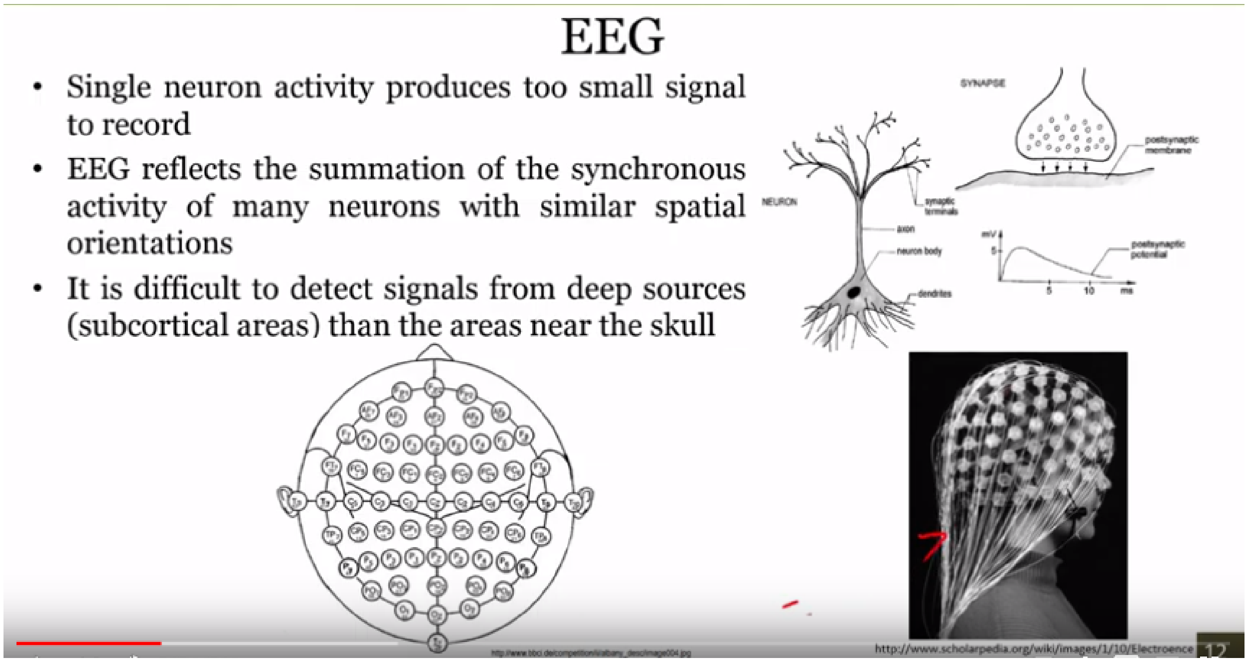

And, this is a schematic of the electrodes placed on the head of a patient.

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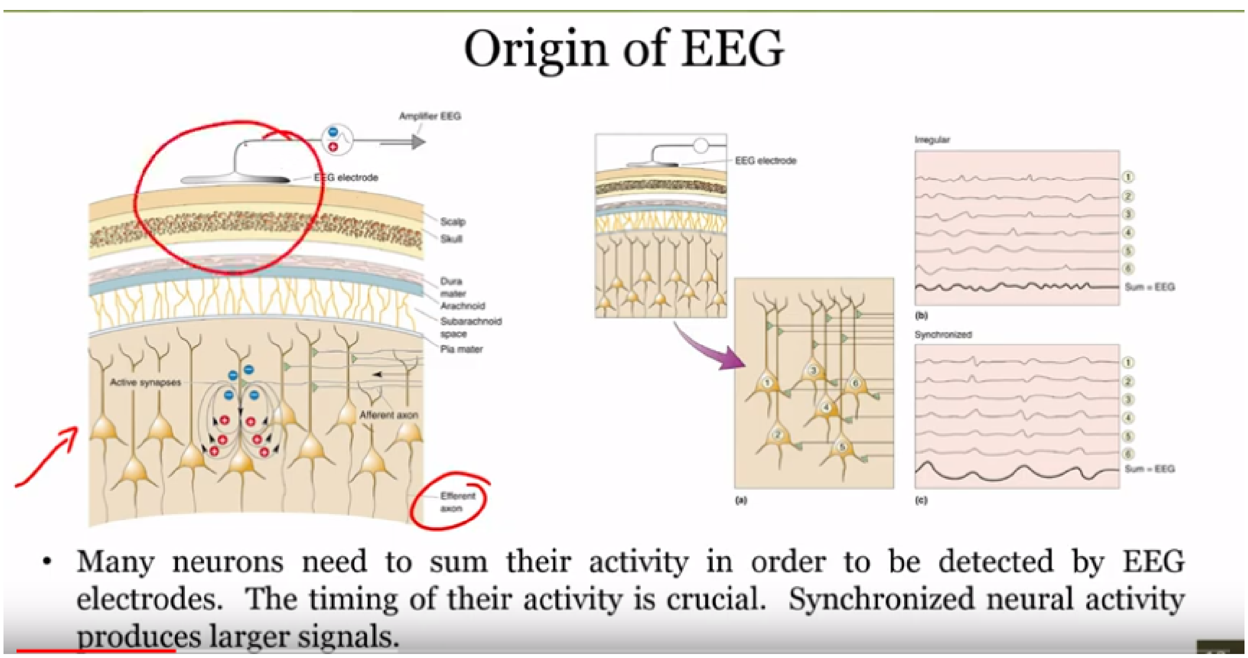

And, then like I said, we are understanding the signals that are generated from the near area of the skull this is how the origin of EEG we can describe you see this particular figure there are active synapses and there are efferent exons, and there is a different exons. So, efferent exons is on the backside Efrain exons are at the front side and then there is a pia mater and then there is a dura mater skull and scalp and, on the scalp we are actually placing the EEG electrode.

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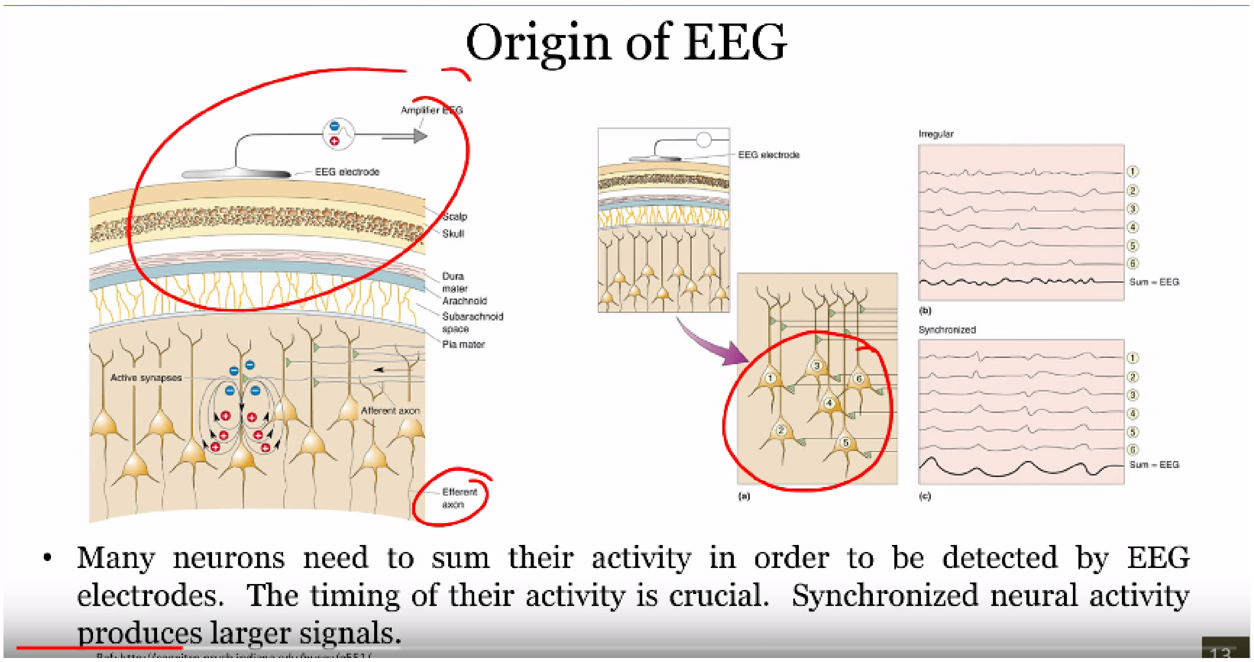

So, if I further magnify this particular area then what will I have is, the functions and the potentials that are generating from the group of neurons causes the change in the signal which we are measuring through EEG electrode.

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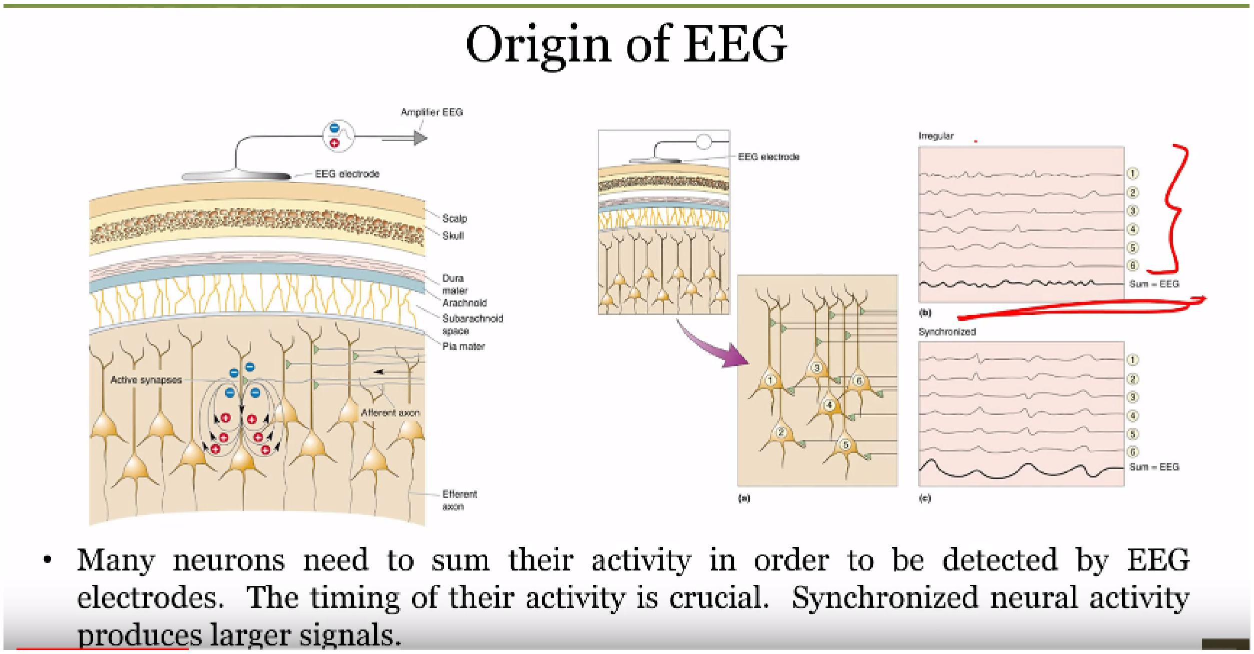

And, if you see the EEG pattern then you can see here and this this is some EEG from several neurons this is an irregular pattern well it's a synchronized one. So many neurons need to solve their activity in order to be detected by EEG the timing of the activity is crucial and the synchronized activity produces large signal.

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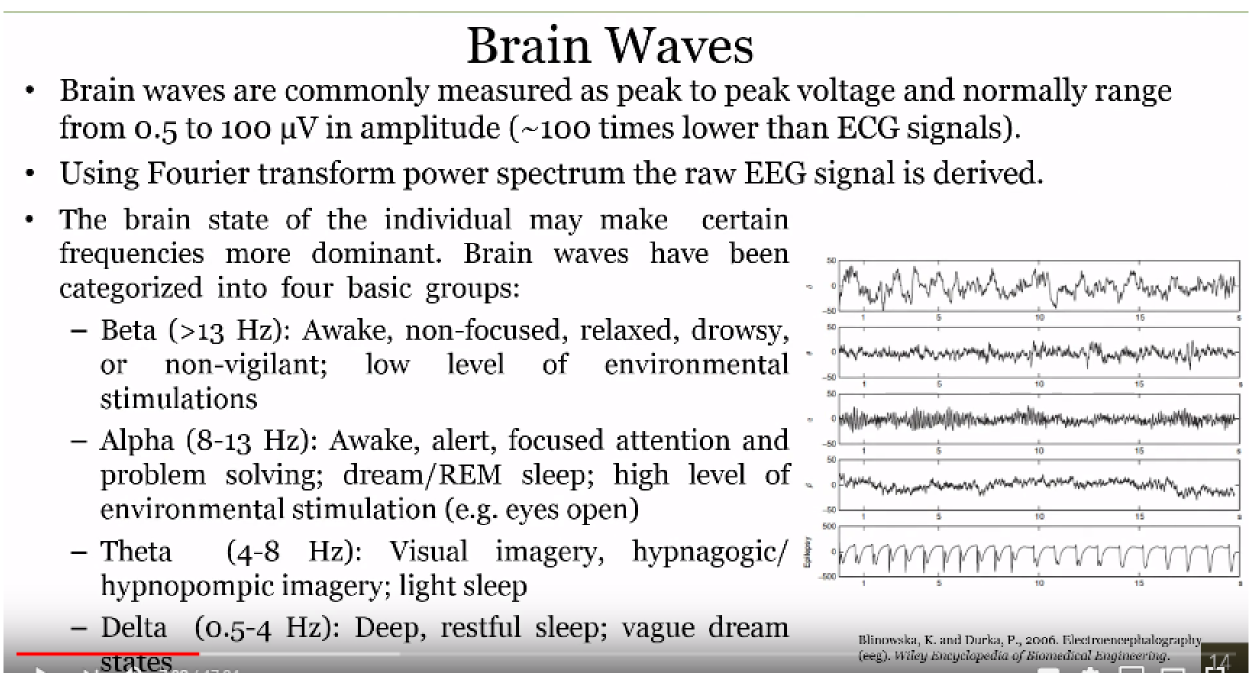

So, if we talk about brain waves then brain waves are commonly peak measured as peak to peak voltage as normal range from 0.5 to 100 micro volts. Now, if you see the ECG or EMG these the voltage is really high, but when you talk about EEG, we are looking at some micro volts of signal. Okay? So, which is approximately two times lower than ECG signal? We use for the transform power spectrum to using that photo transfer power spectrum the raw EEG signal is derived and then the brain state of the individual made make certain frequencies more dominant while the brain waves have been cat likes into four basic groups. So, if you see the basic groups, we have beta, where alpha, we have Theta and we have Delta.

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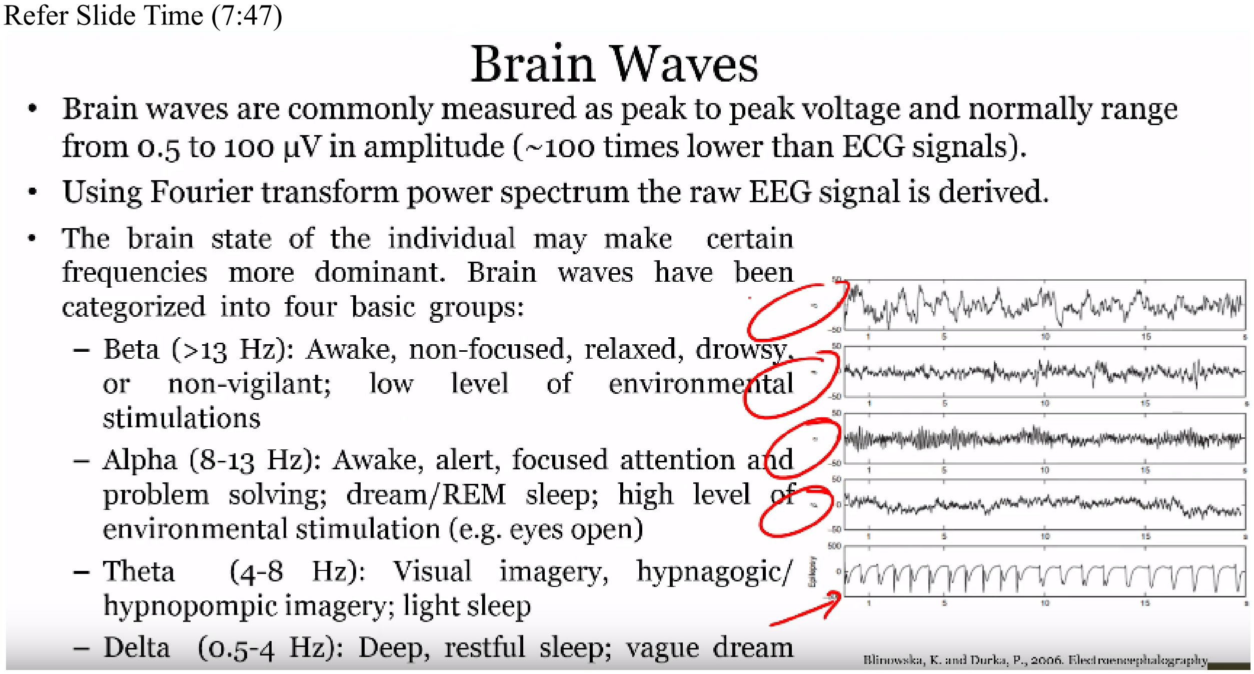

So, this is the model that there is epilepsy and there is a beta signal, alpha signal, theta signal and Delta signal.

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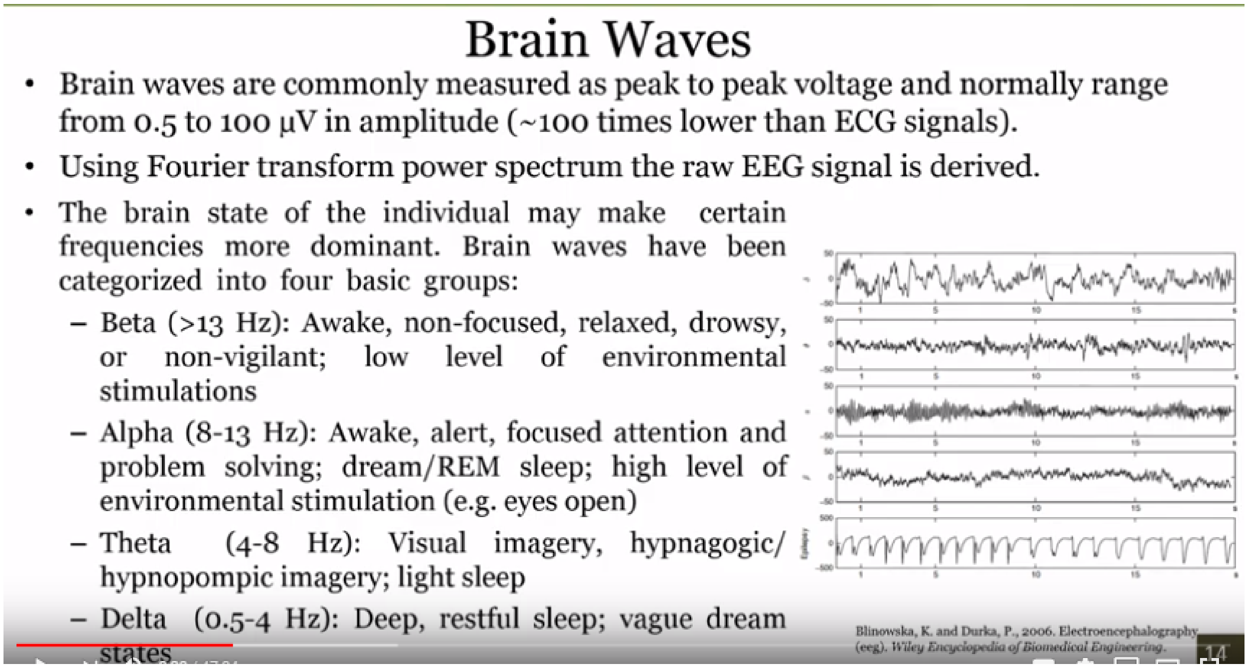

So, what are those groups let us see, and the first one which is beta signal is signal, which is greater than 13 Hertz obtained as aerials and these awaked non focused, relaxed, drowsy or non-vigilant; the low level of environmental simulations. While the Alpha signals, which is between 8 to 13 Hertz we are it's awake, alert focused, attention and problem-solving; dream/REM sleep; high level of environment simulation examples high eyes open. We, we get it at 8 to 13 Hertz. While the Theta, we obtain around 4 to 8 Hertz which is a visual imaginary or it's a light sleeper, you can say or hypnopompic imagery. For those kind of things we can get theta signal which is between 4 to 8 Hertz. While finally, if we are in deep and restful sleep or wave dream states then these signals are obtained around 0.5 to 4 Hertz.

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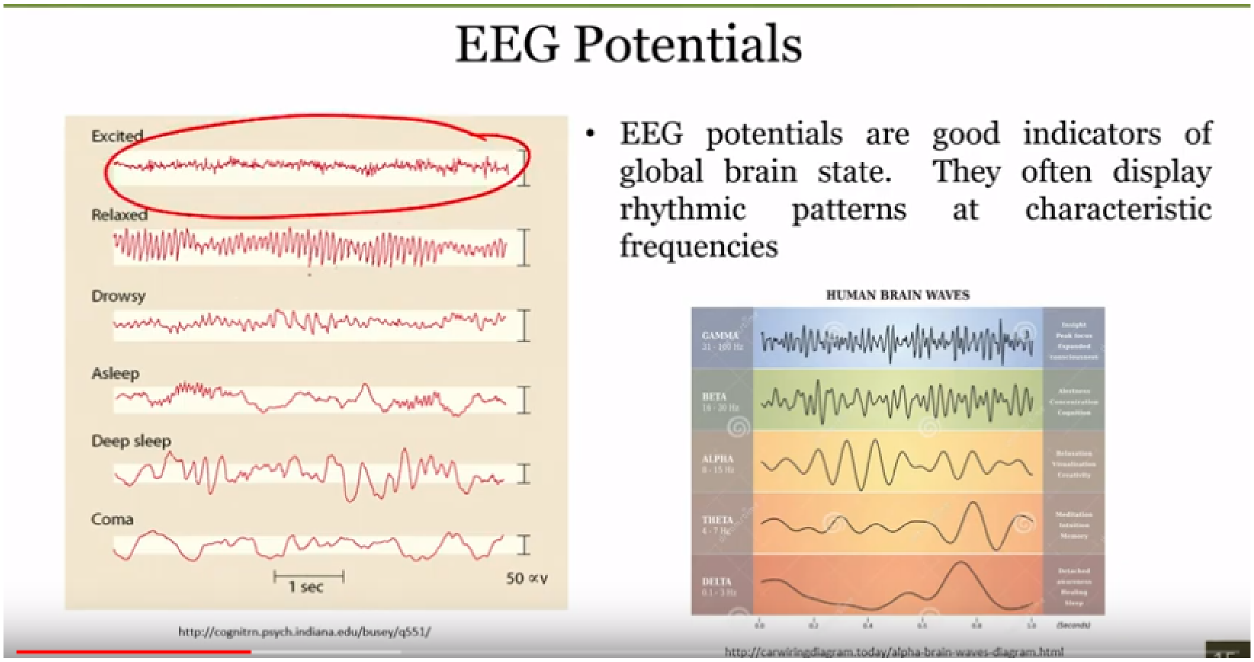

So, if you see here if this is the, these are the signals how it looks like in EEG. If you see it's excited you have this kind of signal.

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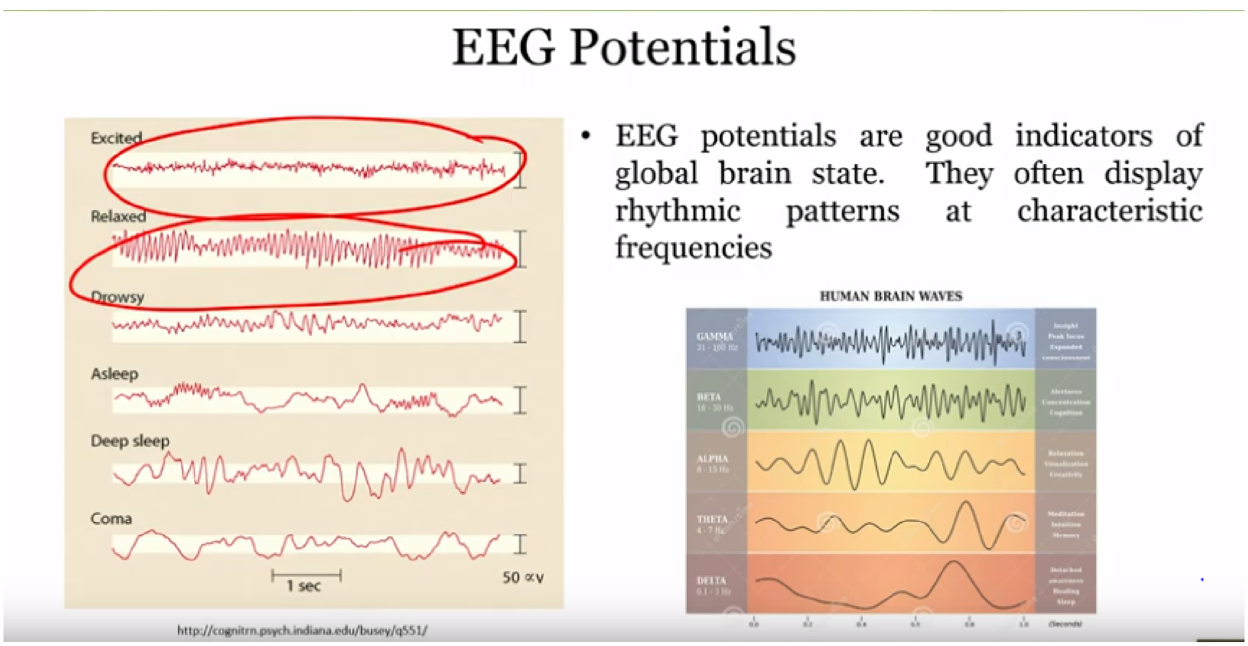

when the relaxed signals are, are over here if you are drowsy then the signal changes,
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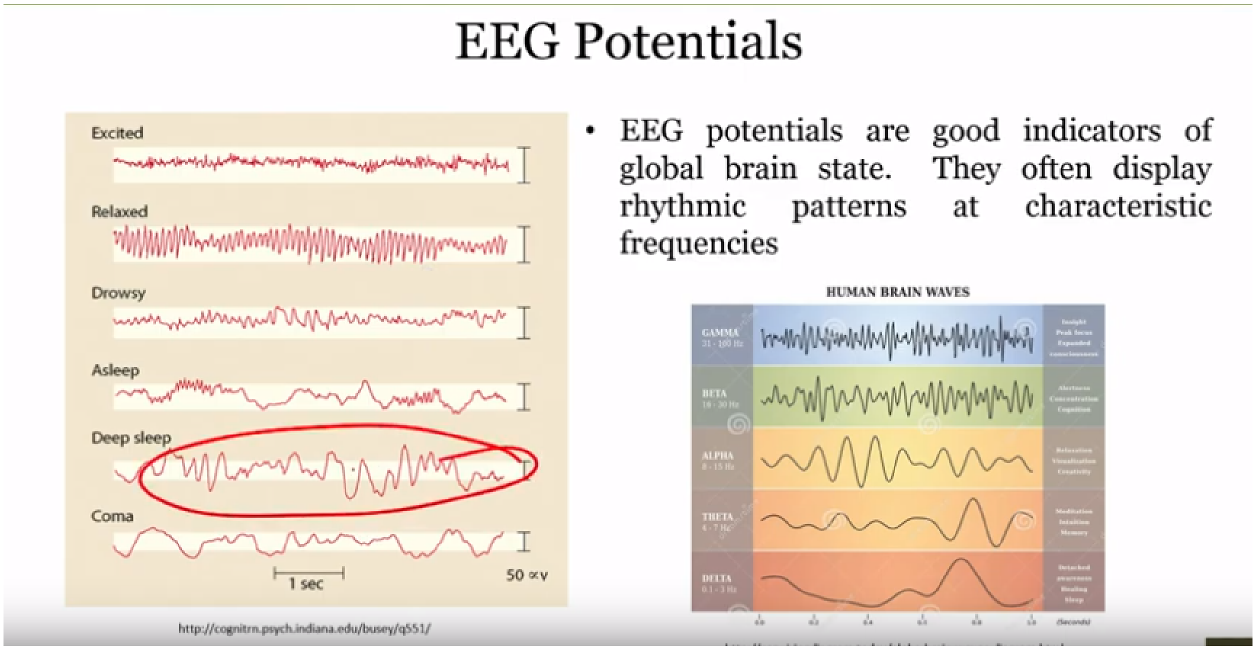

when you are asleep is signal changes when deep sleep the signal changes. Right?

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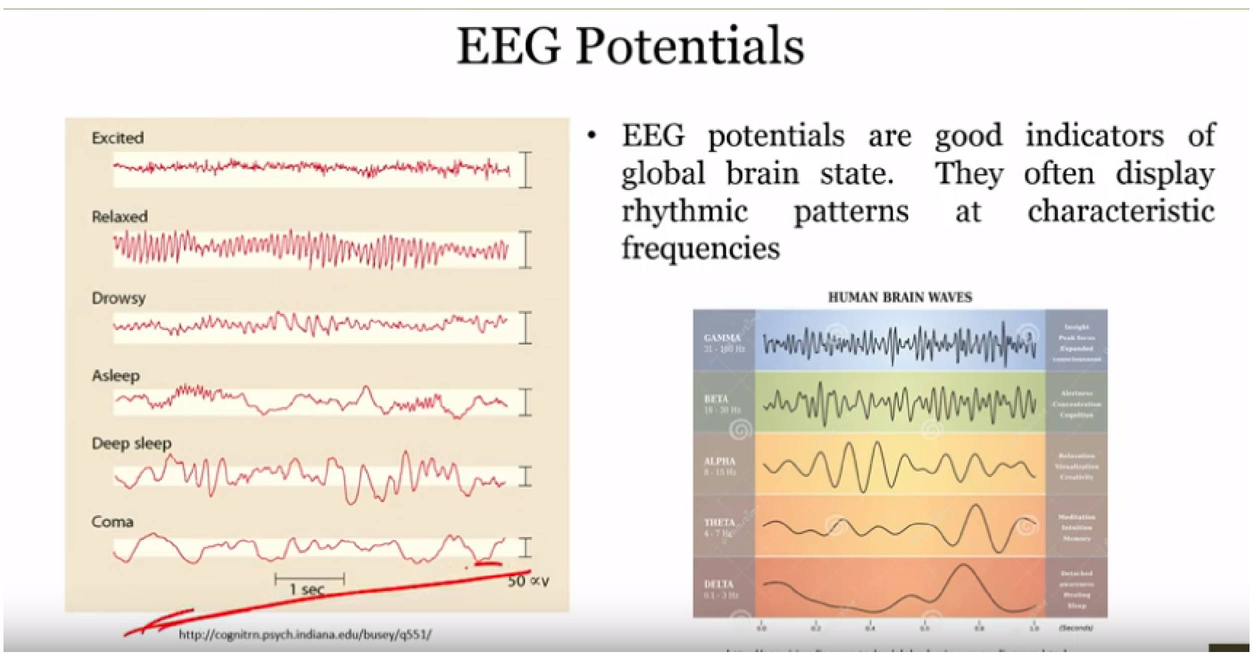

while the person if you see he or she is in coma the signals are Right?

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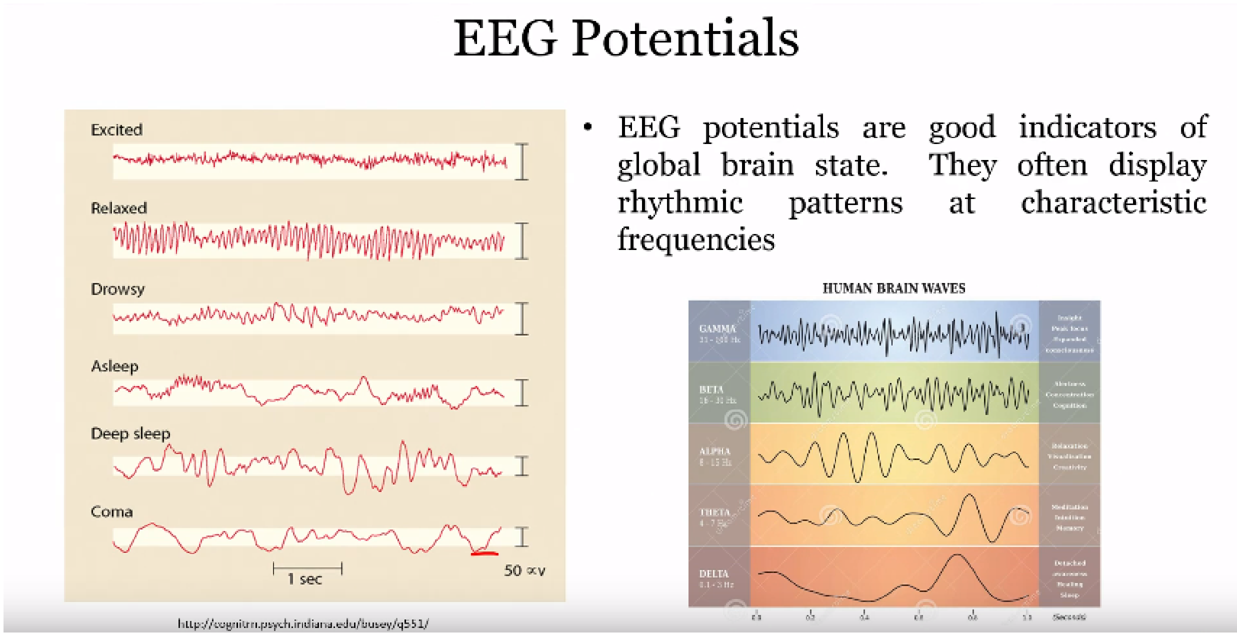

So, the point is that EEG signals are extremely important to understand the state of mind and again when you are talking about human brainwaves like we are discussed the gamma is unduly 31 to 100, beta is 16 to 30, alpha is 8 to 15, theta is 4 to 7, Delta is from 0.1 to 3 Hertz. And, each has their own functions, I chose a particular set of brain, where we talk about Delta then this awareness or healing sleep, we talk about theta it is about mediation meditation or intuition memory, when we talk about alpha it's more about relaxation or visualization creativity, when talk about beta it is alertness and concentration on cognition, where you talk about gamma it's about insight big focus expanded consciousness. So, EEG potentials are not only good indicators of the global brain state, but they often display the diametric patterns at Catterick frequencies which helps to understand the health of a brain or the state of the brain Okay?

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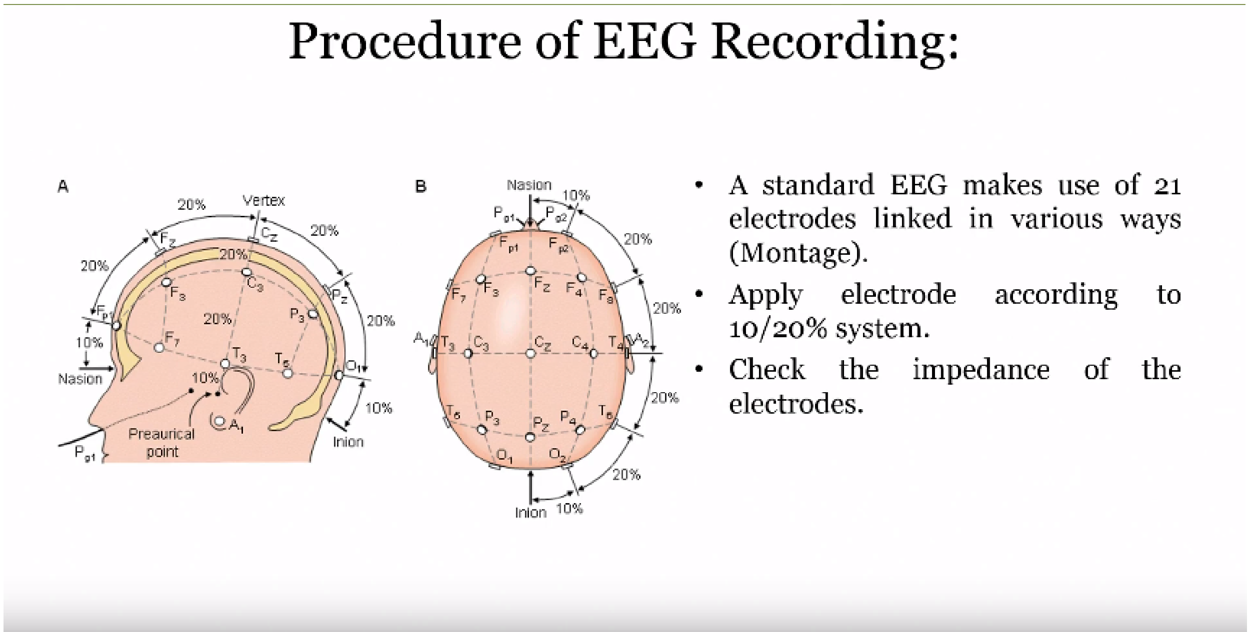

So, I'll move to the next slide and this is how the standard EEG makes use of 21 electors.

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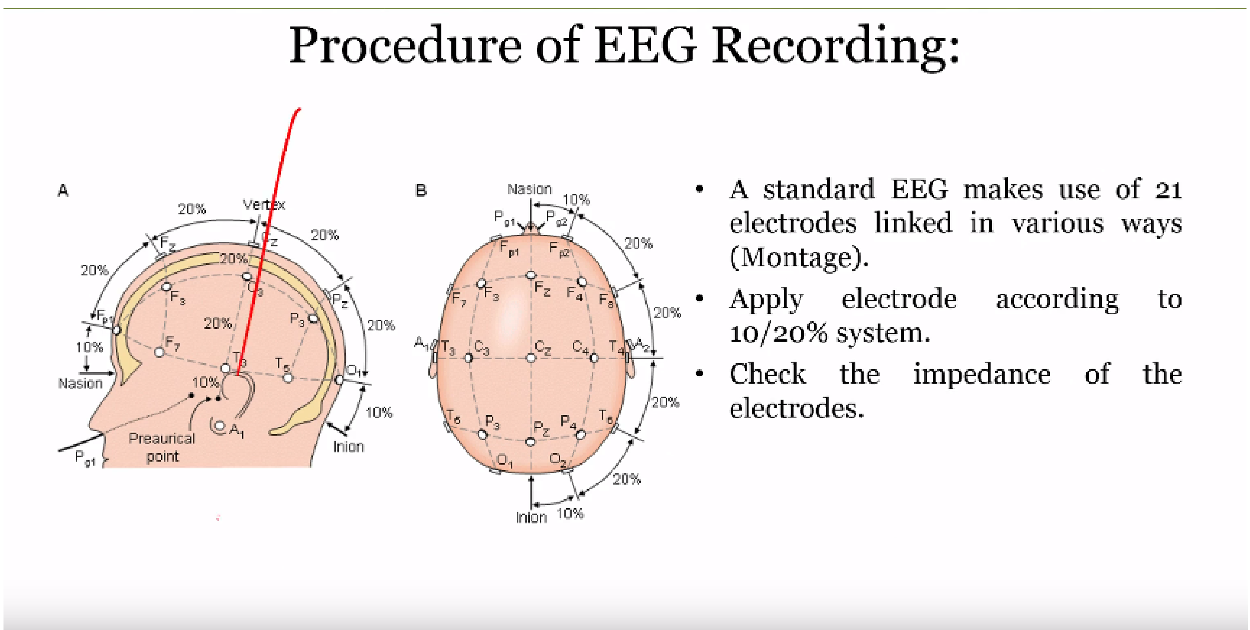

And, like I said its different places that has identified that you need to put the, the electrodes or place the electrodes this is called a vortex. Right? And then we, we have 1020 system, where you put something at the posterior side from the in the central zones and the frontier side, and then we have a pre-Oracle point, we have a nation point about which it is counted.

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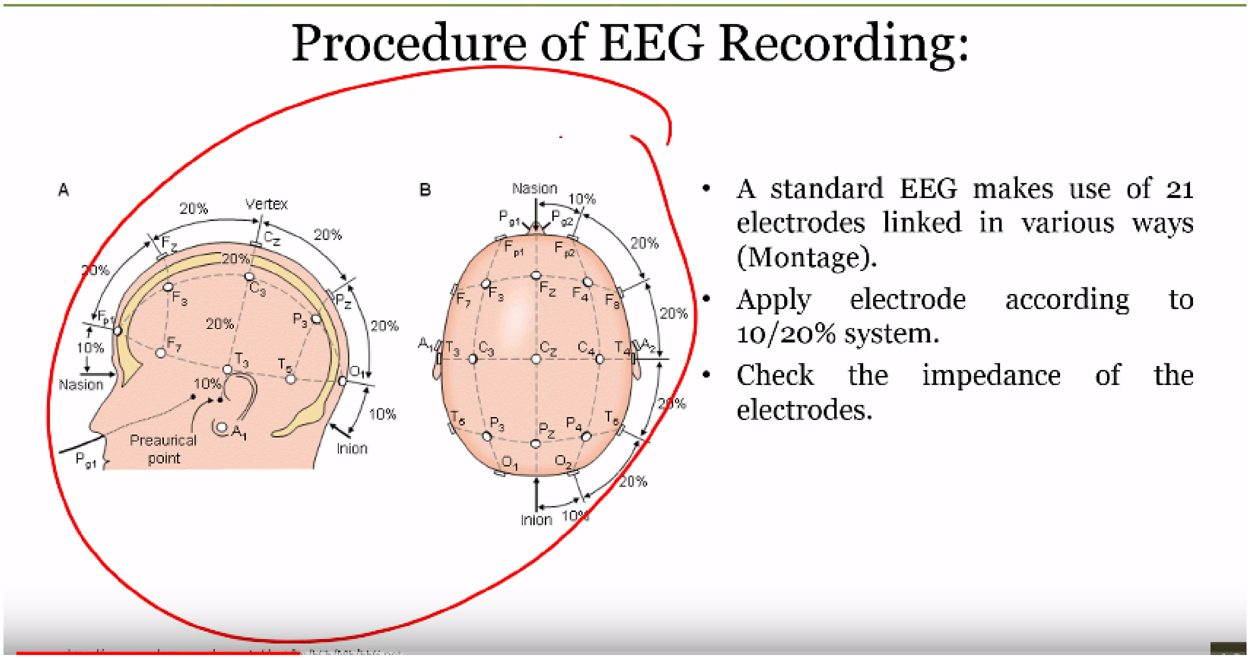

So, this is actually a kind of a complex phenomenon and let's not debate ourselves into this particular domain, rather then we focus it if we want to measure the signals coming out of this is electrodes what kind of signal conditioning system we should developed. Okay?

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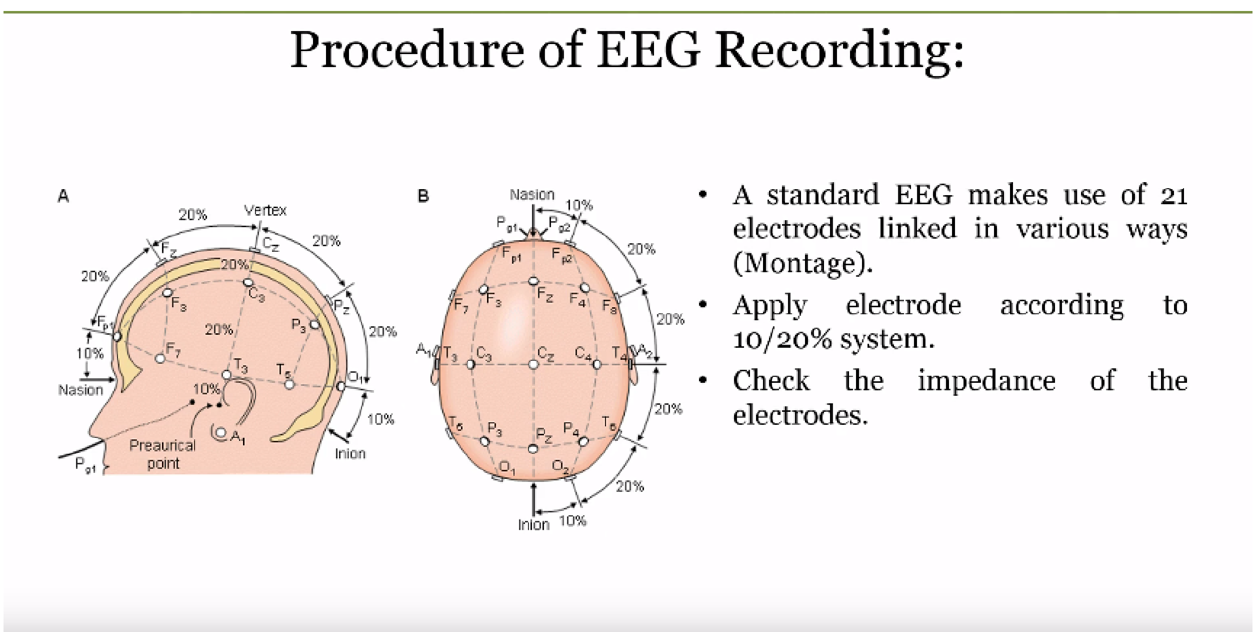

So, the first thing is check the impedance of the electrodes. The impedance to reduce the impedance, we use the gel which are wet electrodes and now there are also new electors that people use, and they are called dry electrons.

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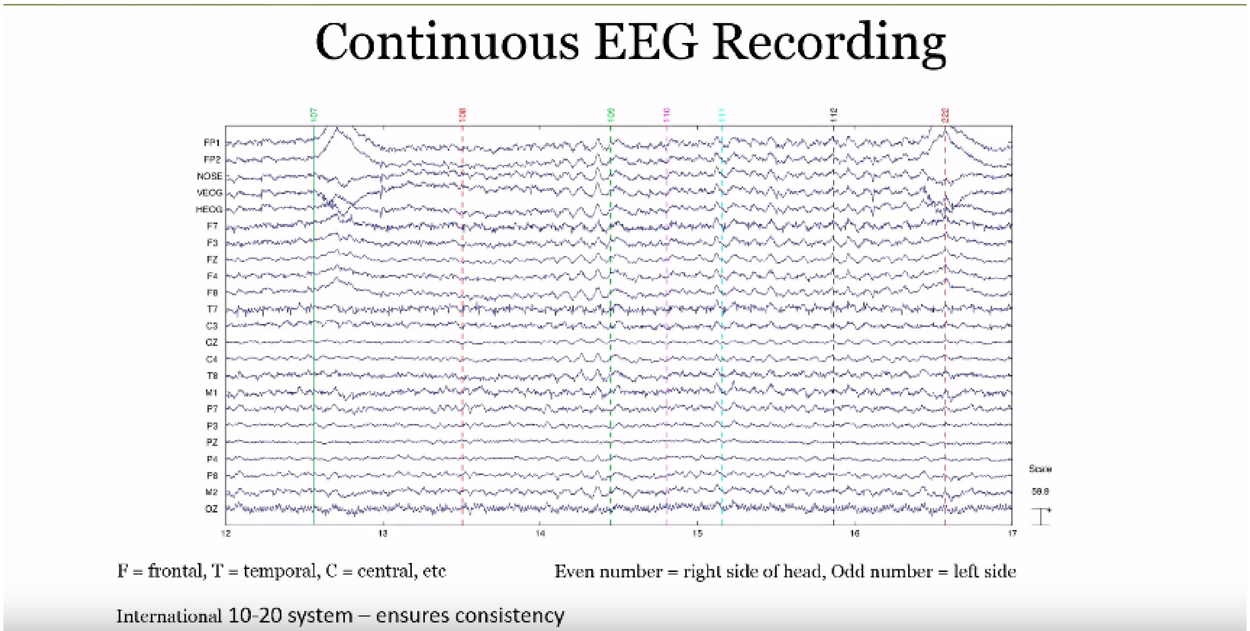

So, we will see the videos of dry electrodes as well and the weight electrons all set.

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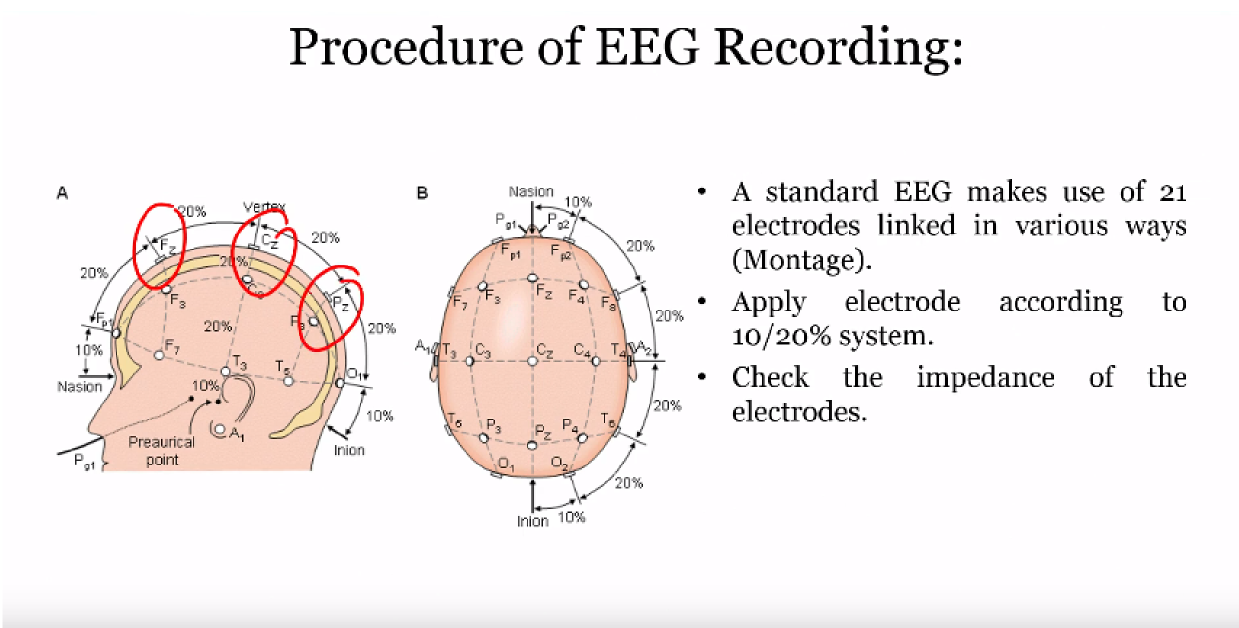

Now, like I said there are several domain that we or our terminology we are using, for example F_z, P_z Right? So, what are those things?

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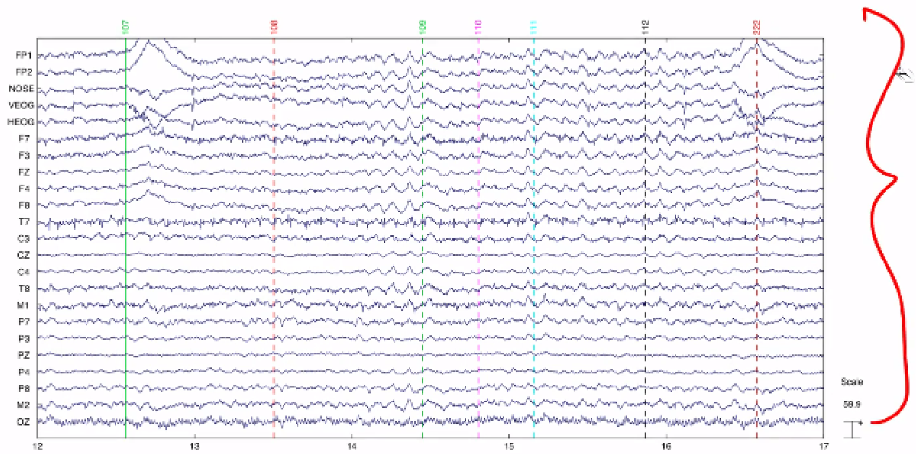
Continuous EEG Recording



F = frontal, T = temporal, C = central, etc

Even number = right side of head, Odd number = left side

International 10-20 system – ensures consistency

So, we have F stands for frontal, T stands for temporal and C stands for central all Right? Even-number there's Right side of the head and odd number is on the left side of the head. So, this is the International 2020 system, which ensures the content consistency and this are the signals are the thickness looks like it's, it's a not so easy to understand just by looking at the signal, but if a person is suffering from epilepsy then you will see a certain change in the pattern well compared to a normal person. So, the scope of further you know optimizing the signals and adding the machine learning part of it to make it easier for a doctor to diagnose.

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EEG

Pros

- Good time resolution, ms compared to s with fMRI
- Portable and affordable
- More tolerant to subject movement than fMRI
- EEG is silent and so useful for studying auditory processing
- Can be combined with fMRI or TMS

Cons

- Low spatial resolution
- Artifacts/Noise

Now, what are the advantages of measuring EEG and what are the limitations are what are the cons and pros? So, the pros are that good time resolution compared to fMRI. fMRI stands for a functional MRI and it's a magnetic resonance imaging, so compared to that we have a good resolution because it's a milliseconds compared to some seconds in fMRI, then the advantage of EEG is that it is not only affordable but also it is portable, further there is a More tolerant to subject moment at fMRI Right? in my eye if you're just in MRI person has to lay down in the in the, in the equipment and then that in the system and then the signals are generated and captured, while in case of EEG of a person is more free to move compared to fMRI. EEG silent and so useful for studying auditory processing as well while in case of a variety is not possible and the advantage of EEG is that can be combined with fMRI as well as our TMS or TMS. The disadvantages, we can say or the or the cons are that it's a low special spectral resolution and artifacts are there there's a noise. Okay?

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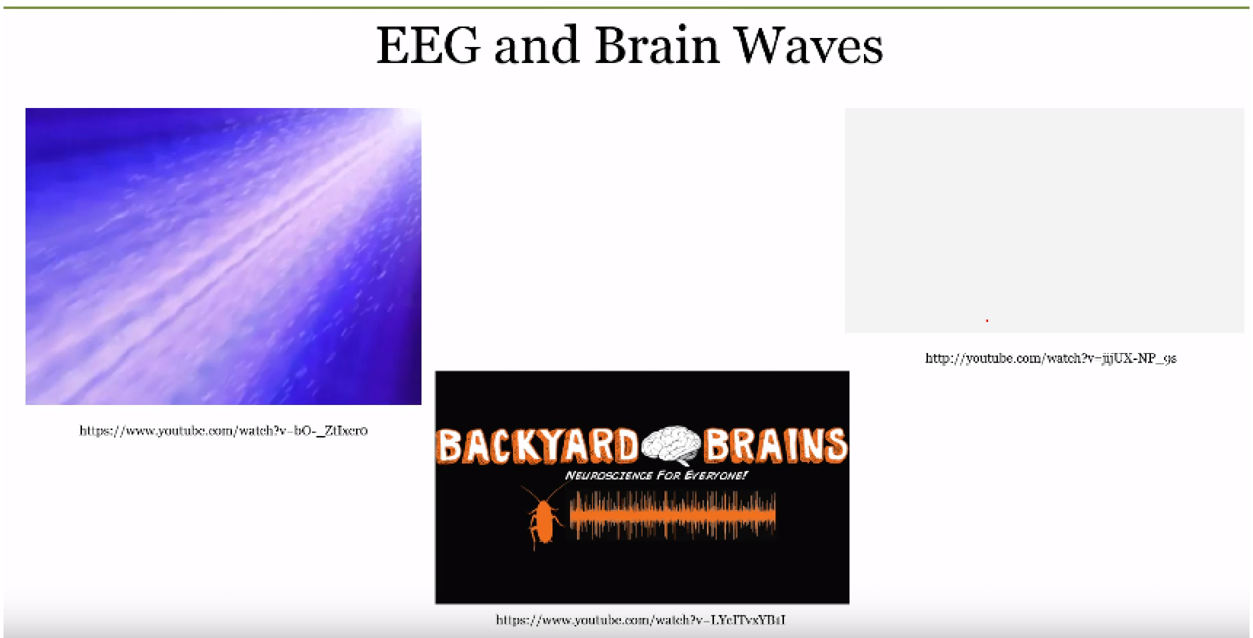

So, let us see how EEG and dream associated, I'll play video one by one and then you look into that let us see the first video.

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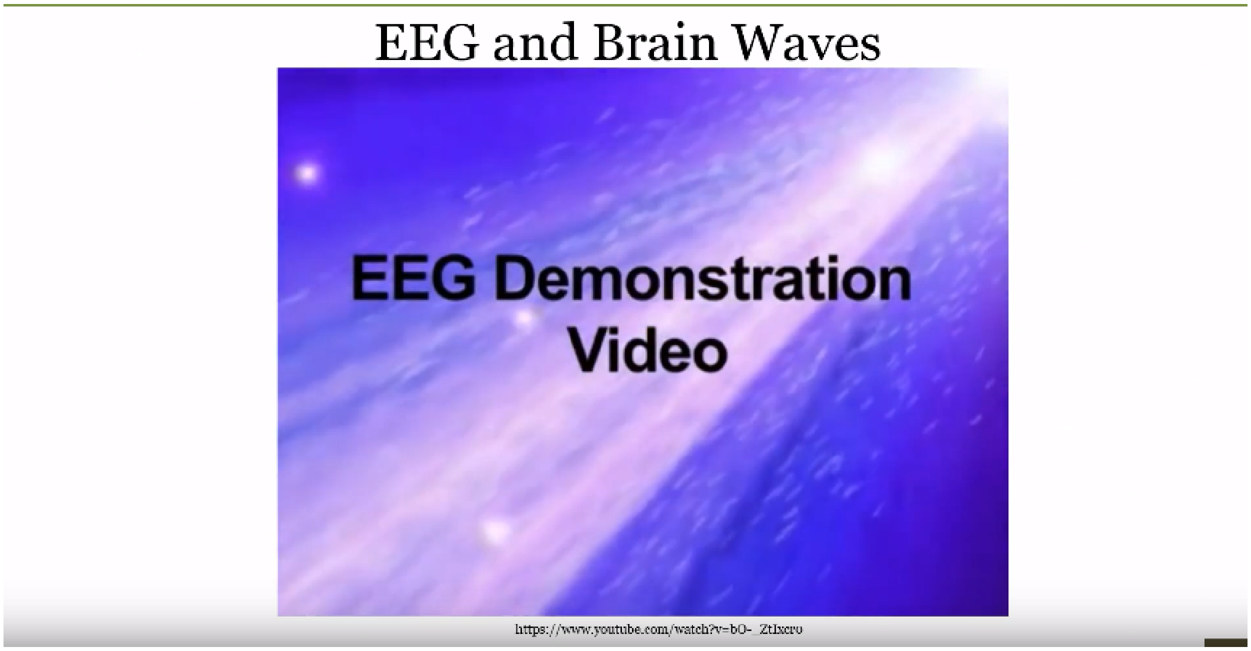

when you arrive for your ERP session you will be greeted by Frank and Nate. You can play with Nate while your family talks with Frank and reads about the study, it was great to see that Charlie was comfortable playing so that I was able to talk to Frank and read about the study, while you play Nate will show you the caps that you will wear during the study, they are stretchy and have lots of little holes in them he will show you the syringe that he will use to help him get the cap ready. It looks like something that you might get a shot with but it's not sharp at all and it won't hurt you. It's only used to put some sticky gel into the holes in the cap you'll be able to put a cap on yourself and play with the syringe. That way you will know exactly what will happen when Nate puts the cap on you. May let him touch the syringe, so he would know that it wasn't sharp or scary it also helped prepare him for seeing it again later when it was his turn.

When playtime is done, you'll sit in a big white chair and pick out some cartoons you'd like to watch. You'll get to watch the first cartoon while Nate gets you ready for your cap. First, he'll have to clean around your eyes and behind your ears with a wet cloth. Next, he'll brush your hair and measure your head to be sure exactly which cap will fit you best. It was nice to get to sit right there with him. So, that I could see what was going on and be there if he needed anything before he puts the cap on your head he'll put a few wires on your face with some stickers, when he's done with the stickers he'll put the cap on your head, while they were putting the cap on they explained the different steps so that nothing came as a surprise. Then using the syringe, he showed you during playtime he'll put some cold gel in each one of the holes in the cap, after there's gel in all of the holes you'll go into the little room to watch a video that you selected audio. You can ask your mom or dad to come with you into the little room if you'd like. I got to go into the sound booth with him which how can feel relaxed I thought it would be hard to help them stay still but the room was calm and quiet, and we just sat and watched the cartoons.

Inside the study chamber it's dark and quiet and you'll get to watch another cartoon while you're watching this cartoon it's important to be very still and very quiet. After you're done watching the cartoon the cap and stickers will be taken off. They took the cap and stickers off and told him what a great job he did. When that's done you'll get to play and have fun in the lab spaceship Charlie thought all the equipment was cool, but I think his favorite part was getting to climb into the spaceship, at the end thanks to their patience and care and explaining the process it was a great experience.

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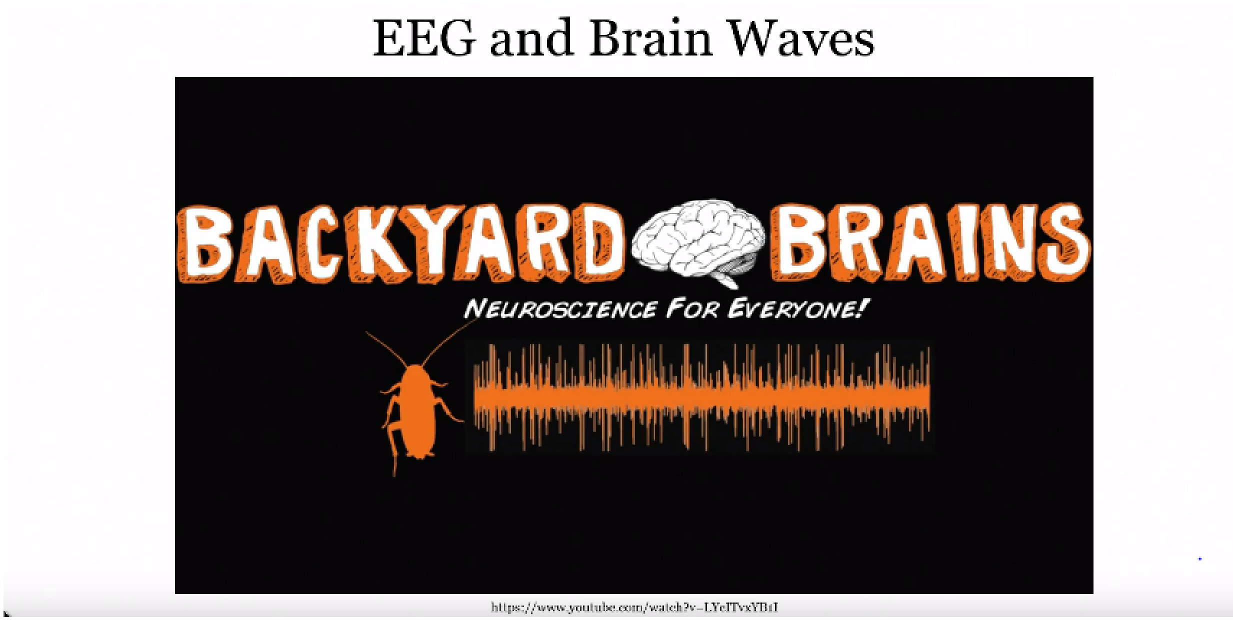
Now, let us see the second video.

Video Start Time (18:46)

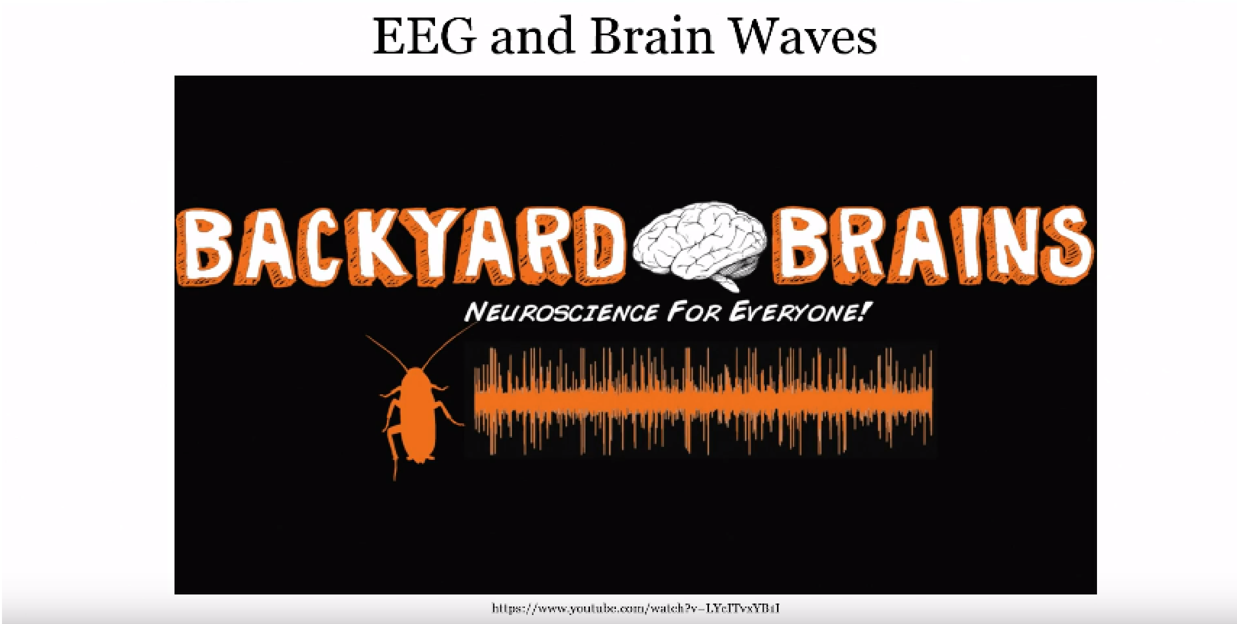


Backyard brain presents, the electroencephalogram also known as the EEG. Observe the alpha waves of the visual cortex of the human brain for this experiment you need a heart and brain spectra shield and Arduino a computer and yourself to begin take the backyard brains custom EEG headband and place it on your forehead subset the electrodes on the back of the headband are located on the back of your head. For the ground will place an adhesive electrode on the mastoid process, which is the bony projection you can feel behind your ear, to improve the interface we'll play some conductive gel in between the electrode and the skin, if you have long hair you can pluck the hair directly underneath each electrode to further improve the quality of the signal. With your orange ear face cable attach the red alligator clips to the electrodes on the back of the head which is which doesn't matter and the black halyard clipped to the ground behind the ear, we then plug the orange cable into the orange port on the heart and brain spider shield and the USB cable on the other side. The other end of the USB cable goes into the computer and we are ready to begin. But, what is going on here? When your eyes are open the visual cortex in your brain is processing a lot of information about your entire visual field about levels of contrast color and light. But, when your eyes are closed that field is dark and hence counter-intuitively, the neurons in your visual cortex become more synchronized.

A popular analogy is to imagine yourself outside a stadium during halftime there are any lot of conversations occurring inside the stadium. A lot of information processing but, outside the stadium all you hear is a dim hum of noise. This is equivalent to the eyes open condition in the electroencephalogram alternatively during the singing of the national an them many of the spectators inside the stadium are saying the same thing they are synchronized, and this signal is strong enough that you can plainly hear though distorted outside of the stadium. This is equivalent to the eyes closed condition of the electroencephalogram. The physiological underpinnings of these EEG signal are complex and still a topic of active investigation in the neuroscience community. But we currently understand it to be some activity of many synapses in the upper layers of the cerebral cortex. Our heart and brain shield thus amplifies the electrical activity of the synapses such that, we can view them on a computer under the appropriate conditions click on the Settings button in our spy recorder software and select connect the via a USB port within a couple seconds, you should see the signal change to HDTV each a signal you can zoom out of the time scale by using the two finger motion on your trackpad or the scroll wheel on your mouse and zoom in under white axis by clicking on the positive button on the left side of the screen.

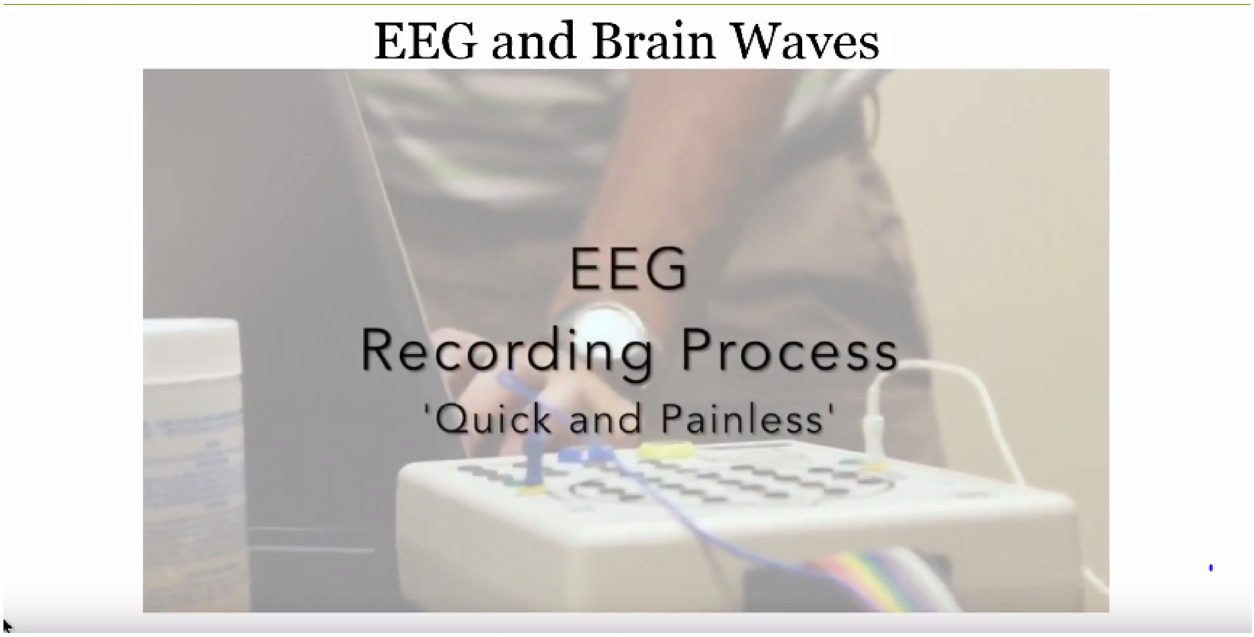
But, how do we know this EEG signal is real? Well let's close our eyes, those ripples are the 8 to 10 Hertz alpha ways of the visual cortex that disappear when the eyes open again. If you click on the FFT button you will bring up a spectrogram view which will show the EEG signal decomposed into frequency, time and amplitude thus when the eyes are closed you will note the increased signal strength at 8 to 10Hertz. Under appropriate conditions the alpha waves of the visual cortex are readily apparent whether you're showing them to your friends on a Friday night in your living room or in front of 200 people for your high school or college lecture course. These alpha waves were first discovered by Hans Berger a German physiologist in the 1920s, and subsequently verified by warden Edgar Adrien at the University of Cambridge in the 1930s. We thank our many friends at the Santiago makerspace in Chile who worked with us to replicate these findings in a compelling and simple way, we also thank our production team and this is just the beginning as we further our explorations into the EEG signal what will you discover backyard brains neuroscience for everyone.

Video End Time (22:39)



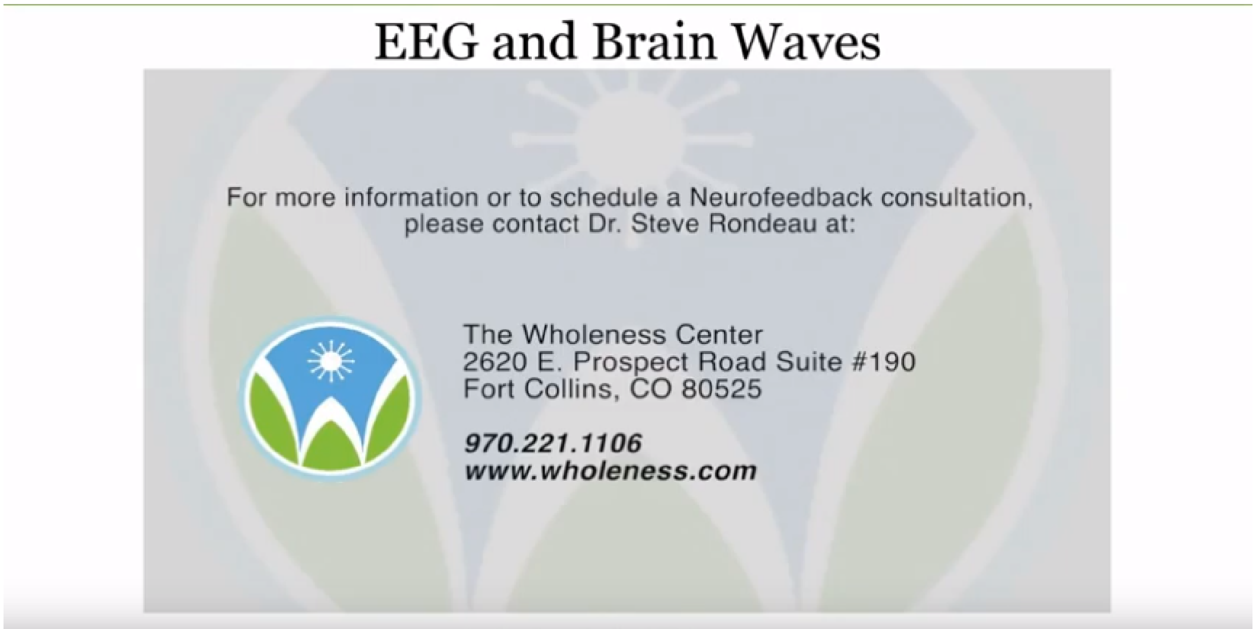
And, let me play the third video as well and then we'll discuss.

Video Start Time (22:45)



Lizabeth, so we're goanna be recording your EEG today and so essentially what we're goanna do is put his one cap over the top of your head. It's it doesn't have any feeling associated with it or anything on covers it's just a pretty easy process. Okay? Put these little these foam sponges on these, now the cap will go so the hair is part of the whole process is Right? Here this cap goes. Right? over the top of your head just above your eyes, just like that you get two ear sensors here Okay? So, the hard part's over so now from here all we do is I have this syringe it looks like the needle but it's not an needle just so you can see it's not sharp or anything here and so what I do is I take this and I put the paste in to each of these sensors each of these holes so that we can get a good connection between the sensors and yours calp. solution be any pain involved or anything like that it's just connection between your sensors and your scalp so that's all there is to it so what you'll do now is just sit here for 10 minutes with your eyes closed you look forwards it nice and still relax your shoulders your jaw your forehead all of that and I'm gonna be behind you here recording the EEG we'll do that for 10 minutes with your eyes closed then we do 10minutes with your eyes open that's all there is to it.

Video End Time (25:01)



Okay, So, what you have seen is three videos, Right? Which shows how the EEG and the brain waves are related.

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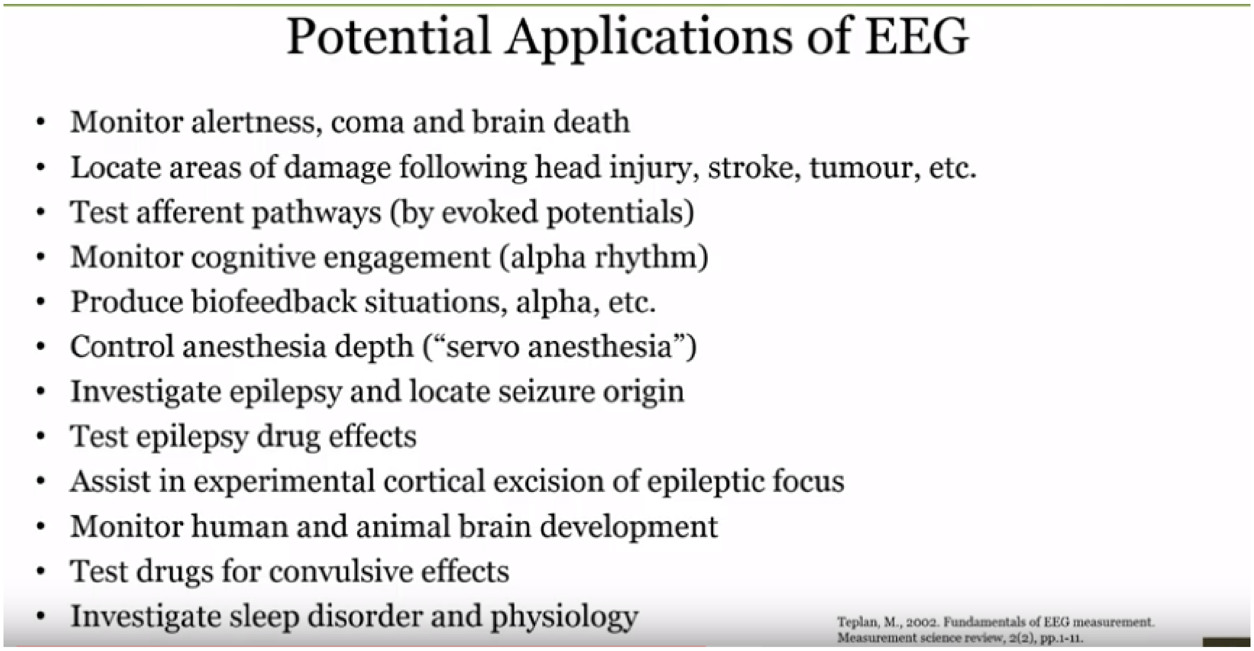

Now, let us first understand the potential applications of EEG before we go to the next slide and the most important part our applicants of EEG are, that it required eight monitors alertness comma brain death, locates area of damage following head injury stroke or tumor, it is used as test efferent pathways by evoked potentials, we will talk about Eve open instance and other signals energy from the brain in the in the next module. Where, one of my student will discuss the experimental part of, of or the application of EEG for a research domain, we can also monitor cognitive engagement which is alpha rhythm, it can be help for producing the bio feedback situations, I can control the anesthesia depth which is also called a servo anesthesia, it can be used for investigating epilepsy and locating seizure, seizure it can be under to understand the efficacy of drug which is anti-epileptic drugs it can be used in assisting in experimental or cortical excision or electric focus, it can be use for monitoring human and brain animal brain activities and development, it can be also used for testing drugs for convalescing effects and investigate sleep disorder as well as physiology or n physiology. So, the applications of easy as you can see are enormous.

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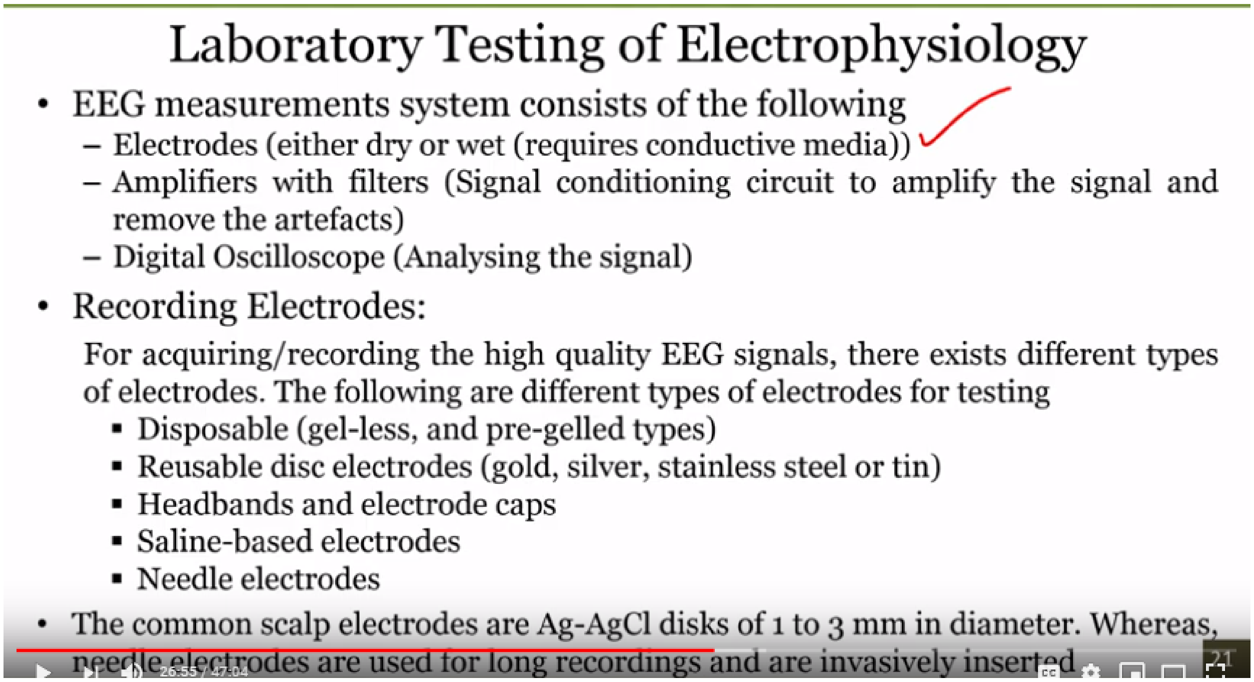

Now, let us understand how we can have a laboratory testing of electrophysiology and so easy measurements in system consists of the following first is electrodes. So, the electors are either dry or wet I will, like I said the, the next module we will show it to you how the dielectric looks like. The wet electrodes we have to use a gel to reduce the impedance. In dry electrode that is not a problem. Then we have amplifiers with filters where we have signal conditioning circuit you have to buy signal and the artifacts then we have a digital oscilloscope. Now, why we have digital sort of scope for enhancing the signal and this is again laboratory testing, so we will have this kind of equipment.

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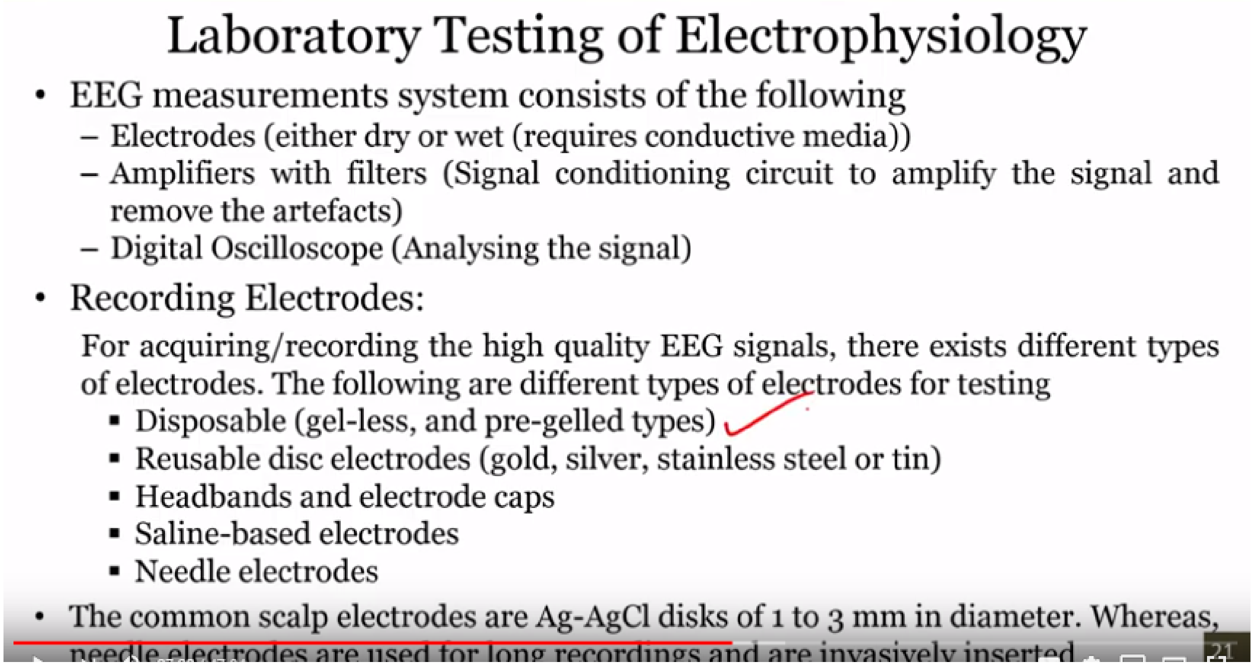

Regarding recording electrodes so when you talk about recording electrodes first is for acquiring or recording the high quality EEG signals that exist different types of electrodes the following are a different a varactor for testing first is disposable, jealous and pre-gelled types of electrode, then second one is reusable disk electrodes which are made up of gold, silver, stainless steel or tin next one is headbands and electrode caps, finally we have saline based electrode and bay electrodes. Okay?

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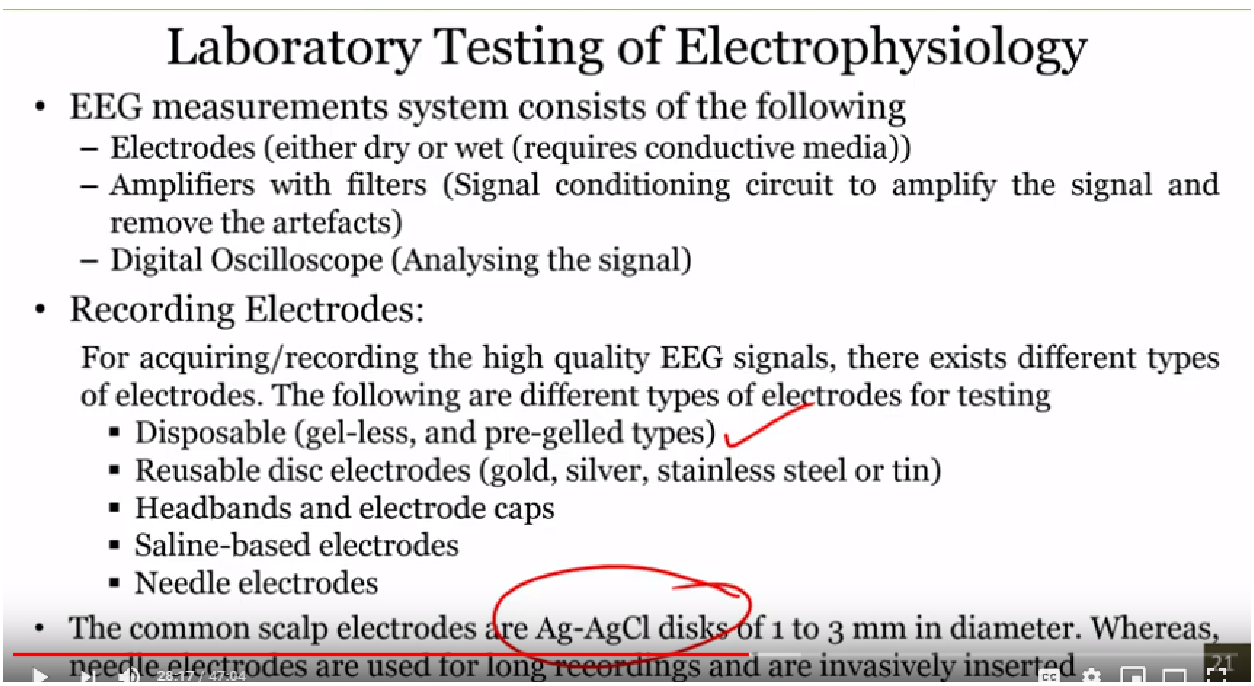

The most common scalp electrodes are Ag-AgCl disks of 1 to 3 millimeter in diameter. Whereas, the needle electrodes are used for long recordings and are invasively inserted. So, Ag-AgCl is where people are using but people are moving towards dry electrodes because of the difficulty of holding these wet electrodes with gel.

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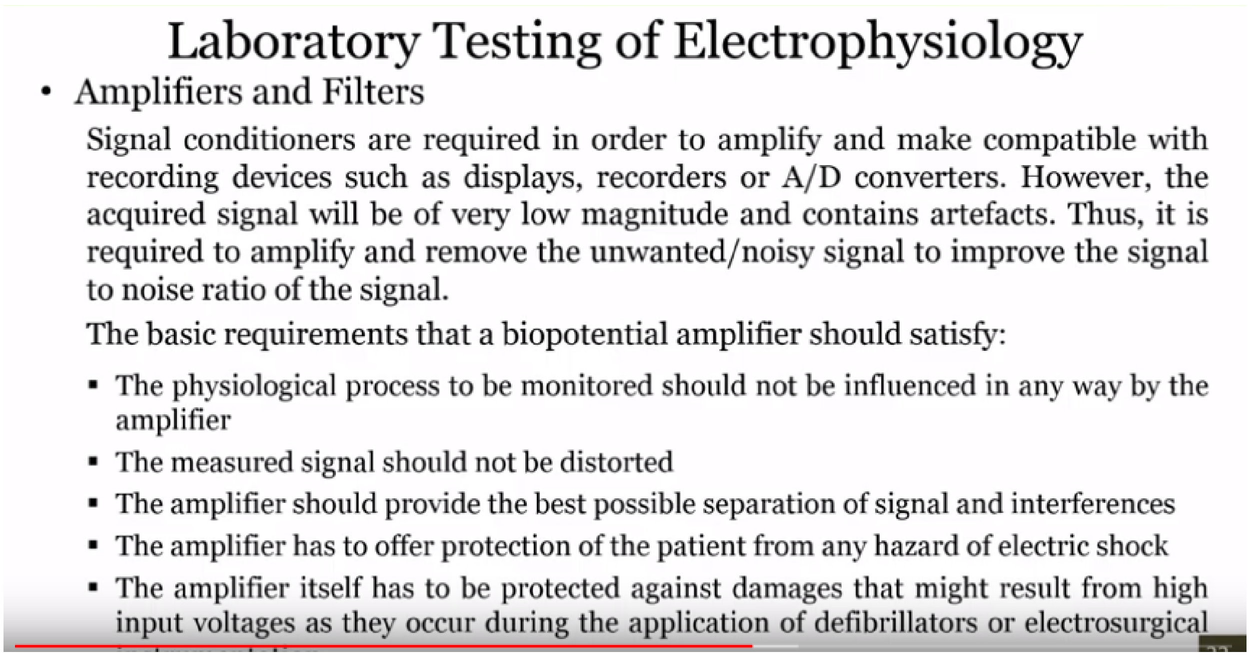

So, what kind of amplifiers and filters will require the signal conditioning are required in order to circuits are required in order to amplify and make compatible with recording devices such as displays, recorders or ADCs. However, the acquired signals are extremely small and low of low magnitude and that's why it contains artifacts. So, what kind of filters we have to use. Right?

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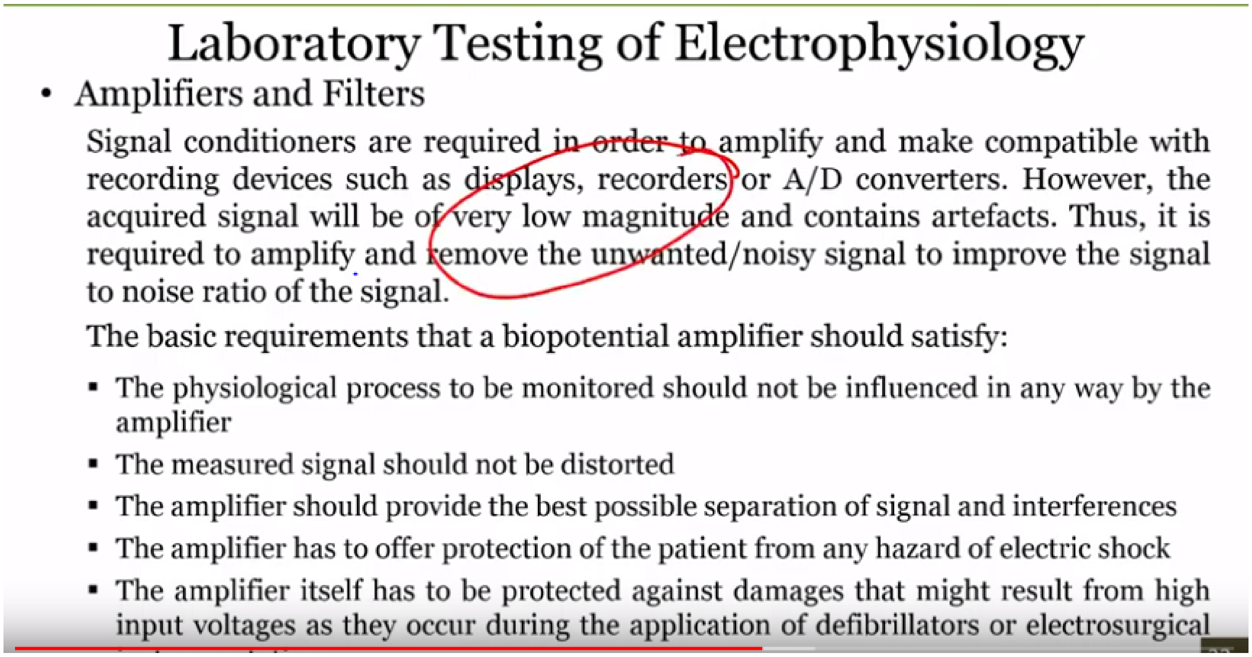

So, if you see the slide thus, we itis required to amplify and remove the unwanted noise, because it is a very low magnitude. Right, and to improve the signal-to-noise ratio so snr ratio we need to improve and that's why the basic environments that are bad potentially files should satisfy those are that the major signal should not be distorted.

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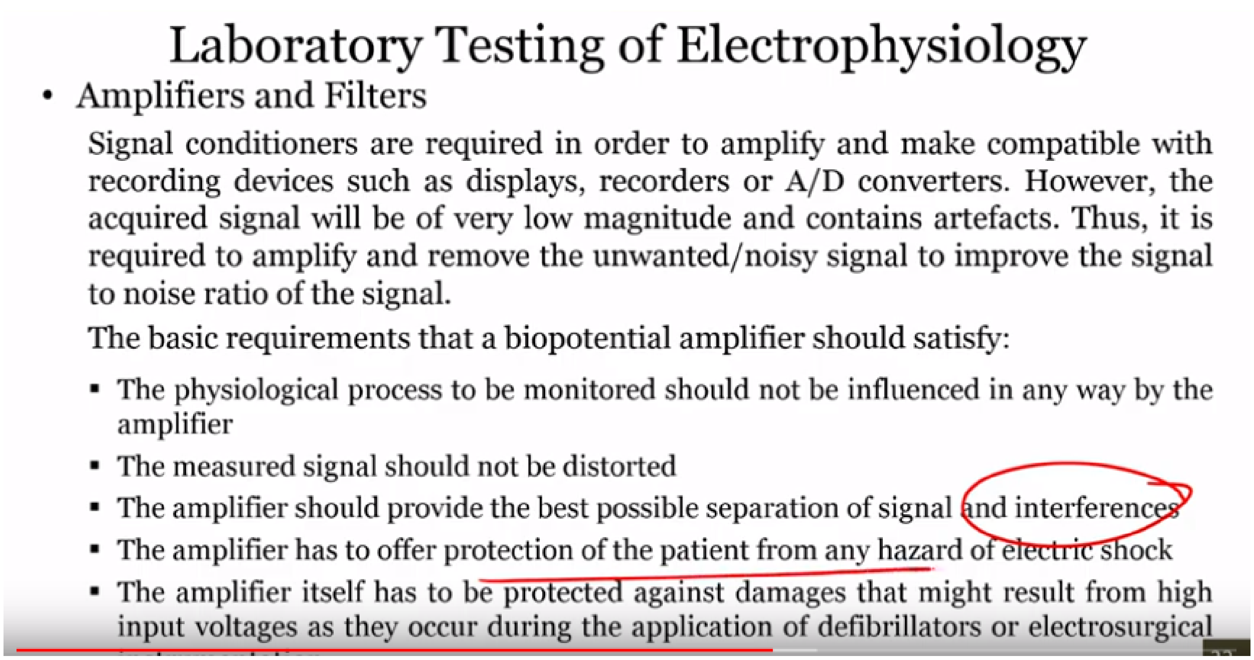

The amplifier should provide the best possible separation in terms of signal interferences the amplifier has to offer protection of the patient from hazard of electric shock and then we amplify itself has to be protector against the damages that might result from high input voltages as they are gone during the application of defibrillators or electro search instrumentations.

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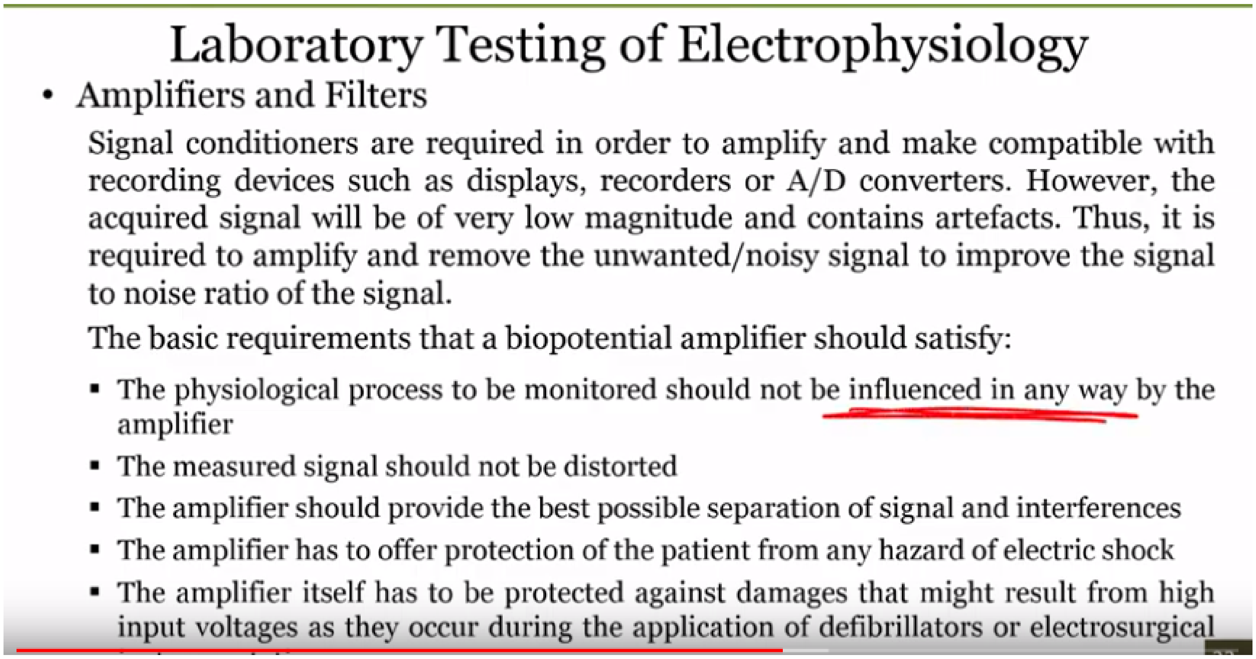

Also, very important part is that physiological possessive model should not be influenced in anyway by the amplifier.

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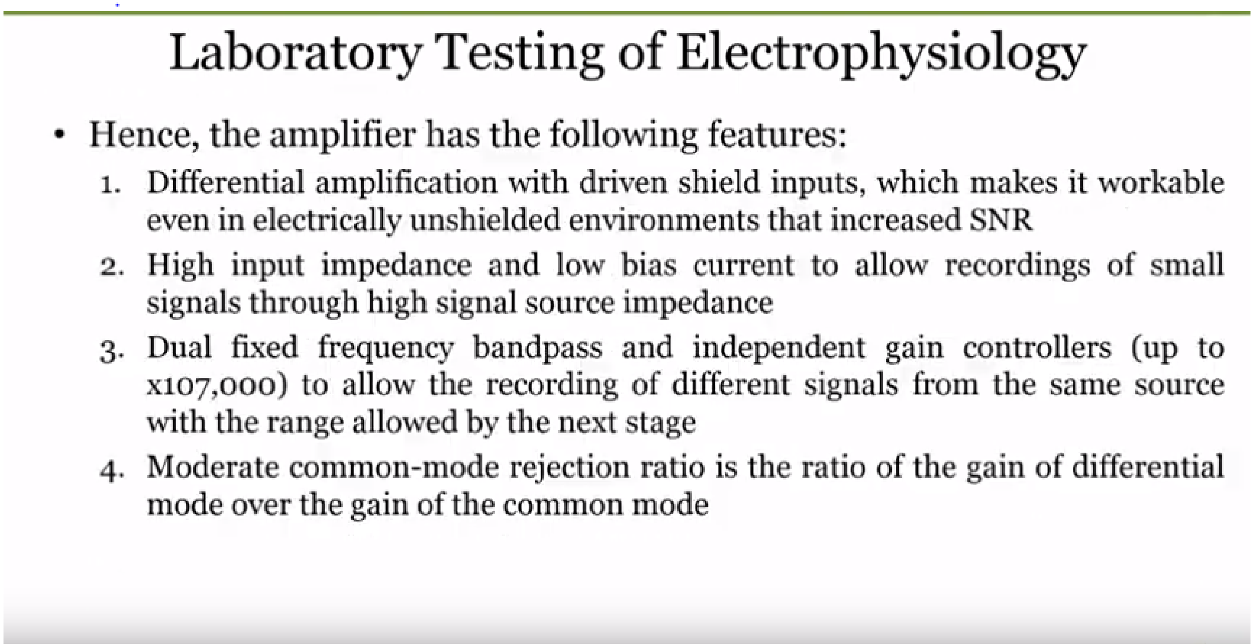

So, a lot of things rely on the instrumentation part and that's why the designing of signal conditioning component is extremely important, so that's why when we design an amplifier, what are the features that amplifier should have? The first feature the amplifier should have is the differential amplification with driven shield inputs which makes it workable even in electrically unshielded environments. So, we should have high signal-to-noise ratio. second thing is it should have high input impedance and low bias current to allow the cuttings a small signal, then we need a dual fixed frequency band pass an independent game controllers somewhere around one hundred and seven thousand to allow the recording of different signals from the same source with the range and out by the next stage. Finally, we should have moderate common mode rejection ratio which is the ratio of gain of differential amplifier more over the gain of common mode. These are few of the feature's amplifier should have.

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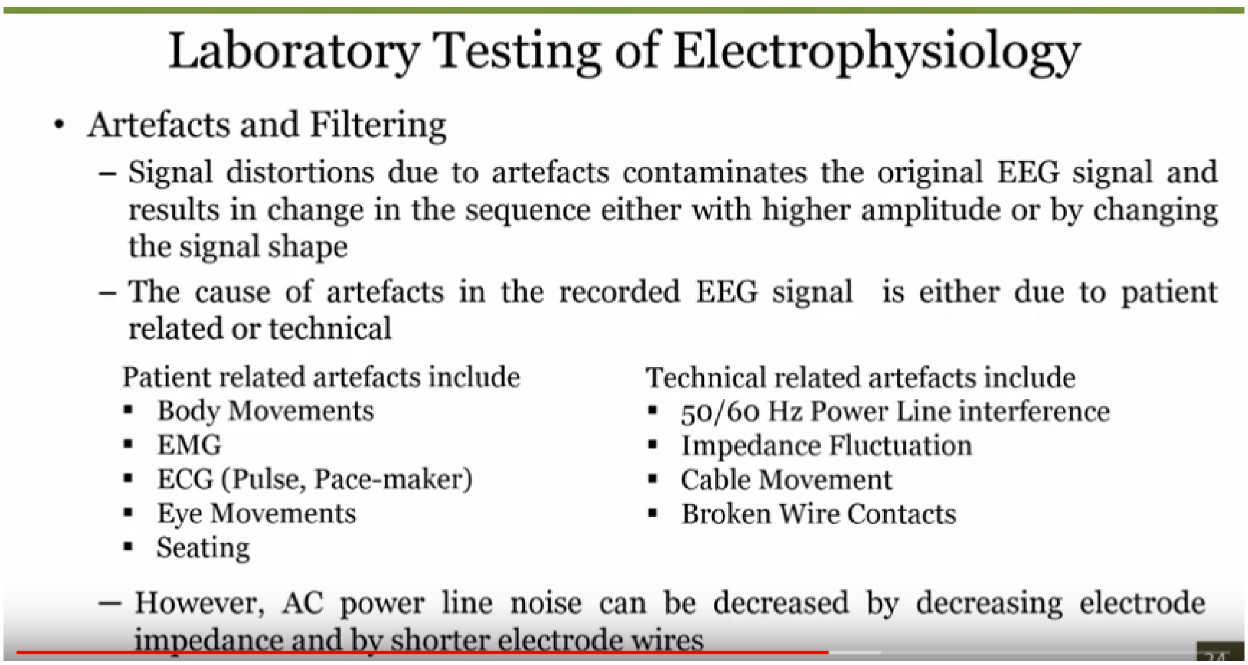

To take care of the artifacts and filtering, the signal distortion due to artifacts contamination easy signal, we know that because these signals are of micro volts and results in change in the sequence either with higher amplitude or by changing the signal shape. We the cause of artifacts in the recorded AC signal is due to the either due to the patient-related or due to the technical things. So, what are the patient related artefact and what are the technical related artifacts? Artefacts is a disturbance it's a noise. Okay? So, patient related artifacts are when, when there is a body moment, then there is a EMG, there is a ECG, there is a pulse of pacemaker, there is an eye moment, there are and there is a sitting posture moment. So, this all can create artefacts in the patient related point. By technical related artefacts includes 50/60 Hertz power line interference that is fasting, second thing is impedance fluctuation, third thing is cable moment, and forth thing is broken wire context. These are the four things that are technical related artefacts. However, AC power line noise can be decreased by, decreasing electrode impedance and by short electrode wire. So, we can reduce this power line noise either by reducing the electrode impedance and that's how the gel is comes into play or if you use dry electrode then the impedance also will be less and we can reduce the wires, all Right? So, that is another way of taking care of the noise.

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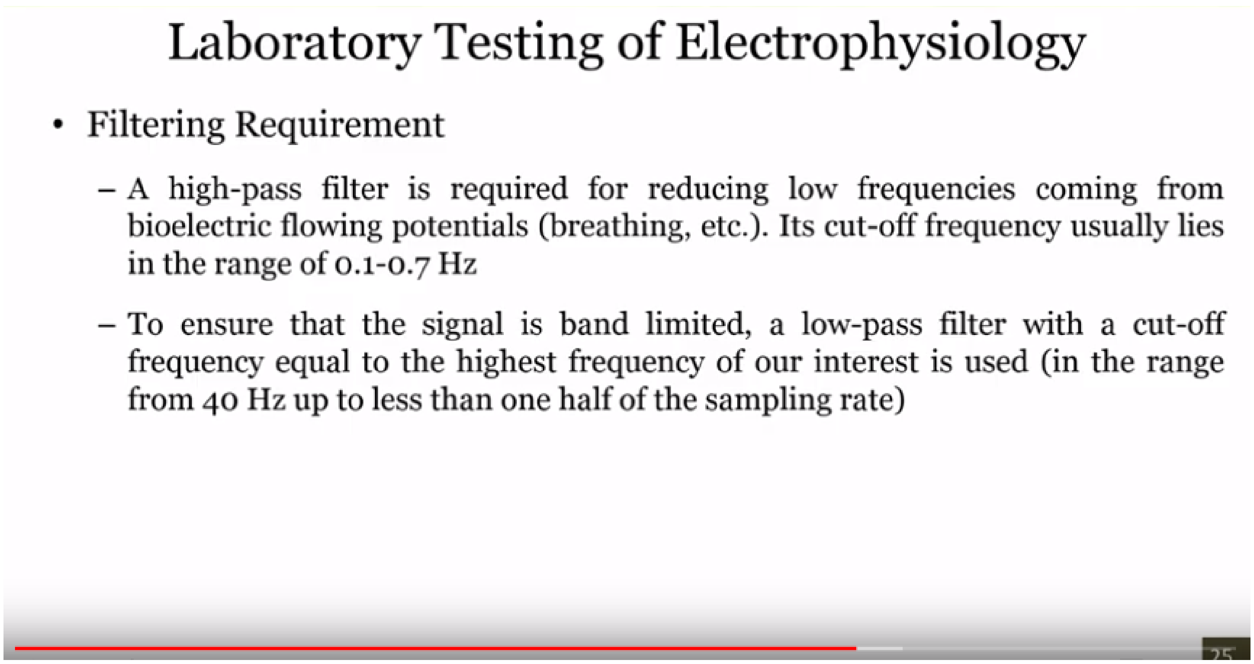

Further, when you talk about this so this about the artifice filtering. So, what are the filtering requirements? we require a high pass filter for reducing low frequencies coming from a bioelectric flow potentials example breathing its cutoff frequency usually lies in the range of 0.1 to 0.7 Hertz. While to ensure that the signal is band limited a low pass filter the cutoff frequency equal to highest frequency of our interest is used which is not only from 40 years up to less than 1/2 of the sampling rate, so these are the filtering requirements.

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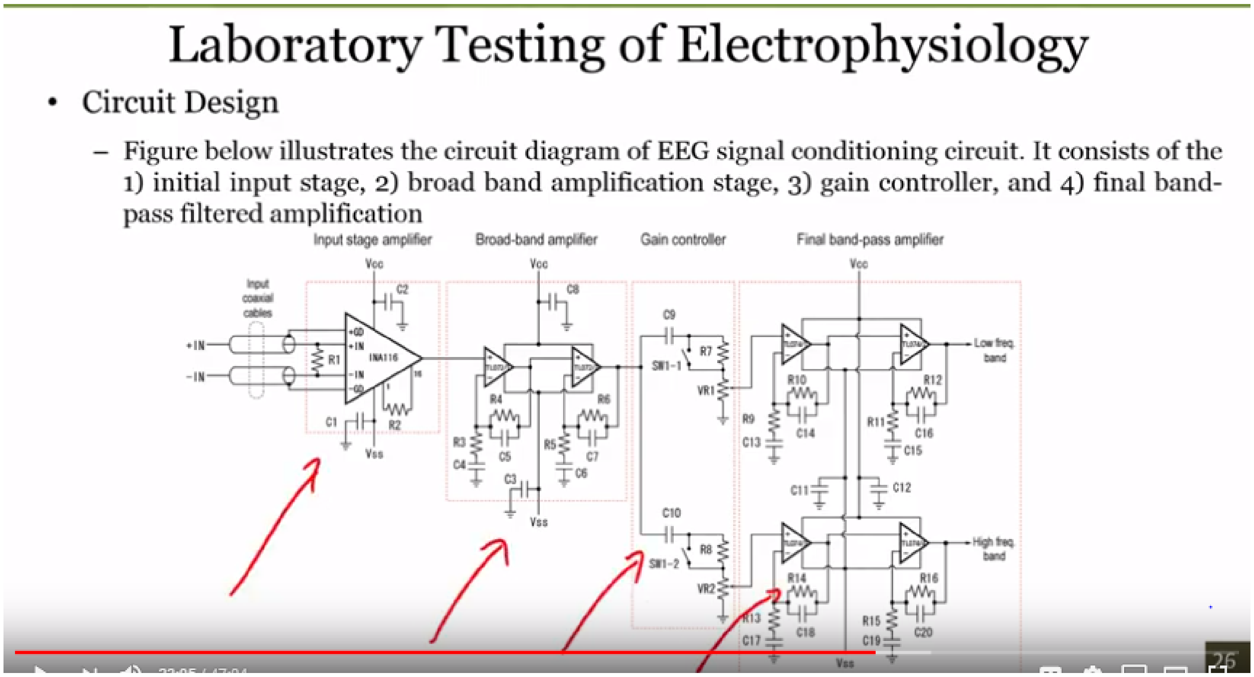

So, if you see the circuit this is our single stage EEG, you know measuring circuit or signal conditioning circuit looks like it consists of input initial stage where it is nothing but the instrumentation amplifier because it has a high signal-to-noise ratio, very high impedance as you know the advantage of say, inter instrumentation amplifier. Then we have a broadband amplification stage followed by a gain controller and finally by a bandpass filter amplification. So, this is how the unit to design a circuit, we will discuss this circuit in a part of the experimental protocol and will show it to you on a simulation how this thing, how the circuit can be designed.

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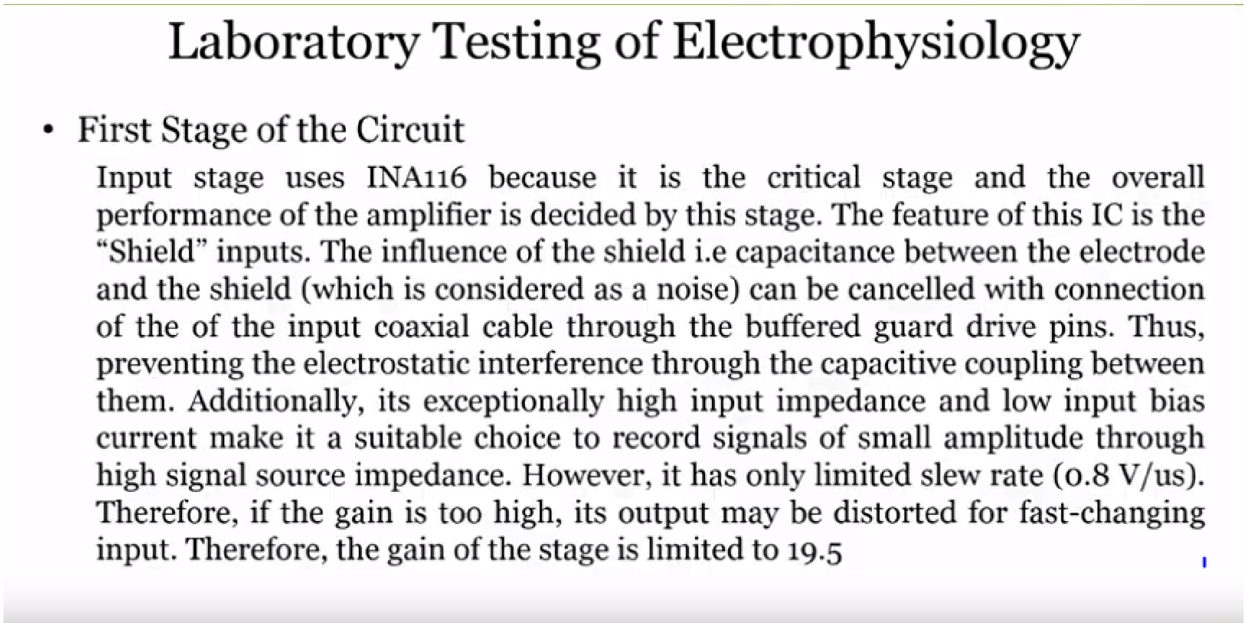

So, if I talk about just a first stage of the mm of this particular signal conditioning circuit, then it uses INA116.

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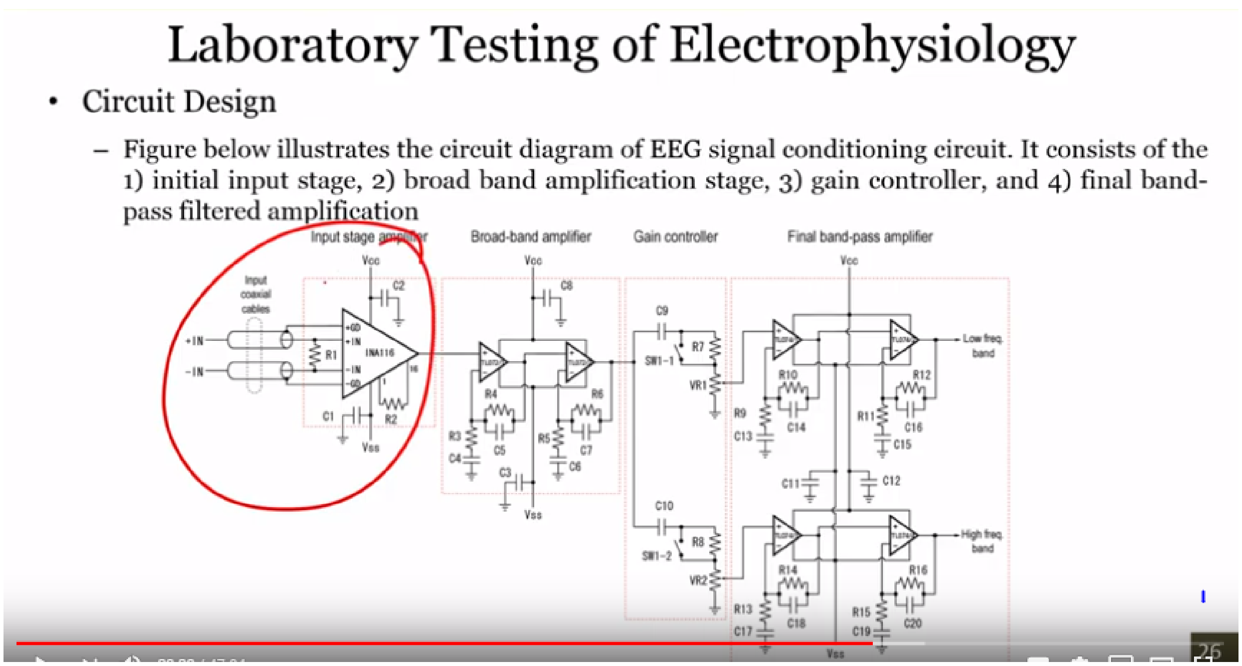

So, this is a INA116, this is the input stage. Right?

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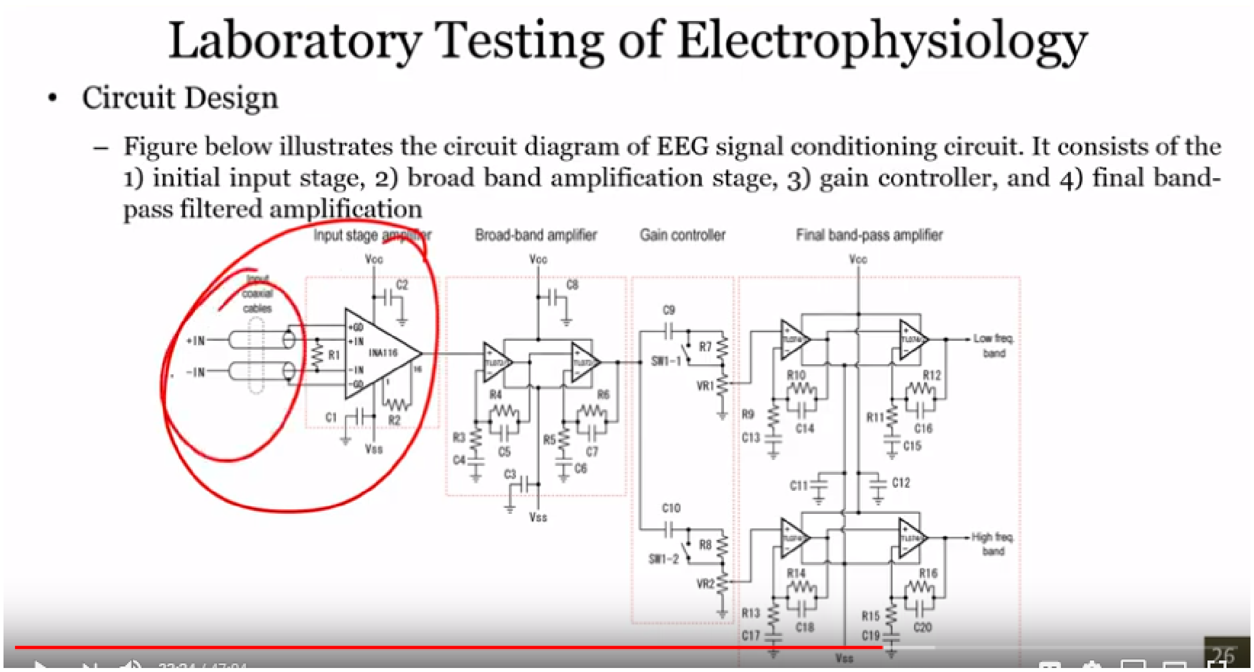

These are the electrodes of the EEG.

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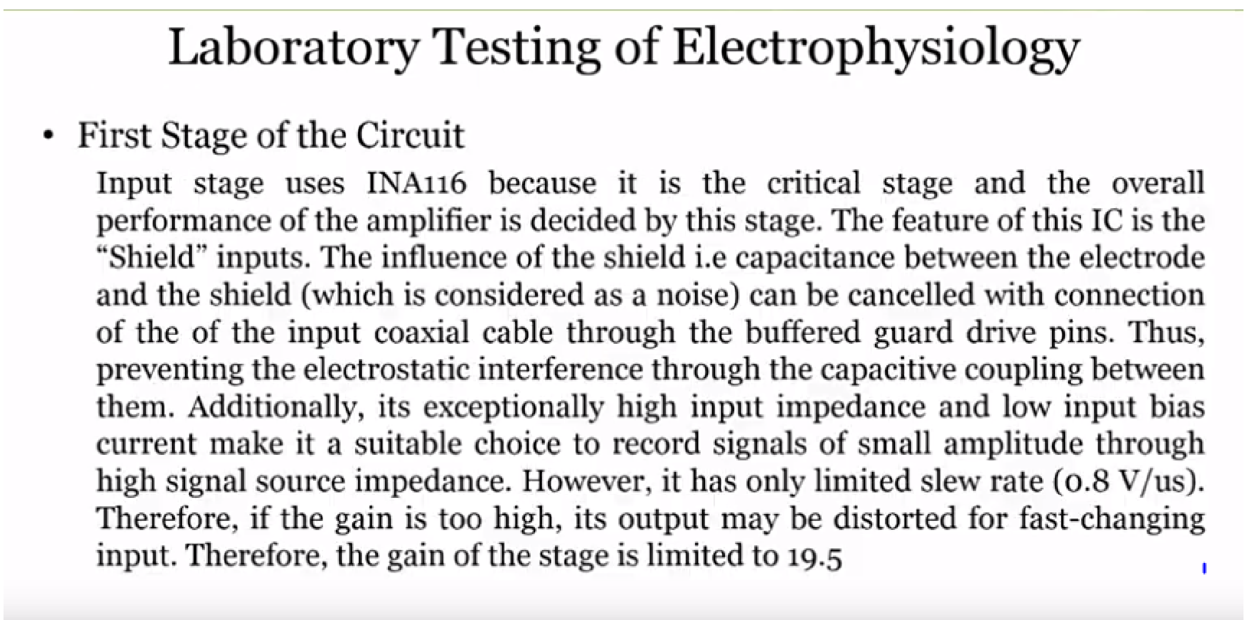

So, because it is critical stage and the overall performance of the amplifier disturbed by this stage the feature of this IC is shielded inputs. The influence of shield is that it can the, the capacitance between electrode and the shield which is also considered as noise can be cancelled with the connection of the input coaxial cable through the buffered guard means that is the advantage of using INA116, that's preventing this electrostatic interference with the capacitance coupling between them, Additionally is exceptionally high input impedance and low input bias current makes it a suitable component to record signals of small amplitude, we know that the easy signals are a few micro volts and that's why it's very important to select the input stage and that's why the importance of INA$_{11}$6.

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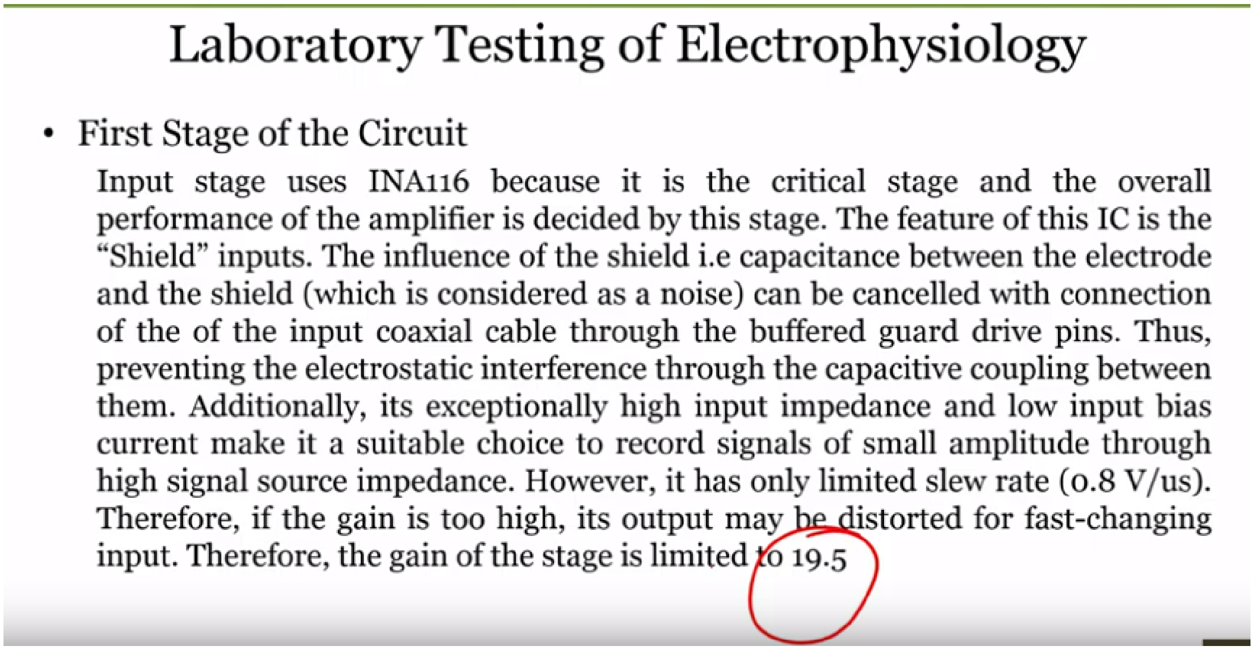

However, it has only limited slew rate which is about 0.8 volts per microsecond. Therefore, the gain is too high. The output may be distorted for fast changing input, the gain of the stage is limited to 19.5. As we cannot have extremely high gain.

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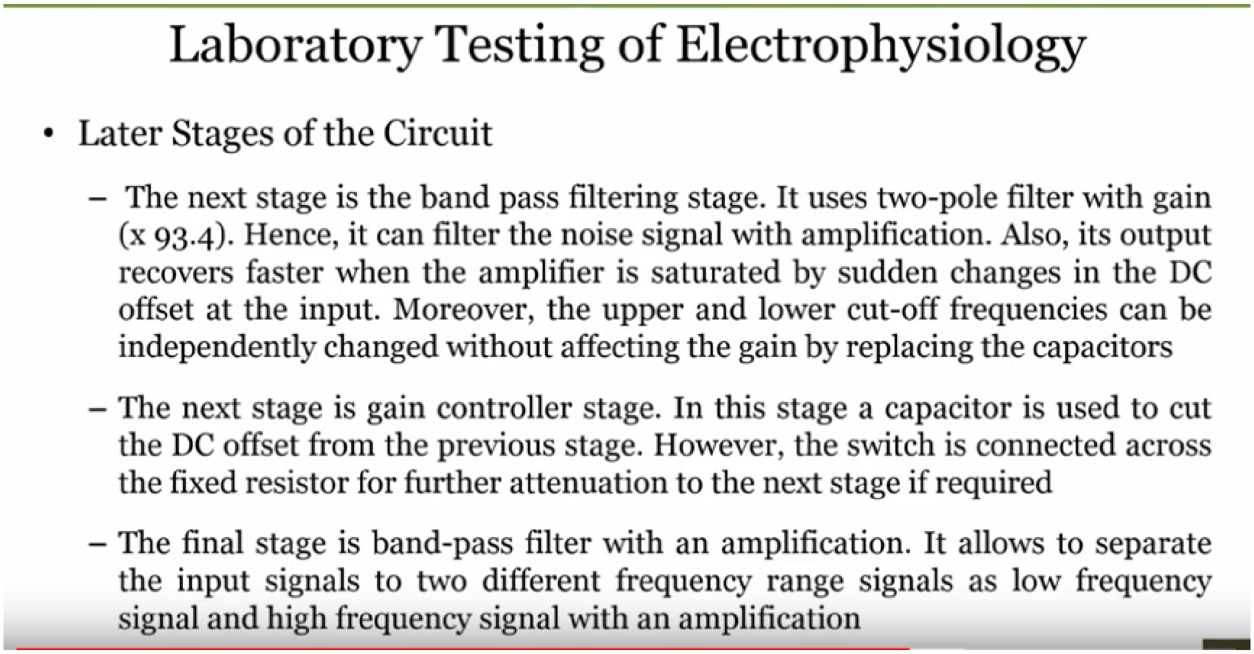

While, if I talk about the second and third stage.

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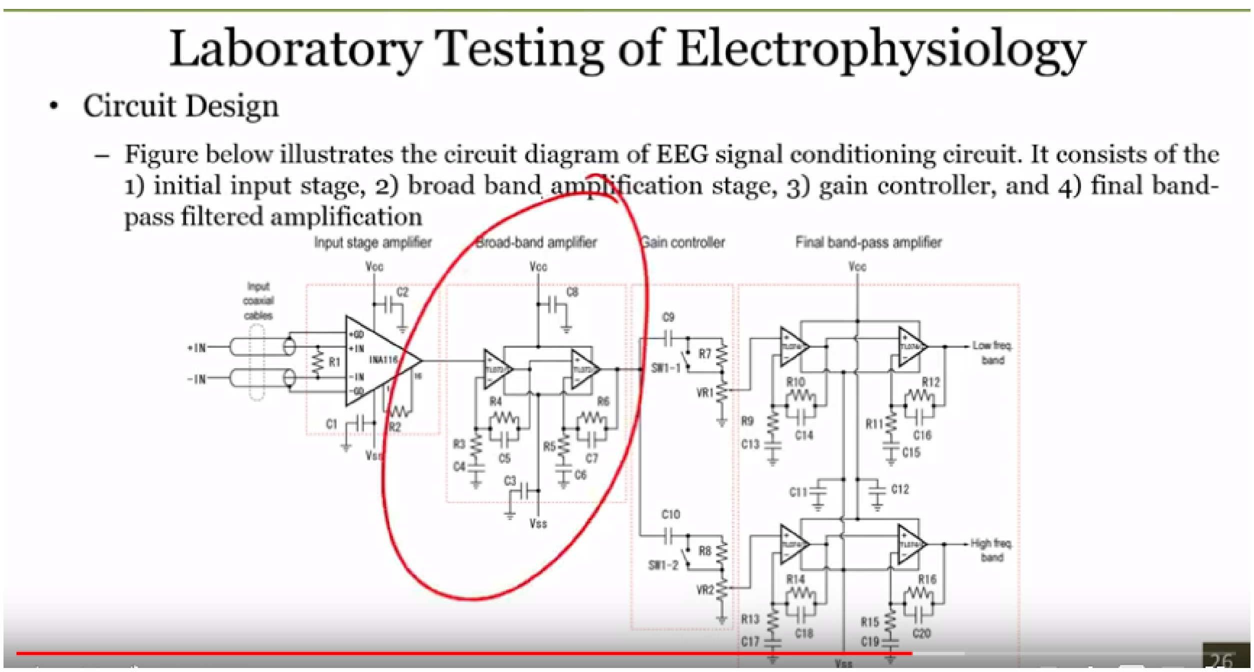

we see that the next stage is a bandpass filtering if I go back you see this is a bandpass filter, Right?

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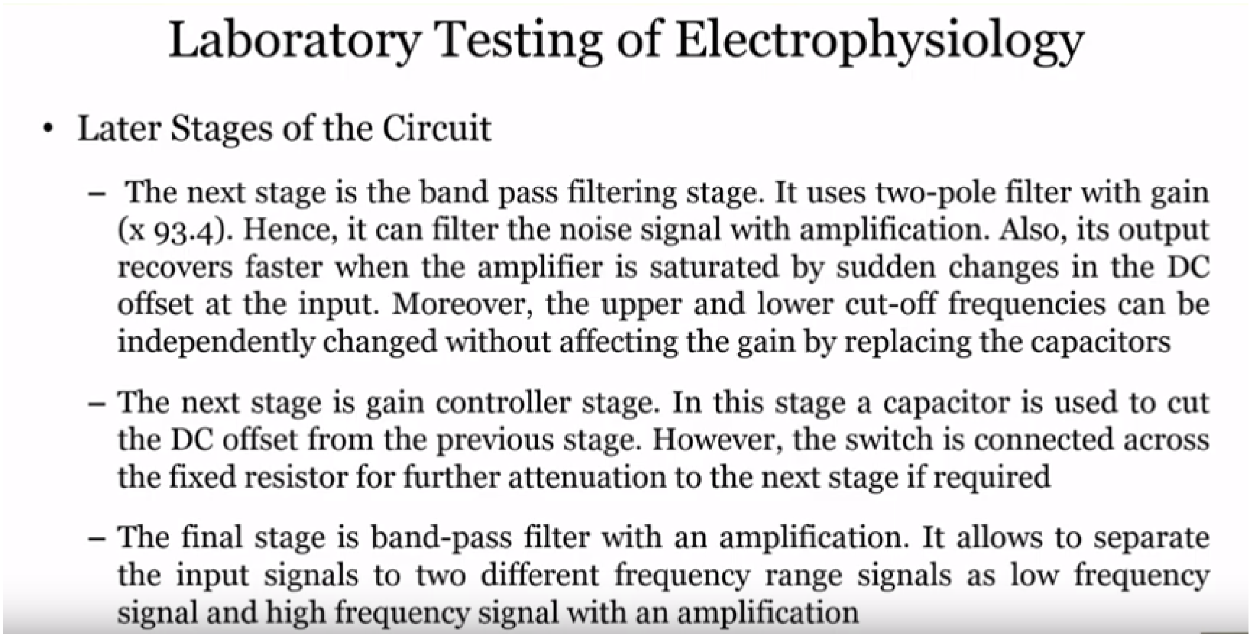

So, what's the role of bandpass filter. The role of band pass filter is, that it uses two pole filter with a gain of 93.4 hence it can filter the noise signal with amplification. Also, its output recovers faster When the amplifier is saturated by sudden changes in DC offset at the input. This the advantage of the filter circuit Right? and the upper and lower cutoff frequency can be independently change we are affecting the gain by replacing the capacitor.

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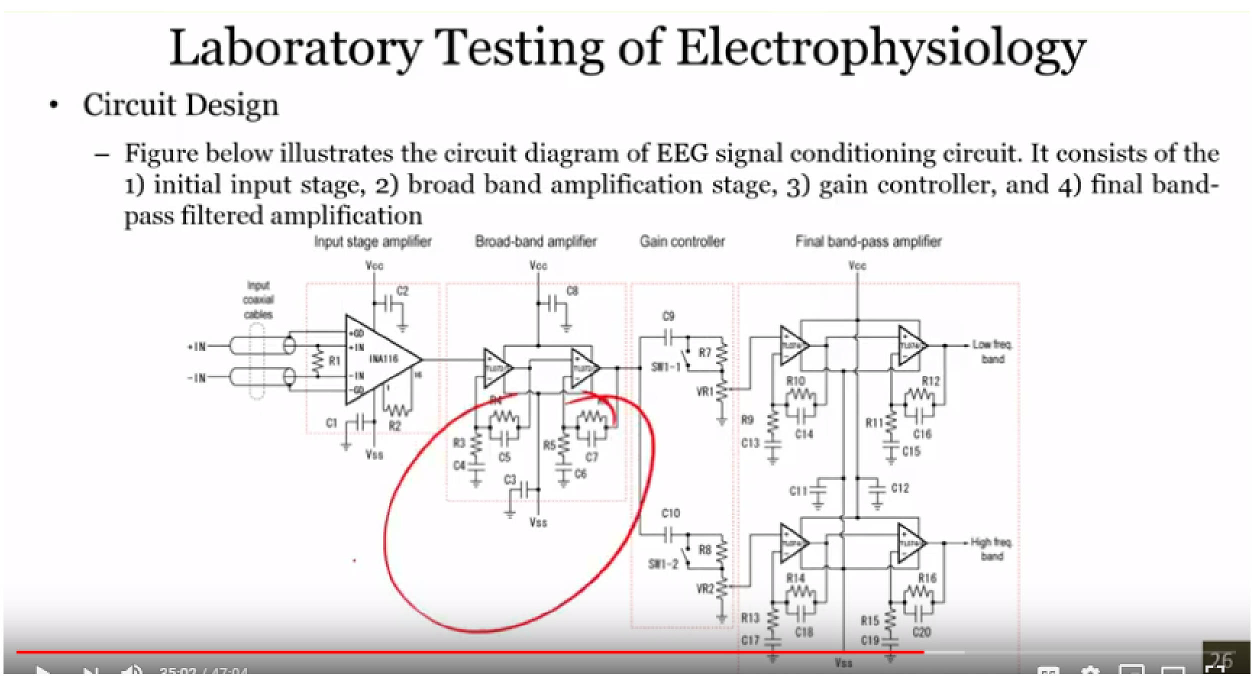

So, you see the upper and lower frequency we can change it Right? By replacing the capacitors. And, so it's not really difficult.

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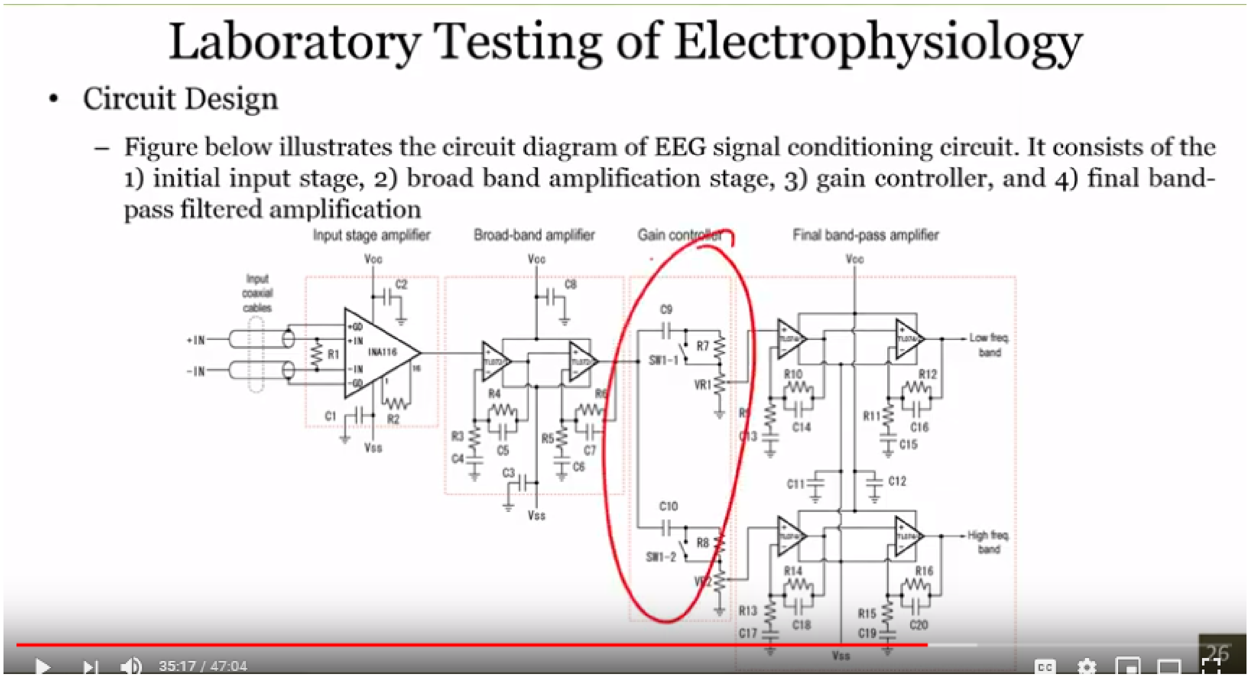

The next stage is again controller and in this stage a capacitor used to cutoff the DC offset voltage from previous stage let us see, see this is a gain controller Right? and here we have a capacitor to cut off the DC offset.

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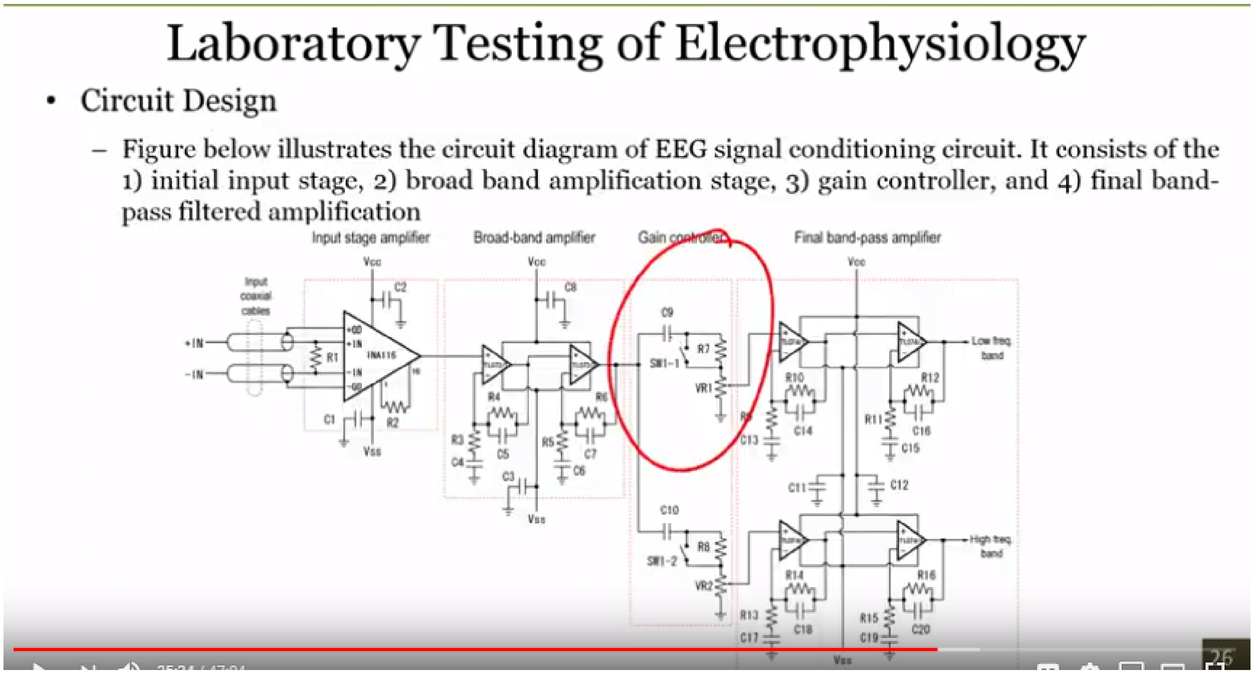

Finally, the switch is connected across the fixture for further education to the next stage so if you want to use this particular circuit then we can use the switch to have attenuation further if required. Okay? So, there is an advantage of our gain controller.

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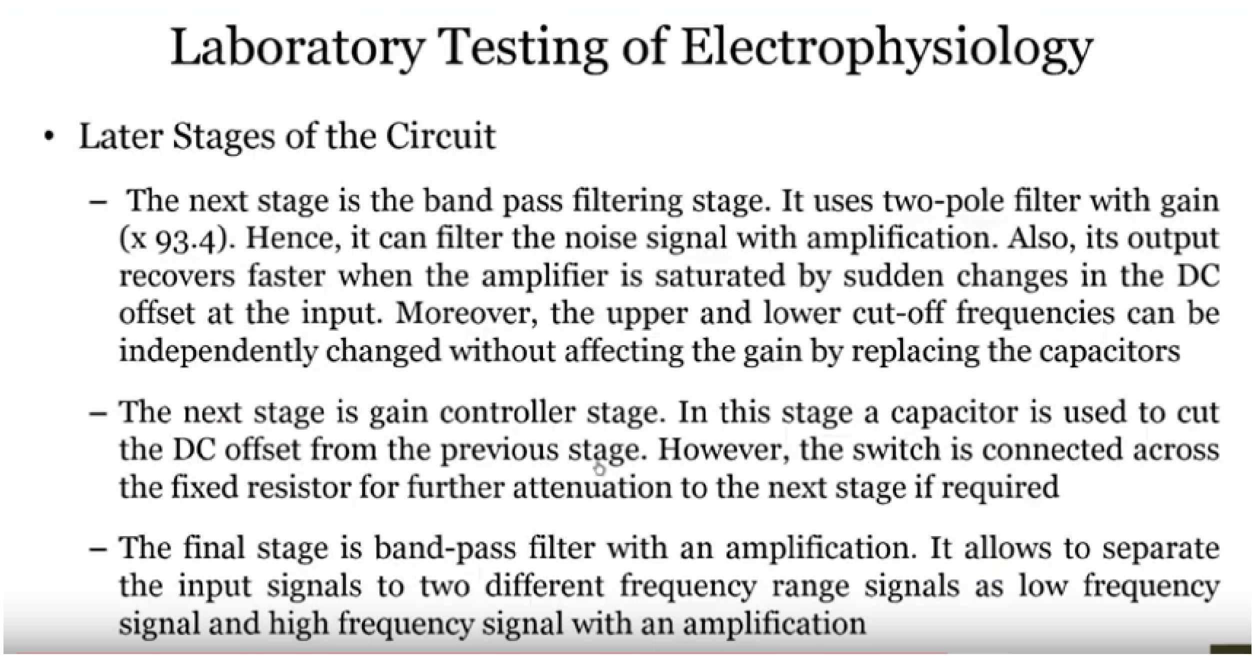

And, if I go to the last one then what I find is that the final stage is a band pass filter with amplification. So, why, why it is important? Because, it allows not only to separate input signals of two different frequency range signals but also high frequency signals with an amplification.

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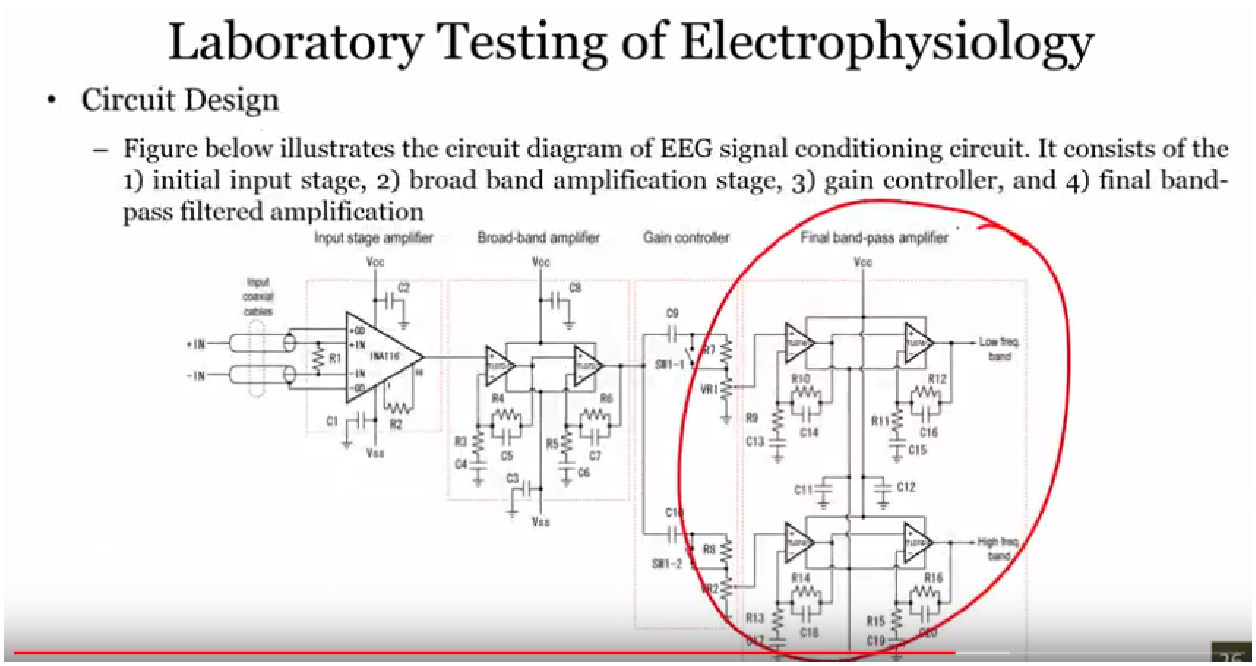
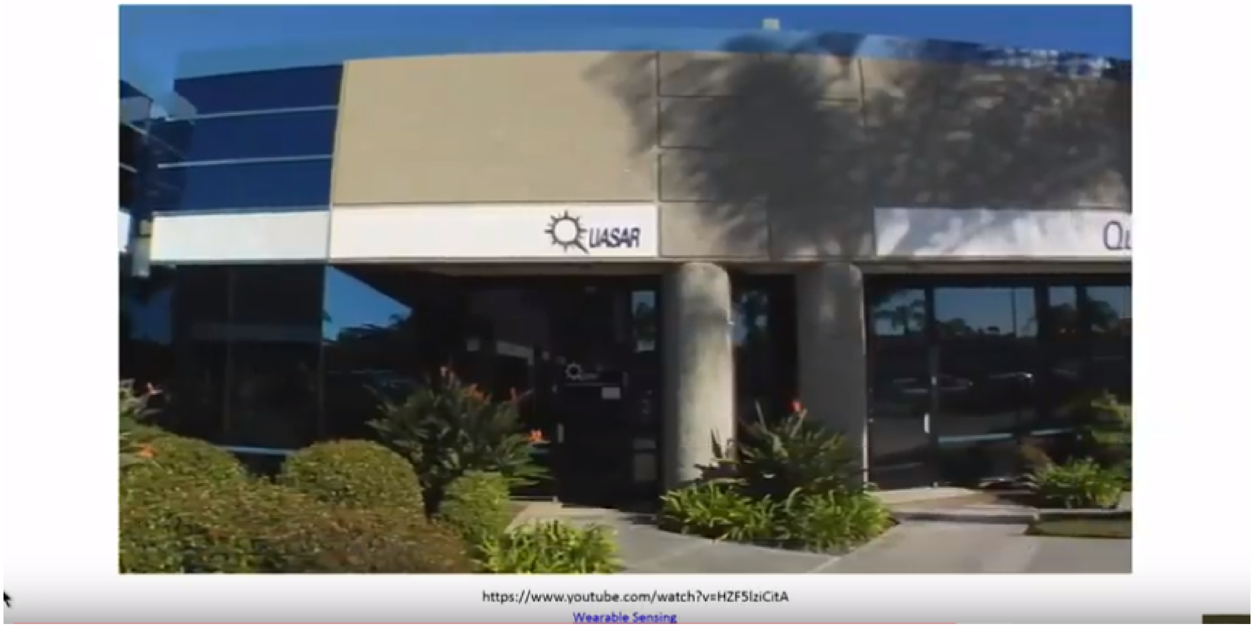


So, that is the advantage of their final, final bandpass filter. Again, like I said we will discuss this thing in the experimental part. So, if I leave it to you with two videos then you will understand more about, what are the dry electrodes? and how the signals in EEG using that can be captured all. Right? So, let me just play the first video.

Video start Time (36:18)

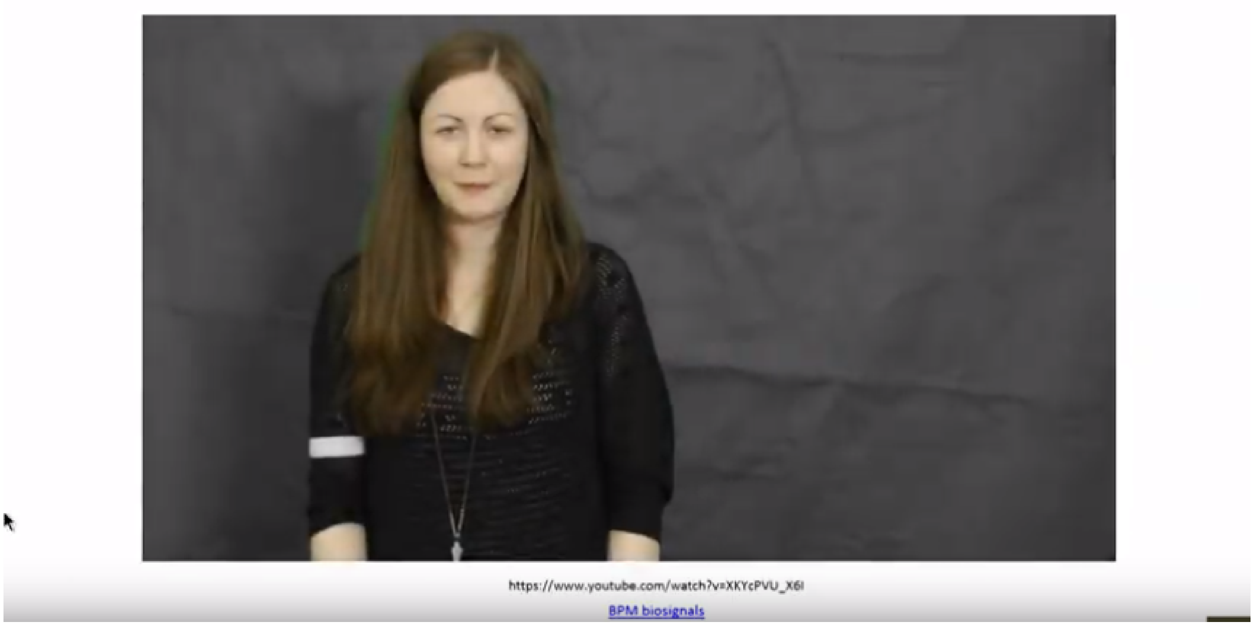


So, 21 sensors according to the 10:20 International System the headset is easy to use and can be put on by the user in less than five minutes. Without skin preparation or the use of gels. EEG data quality has signal fidelity comparable to that obtained with conventional electrical systems. And, is designed to operate in a laboratory or office environment. There we see signal to two blinking your clinches and EEG alpha activity all acquired in real time by history. The data acquisition software designed for use with the DSi attempt lisa has also developed sophisticated gauges for cognitive state classification. These can be tailored for specific research and monitoring applications and implemented in real time. The DSi 1020 is a fully ambulatory system, with wireless transmission capability and on-board memory storage, unencumbered by wires the wearer can move freely and patented technologies reduce environmental and motion artefacts. We always welcome new innovative and scientific and collaborations please contact us to discuss your applications or to arrange for collaboration where we can help you meet your research needs.

Video End Time (38:09)

So, you have seen how the dry electrode looks like and which is a company that makes it we need to import it right dry electrode words for understanding the EEG signals. In the experiment part we will show it to you how the dry electrode looks like. Let me play the second video which shows about how the EEG signals are captured. So, let me play that video.

Video start Time (38:31)



and use that to control games or to fly a helicopter or designated device which is a pair of cat ears and it claims to use your brain power to measure your emotions and shows whether you're happy or whether you're sad and if you're talking to a person whether you like them or do you hate them. So, it's kind of showing the world what you're thinking. So, these devices are all quite interesting quite exciting but as we've seen in previous videos it's actually quite difficult to measure clean EEG signal without also measuring artefacts such as your eye blinks just your movements generally or even like your muscle activity in your face all the things it's a signal so as you can't see what these devices are actually measuring is a raw signal and all you can see is the output. So, the ears moving or the actual game we're interested to see what they're actually measuring because, we find it difficult to do this before. So, as an example we're using the mind flex device today and this is what the mind flex looks like it just has a simple dry electrode which goes on your forehead and then it has a ground electrode which goes to your ear and then your negative electrode goes to your other ear and the internal circuits. The Peris well controls the device controls the game is this and it just takes the signals from these electrodes and it is a Fourier transform on them and so we just get the different frequency bands and it uses that to control the game.

So, we've removed this and we're just interested to see what's actually being measured just by these electrodes. So, we've just taken a cable out Okay? I'll put this on. There we go and then you may remember our bio amplifier from our previous videos, so I'll be using that again today and we're just gonna connect the ground to the middle and then our positive electrode and our negative, let's put this on my arm. Now, you may remember in previous videos when we've been measuring EEG we've used a gel electrode this is our gel electric here that would typically use to measure bio signals and we'd usually clean the area where we connect the electrode and abrade the skin to remove dead skin cells oil that's on the skin or makeup or anything else and that gives a better connection and lowers the skin impedance and allows us to record a cleaner signal but what's interesting about most of these devices are available on the market. So, just use a dry electrode and they don't recommend for you to clean the skin or anything, so if you interested to see what we're gonna record today.

So, let's have a look at our signal and that's clearly 50Hertz noise we're just seeing in a minute so we can remove that with our notch filter and see what's underneath. Now, there's definitely a signal we can look at the Fourier transform of that see what frequencies we're measuring and now we can see if we can measure any artefacts, so we'll try it I blinks and that's definitely having an effect on the signal. But it's still very noisy. There may be some EEG in there but just using the dry electrode we're not getting a good enough contact with the skin. So, what we can do is we can leave this for 10 minutes and see if we can get a cleaner signal after we after we've got a better connection.

Okay, So, it's been about 10-15 minutes and now we can have a look at our signal and see if it's clearer ok and so we definitely reduce the amplitude of our signal after 10-15 minutes, and what we could be seeing now is EEG. But we could also be seeing other artefacts as well. So, we can demonstrate these to you just by me blinking my eyes so you can clearly see the jump in the signal is to do with my eye movements and that's because the electrodes right beside my eyes, and then if I do some facial expressions, so I'm really happy I'm using the new coming yeah! and that's a EMG coming through so that's me moving different muscles in my face and just even me talking right now is creating artifacts just by me again moving my facial muscles and there's also movement artefacts in there. So, if I move my head, so it's something that I could be doing. While, I play the game because there's nothing in the instructions that say you're to remain completely still, but you can clearly see that this is all affecting the signal.

So, looking at our frequency spectrum we're getting therefrom the Fourier transform we're definitely getting frequencies in the EEG band so that's good. That means there is EEG in there but as we've just demonstrated. The so many other our sites going on. It's difficult to see how these devices are just measuring the EEG and using that to control the device it's completely up to you. Whether, you believe these devices are working the way they say they are, but it does seem quite obvious that. It's, it's very difficult to just measure your brain waves or your EEG without measuring other artifacts as well, and this is all going to have an effect on the output of these devices.

Now, we don't know exactly what kind of filters all these devices are using, and they may claim that they remove different artefacts by doing different things. But the EMG spectrum it's within the EEG spectrum so it would be impossible to completely remove the EMG. While, still leaving the EEG. So, it's probably unlikely that they're doing that. So, we've created a You Tube playlist so you can have a look at lots of the different devices that are available commercially and also different applications of the same kind of hits device different electrodes and you can make up your own mind or you think and these videos are showing or what do you think the device is measuring.

Video End Time (45:15)

Okay, so you have seen this video as well so just to summarize the entire you know lecture. In, in one in one or two sentences what I will like you guys to do is you understand what kind of electronics conditioning circuits you can design for ECG as well for EMG as well. That will be kind of homework where, I had to trust you that you are doing homework. Right? Of course we will give you a lot of assignments and a lot of tests that you need to appear for, But as a part of you know understanding the signal conditioning circuit further, if you can understand how can you design a leptons and conditioning circuit for ECG and how can you send for EMG. Then you can understand the, the ease or difficulty that you have, when you are designing for EEG, being the lowest or in amplitude of curve is few micro volts compared to those signals that you obtained from the heart or from the muscles Right? So, you just think about this again look at this particular class and focus on the next one where I have discussed with my tears of, of how to show it to you the performance of this EEG circuit and we will also show it to you how understanding eg can help you to solve a particular problem particularly when you are talking about the deafness. Okay? Deafness in units. So, that is what our interest is that how can you understand using the EEG signal whether a new one baby can hear or not all Right? so, that we will discuss in experimental part till then you take care, for any questions feel free to ask us the forum and I'll see you in the next class.