Lecture-46
Electronic Modules for Industrial Applications using Op-Amps

Hi, Welcome to this lecture and this lecture will cover what are the hearing losses that can be detected with the help of EEG signals. Now in the last module if you remember we have discussed what exactly is ECG, what is the EMG, what is EEG Right? and only focused more on EEG. This lecture I will tell you that how we can understand the signals coming from the brain, in terms of EEG signals and how it can be you know analyzed to understand whether a person has a hearing loss, and we will be focusing more towards and neonates or infants, neonates are babies that are born within one month of their birth while infants are anywhere anyway any baby which is about 2, 3 years old. So, what, what we want to understand is can we understand by using this EEG whether that baby is suffering from any kind of hearing loss or not.

Now in that process we also have to understand what kind of electrodes that will be using. Okay? and we also have to understand that how this EEG signals are generated. Right? And if they are generated how we can capture those signals. Right? A lot of things are there that we will cover in this particular module, so please focus on the lecture so this like I said we will be discussing on hearing loss detection using EEG signal and,

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Brain Signals (EEG)

Brain signals or potentials (EEG) are generated by neuronal firings. Even in absence of any external stimulus, a person's brain has scalp potentials due to various processing functions executed by human brain.

Event Related Potentials

When external stimulus is provided to a person the brain signals change according to the stimulus provided and reflect functioning of the brain in response to that stimulus. These potentials are called Event Related Potentials (ERPs). The stimulus can be auditory, visual, somatosensory etc.

Hearing deficits can be detected by observing Auditory Event Related Potentials (AERPs). Different components of the response reflects potentials generated by different parts of auditory pathways.

when talk about EEG you know that EEG is nothing but brain signals, and when the brain signals brain signals are generated by neuronal firings. Even in the absence of any external stimulus a person's brain has scalp potentials due to various processing functions executed by human brain. Now generally if you if

you again see look at me what I will show it to you is if you yes, there is a hair there is a cap with lot of electrodes placed on the brain. I play the video so you understand it but just to help you out and the electrodes are placed in a 10, 20 system what is 10 20 that is a percentage so what is 10, 20 percentage so we had to understand what is nasion, nasion is somewhere area right over here it's a nasion it goes through your eyebrows like this. Okay? this is a nasion and then we have inion and then we have a pre auricular so nasion comes somewhere and the backside here. Okay? and then preauricular is somewhere here on their ear here. So, nasion nasal nasion. Right? inion and preauricular. So, with respect to that the electrodes are placed in 10, 20 percentage we will see that. Okay? another thing that is very important is to understand how the electrodes are given number and what does the number stands for, for example the even numbers they are for the right side of the brain, the odd numbers are for the left side of the brain, and then you have a symbol for that or alphabet for that. For example, F stands for frontal, C stands for central. Right? we have P for parietal, we have another letter called T for temporal Right? then, we have O for occipital.

So, let me understand frontal, central. Right? temporal, temporal is here on the sides temporal right frontal is in front here, then so frontal polar is somewhere here, frontal is here then we have central alright. we had temporal here on the sides we have occipital on the back side alright. and then same way we have FZ, so middle frontal and CZ middle central and so on alright. So, you will see in the video and this is a given example the point is that this is how the electrodes are placed in the brain. Okay? or on the brain to capture the electrical signals now very important thing is how we can get a better electrical signal. we can capture better electrical signal if we our impedance is extremely low, how to reduce that impedance by using a gel. So, gel will reduce the impedance if you are using wet electrodes, how does wet electro looks like. Right? and how it is placed so we will see in a while I have brought for you the varieties of wet electrodes, varieties of dry electrodes, some clip electrodes, so you see how it looks like. Okay?

So, let us before we go there let us understand the existing technologies and finally our idea since we are understanding in, interested in understanding the application of operation amplifier. Right? our idea is that how can we design an electronic module, with the help of op-amp, so as to capture these EEG signals Right? we require a signal conditioning circuit but if you want to design a signal conditioning circuit is to understand where the signals are coming from and that's why we are talking about this EEG and is principle. Okay? So, one part of the EEG is called event related potentials.

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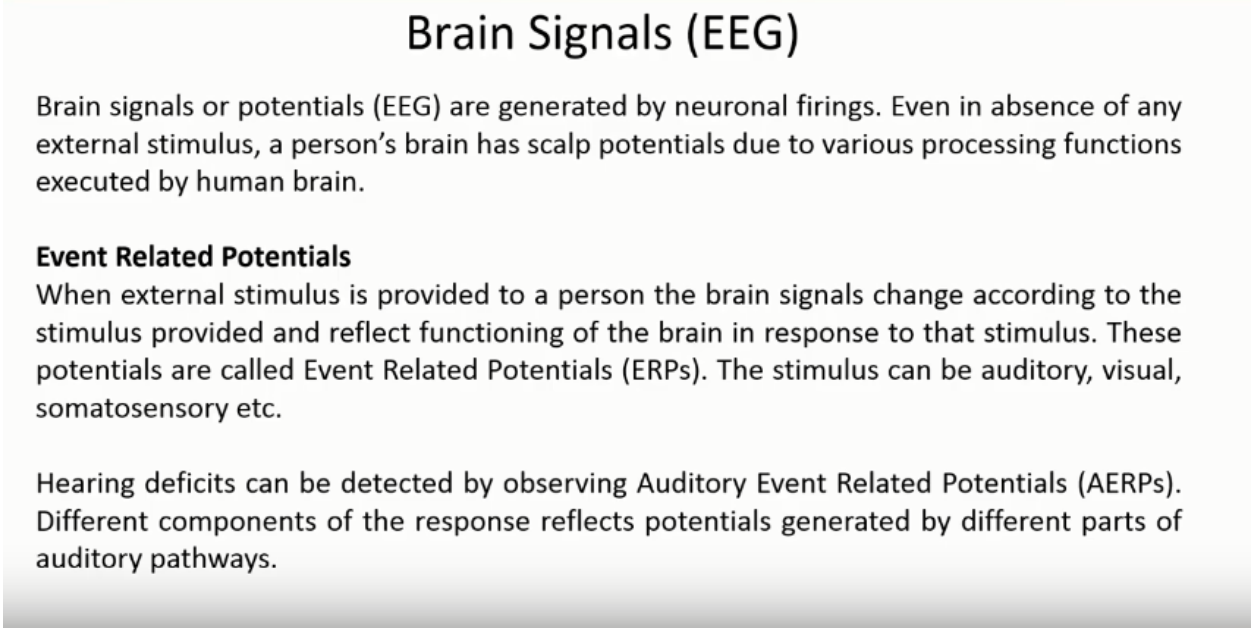

So let us see what is even rarer potentials is also called ERP, so when an external stimulus is provided to a person the brain signal change according to this stimulus provided, and reflecting functioning of the brain response to that stimulus, these potentials are called ERPs or event-related potentials. The stimulus can be alter is visual or somatosensory. So, if I if I'm understanding or hearing, Right? continuously you send a signal let's say let's say a particular frequency it sounds like b b b b b and b so suddenly you see the the the there is a some change. Right? in the auditory, so what will happen suddenly the signals coming out from the brain that particular peak will change alright. Suppose visual now looking at let's say I'm reading a book convey one page, second page, third page suddenly in front of me let's say a picture of let's say food appears. Right? On a mouse appear suddenly, while reading a book. Right? On the screen suddenly mouse appears so when suddenly mouse appears that was not expected. Right? Again, is there a change in the signal. Right? there is a auditory there's a visual, and there is something called mismatch negativity will discuss about that later if required. Right? Now you understand these are all event according to event there is a potential that is created that's why it's called event-related potentials alright.

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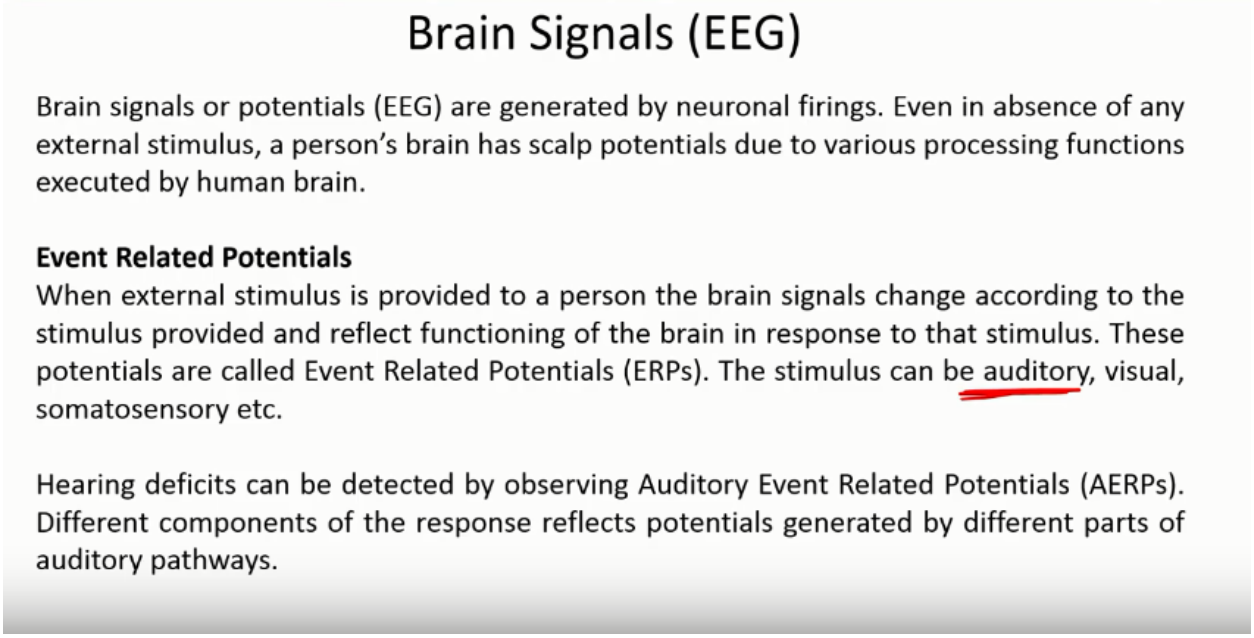

So, hearing defects can be, or deficits can be detected by observing auditory event-related potentials. Right? you see the stimulus can be auditory I told you right a frequency at b b b b and then suddenly you have long B then then there is something else right da da da da da da something so suddenly if there is a change this we can even be able to hear and distinguish the change auditory Evo event related potential called AERPs. Right? So, we because we are looking looking at the hearing loss, we are focusing on AERPs alright.

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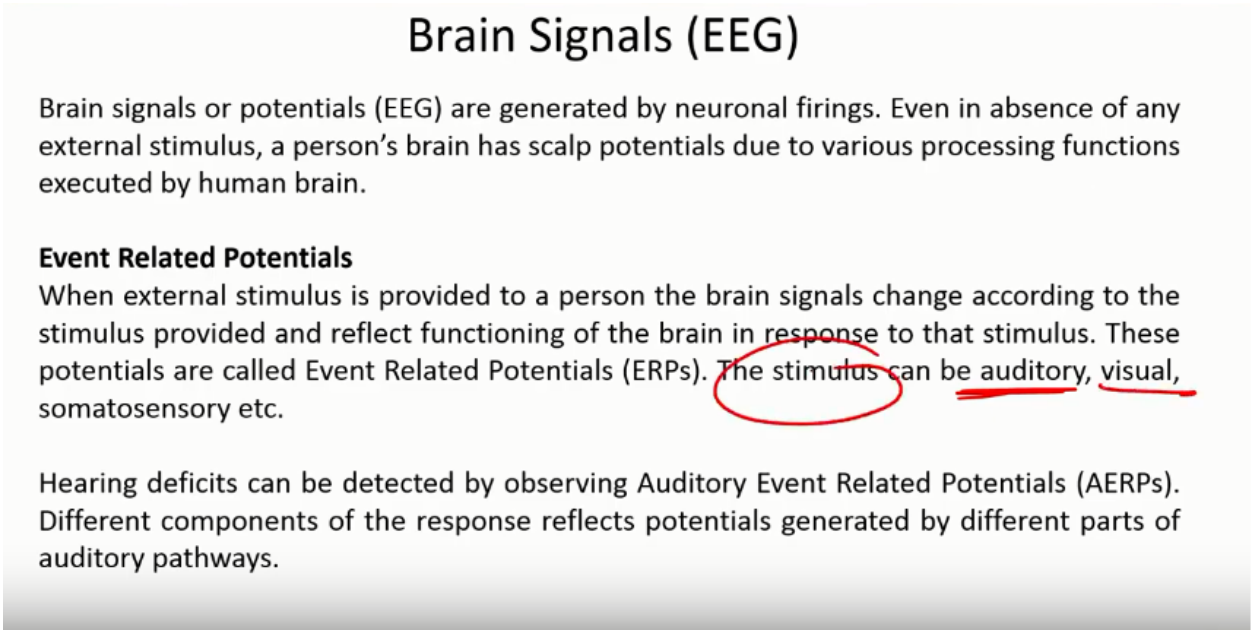

So, if you see different components of the response so in ordinary visual and somatosensory the stimulus that we give we are interested in auditory event-related potentials where different components of response reflects potential generated by different parts of the auditory pathways.

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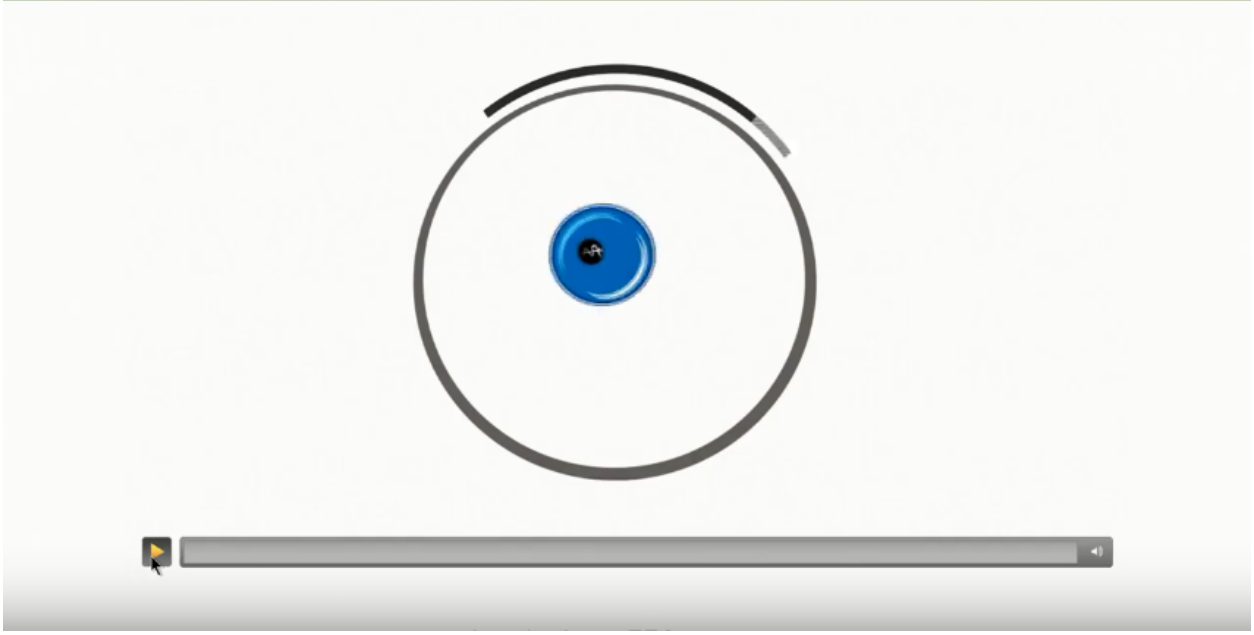

So, let us first see how the EEGs are generated like I said, and I have discussed that there are several regions like nasion I know inion preauricular then there are a frontal region, central region. Right? and there are parietal it religion, the temporal region, occipital region. So all these things we will see in this video let me play the video and then we continue, Hey whoa I'm studying for my MRCPs and I cannot get my head around EEGs I know that's your field of expertise so you wouldn't mind helping me I sure think Mary Claire how about we go through the basics of the EEG today it may be useful for you guys at home too. So, what exactly are EEG is used for.

EEG s are primarily used in the diagnosis of epilepsy, numerological condition associated abnormal activity in the brain. With another important use of the EEG is distinguishing organic disorders from psychiatric or functional illness. An EEG can also be used when predicting the outcome in some types of coma and to investigate sleep disorders. EEG can also be used to detect some other neurological abnormalities such as and Encephalitis and some types of dementia although its affinity of diagnosis in these cases is by other investigations. So how exactly does an EEG work what's the science behind it. Well electrical activity in the brain is generated by action potentials in neurons, cortical pyramidal neurons contribute most of the EEG signal as they have long axons and a unique orientation perpendicular to the cortex. The cell body is heading away from the surface while the apical dendrites are

heading towards the surface as a result the electrical fields are likely to project towards the scalp service ready to be picked up by the electrodes.

I've heard of a concept called impedance could you explain what that is, impedance is the opposition to the flow of current it is measured in units own a good electrical connection between electrode and scalp is essential in the recording of clean EEG signals. A low impedance ensures that the recorded EEG signal reflects brain activity as opposed to artefacts such as noise from the electrode the environment all the subject themselves fire blinking muscle movement and their heartbeat. It may be necessary to perform electro or kilogram, electromyography and electrocardiogram to eliminate those waveforms which are not suitable in origin. Whoo! sounds interesting crackling EEG sure but first I need to tell you about some potential adverse effects of undergoing an EEG. Some main ones are that there is a risk of skin abrasion which can become infected.

The skin can also become inflamed you can also get a headache from the electrode cap in this video the EEG electrodes are placed on the scalp according to the 10 to 20 international placement system. This method was developed to ensure consistent protocol between studies to allow for comparison between subjects the 10 and 20 refer to the placement of electrodes are fixed distances or 10 percent and 20 percent from anatomical landmarks. For example, the nasion the inion and preauricular points. Thus, allowing for consideration of variations in head size. The electrodes are labeled with birth and letter, and a number according to the site at which they are recording brain activity. Even numbers denote the right side of the head, and odd numbers the left. Let is referred to the area of the brain underlying the electrode for example F for frontal, C for central, P for parietal, T for temporal O for occipital, FP for frontal polar FZ for midline frontal, CZ for midline central, PZ for midline parietal, OZ midline occipital.

So, the first thing you have to do is measure head size you do this by measuring from the nasion this is the depressed area directly between the eyes to the inion the bony process at the back of the head. This will allow us to choose a corresponding EEG cap size you then plug the electrodes into the correct size cup each splitter box has 32 electrodes, where each electrodes corresponds to the number on the cap. We then clean the face around the eyes and behind the ears using alcohol and scrub too. This exfoliates the skin to allow a better connection with the ground electrode put the cap on by centering the front of the cap on the participants forehead and then pulling the rest of the cap backwards over their head. Now adjust the caps alignment to ensure that the CZ electrode is on the midline of the head that's halfway between the nasion and the inion. We now secure the chin strap and place the splitter bolts on the shoulder of the participant and fixate with tape. In order to record our movements and electro ocular graphene EOG is performed by sticking the following electrodes to the participants face. The vertical EOG electrodes should go above and below one eye, the horizontal EOG electrodes should go on each temple, the ground EOG electrode

should go on one ear note, other signals may also be recorded in conjunction with the EEG as mentioned previously.

Carefully push the blood syringe tip through the plastic groove gently twirl the syringe to move hair away from the scalp, and squeeze gel onto the scalp until the LED turns green. This means the impedance is good let the participant produce artifacts blinking looking left and right and chewing and explain their effects on the EEG signal. Once you are happy with the signal quality when all of most electrons are green you are ready to start recording. So, what type of results does an EEG produce could you give me some examples of waveforms. The various waveforms are recorded during the EEG procedure I'll take you through in-depth interpretation of such waveforms another time. But a few examples are this is a wave pattern during waking this is a wave pattern during an absence seizure in childhood and here is a wave pattern during same.

Video End Time: (15:57)

Okay? So, the use you have seen the video whatever I was discussing in detail. Right? and then you now you can understand how the signals are generated are how they are captured. But once the signals are captured this signals are in micro volts you see ECG is where your signals are generated in terms of millivolts, brain is in terms of micro volts, EMG again in in millivolts. So, EMG is muscle moment. Right? but when if somebody is taking the easy signal Right? from my brain at that time if I move my eyes if I'm if I move my muscles and of course the heart is beating then all three signals may create an artifact into this particular signal, and thus it is very important to also take simultaneous measurement of

EMG, ECG and also the electro choreographer like we said for the eye moment. Right? eyelid moment. So, and along with the EEG signal. Okay? So the this is what is important also very important is how can we design a circuit that can have a higher signal-to-noise ratio because the voltage is in micro volts there will be lot of artifacts coming into picture so we have to reduce the noise and that's why we can reduce the noise by having a higher SNR amplifier.

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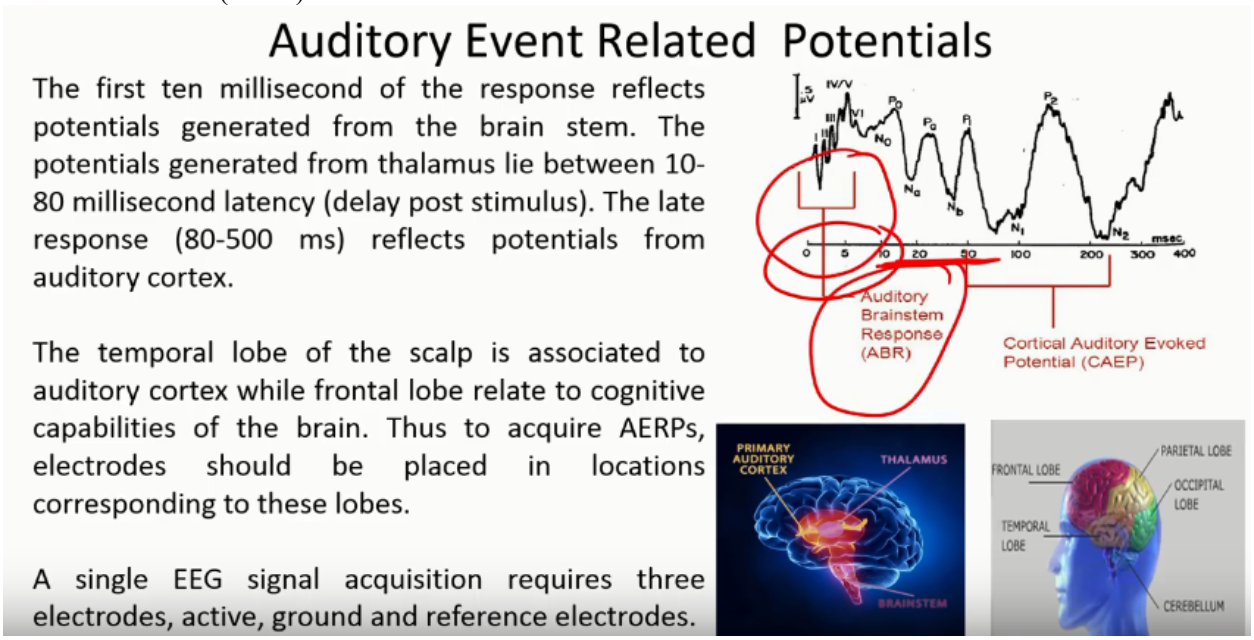

So, we will see how can we design that before that let us understand what exactly auditory event-related potentials. Now you see this one this is how the signals are generated in the EEG and you can see this bar is of 5.5 micro volts. So, it's very tiny signal. Okay? Now the first 10 milliseconds which is first 10 milliseconds of the response reflects potential generated from brain stem the petitioner from tamale's lies between 10 to 80 milliseconds from here to somewhere here the late response is from 80 to 500 milliseconds reflect potentials from auditory cortex. So, this is how the EEG is seen very auditory brainstem response is called ABR which is only from first five milliseconds is what is measured while where you are understand the cortical auditory evoked potentials it is from 50 to 200 milliseconds this is ca EP that is measured. Now we also have to understand if you just took, they take a brain this is a brain stem and then there is a primary auditory cortex and there is a telomers. If you see from the lobe side, then frontal lobe like a here temporal lobe which is here or temporal lobe parietal lobe which is here or CPT lobe which is in the back side and then there is a cerebellum. Right?

So, you see at the different regions of the brain and then the temporal lobe of the scalp we associated the auditory cortex so which one the one this is right over here which is above our ear. Okay? Or just in front of like this particular part this is responsible for the auditory associated the auditory cortex. Right? and it

also through the frontal lobe this is temporal lobe. Right? while the frontal lobe which is the in the front this particular lobe is this is the one. Right? Is right over here this is the temporal lobe, and this is the frontal lobe temporal lobe is for the auditory while the frontal lobe is for the cognitive capabilities of the brain visual. Right? Cognitive capabilities of the brain thus to acquire auditory event-related potentials electrode should be placed in the location corresponding to this lobes. Right? The way to place one here to place one here and with respiratory reference to here that's with some ground. Right? So, this is how the signals are generated one is in frontal version temporal these are electrodes are placed when we are talking about understanding the auditory event-related potentials understanding the hearing deafness. Okay? alright.

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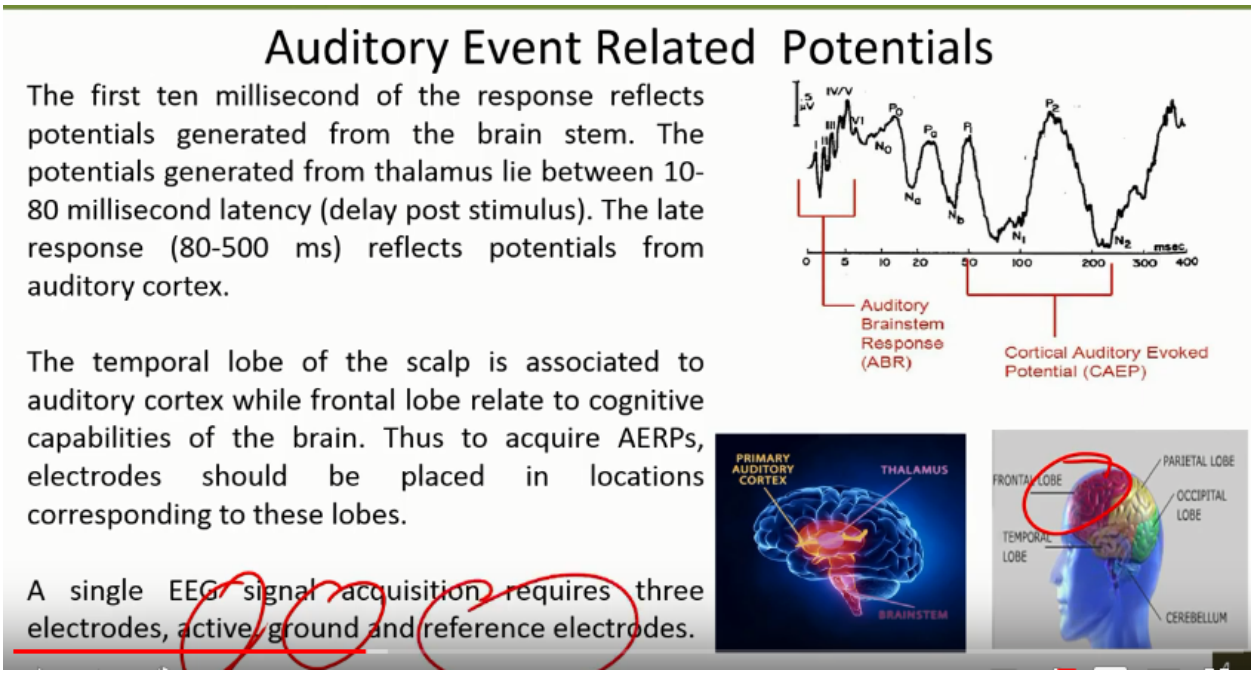

So, a single easy acquisition system requires three electrodes active ground and a reference electrode. Right? we require three electrodes back to ground active ground and reference.

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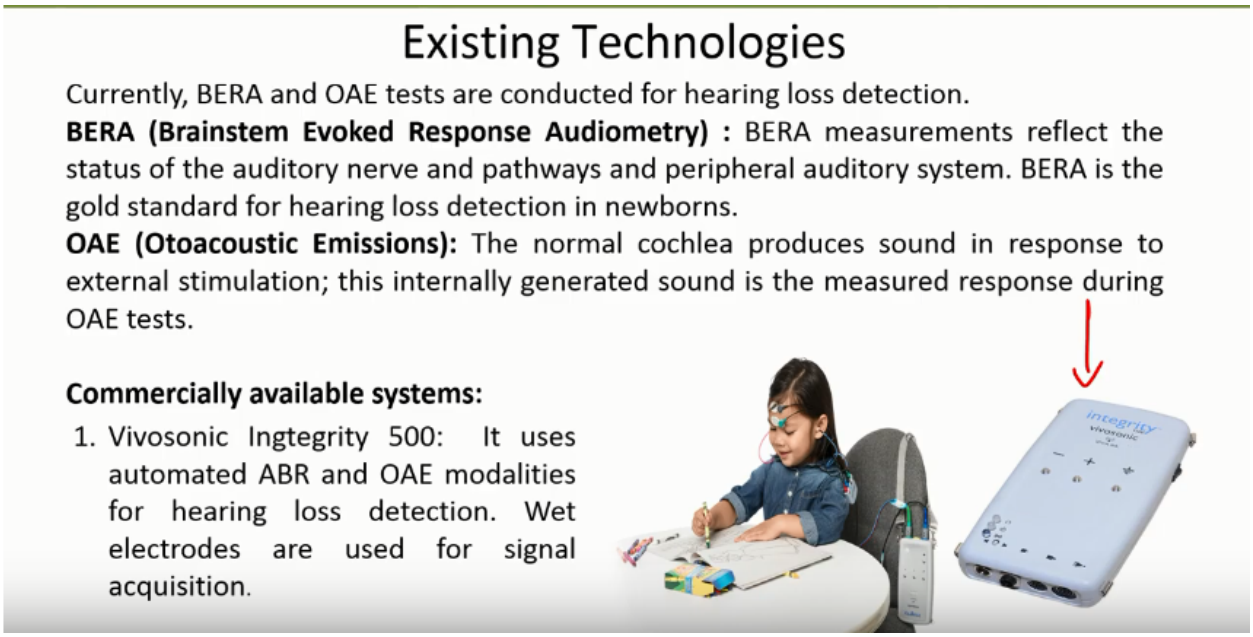

So let me go to the existing technologies now there are several commercially available systems and I have for you videos of different system just look at the videos you will understand in detail how each system works and it's extremely important to understand this and it's very easy to also understand. So, let us first understand the the current system so current systems that are used for hearing loss detection exclusively and they are also kind of we can say it's a gold standard our BERA and OAE test. The BERA stands for brainstem evoked response audiometry where OAE stands for auto acoustic emissions. So there measurements reflect the status of the alter inner and pathways and peripheral orderly system while it is a gold standard like I said for hearing loss detection newborns as soon as the baby is born in inner in within 24 hours this BERA and OAE we have you know we have to do it. So, to understand the that the hearing loss detect for hearing loss detection and the normal Kokila produces sound in response to external stimulation this internally generated sound is the measured response during the auto acoustic emissions. Now the commercial oil system the first one is Vivo sonic integrative 500 which looks like the one that I have here, and it uses automated ABR in OAE modalities for hearing block detection, it uses very lictors are used for signal acquisition.

So, I will show you how exactly the weight vector looks like so if you see here in my hand these are the vet electrodes that I am holding these are the wet electrodes I am holding that these are the buttons on that. So, if you see with with yes that's good so if you see here. Right? you can see this particular part is the part where you have to put the gel and then you have to attach these electrodes on the head alright. So these are the wet electrodes so if you see how we can take a better signal you can only take a better signal when you can put a gel so when you put the chair what happens the impedance will reduce so to reduce this impedance we have to put a gel, and the electrodes like you see here the conduction is here these are

the buttons. Right? So, two holes electrodes you can you can pick and place it like this. Now in the same time you also have the clip electrodes. Let me show you to you the replacement electrode which is AG AGCL ear clip electrodes I have with me here let me just show it to you so you see this is just like a crocodile pin that you use in the you know in the in your lab, but there is here there are two electrodes metal it is in between this pin so what I had to do I had to connect to my ear like this like this. Okay? These are ei ear electrodes and it's very simple it's also quality ear electrode this is from open BCI Florida research instrument.

It is the number is TDE four three one two and it's called ear clip it's called ear clip. Okay? This is another electrodes that people use. Right? Then we have another one which is your dry electrode. Let me first show it you how do I electron looks like, and you need to little bit zoom in so that they can see. Okay? I'm holding it right in my hand please try to zoom in yeah. So, these are the electrodes this is a dry electrode that I am holding. Okay? and if you see clearly if you focus there are lot of pins at the end the lot of pins at the end in this particular region alright. and what I'll do is I'll place the electrode light like this why because you see now you can see clearly there are lot of pins here. Right? you see there's a probes the advantage of dry electrode is that now we don't have to use gel. So if you don't have to use gel why because now it is a basis has many contacts and the impedance will be extremely low if I use dry electrodes and it's easier because there is no gel, there is no no worry of electrons falling down and the dry electrodes are are very easy to use.

This is again from the same company Florida research instruments however let me show you two few other directors you see this is a kind of easy to see these are also called as SM spike electrodes, spikes because there are spikes in that in the top of the selectors can you see again can if you zoom in. yeah! this is but much much more easier to see if you see this has spikes again if I place it he is kind of easier. Right? So these are the spikes can you see the spikes so these are the spikes I place it on my head it becomes kind of easier so this is how the electrodes is is in reality of course there is a holder to hold this electrode right like I have shown you earlier. Okay? Let me show you the headband so it becomes easier you see in this head bed here is a dry electrode. Right? So, if I if I put the headband on my head. Right? of course I do wear wear it I will do it later for that actually right now also. Okay? Let me show it to you guys so suppose this is the electrode that I want to use it. Okay? and I am wearing it alright. Okay? So now you see here the electrode is right over here alright. and this electrode is this spike electrode here in my hand. So now I can connect this thing. Right? To the electronic conditioning circuit and I can understand what are the EEG signal generating from the brain. Right? This is a headband again for you know it's a headband kit it's called FRI 2147 from open BCI and the electrode is right over here electrode is right over here this one. Now because of the bend you know electrode is touching it and I don't have to

use gel because a dry electrode. Right? This is how these signals are taken. Now there are certain pros and cons of using wet electrodes our dry electrodes are electrons over wet electrodes but that is not our idea to see right now our idea is to see what kind of electrodes are present and can we use it and how can we use it. So easy to use now you can connect this one to the electronic conditioning circuit and then we can use the use it for measuring the EEG.

Now we will also see how the electronic conditionings are kid we can design because there is a far more more of our interest rate rather than understanding how the electrode looks like, but if one whenever you want to design any electronic module you have a some kind of sensor or transducer. Right? So that signal only you are amplifying you need to know how what is the principle behind that particular sensor then only you will understand how can you design the electronic module accordingly I have the electronic module with me I will show it to you once we see the slides.

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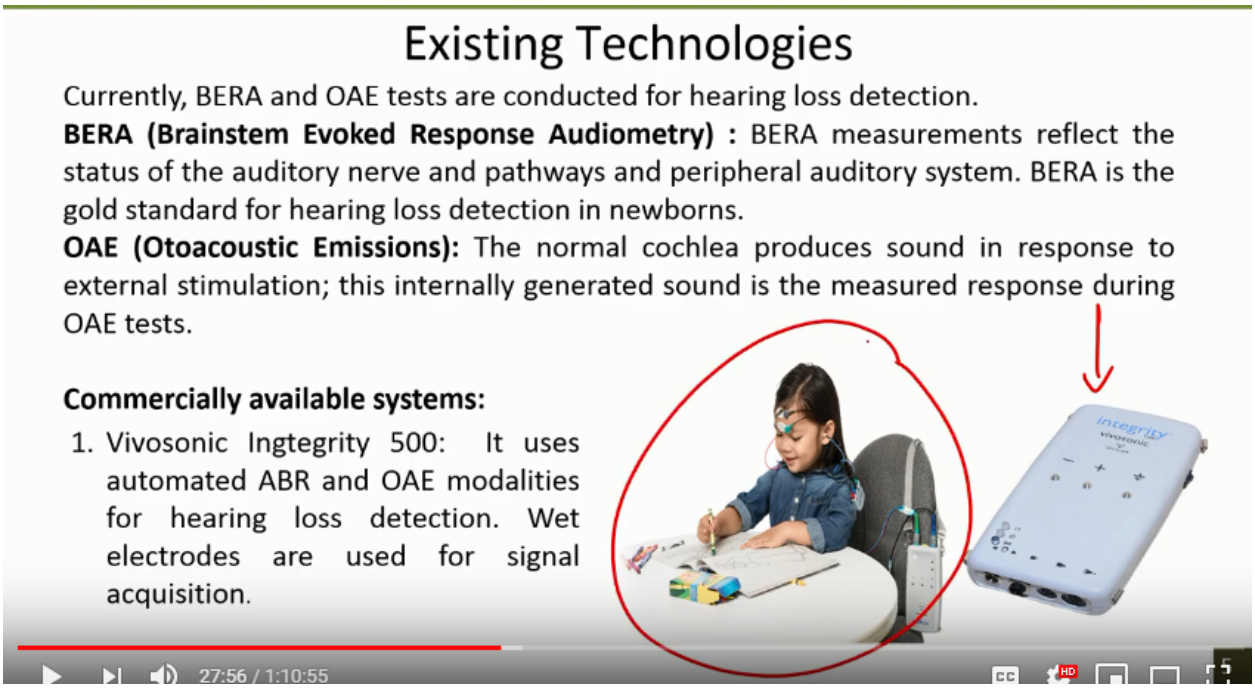

So the point is if you see the schematic or the picture of this particular baby you can see that the Vivo sonic is connected and there are electrodes right over here along with here you I told you that you require minimum three electrodes one for the active electrode one ground and one reference electrode. Okay? So now let us see several videos related to the existing technologies and then we will again discuss about the conditioning circuit.

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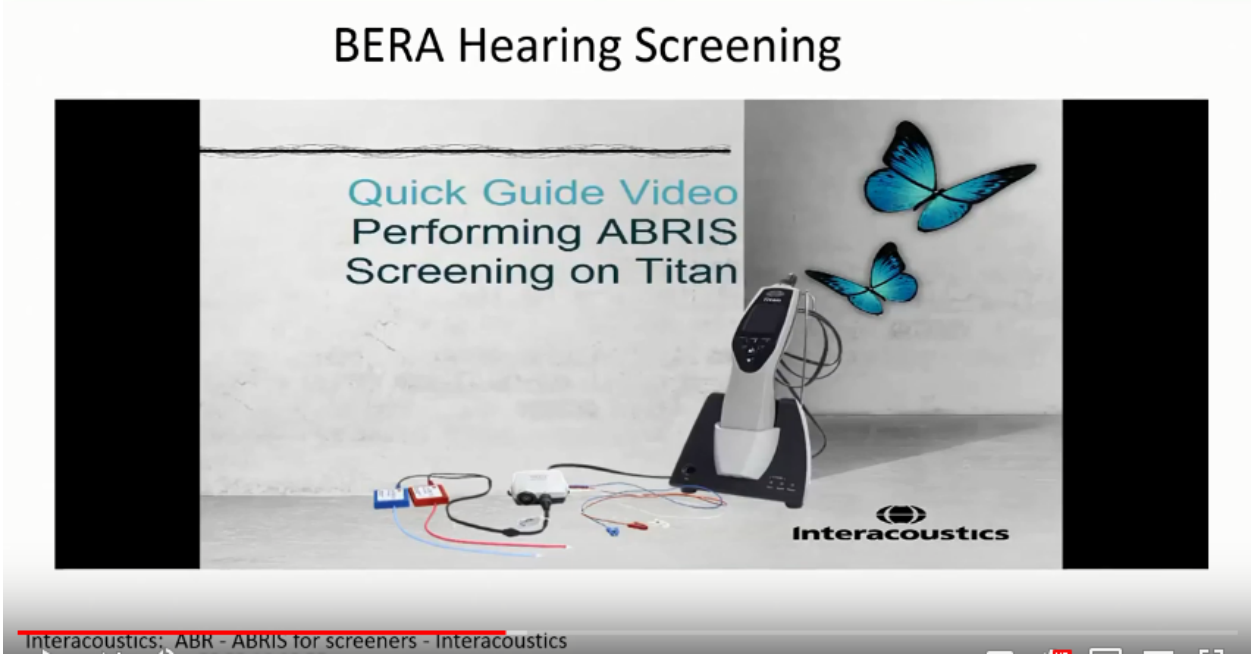


So, let us see the first video this is BERA hearing screening I'll just play the video this is from Interacoustics ABR ABRIS is for screeners. Right? and we played this quick guide video shows how to prepare the baby for an a ABRIS test and how to perform and interpret the measurement the following instructions assume that Titan is switched on, and with the correct ABRIS protocol selected and the preamplifier properly connected in order to prepare a baby for a ABRIS testing. Four easy steps need to be carried out firstly the skin where the electrodes will be placed needs to be cleaned, secondly the electrodes need to be attached to these sites and connected to the cables which are attached to the preamplifier, thirdly an impedance check needs to be performed to ensure the electrodes have good contact with the skin, lastly ear cups need to be placed over the ears and the speaker tubes need to be connected to these air cups. ABRIS testing requires three electrodes to be attached to the baby one is placed precisely at the center of the forehead, a second at any place on the cheek or chin and the last on the nape.

The skin of these areas should be clean and free of oils or lotions only if there is excess oil or lotion use an alcohol wipe to remove this otherwise start by putting some skin preparation gel onto a piece of gauze and rubbing each electrode area thoroughly the skin might turn a little red this will ensure good electrode impedance. Detached an electrode from the pack trying not to touch the sticky side and place it on the skin of each of three cleaned areas high forehead cheek and nape of the neck. If these areas have become dry, then apply a small amount of conductive gel to the baby's skin prior to connecting the electrode. Once the electrodes are in place the cables attached to the preamplifier need to be connected to the electrodes. The white cable must be attached to the electrode on the high forehead. The red cable to the

electrode on the cheek, and the blue cable must be attached to the electrode on the nape of the neck. After all these free connections are established Tyson will automatically detect the electrode impedance on an indication of the impedance or how well the electrons are attached will be displayed on a different picture in either green or amber.

Green indicates good arrowed impedance, whereas amber indicates poor electrode impedance if you see amber and check the appropriate electrode as shown on the picture to see if it is slipped if the impedance cannot be changed from amber despite several attempts to reduce it then you can still continue with testing by pressing start, a prompt will appear asking whether or not you wish to proceed here you can select yes to continue the test or no if you wish to try and clean the electrode site again and try to reduce the impedance. The last step in impatient preparation is making sure that the stimulus is presented to the baby ensure that air cups are connected to the speakers and that these are connected to tighten remove the foil from the ear cups and place the ear cups over the baby's ears. If the Titan probes attached at the same time as the ear cups you must either remove the probe or select ear cups from the list that Titan shows.

We are now ready to begin testing to do so press the start button on the Titan keypad after starting the test the patient noise bar is displayed at the top of the screen. If the patient noise goes above the black line the measurement is automatically paused perhaps try to calm the baby in order to reduce movement to crying sucking etc., If the baby appears calm and the patient noise is still not ideal stop the test and try the following. Firstly, turn off all electronic devices such as lights computers and mobile phones, secondly ensure the Titan battery is not being charged via the cradle during the test. If the impedances were initially poor clean the skin using the conductive gel and replace the electrodes. If an electrode falls off or becomes disconnected during testing the preamplifier will detect an abnormal input and a pop-up will ask you to reconnect electrode. In such case discard the old electrode take a new electrode and place this on the baby when you connect the cable to the new electrode Titan will continue testing automatically.

During the measurement you will see one separate bar graph for each ear a blue and a red color will begin to fill the graph when the test starts. The red bar graph corresponds to the right here, and the blue bar graph indicates the left ear is being tested. The aim of the ABRIS test is to ensure that the bars bill completely and turn green. When this happens, the test will automatically end and give a pass as a test result, in case the time runs out before a pass is obtained the result will indicate refer. In case the test is stopped manually the result will indicate incomplete, were test is passed this indicates that is very likely incomplete no conclusion can be made it is defined by the authorities of your screening program that when and here does not pass a screen whether or not it will be screened again or seen out for follow-up Diagnostics. This concludes this quick video on how to prepare a baby for an ABRIS test and how to perform the interpretations.

Video End Time: (34:12)

Okay? So now let me play another video which is from viva sonic. Okay?

Video Start Time: (34:19)

And you you see how this particular Vivo sonic equipment can be used. Let me play the video introducing the sonic integrity ABR. Vivo sonic integrity system works via Bluetooth technology. Bluetooth technology allows for Portability and flexibility while testing infants can be carried rocked or cradled

during testing without interfering with the testing process the wireless people link can also be used in neonatal intensive care units or operating rooms where wires create barriers to safe and effective testing. The earphones and bone conductor are simply plugged into the corresponding colored outlets on the bottom of the vivo link calibration data is stored in the plug and automatically uploaded into the system. Vivosonic has two electrode options the vivo amp or the amplitude. The amplitude contains a pre-filter and an Institute amplifier which boosts the signal as soon as it's recorded from the head this reduces environmental noise from entering the signal.

The vivo amp uses the same technology as the amplitude and has superior noise shielding with removable leads for a more flexible recording whichever technology you use simply plug it into the Vivo link on the integrity system a Learning Library is easily accessible on your desktop. The Learning Library contains many helpful instructional videos to guide you through the integrity system. Once the vivo link is powered on the integrity software automatically detects your Vivo link and establishes a Bluetooth connection enters or select an existing patient and navigate to the test screen to begin your ABR. Other available tests include the ASSR 40 Hertz ERP and otoacoustic emissions. You will notice that soap Kalman is the default algorithm for running your ABR. The soap algorithm uses a technique called Kalman weighted averaging this type of weighted averaging is effective at reducing noise in the response waveform but does not throw out important ABR data, with traditional artifact rejection all sweeps that have noise above a certain level are completely tossed out with Kalman weighted averaging each sweep is analyzed and included in the averaged to a differing degree depending on the level of the noise. The soap algorithm also contains additional noise reduction techniques that aid in cleaning the signal. This allows for an ABR result in less time and makes an ABR possible in less than ideal conditions.

Protocols can be selected in the drop-down menu if you have specific ABR parameters that you use in your clinic you can create your own protocol with the flexible options available in the protocol window. Recommendations for certain parameters such as stimulus rate can be found in the user manual testier is selected here changing the intensity is a slider or toggle on the keyboard check-in peanuts start and soon after you start recording you will see the number of noise adjusted sweeps counting these are noise adjusted sweeps because of the advanced so Kalman processing that's going on in the background. In your ABR experience you may be familiar with collecting one waveform at a time. Integrity automatically collects two separate waveforms at the same time this means you can simply compare these two waveforms to decide if they are replicating if you're happy with the result you don't need to collect another tracing.

The average of these two waveforms is automatically displayed at the top as you continue to collect sweeps through the soap Kalman algorithm the residual noise will decrease over time. If you would also

like to see your noise visually there is an additional waveform that you can turn on a minus B which shows a visual representation of the noise. The correlation coefficient tells you how well your two simultaneous recordings are correlating stop if you are recording using two channels both the ipsilateral and contralateral channels are recorded. The ipsilateral channel is automatically displayed but you can choose whether you would like to display or hide the contralateral recording. If you're unsure of normal wave file agencies latency data is preloaded into integrity yellow highlights guide you to where you would expect to see ABR Peaks from various stimuli and age groups. Marking your ABR Peaks is quick and easy the marker jumps from peak to peak as you move your mouse along the waveform. Placing a note on your waveform is also simple with the comment bubble once you have finished your recording save your record to the database to be reviewed again later.

Both of these waveforms are alternating polarity you also have the option to collect a rarefaction and condensation waveform at the same time. This is simply done by selecting alternating split for polarity here we can compare the condensation waveform with the rarefaction waveform if you would like to include a clinical summary type in your report to the clinical interpretations you can easily print or save a PDF of your recording by clicking the print button. Here you can select which items you wish to show in your printout you can choose to show or hide identifying patient information which is useful for sharing your PDF with your colleagues and keeping identifying patient information confidential. You can even export the complete record in a confidential way so that other integrity users can review your waveforms on their computer thank you for watching the introduction to integrities ABR. Please feel free to contact a viva sonic representative for a live demonstration.

Video End Time: (41:00)

Okay? Now let us see the third one which is from my Co Diagnostics.

Video Start time: (41:12)

This is from Germany and GmbH and let us and again see how this particular you know system is used again for ABR. The MAICA MB 11 is a hearing screening system that uses auditory brainstem response ABR technology to screen infants for hearing loss. It uses state-of-the-art test methods and an automated response detection procedure that can produce very fast test times with a high degree of accuracy the MB 11 is a pc-based system. The MB11 comes with everything you need to conduct a newborn hearing

screenings. The BERA phone comes with its attached cable connection for the USB box, a USB cable a cradle for holding the BERA phone electrode Joe, an operator's manual, and software on a USB Drive. The MB11 hardware connects to a PC using a standard USB cable when the PC is turned on you will see a red light on the MB11 Hardware indicating that it's receiving power from the PC through the USB connection.

When a battery-powered PC is used screenings can be performed on battery power alone without connection to an electrical outlet. The MB11 BERA phone includes three integrated reusable electrodes and an ear cushion surrounding the acoustic transducer. The electrodes are mounted on a spring mechanism that allows them to conform to the shape of the baby's head; the vertex electrode is mounted on a disc that rotates 180 degrees to fit a wide range of head sizes, for smaller heads of premature babies you may need to change this position. The BERA phone has been used successfully on babies as young as thirty-two weeks post menstrual age. Be sure to follow the handwashing and infection control procedures required in your facility in this video we may show the use of gloves for touching the baby, but this may not be required in your facility. If you're unsure whether the BERA phone was properly cleaned and disinfected after its last use, then clean and disinfect it before applying it to the baby's skin. The Bayer phone electrodes make contact with the baby's head at three locations one is just below or behind the ear lobe this is referred to as the mastoid electrode one electrode lays just above the ear this is the ground electrode the vertex electrode lays on the forehead at the hairline. The skin of these areas must be prepared using electro gel so that the electrodes can achieve good contact for recording the ABR squeeze enough electrode gel out of the tube for screening both ears apply it to the back of your gloved hand are on a 2 by 2 gauze pad or paper towel. The locations that must be prepared can be identified precisely by placing a small amount of electron Joe on each of the electrodes and positioning the bearer phone on the baby's head the best location for the vertex electrode is toward the baby's hairline at the forehead rather than back towards the crown of the head a more forward position allows better contact of the ear cushion to the skin around its full circumference and avoids areas of thicker hair.

Once the bearer phone is placed properly remove it from the skin and set it aside residual gel will remain on the skin of the electrode locations marking the proper spots using an additional drop of electrode gel rub the skin at the mastoid location 15 to 20 times in a straight line from the back to the front repeat this procedure at the two other electrode locations keep the gel at the three areas parallel to one another so that there's no chance that the gel from one location will contact the gel at another electrode site. Avoid using too much gel and avoid rubbing the gel in circles apply a small amount of electro gel just enough to wet the top of the electrode onto each of the electrodes. Place the mastoid electrode on the prepared skin lay the top of the bear foam down gently so that the ground electrode and vertex electrode make contact with

the prepared skin sites. Verify that the ear cushion is making contact with the baby's skin all around the ear with no large gaps between the cushion and the skin you will need to hold the Barrow phone in place so that it remains on the prepared skin throughout the test you shouldn't apply any pressure to the bear phone you're merely supporting it in place.

When the bearer phone is in place and the baby is quiet select the start measure button to begin the screening refer to the software chapter for information about the screening process when the screening is complete remove the Barrow phone from the baby and set it aside gently remove excess gel from the baby's skin try not to wake up the baby position the baby for testing the other ear and repeat the skin preparation process and screening for the other ear. When both ears have been screened clean and disinfect the Bayer phones so that it's ready for the next screening. To perform an ABR screening using the MB11 software involves a few simple steps first enter the baby's information including the baby's last name, first name, birth date gender, and an ID or medical record number choose the screener name from a drop-down list if the baby's information was previously entered into the database do not enter it again instead select the search button to access a list of names in the database, you can scroll the list to locate the desired baby's name they are sorted by last name in alphabetical order. If the database is large you can use various filters to shorten the list to find the desired baby faster. For example, you can enter the last name to reduce the list to the names of the babies whose last name matches your entry as you type more characters the list is shortened more and more or you can filter based on a test date range for example if you select data from today from the list only the babies who were tested today will appear on the list. When you see the name of the baby you wish to scream double click on the name the selected baby’s information appears on the main screen its ghosted out since it cannot be edited.

Select the year you want to test first by clicking on the right or left symbol, or by clicking on the ear button until the correct ear is chosen when the background of the ear button is read their right ear is selected, when the background is blue the left ear is selected, when the ear is selected select the measure button to proceed to the measurement screen when the baby is prepared for screening select the start measure button to begin the screening. When a screening has started the quality of the contact of the electrons to the skin referred to as the impedance is checked feedback is shown on the top of the screen with three traffic lights one for each electrode. When all three traffic lights remain yellow are green for several seconds the ABR data collection will begin automatically if any of the traffic light shows solid or flashing red then this electrode does not have good contact with the baby's skin, you'll need to resolve the problem before the data collection will begin please see the chapter on troubleshooting tips.

After a successful impedance check the ABR measurement will be get automatically a line will begin to appear on the time graph after each one second of data sample is collected a segment of the line will be

drawn the line will be red for the right ear, and blue for the left ear. Data samples that contain too much noise will be rejected as artifact and you'll see that the growth of the line pauses these artifacts generally occur because the baby is active or because the electrode contact has been lost artifacts can also be observed by watching the signal quality feedback at the top of the measurement screen under good conditions the signal quality will display green but yellow or red if there is interference. If you prefer the alternate EEG view you will see that under good test conditions the EEG line will be virtually flat if there is interference this line will reflect this activity, also during the ABR measurement the LED light on the MB11 hardware will be green when good data samples are occurring but will flash yellow or red as artifacts occur. When the data collection line ascends and moves into the green area at the top of the graph a past result will display and the test will stop automatically, after 180 seconds of good ABR data samples have been collected without the line crossing into the green area the screening will stop automatically with a refer result. When the screening is complete on one year select the other ear button on the measurement screen to change the test ear, prepare the baby for testing the other ear and select measure when you're ready to begin the screening.

The Bears one is intended for use on intact external skin around the ears and on the scalp, it should not be used if the skin has any open wounds or sores or if the baby has a contagious skin condition. The bear phone must be cleaned and disinfected after use on each baby, clean off any residual gel from the electrodes and ear cushion using a gauze pad or disinfectant wipe if you set the Bayer phone in the cradle during the baby's screening it must also be cleaned and disinfected. Disinfect the electrodes ear cushion, cable and other components that made contact with the baby or the baby's bedding by wiping them with a fresh disinfectant wipe. Use of a non-alcohol based disinfected product is recommended if an alcohol-based disinfectant is used the ear cushion material will be affected over time causing it to harden and crack it will need to be replaced more frequently be sure to follow the directions for use in the handling precautions on the disinfectant product. Allow the disinfectant to dry thoroughly according to the manufacturer's recommendations before using the Bayer phone on the baby. On a regular basis the electrodes should be removed from the Barrow phone and inspected for the presence of gel buildup inside the black gel protector.

The gel protector can be removed from the stainless-steel electrode for more thorough cleaning additionally the earphone cushions should be removed periodically for inspection and cleaning of the plastic under the ear cushion. When the components are clean and dry reinstall them onto the BERA phone making sure they're securely attached. Choosing a suitable test time based on the state of the baby is a critical part of successful efficient screening try to screen the baby shortly after feeding when the baby's sleeping comfortably, swaddling the baby in a blanket helps to limit the movement of the arms and

calms the baby delays and screening progress occur when the baby is moving this movement can be obvious when the baby, is crying or actively moving the arms and legs, or the movement may be more subtle such as eye blinking sucking our muscle tension in the neck and shoulder area near the electrodes.

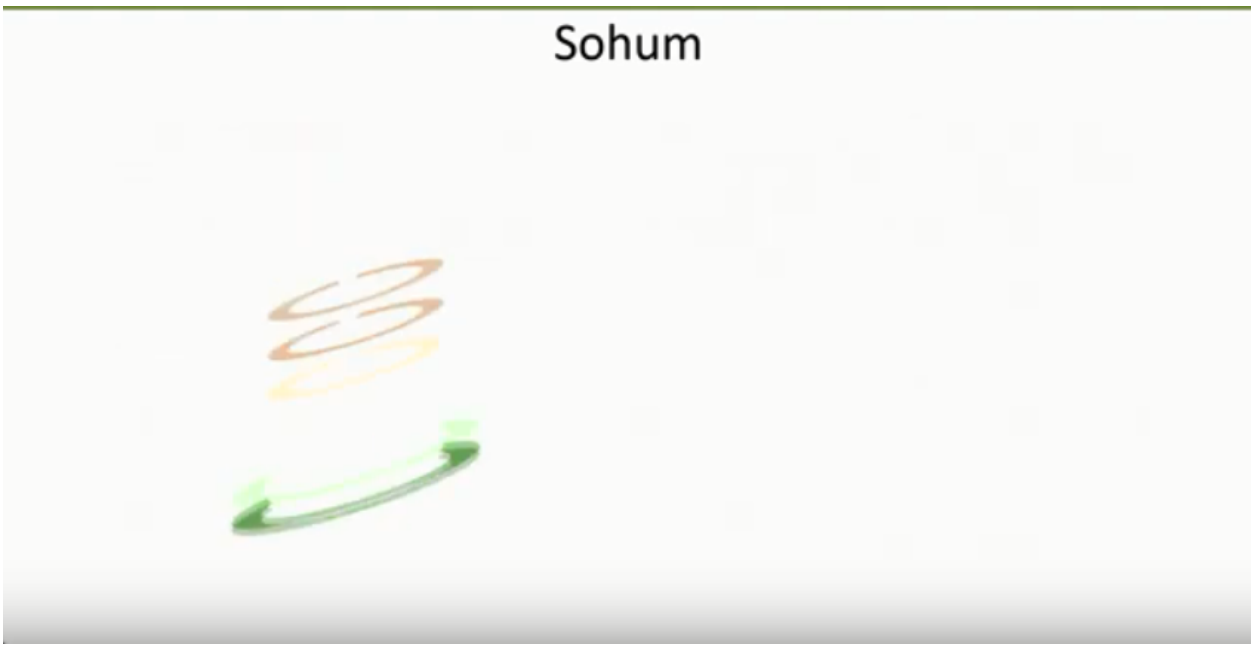
The baby can be tested while being held are even while breastfeeding when the sucking activity has slowed down infants can also be screened while sleeping quietly in a car seat, if it appears that the baby will not quiet down quickly select the pause button on the measurement screen to suspend data collection. When the baby has quieted again select the continue button to resume if the baby appears to be quiet, but artifacts are occurring check the electrodes to make sure they're still in good contact with the prepared electrode sites reposition them if it's necessary. To resolve poor impedance at one or more of the electrode locations check that the Bayer phone is resting on the skin that you prepared with the electrode gel move the position of the Bayer phone electrode slightly to see if you can achieve improved impedance, lift up the electrode that shows poor impedance and massage a little more gel into the skin. If good impedance can't be achieved with the electrode gel rub a small amount of new prep electrode skin prep which is slightly abrasive into the skin at the site and try again. If you continue to experience a problem achieving good electrode impedance try testing on PC battery only rather than using AC electricity, also check the connection of the MB 11 USB cable to the PC and to the MB 11 Hardware module, to make sure that it's securely connected on both ends.

Electrical interference in the test environment can be difficult to identify it can be caused by cellphones and other computers large monitors, RFID tags on the baby, or other monitoring equipment attached to the baby or nearby x-ray or MRI equipment. When electrical interference occurs, it may take trying different troubleshooting techniques to discover the source moving to a different location turning off non-critical electrical devices is suggested. Of course, you'll need to check with the baby's nurse or doctor to determine whether other medical devices attached to the baby can be temporarily disabled or removed. Thank you, for choosing the Mako MB 11 ABR screening if you have additional questions first your operators may know or contact your local maco representatives.

Video End Time: (56:55)

Okay? Now we have one more equipment, which is Indian made and it is called ‘Sohum’. We are happy to show this video that is making in India we had made something, and we are progressing it. There are lot of opportunities to improve this is what close to what to we have in terms of competition in the current market is novel devising system to screen the newborn. let me play the video,

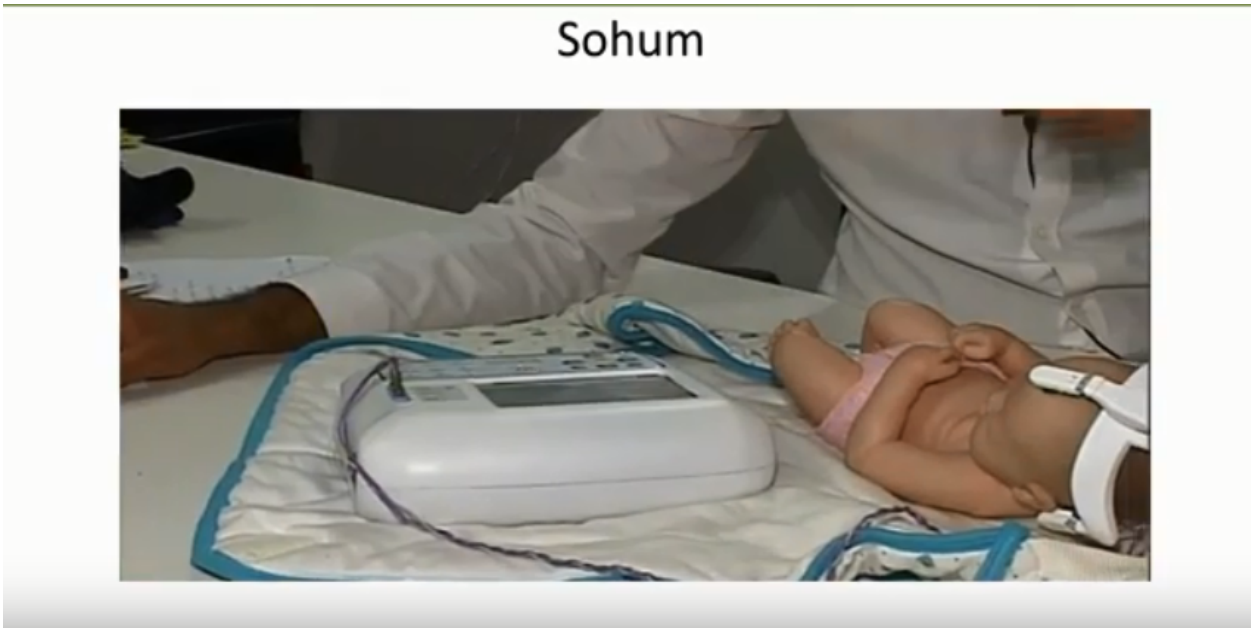
Video Start Time: (57:04)



Sohum screening device is a highly proprietary non-invasive safe device to screen new needs for hearing impairment with high sensitivity and specificity and is specially designed for mass screening of Mew needs in resource constrained settings. Presently hearing screening is done with subjective tests such as questionnaires observations or Auto acoustic emission which have a high false positive rate. Besides India forty low-income and fifty-three low middle-income countries do not have an affordable solution for early screening of hearing impairment. This device is based on the principle of auditory brainstem response in which we place three electrodes onto the head of the baby and it connects EEG waveforms and then within 90 seconds it will tell you whether the baby can hear or not with an automated result despots refer or verify this device is also enabled with telemedicine module so every data is sent to our centralized server.

This non-invasive device was made with an inbuilt algorithm that filters out ambient noises from the test signal the optimized design reduces test duration by reducing the time required for preparation and analysis making it idle for mass screening the electrode system is reusable which reduces the cost of the procedure. The telemedicine or the Internet livability the device they even on on a very low bandwidth it transmits the data or the results to a centralized location where a specialist can be verified the results.

Video End Time: (59:51)



Okay? So, if I talk about the existing technologies further now you have seen this videos Right? you understand how this signal how the most of the electrodes can be placed and how the signals are captured but,

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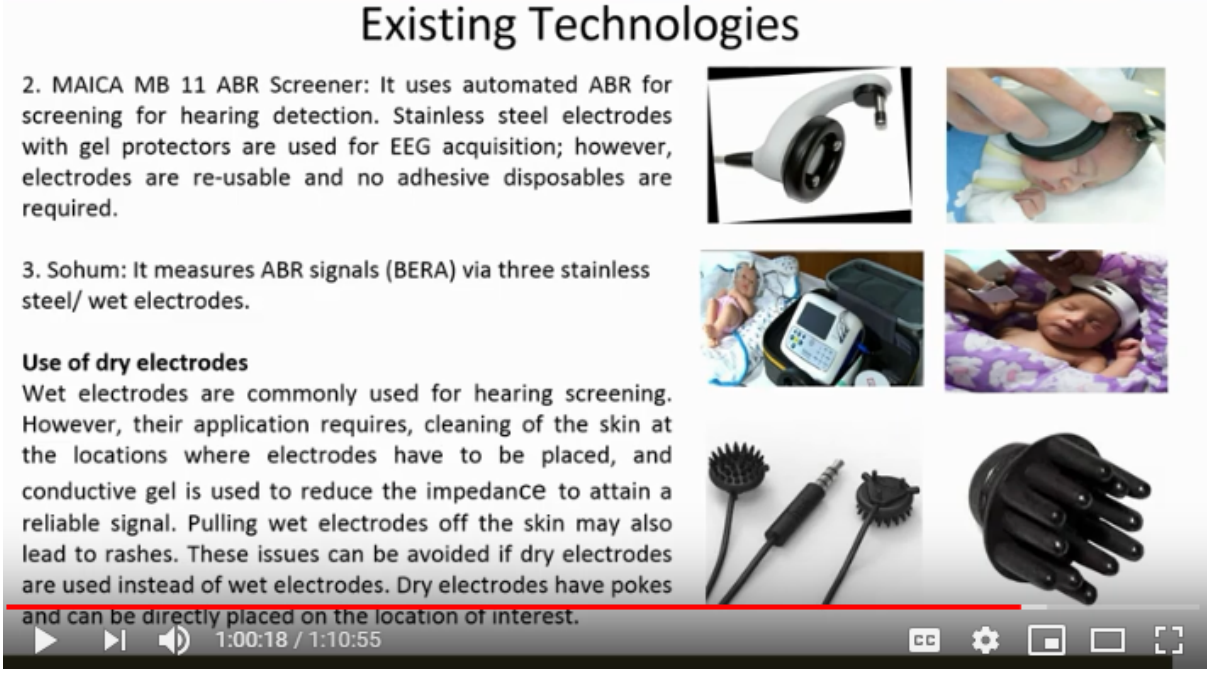

let us quickly see what this particular system works for example, I see a MAICA MB 11 ABR screener it uses automated ABR for screening for hearing detection stainless steel electrodes are used with gel protector for a EEG acquisition however, the electrons are reusable and no ADC disposables are required there is an advantage there is a system that you can see is the use of the system actually on the neonate it much easier to use the cost of the system is close to 15 lakh where, we have 'Sohum' which is measuring the ABR or BERA 3standard stills wet electrodes you can see here you can see here right So, this is how it is now let us see see the use of director now vet electrodes are commonly used for hearing screening. However, the application requires cleaning of the skin first thing at the location where the electrodes had to be placed and, second is it requires conductive gel to reduce the impedance.

Why so, tough to attain the reliable signal? Now another disadvantage of we electrode is that when you pull the electrodes that may cause skin rashes that may cause inflammation of the skin. So, this issue can be avoided if I go for dry electrodes like I have shown you I wore the dry electrodes, I remove It very easy to use it. Right? So, dry electrodes have pokes and can be directly placed in the location of the interest

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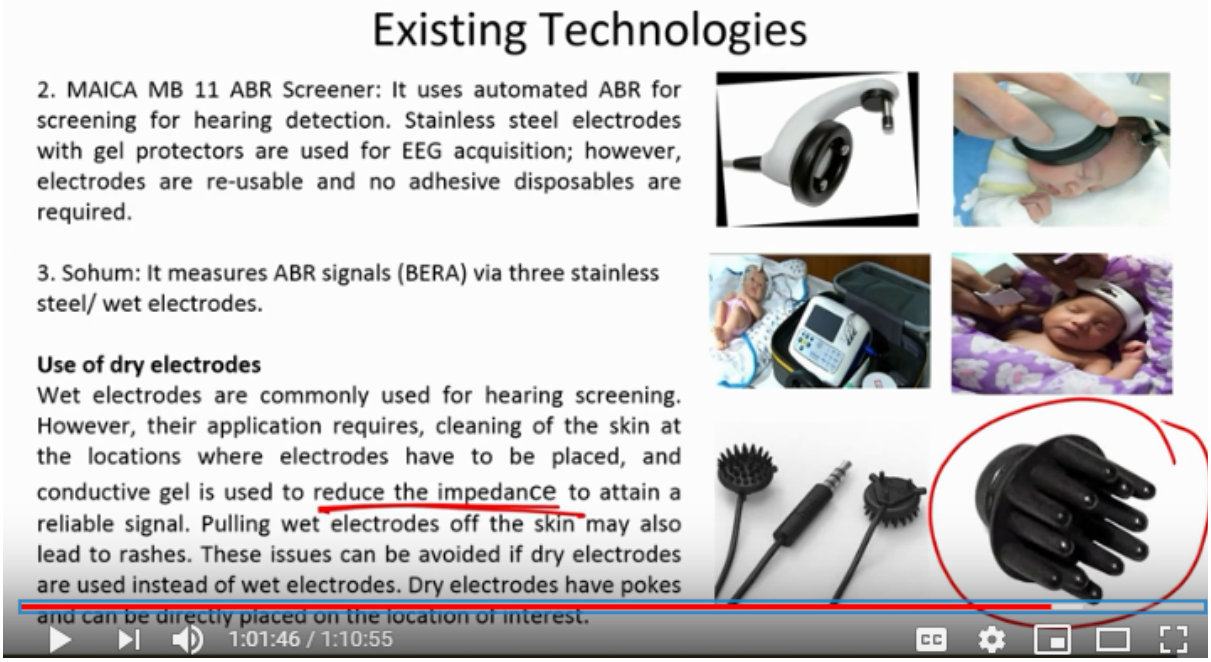

as you see here in the screen you have seen these directors I have shown it to you right several kind of trial actors, So, this is the advantage of dye electrodes over the wet electrodes

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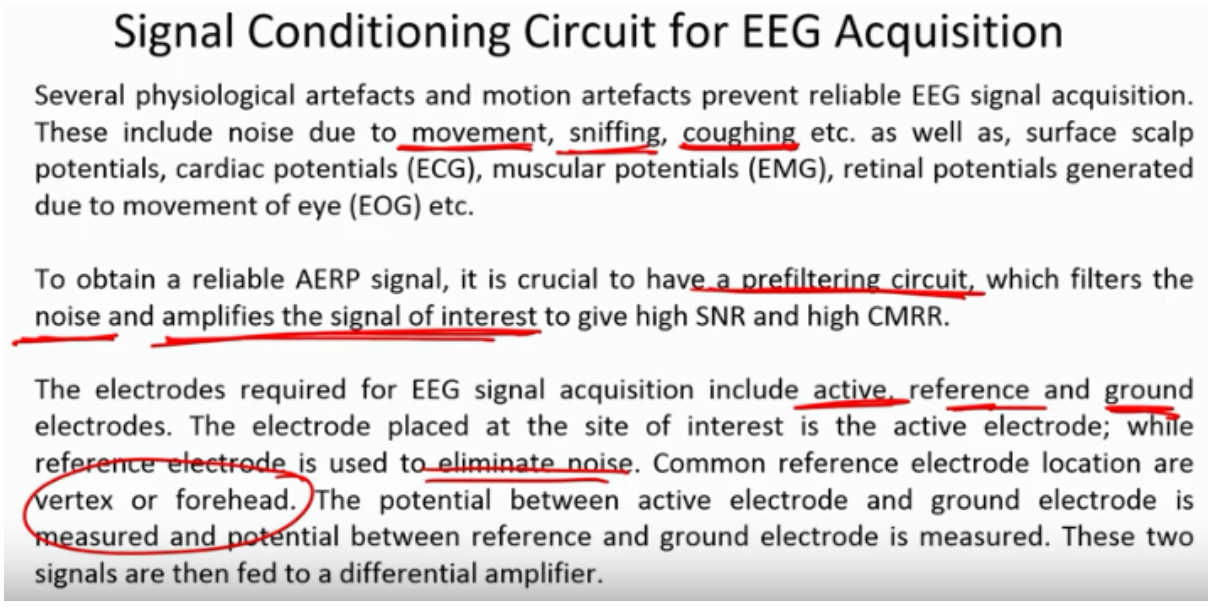

now if I talk about signal conditioning circuit for e.g. acquisition what's the first thing you have to understand that the EEG signals are of micro volts and that's why the signal conditioning circuit should be extremely accurate. So, several psychological artefacts and motion artefacts prevent reliable, easy

signal acquisition these includes noise due to movement sniffing coughing, etc. as well as surface scalp potentials like cardiac potentials ECG, muscular potentials EMG, retinal potentials EOG. Right?

Which is the moment of I that I was talking earlier to obtain a reliable ERP right auditory evoked related potential signal it is crucial to have a pre filtering circuit which filters the noise and amplifies the signal of interest to give high signal-to-noise ratio and, high common mode rejection ratio Right? So, this is very important that we need to have a pre filtering circuit which filters out the noise and which amplifies the signals of our interest. Okay? So, this electrodes require for easy evacuation includes an active reference and ground electrode the electrode placed at the site of interest is active electrode while the reference electrode is used to eliminate any noise right reference electrode is used for eliminating noise common reference electrode locations are either on the vortex, or on the forehead the potential between the active electrode and ground electrode is measured and the potential difference between reference and ground electrode is measured these two signals are then fed to the differential

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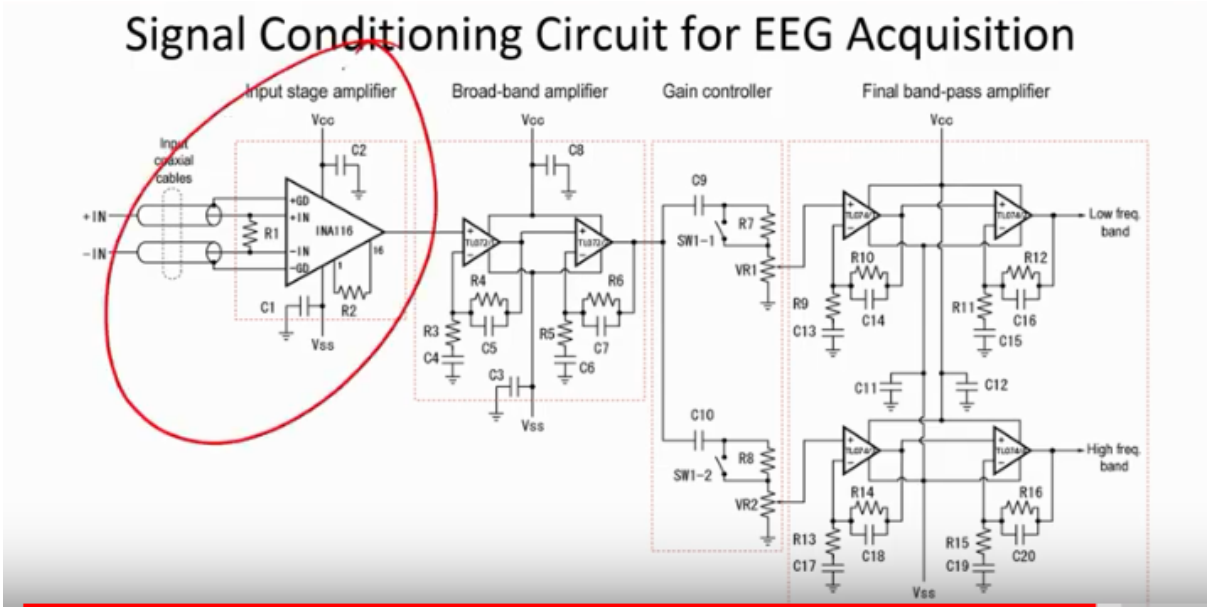

Amplifier. So, this is the actual signal conditioning circuit and we will show you the simulation version of this particular circuit in one of the experimental lectures where one of my TA will show it to you how the we can do a simulation to understand how this particular signals and hissing circuit Vox. So, we have an input simplifier, we have broadband amplifier, we have gain controller, and final we have a bandpass amplifier. So, let us understand each stage the first stage which we talked about in stem brief a stage. Right?

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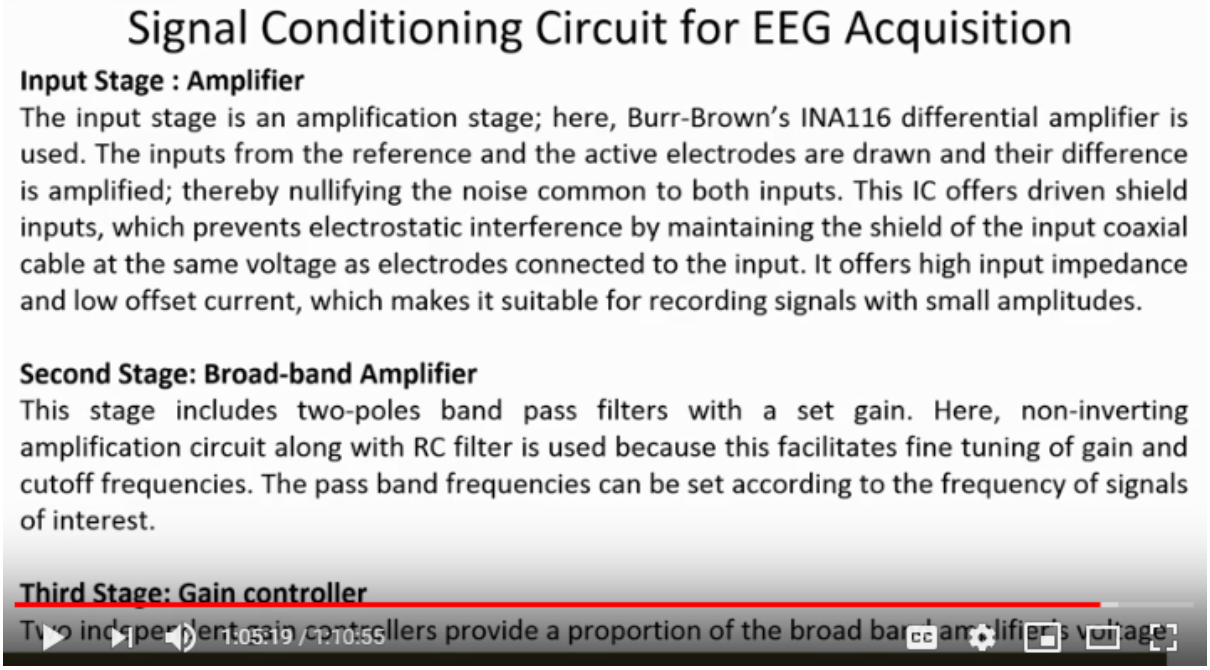

This particular stage this is an amplification stage; here, the Burr-Brown's INA116 differential amplifier is used the inputs from the reference and the active electors are drawn and their difference is amplified there by nullifying the noise common to both the differential amplifies the noise will be cancelled it will be the real difference of noise this IC offers different shield inputs which prevents electrostatic infrared interference by maintaining the shield of the input coaxial cable in the same voltage as electrodes connected to the input. That is a main advantage because it has the shielded inputs which you can see here right over here, and this is why we require this thing? So, that the shield of the input coaxial cable can be kept at the same voltage as the electrode is connected to the input set advantage. It offers are extremely high input impedance and low offset current which is another advantage which makes it suitable for recording signals with small amplitudes and amplitudes are a few micro volts the second stage,

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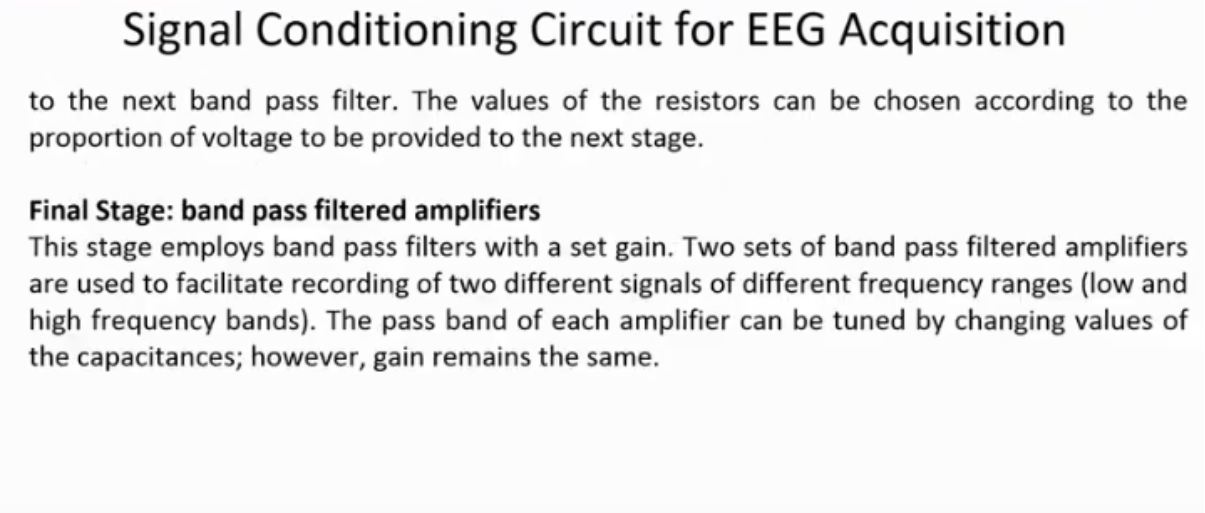

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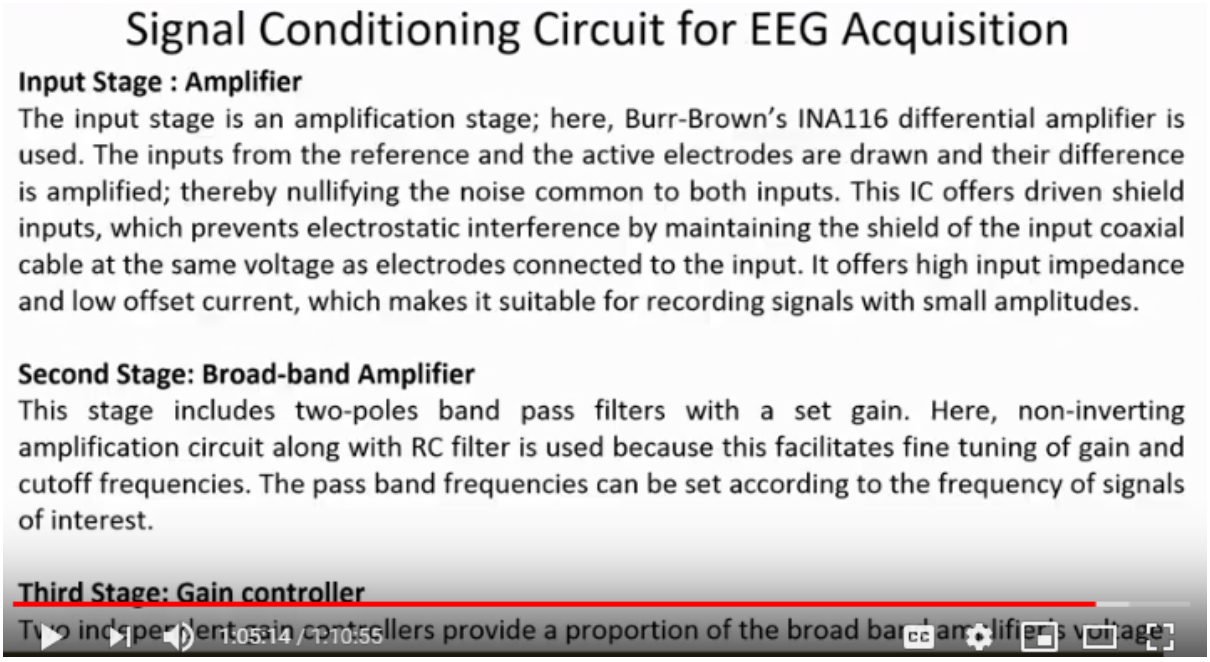

which is a broadband amplifier which is a broad band amplifier,

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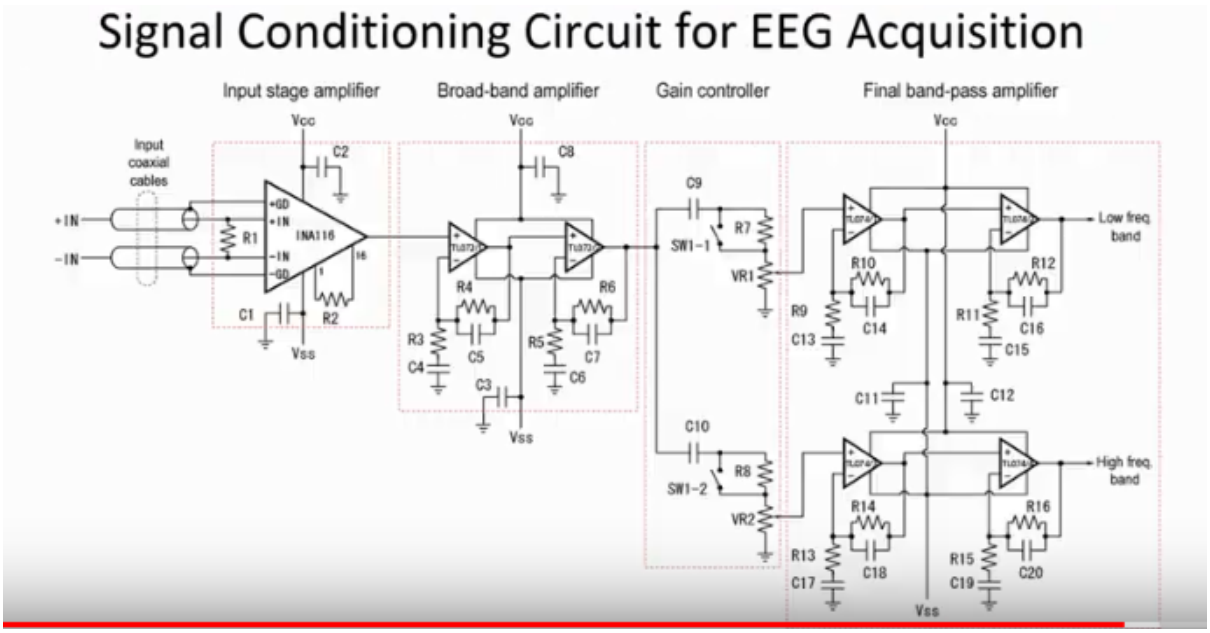

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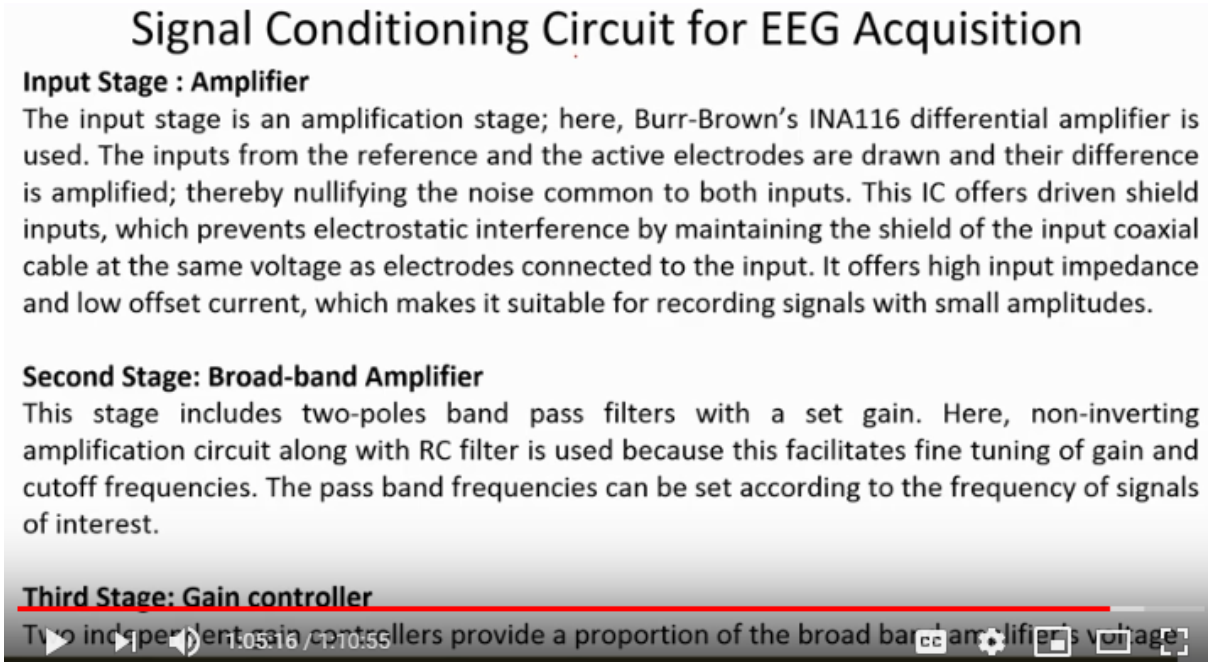

this stage includes two pole bandpass filters as you can

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Signal Conditioning Circuit for EEG Acquisition

to the next band pass filter. The values of the resistors can be chosen according to the proportion of voltage to be provided to the next stage.

Final Stage: band pass filtered amplifiers

This stage employs band pass filters with a set gain. Two sets of band pass filtered amplifiers are used to facilitate recording of two different signals of different frequency ranges (low and high frequency bands). The pass band of each amplifier can be tuned by changing values of the capacitances; however, gain remains the same.

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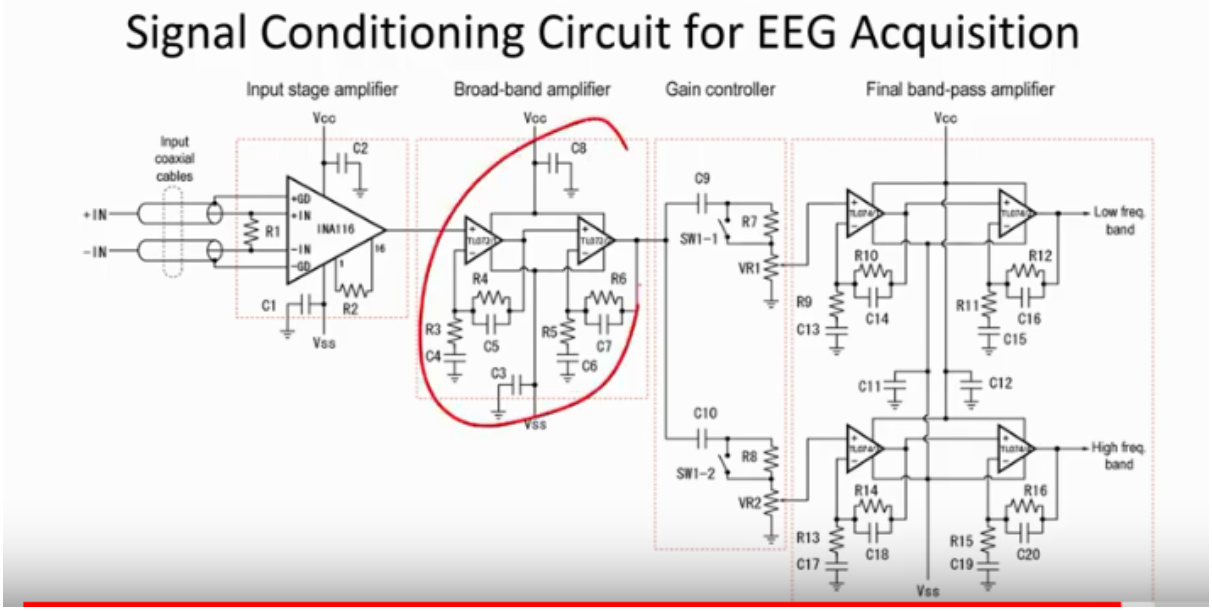

see here. Right? Two pole bandpass filter

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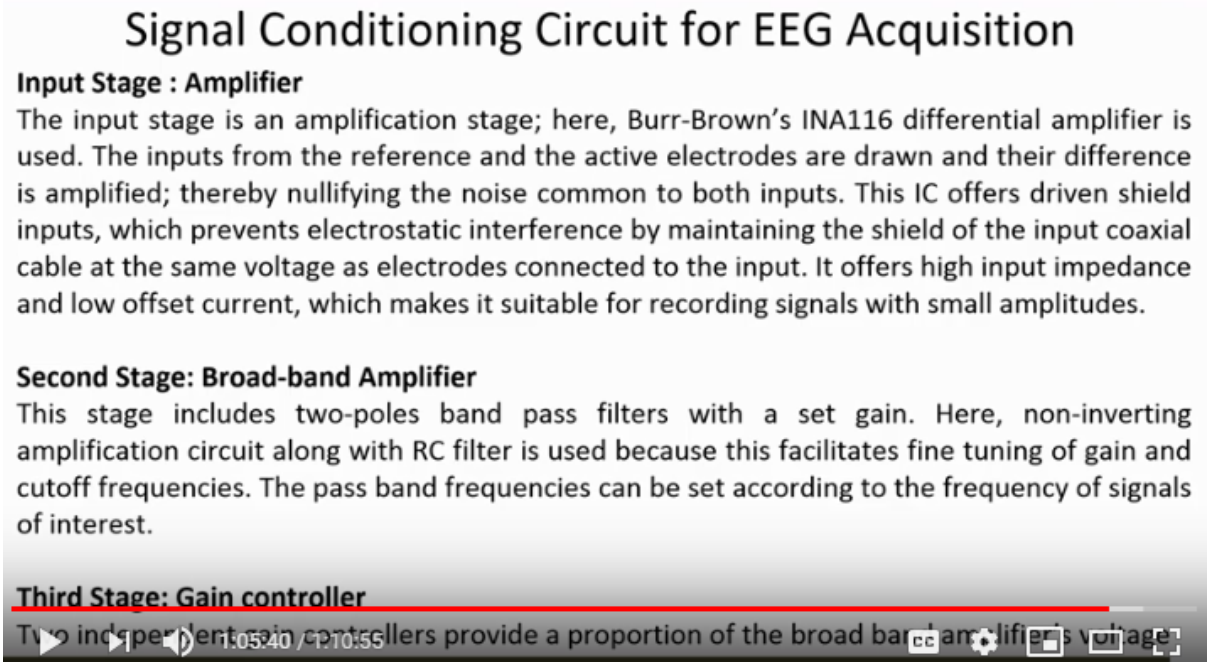

And we will set gain here non-inverting amplifier in circuit along with RC filter is used because this facilitates fine tuning of gain and cut off frequencies the pest by the pass band frequencies can be set according to the frequency of the signals of interest it's very easy to understand

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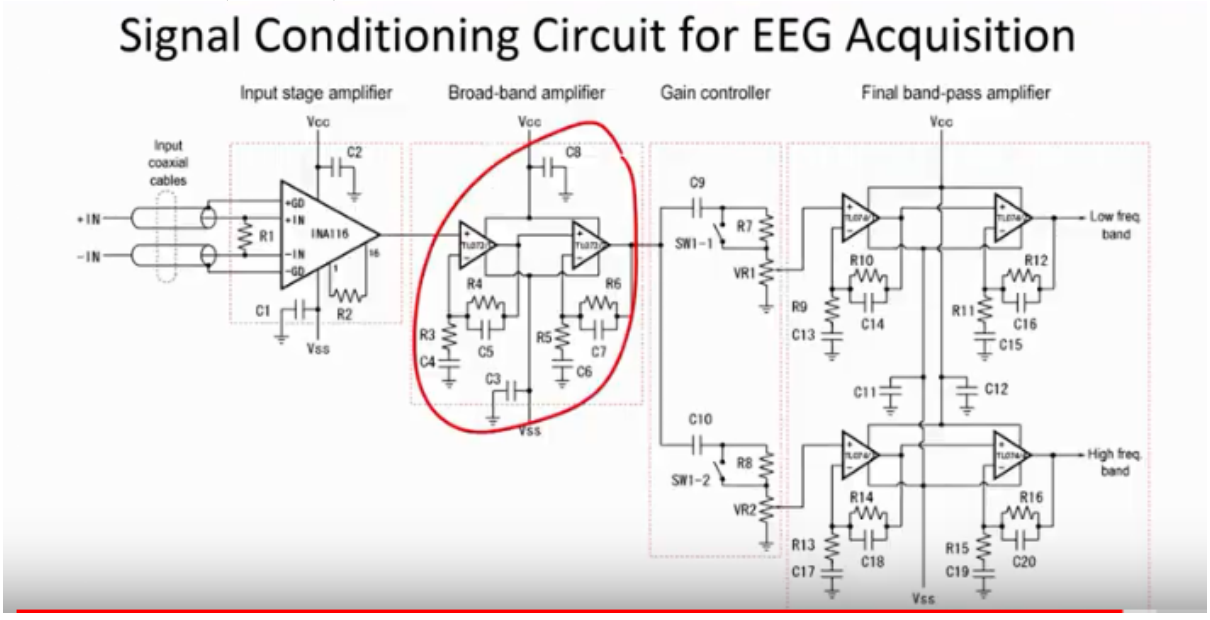

while the third stage is the gain controller which is this particular stage

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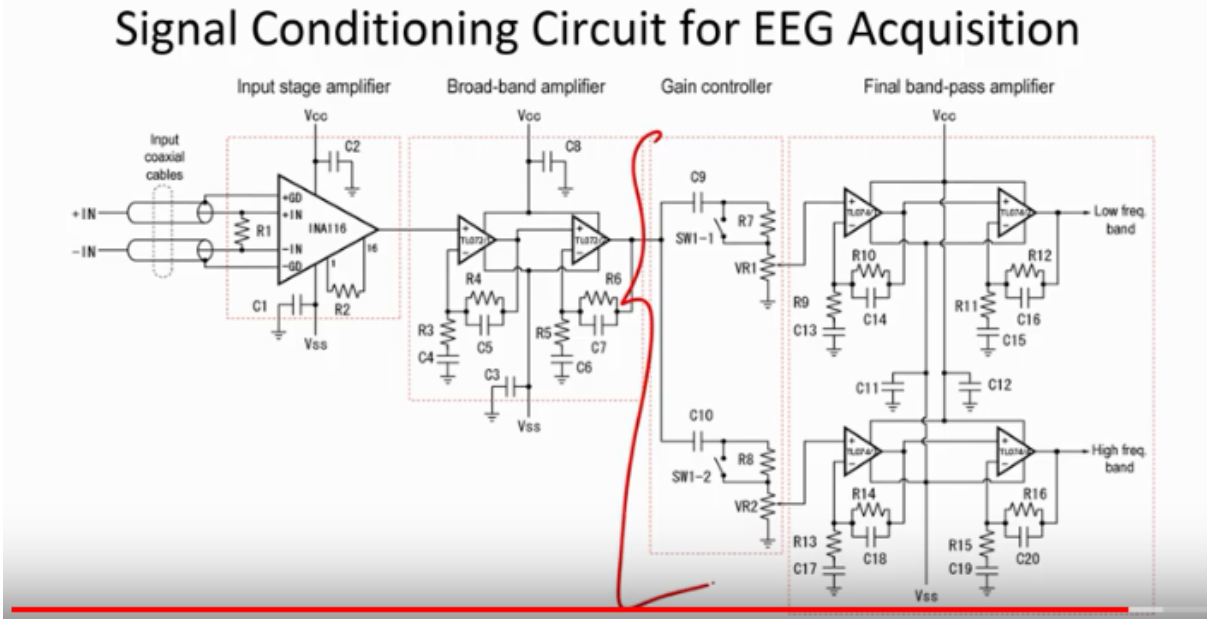

we have this one. Right?

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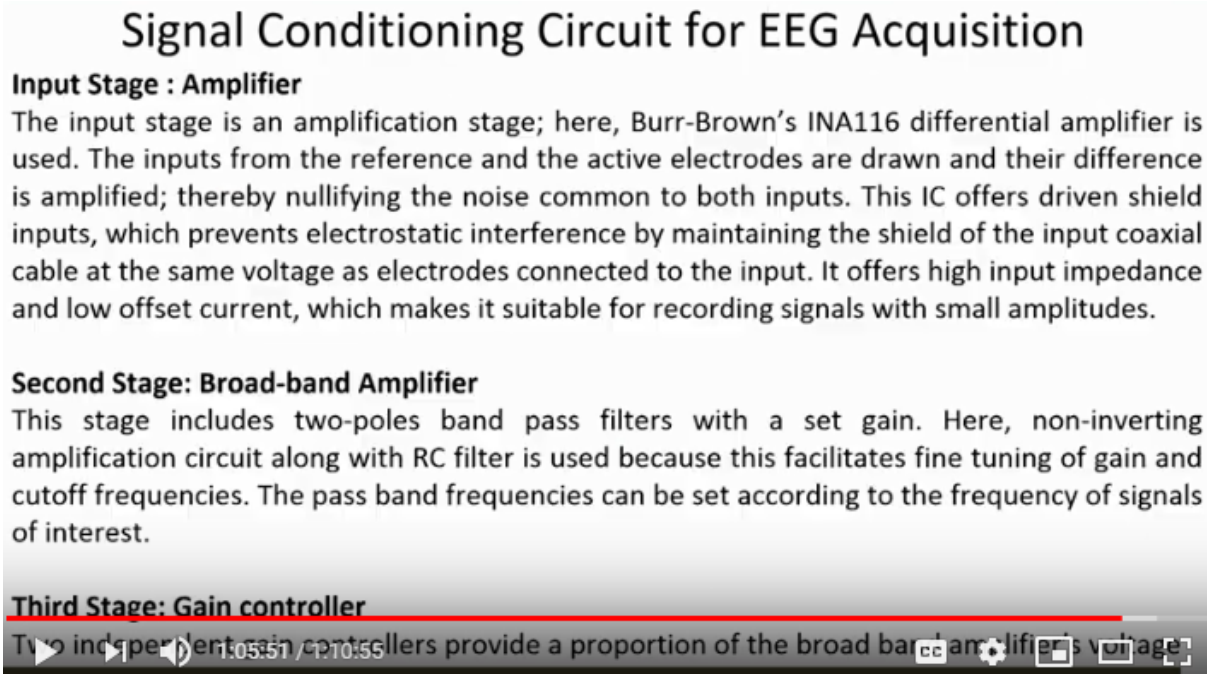

And here if you see then the two independent game controllers provide a proportion of the

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Signal Conditioning Circuit for EEG Acquisition

to the next band pass filter. The values of the resistors can be chosen according to the proportion of voltage to be provided to the next stage.

Final Stage: band pass filtered amplifiers

This stage employs band pass filters with a set gain. Two sets of band pass filtered amplifiers are used to facilitate recording of two different signals of different frequency ranges (low and high frequency bands). The pass band of each amplifier can be tuned by changing values of the capacitances; however, gain remains the same.

Broadband amplifier voltage to the next bandpass filter and the values of the resistors can be chosen according to the proportion of the voltage to be provided for the next stage. Right?

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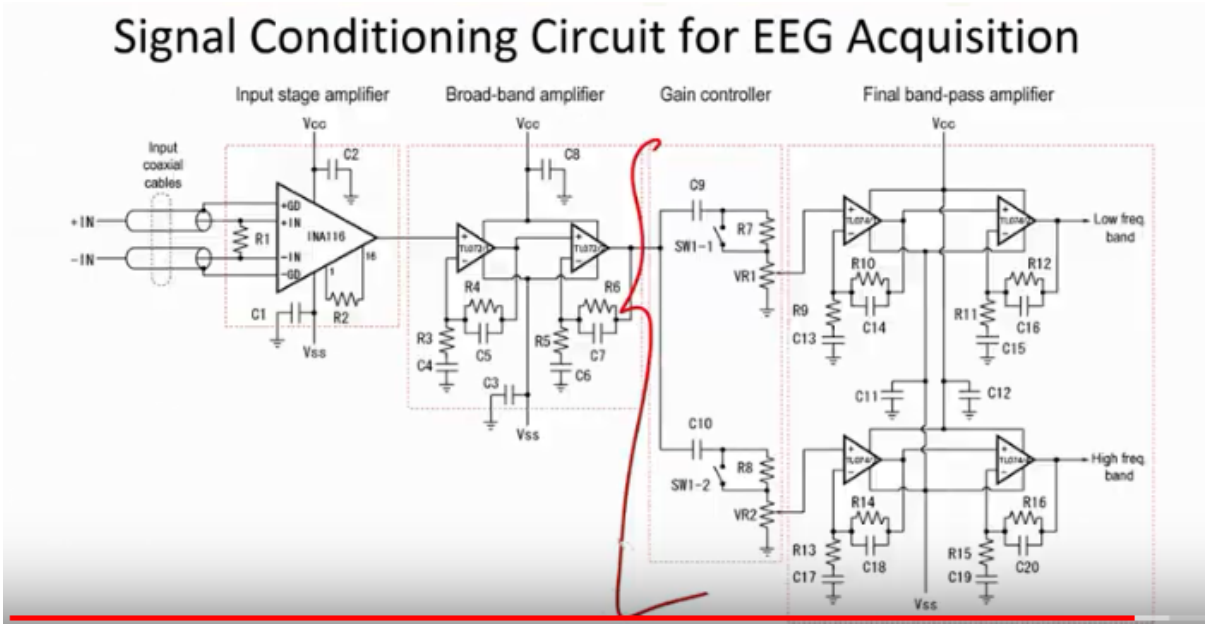

Which, which one is a resistor value of these resistors can be selected.

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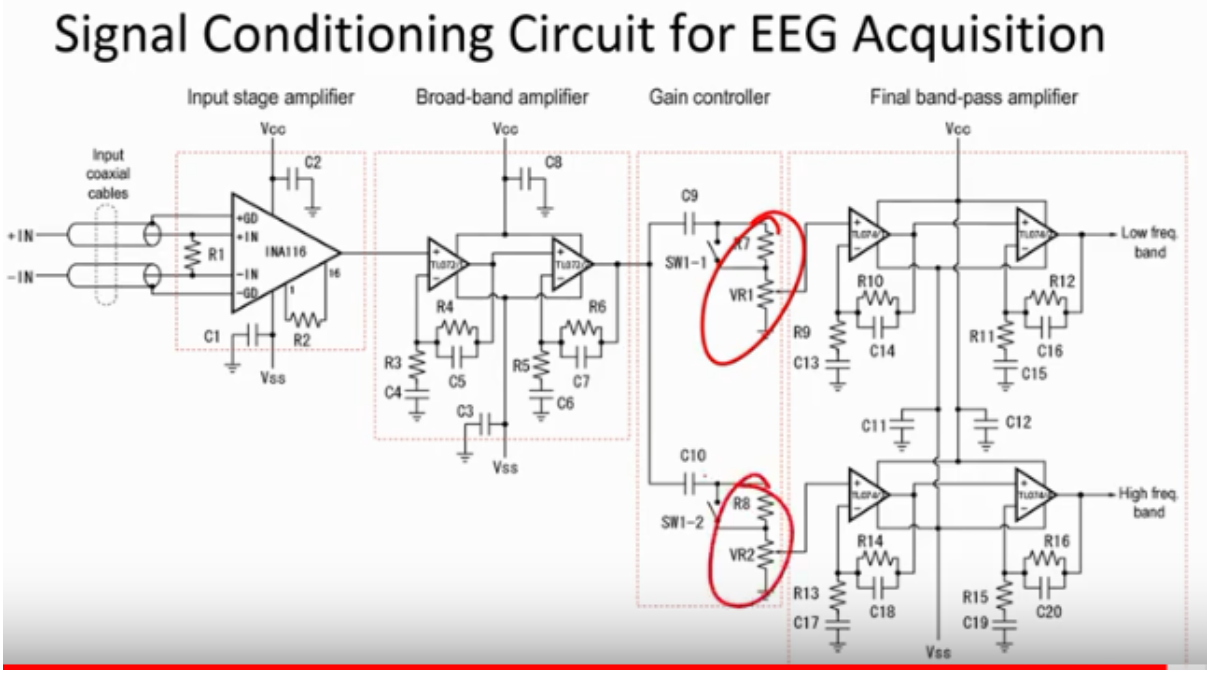

So, that we can change the gain according to what we want to provide to the next stage

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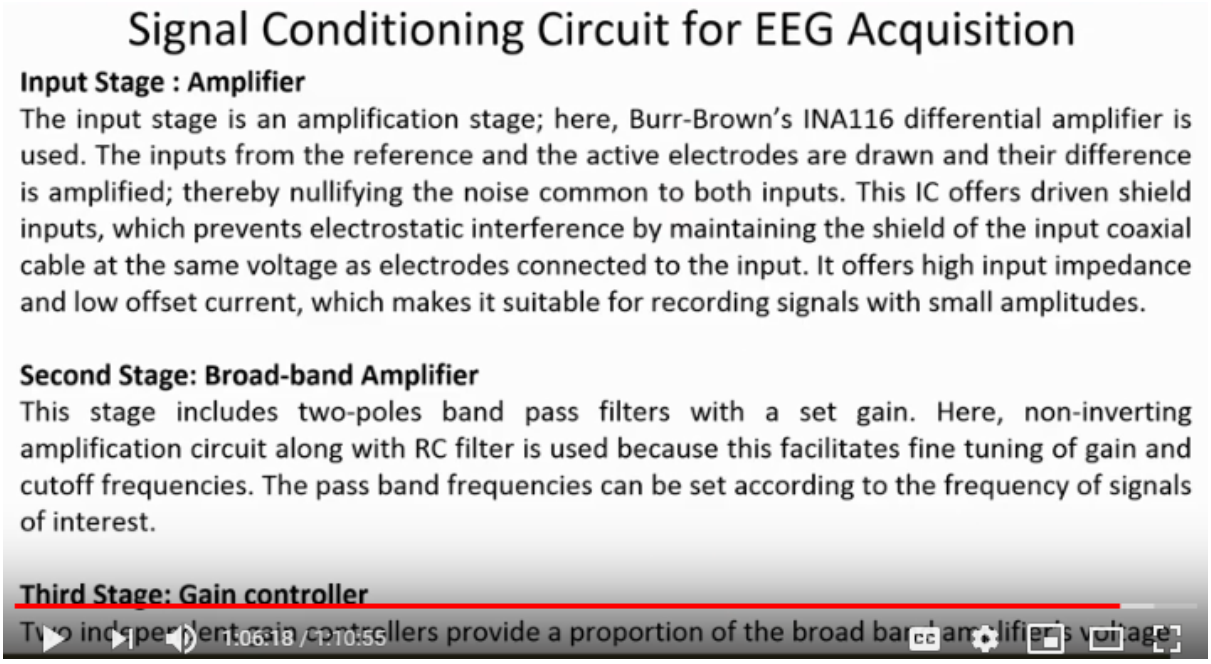

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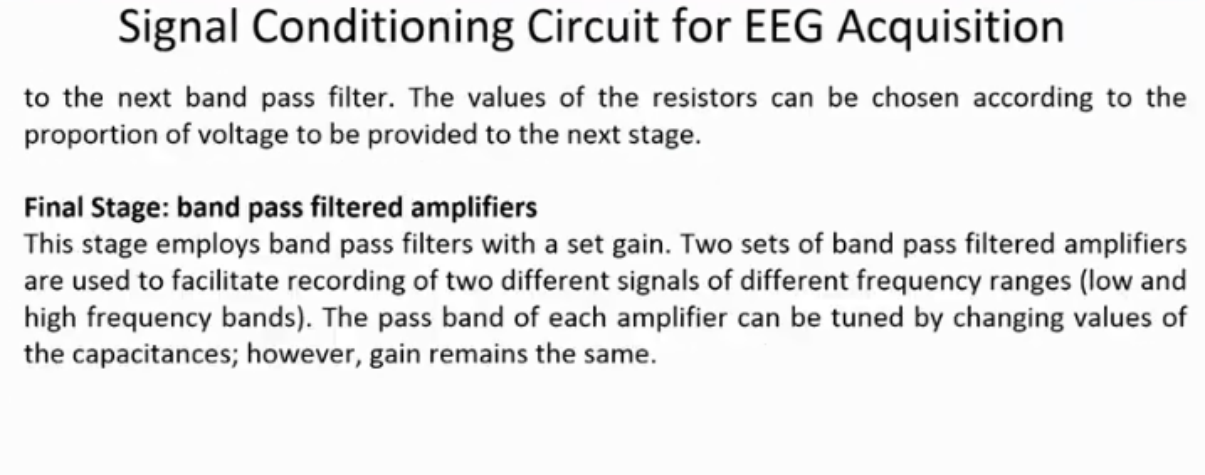

which is our final bandpass filter and a final sense is a bandpass filter amplifiers this stage employs band pass filter with a set gain two sets of bandpass filtered amplifiers are used to facilitate recording of two different signals of different frequencies one for the low frequencies one the high frequencies the passband of each amplifier can be tuned by changing the values of capacitors however, the gained immense the same.

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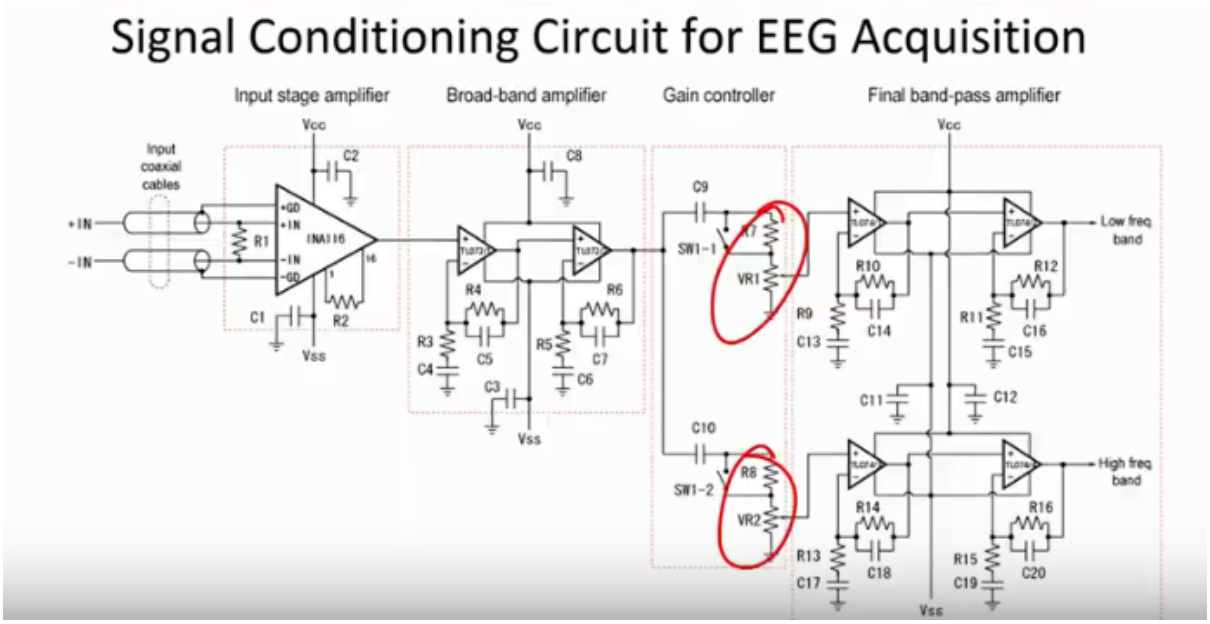

You can see here it's very easy and if you change the values of the capacitors.

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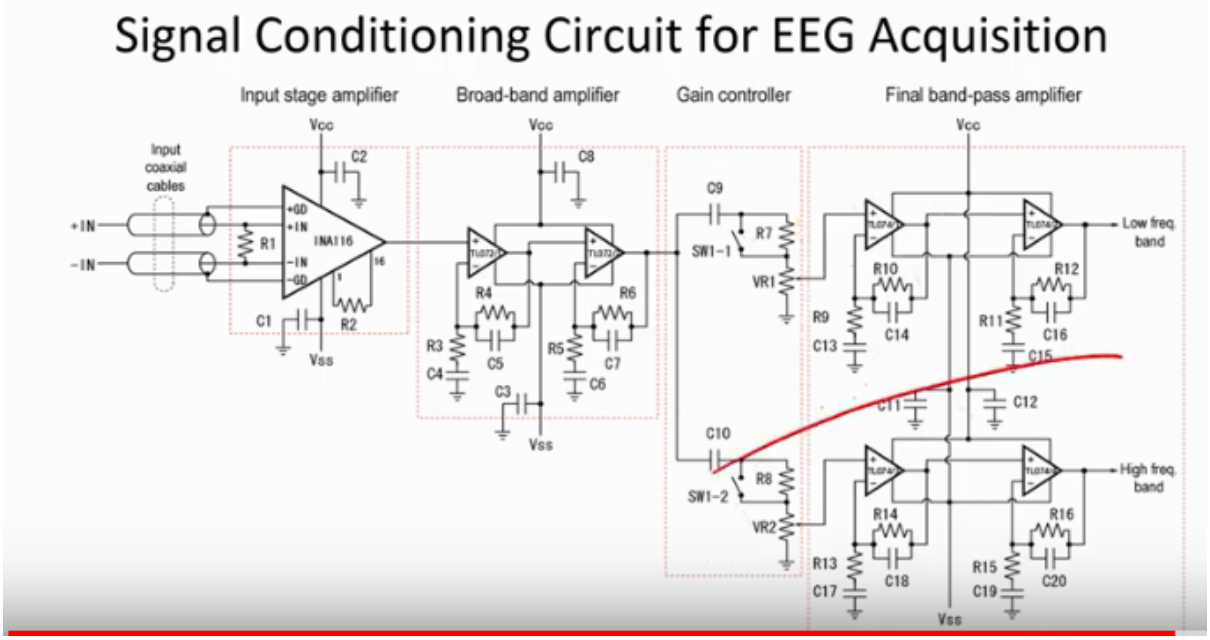

What would happen the gate the passband will change but, the gain will remain same right because the resistors are fixed. Right? And that will be the final circuit for the EEG. So, what we have seen we have seen in this particular module several. So, now if I had to show it to you how this particular circuit looks like the schematic that we have seen you may want to make a PCB out of it then I can make a small PCB which I have right in my hand yeah this is my signal conditioning circuit right this is the PCB with assembly components we have a resistor to change the gain right and it's So, it's a double sided PCB as you can see we have components on both the sides and then we have a further controller right with us now it can be used for wireless transmission we can use a wired version right we have a photon micro photon controller with us and this maybe, we are using this party for this particular controller however, we can also, use other electronic modules for wireless transmission this is just one way of transmitting we can also, use P Sock as an alternative way. Right?

But here we are using the electronic module which is our circuit right over in my hand and we do connect with this guy. So, that we can wirelessly transmit the signal. Right? From the EEG to the laptop and then we can further process it So, there are ways of you know using the EEG signal and using the electronic signal conditioning circuit finally you are talking about this thing when we talk about the input stage amplifier broadband amplifier gain controller we are talking about the final band pass filter, we are all talking about this guy only the only this one that's it to transmit the signal we can use this if you don't under you see directly my transmission is also possible we can dowel with the photon but, there are several options to use this but, my point is that once you know how the electrodes are once you know how the electrodes are placed once you know the types of electrode. Right?

You can design and you understand that what kind of signals you are getting at the output of the electrodes you can design a signal conditioning circuit accordingly. Let us see in the experimental part how we Can do the simulations of it if you are stuck anywhere during this entire module and if you have any questions please free to ask me it be precise So, that we can give you a proper response again the idea of you know this particular lecture and several other long lectures is to educate you that this kind of systems or the, the basic knowledge of your analog electronics can be used to design a signal conditioning circuit and merge with such kind of applications whether it is industrial applications, whether it's biomedical applications, or whether it is communication So, the the problem remains after the problem statement changes but, the but, the heart remains the same you see. So, once you know how to design the analog electronic analog circuits you can use it for several different applications alright! So, I hope you got a little bit understanding or you understood a little detail about how the EEG electrodes can be used. What are kind of each electrodes wet and dry? How the each signals is generated? What are the existing systems for hearing loss and then? What kind of electronics in the air conditioning circuit you can design? Right? well then I'll just take a leave and I'll see you in the next class you just focus on this particular lecture notes also do well in your quiz in your assignments and also in your exam right and I'll see you later bye.