Khulna University of Engineering & Technology, Khulna

Department of

Electronics & Communication Engineering

Project Report on:

Circuit for Extracting (γ)-band EEG Signal

Course No: ECE-3200

Course Title: Electronics Project Design & Development

Year: 3rd Term: 2nd

Session: 2021-2022

Supervised By

Dr. Sheikh Md. Rabiul Islam
Professor
Department of Electronics & Communication Engineering
Khulna University of Engineering & Technology

Submitted By

Md. Kamruzzaman (1909027)
Md Sajib Rahman (1909028)

Date of Submission: 28-Nov-2023

Motivation:

A study of Archives of Public Health states that, people with motor disabilities constitute about 10% of the total population of Bangladesh. These people are more likely to undergo poor health and associate facilities than those without disabilities. According to the World Health Organization (WHO), about 15% of the world's population lives with some form of disability, of whom 2-4% experience significant difficulties in functioning. The global disability prevalence is around 10%. An estimated 1.3 billion people, or 1 in 6 people worldwide, experience significant disability. Thinking about providing a better life for this huge amount of population, hopefully this project will help to contribute in designing cost-effective EEG signal (Gamma Band) extraction model that will pave the way of creating suitable solutions like brain-computer interface for solving and timely detection of certain motor disabilities which will decrease the difficulties faced by motor disabled people. The successful achievement of this project goal will bring me profound satisfaction and a sense of inner fulfillment. The project will also provide a certain pathway in medical sectors for implementing necessary tools and technologies which can ease the sufferings of such a large number of people.

Objectives:

The main objective regarding this project is to develop a gamma (γ)-band EEG signal extraction circuit and analyze particular circuit blocks based on the model to obtain certain comparative results. The specific objectives can be summarized as follows:

- To ensure proper detection EEG signal
- To implement individual circuit blocks in NI Multisim
- To analyze voltage gain referred to the source voltage
- To calculate compatible resistance and capacitance values
- To implement the circuit in the beadboard
- To visualize the ultimate EEG signal in the oscilloscope

Literature Review:

Electroencephalogram:

The Electroencephalogram (EEG) is a test that detects abnormalities in your brain waves, or in the electrical activity of your brain. During the procedure, electrodes consisting of small metal discs with thin wires are pasted onto your scalp. The electrodes detect tiny electrical charges that result from the activity of your brain cells. The charges are amplified and appear as a graph on a computer screen, or as a recording that may be printed out on paper. The healthcare provider then interprets the reading. Evoked potential studies are related procedures that also may be done. These studies measure electrical activity in your brain in response to stimulation of sight, sound, or touch. The EEG is used to evaluate several types of brain disorders. When epilepsy is present, seizure activity will appear as rapid spiking waves on the EEG. People with lesions of their brain, which can result from tumors or stroke, may have unusually slow EEG waves, depending on the size and the location of the lesion. The test can also be used to diagnose other disorders that influence brain activity, such as Alzheimer's disease, certain psychoses, and a sleep disorder called narcolepsy. The EEG may also be used to determine the overall electrical activity of the brain (for example, to evaluate trauma, drug intoxication, or extent of brain damage in comatose patients). The EEG may also be used to monitor blood flow in the brain during surgical procedures.

Source of EEG Activity:

The Central Nervous System (CNS) consists of two types of cells, nerve cells shown in Figure 1.1 and glia cells. All the nerve cells consist of axons, dendrites and cell bodies. The proteins developed in the cell body are transmitting information to other parts of the body. The long cylindrical shaped axon transmits the electrical impulse. Nodes of Ranvier interconnect each of the axons. The nucleus is the driving force of every neuron inside a cell body.

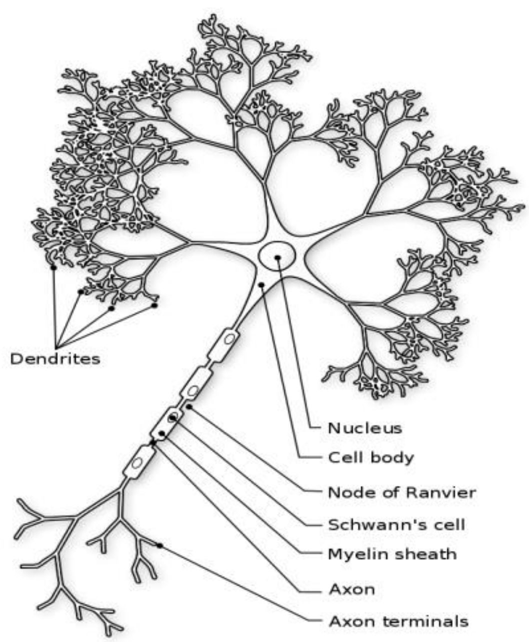


Figure 1.1: Structure of a typical neuron

Dendrites are connected either to the axons or dendrites of other inside cells and receive the electrical impulse from other nerve cells. The study of the brain found that each nerve of a human is approximately connected to 10000 other nerves. The electrical activity is mainly due to the current flow between the tip of dendrites and axons, dendrites and dendrites of cells. The level of these signals is in mV range and its frequency is less than 100Hz . The cerebrum, cerebellum, and brain stem are the three structurally distinct parts of the brain. The beginning of movement, conscious feeling, and mental state are all defined by the cerebrum. The cerebellar area is involved in voluntary movements of the muscles. The breathing process, heart rate, biorhythms, and neural hormones are all under the direction of the brain stem area. Therefore, it is evident that braingenerated EEG signals can assess the condition of both brain and body illness.

Generation of EEG Signal:

The current between nerve cells' dendrites in the cerebrum area of the brain during synaptic stimulation is what is detected as the EEG signal. This current is made up of the magnetic field, which electromyogram (EMG) equipment measures, and the electric field, which is detected by EEG equipment. The scalp, skull, and brain are just a few of the many components that make up the human head. Due to the recording technique, the noise will either be generated internally in the brain or externally over the scalp. Nearly a hundred times more attenuation is induced by the skull than by the soft tissues in the head. The higher number of neurons in an excitation state can only produce a recordable potential by the scalp electrode setup because the signal amplitude is so low. As a result, the level of signals is raised using amplifiers in preparation for further processing. A typical human brain generates an electric current of only a few microvolts. Ionic current that travels between the brain and the neurons causes these voltage changes. For roughly 20 to 40 minutes, the brain's spontaneous activity is recorded. The EEG signals are created as a result of this. Since the electric potential detected by a single neuron is so tiny, it cannot be seen. Therefore, the EEG measures the whole synchronous activity of a large number of brain neurons. Similar spatial orientation may be obtained for these neurons.

Frequency Bands of EEG:

Basically, an EEG wave can range from 0.5-100 Hz which are classified as five frequency bands named as: delta, theta, alpha, beta and gamma. In adults, typical frequency bands and their approximate spectral boundaries are delta (1–3 Hz), theta (4–7 Hz), alpha (8–12 Hz), beta (13–30 Hz), and gamma (30–100 Hz).

Table 1.1: Different types of EEG waveform

EEG waveform	Amplitude (µV)	Frequency range (Hz)	State of the brain
Delta (δ)	20-200	0.1-3	Deep, dreamless sleep, unconscious
Theta (θ)	2-100	4-7	Intuitive, creative, recall, fantasy, dream
Alpha (α)	20-60	8-12	Relaxed, not drowsy, conscious
Low-range Beta (ß)	2-8	12-15	Relaxed yet focus, integrated
Mid-range Beta (ß)	9-13	16-20	Thinking, aware of self & surroundings
High-range Beta (ß)	14-20	21-30	Alertness, agitation
Gamma (γ)	100	30-100	Motor functions, higher mental activity

From Table 1.1, we get to know all the possible classifications of EEG waveform where beta range has been sub-sectioned in low-range, mid-range and high-range. The amplitudes along with the frequency ranges are also shown in the table and state of the brain attached to it. The above-mentioned frequency bands which are associated with the brain signal as EEG, can be expressed using pictorial representation in terms of time domain or frequency domain.

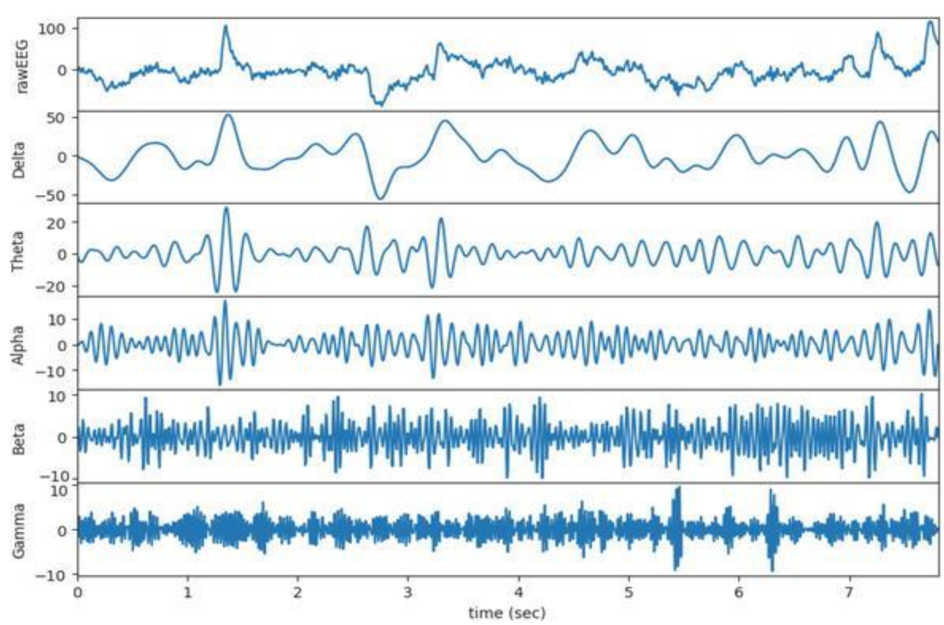


Figure 1.2: EEG sub-bands waveform

The above illustrated Figure 1.2 provides a crystal-clear idea about the waveforms of EEG signals generated from the human brain. The raw signal is shown on top followed by all the frequency sub-bands of EEG. The gamma band provides the highest frequency and delta band provides the lowest frequency as the signal intensity is understandable from the illustration. The waveforms do vary depending on the activities that are going through the brain as an impact of human interaction. By analyzing these waveforms, certain diseases and health conditions can also be examined which becomes handy for treating the patient accordingly.

Research Methodology & Implementation:

The initial data extraction of EEG signal can be executed by following two of the below-mentioned proposed processes.

i. **Accessing reference data being oriented with power source:** The reference brain signal data will be collected for both the normal person and motor disabled person. We would like to simulate the probable circuit by providing a power source that matches with the collected signal data characteristics. After passing through several circuit blocks, the extracted signal will be compared to characteristics of the reference signal.

ii. **Accessing reference data being oriented with direct human body interaction:** Direct biological artifacts related to different motor disabilities will be used as a signal source for the extraction circuit. The probable circuit will use that direct interaction as its power source of the signal. After passing through several circuit blocks, the extracted signal will be compared to characteristics of the reference signal.

Between the two possible or proposed methodologies, we will be focusing on the first one which is **Accessing reference data being oriented with power source.**

We can design a modified block diagram that will be the sequential implementation of our implemented methodology for the circuit

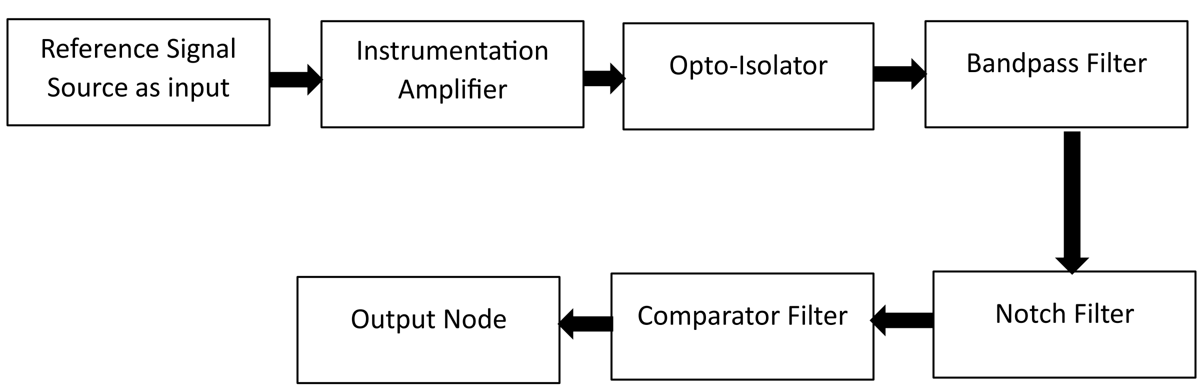


Figure 1.3: Block diagram for gamma (γ)-band EEG signal extraction

The connection between the preferred methodology and the above-mentioned block diagram is that the ‘Reference signal source or input node’ is referring to the access of reference data along with power source (function generator) without being exposed to direct human body interaction. In the methodology, human body interaction is indicated to the human brain scalp, from where the source signal is likely to be extracted using the 10-20 electrode placement method. Later on, the signal is needed to be pre-processed before applying to the input node of the circuit model. To avoid these complications and due to limitations regarding hardware access, the reference source signal is selected as the primary voltage source of brain signal which will provide almost similar amplitude and frequency of a brain signal.

Table 1.2: Necessary Components for the project:

SL No	**Component name**	**Rating**	**Quantity**
01	Capacitor	3.3uF,.1uF,10nF,.47uF	11
02	Signal Diode	1N4148	04
03	Variable POT	100k,1k,500k	04
04	Optocoupler	4N35 DIP6 30V	01
05	OP-AMP	LM358,741	04
06	Resistor	8.2k,180,180k,10k	13
07	Instrumentation Amplifier	AD620	01
08	Dc Voltage Source	0-20V	01

1.Instrumentation Amplifier Block Design:

An instrumentation amplifier (abbreviated in-amp or InAmp) is a form of differential amplifier featuring input buffer amplifiers that minimize the requirement for input impedance matching and therefore making the amplifier particularly ideal for use in measurement and test equipment. Other properties include comparatively low DC offset, exceedingly low drift, relatively low noise, exceptionally high open-loop gain, extremely high common-mode rejection ratio, and exceedingly high input impedances. Instrumentation amplifiers are employed in situations where high precision and long-term circuit stability are required.

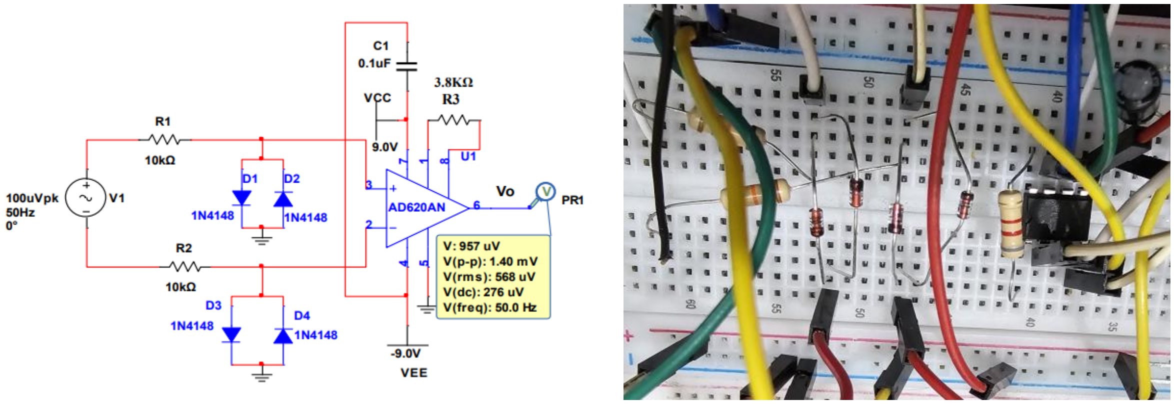


Figure 1.4: Design of instrumentation amplifier block in Multisim

The AD620AN IC is used as an instrumentation amplifier for the design of the modified circuit model. Signal from the reference input source is directly fed to the AD620 instrumentation amplifier through resistor R1 of 10 KΩ from the positive terminal of the source and through resistor R2 of 10 KΩ as shown in figure 1.2 above. The resistors R1, R2 & R3 have been used for current limiting purposes. The value of R3 has been determined by equation 3.1 as shown below.

$$Rg = Rint/\ G - 1$$

Here, Rint is the value of total internal resistance of AD620 used in instrumentation amplifier design in figure 1.4 which has the value of 49.4 KΩ and Rg is the value of R3. For better understanding, the characteristics table of AD620 along with the pin diagram have been provided below in table 1.3 and figure 1.5 respectively.

Table 1.3.: Characteristics table of AD620 instrumentation amplifier

Characteristics Parameters	**Estimated Values**
Power supply range	2.3-18 V
Gain (single external resistor)	1 to 10,000
Low input offset voltage	50 µV max.
Input offset drift	0.6 µV/°C max.
Common mode rejection ratio	100 dB min.
Input bias current	1.0 nA max.
Input voltage noise	0.28 μV_{pp} noise (0.1-10 Hz)

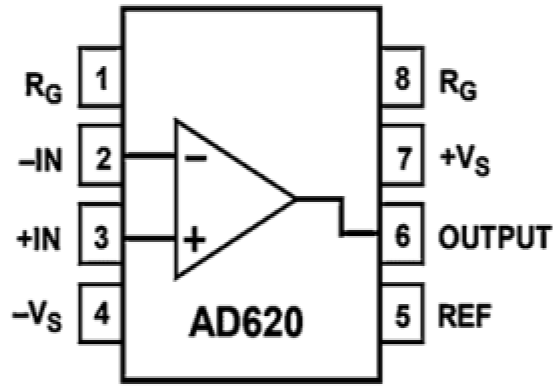


Figure 1.5: Pin diagram of AD620 instrumentation amplifier

The 1N4148 diodes are placed in the circuit by following anti-parallel structure (D1, D2 & D3, D4). The main reason for this structure implementation is to limit the current. The anti-parallel diode pair is a nonlinear device that generates harmonic components for the Q-band input signal (33–50 GHz). To remove bias circuits and so reduce the number of circuit components for lowcost hybrid production, the diode is zero-biased. A bypass capacitor C1 of 0.1 µF is used to keep noise out of the system by bypassing it to ground. To decrease power supply noise and voltage spikes on the supply lines, it is linked between the supply voltage (Vcc) and ground pins. The capacitor offers a low impedance channel for the AC components in the DC power line to travel to ground. It also serves as an energy reserve, holding the charge that helps fill up voltage dips caused by changes in the load.

2.Opto-isolator Block Design:

An opto-isolator (also called an optical coupler, photocoupler, or optocoupler) is a semiconductor device that uses light to convey an electrical signal across separated circuits. These semiconductor devices are used in a diverse range of communicating and monitoring tools where electrical isolation is required to prevent high - voltage power emitters from impacting lower power circuits absorbing a signal. An opto-isolator diagram includes an emitter, in this example an infrared lightemitting diode (IRED) or laser diode for input signal transmission, and a photosensor (or phototransistor) for signal reception. As a result, the input signal can either produce or modify an electrical current originating from that of an electrical appliance or other power source. In this design procedure, MCT2E optocoupler has been used, which can be observed from the below-illustrated figure 1.6, for transferring electrical signals between two isolated circuits. The node A, shown in the figure 1.6, is the input received from the instrumentation amplifier circuit block and. It has been used to isolate small signals from noise. The resistance values that have been put on in the design process, are R4 of 820 Ω and R5 of 180 KΩ. The value of R5 has been kept high due to the intention of getting high voltage drop across the high pass filter that is to be implemented in the modified circuit model design.

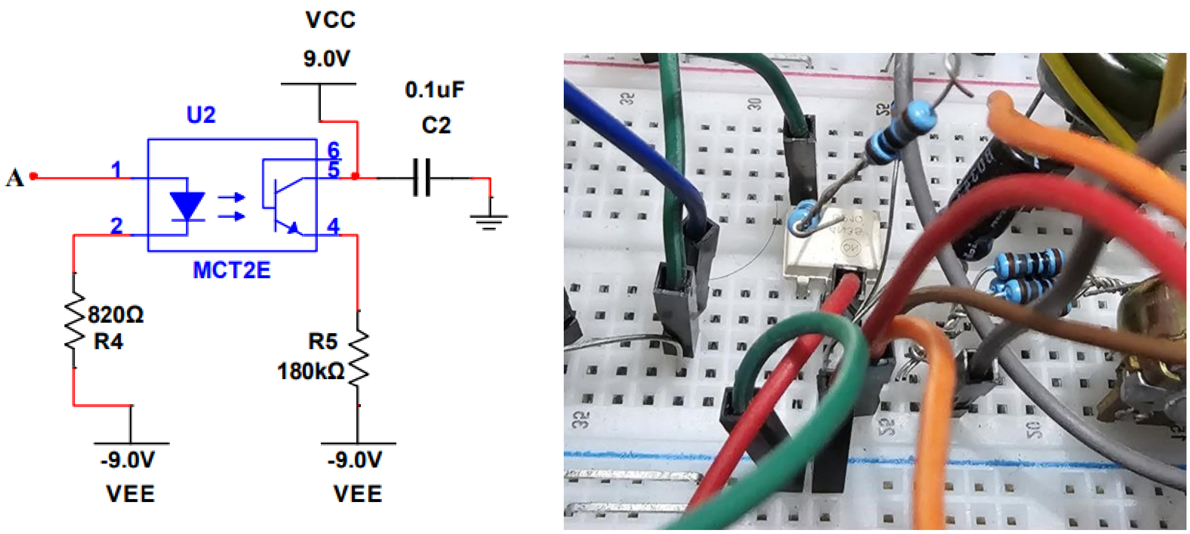


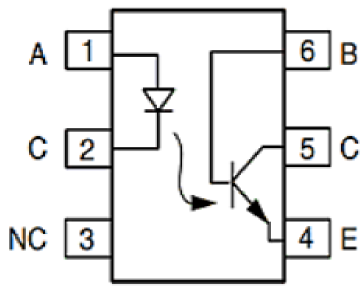
Figure 1.6: Design of opto-isolator block

The characteristics table of MCT2E opto-isolator has been attached below for the better understanding of the component's functionalities.

Table 1.4: Characteristics table of MCT2E opto-isolator

Characteristics Parameters	**Estimated Values**
Input reverse voltage handling	3 V max.
Total device power dissipation (25 °C)	150 mW or 1.76 mW/°C
Forward current	60 mA
Input bias current	1.0 nA max.
Operating temperature range	-55 °C to +100 °C
Rise and Fall time	5 µs
Amplification factor (ß)	300

The pin diagram of MCT2E opto-isolator is shown in figure 1.7 below, from which the information regarding individual pin operations is provided for the design of proper circuit model along with appropriate connection establishment.



- Pin-1: Anode (A)
- Pin-2: Cathode (C)
- Pin-3: No Connection (NC)
- Pin-4: Emitter (E)
- Pin-5: Collector (C)
- Pin-6: Base (B)

Figure 1.7: Pin diagram of MCT2E opto-isolator

3.Band-pass Filter Block Design:

A band-pass filter, commonly referred to as a BPF or a pass band filter, is a device that only permits frequencies that are within a particular frequency range and excludes or attenuates frequencies that fall outside of that range. A band-pass filter consists of both low pass filter (LPF) and high pass filter (HPF). Signals with frequencies greater than the cutoff frequency are isolated using the low pass filter. Similar to the low pass filter, the high pass filter is applied to separate signals with frequencies below the cutoff frequency. In this circuit design, shown below in figure 3.6, we are going to use band-pass filter for band limiting the reference source signal i.e., the EEG signal.

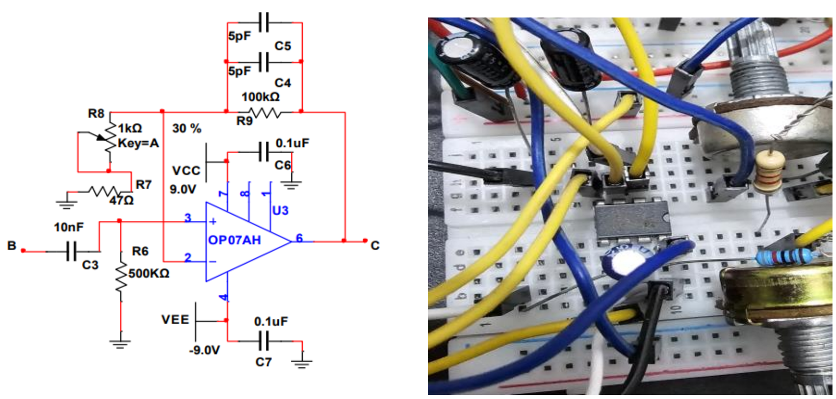


Figure 1.8: Design of band-pass filter block

In figure 1.8, node B is the input received from the opto-isolator circuit block and node C is the outgoing node of the band-pass filter circuit block which will be the input node for the notch filter circuit block. Capacitance of 10 nF (C3) is applied in series with resistance of 500 KΩ as per the equation 1.2 mentioned below. $Fc = 1/\ 2\pi RC$ Here, Fc is the cut-off frequency of the band-pass filter and capacitance C is the value of capacitor C3 used in the circuit design shown in figure 1.8. The terminal is passed through an operational amplifier OP07AH which is a dual operational amplifier (Op-amp) with low offset voltage. For better understanding of the operations, the characteristics table and pin diagram of OP07AH has been attached below in table 1.5 and figure 1.9 respectively.

Table 1.5: Characteristics table of OP07AH op-amp

Characteristics parameters	**Estimated Values**
Input offset voltage	75 µV max.
Input bias current	±4 nA
Open loop gain	200 V/mV
Quiescent current	< 350 µA
CMRR	106 dB
Input voltage range	±14 V

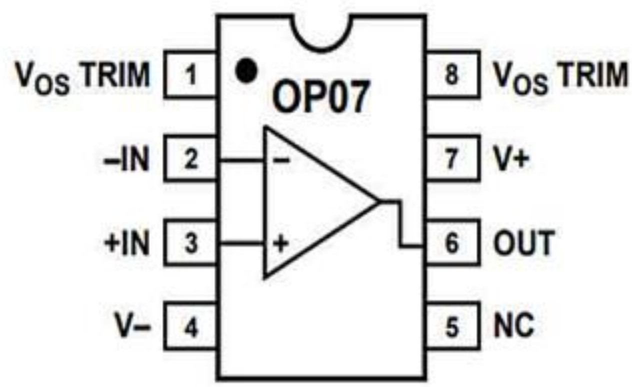


Figure 1.9: Pin diagram of IC OP07AH op-amp

4.Notch Filter Block Design:

A band-stop filter, or notch filter, is a form of filter that attenuates frequencies in a certain region while allowing all the other frequencies unmodified. This frequency range is quite constrained for a notch filter. The stopband is the frequency range that a band-stop filter attenuates. A notch filter gets its name from the fact that its frequency response resembles a deep notch due to its narrow stopband. Additionally, it indicates that notch filters have a high Q factor, or the ratio of central frequency to bandwidth. Depending on the design, a notch filter may be either active or passive. Resistors, capacitors, and inductors are the only passive components that make up a passive filter. Some notch filters employ active filters, which have an amplifying component like an op amp.

Two IC OP07AH op-amp has been used for implementing the notch filter as shown below in figure 1.10 along with the single capacitance of 0.47 µF which is in the inverted input of the op-amp. The value of non-inverting pin resistance to ground is 1 KΩ as R16. The resistor R13 has been used for rejection of line frequency noise using the equation 1.2 as stated above.

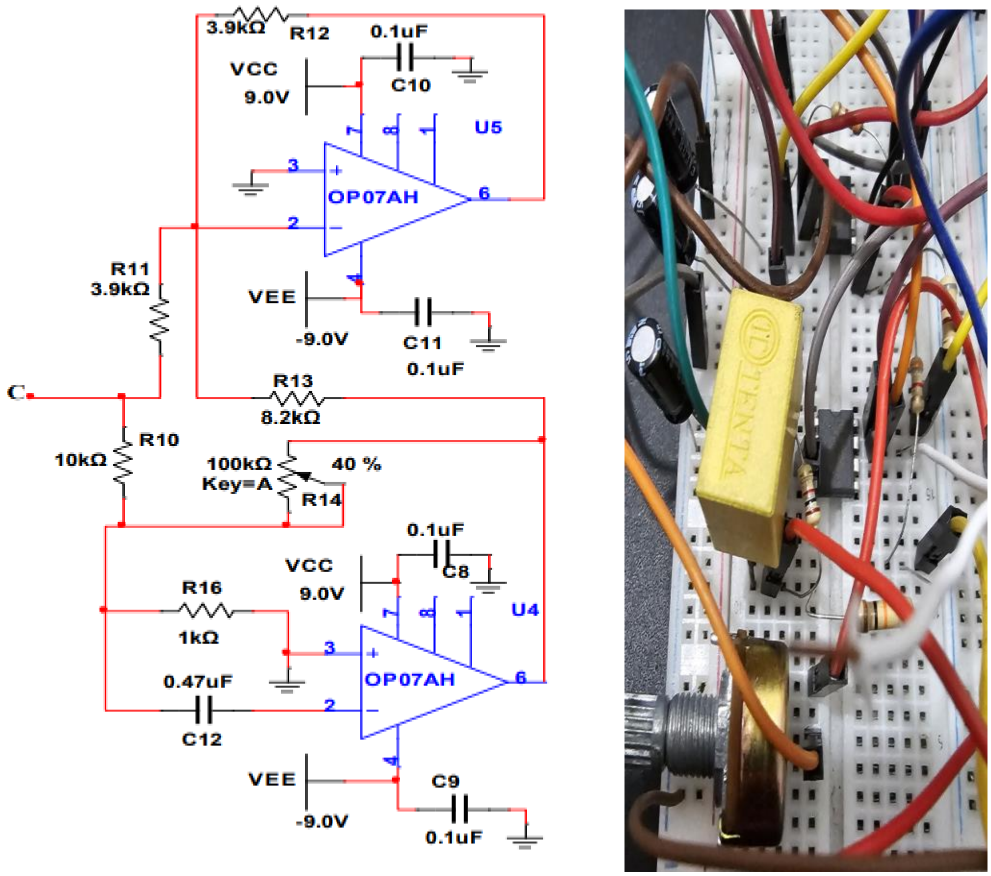


Figure 1.10: Design of notch filter block

The Q factor of the circuit can be calculated by using the equation 3.3 stated below

$$Q_N = \frac{1}{2}\sqrt{\frac{R_{inv}}{R_{in}}}$$

Here, R Here, Rinv is referred to as resistor R14 and Rin = R10/R16 according to designed figure 1.10 above. The maximum gain (Av) can be calculated as equation 1.4 given below. is referred to as resistor R14 and Rin = R10/R16 according to designed figure 1.10 above. The maximum gain (Av) can be calculated as equation 3.4 given below.

$$A_v = -\frac{R_{inv}}{R_{in}}$$

5.Comparator Block Design:

A Comparator refers to an electrical circuit that compares the two inputs it receives and generates an output. Both of the inputs are more or less shown by the comparator's output value. It is important to keep in mind that ICs are used in non-linear applications, such as comparators. An op-amp based comparator compares both inputs that are delivered to it and produces the comparison's result as the output since an op-amp has two input terminals. The topic of op-ampbased comparators is covered in this chapter. There are two categories of comparators: inverting and non-inverting. An inverting comparator works in a relatively straightforward manner. One of the two values is produced either +Vsat or -Vsat depending on the values of its input voltage at the output and the reference voltage. In this design operation we are going to use non-inverting comparator implementation through IC 741 op-amp and for that reason a reference voltage VEE of -9 V is applied to its inverting terminal and the input voltage that is coming from the inverting op-amp of the notch filter shown in figure 1.10, is applied to its non-inverting terminal at node E. Besides, the output is to be extracted from node F shown in figure 1.11. A potentiometer R16 of 5 KΩ has been used with reference voltage for adjusting the inverting input of the op-amp as shown in figure 1.11 below.

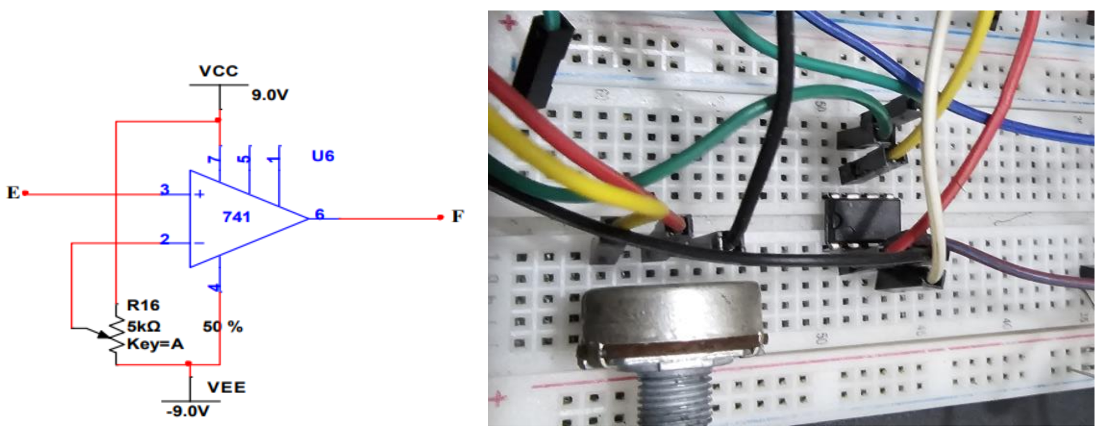


Figure 1.11: Design of comparator block

For better understanding of the operation, the characteristics table has been attached in table 3.4 below.

Table 1.6: Characteristics table of IC 741 op-amp

Characteristics Parameters	Symbol	Ideal Value	Typical Value
Open loop voltage gain	A_{DL}	∞	2×10^5
Output impedance	Z_{out}	0	75 Ω
Input impedance	Z_{in}	∞	2 MΩ
Input offset current	I_{ios}	0	20 nA
Input offset voltage	V_{ios}	0	2 mV
Input bias current	I_b	0	80 nA
Bandwidth	BW	∞	1 MHz
CMRR	ρ	∞	-90 dB
Slew rate	S	∞	0.5 V/µ sec
Power supply rejection ratio	PSRR	0	30 µV/V

The pin diagram of IC 741 op-amp is illustrated in figure 1.12 below

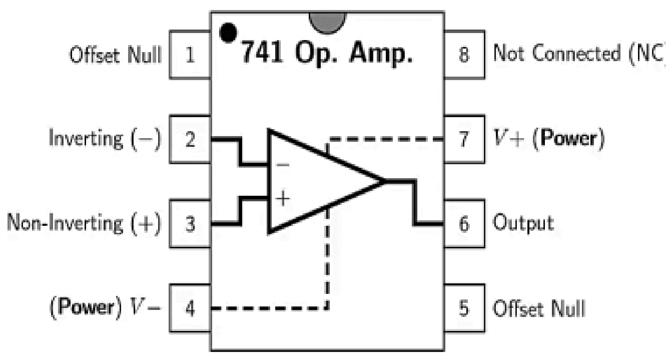


Figure 1.12: Pin diagram of IC 741 op-amp

After designing the above-mentioned circuit modules in NI Multisim, the graphical representation of the desired output will be extracted from the output node F as shown in figure 1.11 along with different nodes across the whole modified circuit model which has been designed in Multisim for serving the objectives.

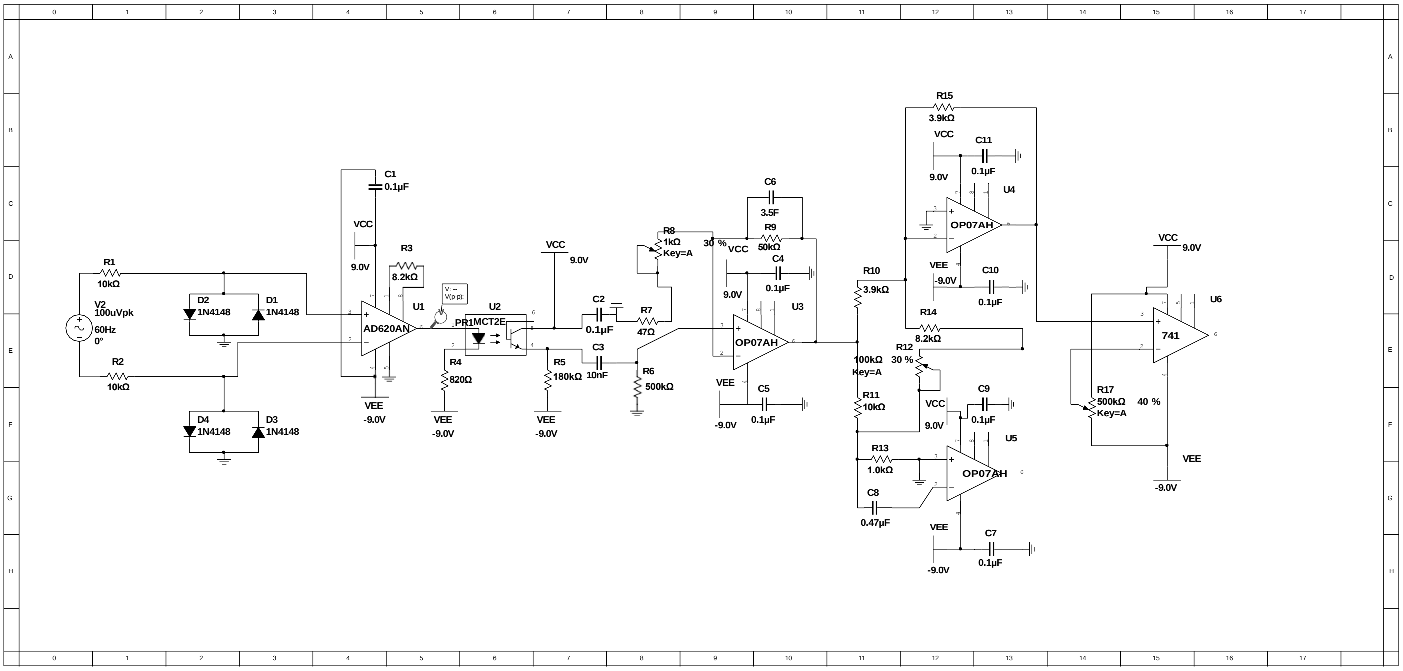


Figure 1.13: Complete design of modified circuit for extraction of gamma (γ)-band EEG signal in Multisim

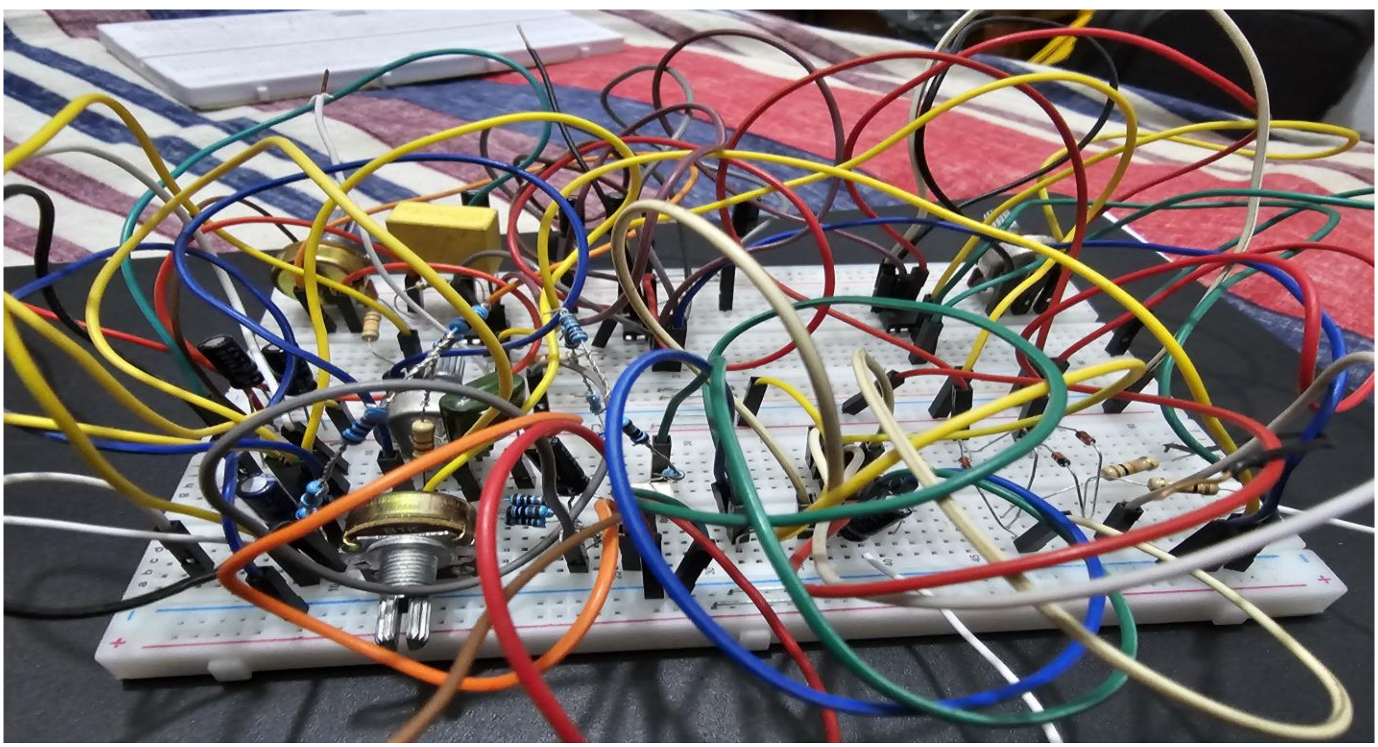


Figure 1.13(b): Circuit implementation in Breadboard

Calculation & Result Analysis:

1.Instrumentation Amplifier Block:

In the instrumentation amplifier block, output voltage (p-p), Vo = 1.40 mV and reference input voltage of EEG signal is 100 µV.

We know,

Gain = output voltage (p-p) / input voltage(p-p);

which implies Gain = 1.40 mV / 100 µV = 14;

The resistance value of R3, calculated by using equation 1.1 is 3.8 KΩ. This resistance contributes to the additional gain of the instrumentation amplifier. The graphical representation from figure 1.14 also verifies the fact about gain improvement, which is shown below.

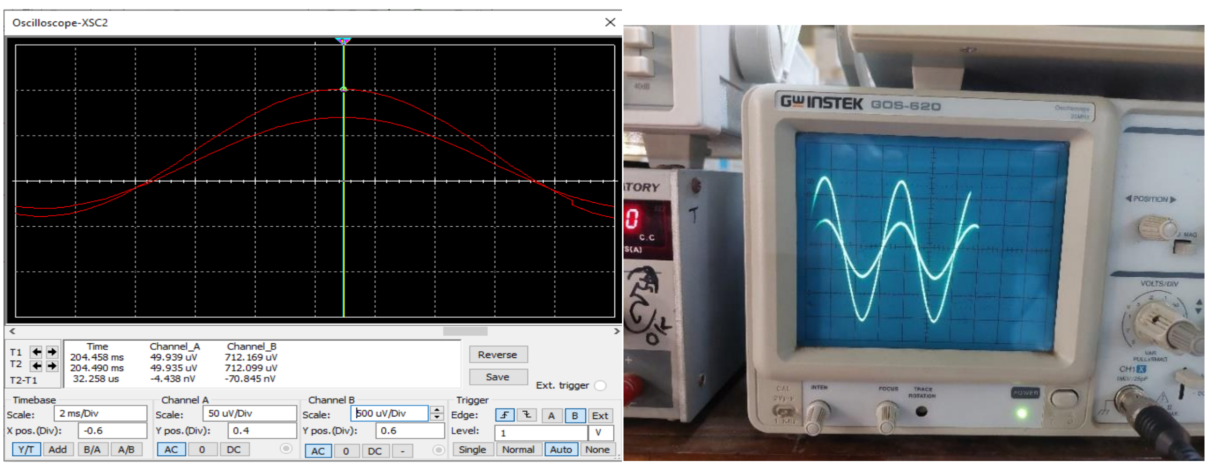


Figure 1.14: Oscilloscope graph showing input & output node signal of instrumentation amplifier using simulation(left) & practical output(right)

Here, both simulation and practical output of instrumentation amplifier are identical.

2.Opto-isolator Block:

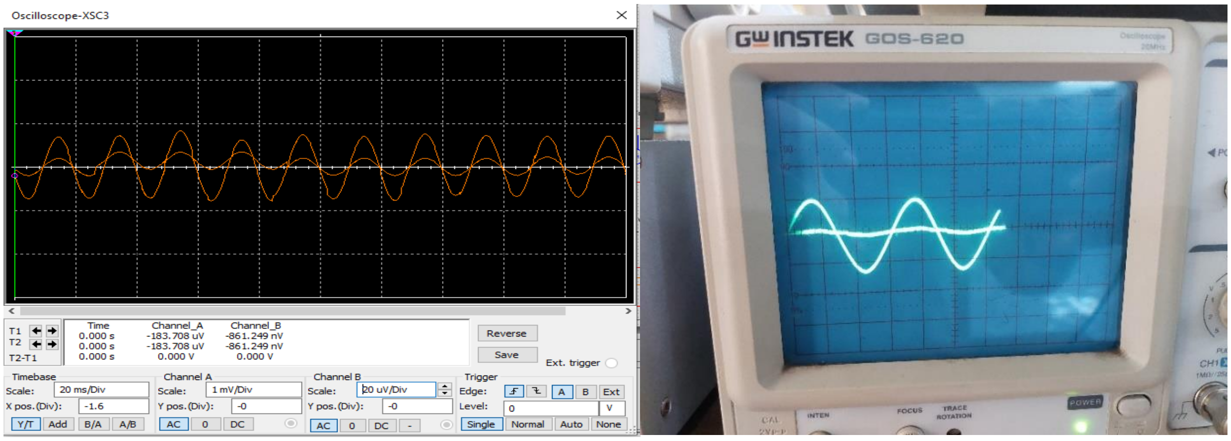


Figure 1.15: Oscilloscope graph showing input & output node signal of optocoupler using simulation(left) & practical output(right)

Here, both simulation and practical output of optocoupler are identical.

3.Band-pass Filter Block:

The main purpose of this block is to band-limit the signal between the gamma (γ)-band frequency region which is approximately 30 Hz to 100 Hz. For achieving the cut-off frequency values, equation 3.2 has been applied to determine suitable capacitance values for C1 and Cs (C4+C5) as shown in figure 3.6. The value of capacitor C1 is determined 10 nF along with resistance R6 of 500 KΩ for lower cut-off frequency and the value of Cs is determined by C4+C5 as they both are in parallel, having the value of 10 pF (C4 and C5 are 5 pF each) and connected with resistor R9 of 100K.

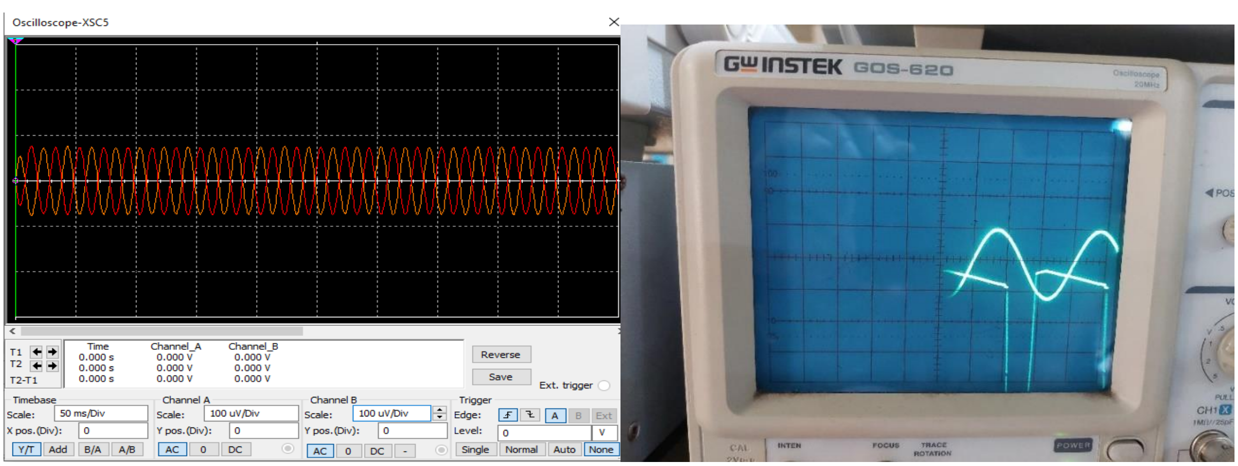


Figure 1.16: Oscilloscope graph showing input & output node signal of band-pass filter block using simulation(left) and practical output(right)

Here, simulation and practical output of bandpass filter are not identical. The practical filtered output got chopped off. It occurred because of our simulation component value and practical implemented component value are not exactly same.

4.Notch Filter Block:

The value of resistor R13 has been determined as R13 = 8.2 KΩ and for that reason the potentiometer with 40% access i.e., R14 of 40 KΩ (originally 100 KΩ) has been applied in figure 1.12. The Q-factor has been determined by using equation 1.5 which implies: Q-factor = 0.5 × (R14 / (R10/R16))1/2 = 0.5 × (40 / (10 /1))1/2 Finally, the value of Q-factor becomes: 1 and due to the high value of Q-factor the designed circuit is suitable for operation. Applying equation 1.4. the gain is calculated as Av = -0.5 × (R16 / R10) = - 0.5 × (1 / 10) And, the gain is -0.05 for notch filter block which implies output is inverted from the input and evaluates the op-amp as an inverting amplifier.

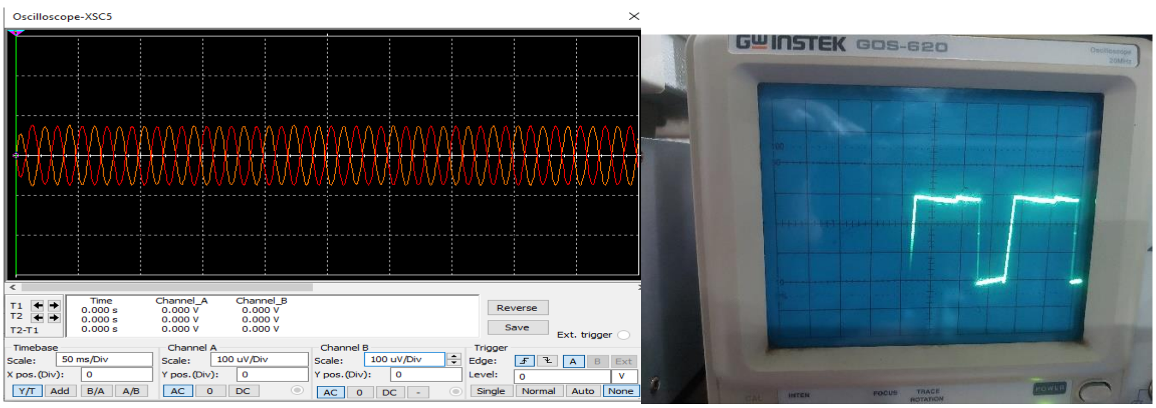


Figure 1.17: Oscilloscope graph showing input & output node signal of notch filter block using simulation(left) and practical output(right)

Here, also simulation and practical output of notch filter are not identical. The practical filtered output got chopped off because of previously mentioned issues.

5.Comparator Block:

The final block of this whole designed circuit model gives us the required output to verify our objective by showing almost similar frequency response in the bode plotter which is around 65-66 Hz. As the provided input source was of 60 Hz, some percentage of convergence error is encountered due to system noise, circuit components values, limitations regarding gain control or adjustment, lack of precision during band-limiting process of band-pass filter and so on. The below illustration of figure 1.18 provides strong verdict, as extracted with bode plotter, on the side of estimated outcome regarding the extraction of the frequency response of gamma (γ)-based EEG signal through this design of the modified circuit model.

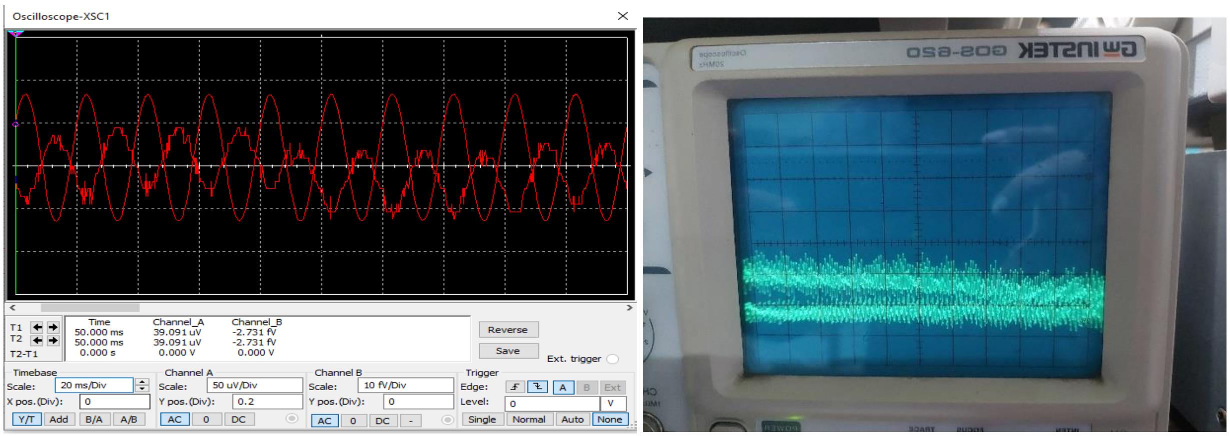


Figure 1.18: Oscilloscope graph showing input & output node signal of comparator block using simulation(left) and practical output(right)

Here, is the final output. Where practical output is different from simulation output. It may occur because of many issues. Gamma band frequency rage is 30 to 100 Hz, we took 50 Hz from function generator. Also, the peak voltage we took practically was 0.1V where 100uV was supposed to taken. Again, some capacitance and resistance value we took were not as same as simulation value. So, the final output is not as same as expected.

Work Timeline:

We've started working from 03 September, 2023. And we've given 4 hours each week on average for the project.

Week Count	**Works & Progress**
1st week	Studied for the project
2nd week	Consulted with supervisor for Planning how to start the project
3rd week	Started Designing the circuit in Multisim
4th week	Collected Component from market
5th week	Started implementing the project in Breadboard & discussed about the limitation of input parameter & component unavailability with supervisor
6th week	Finished 1st four portion of the circuit
7th week	Finished last two portion of the circuit
8th week	Final checked the circuit & analyzed the result. Also discussed with supervisor.
9th week	Submitted the project

Cost Analysis:

Sl No	Component	Rating	Quantity	Price
01	Capacitor	3.3uF	01	005
02	Capacitor	.1uF	08	048
03	Capacitor	10nF	01	009
04	Capacitor	.47uF	01	018
05	Signal Diode	1N4148	05	020
06	Variable POT	100k	01	020
07	Variable POT	1k	01	020
08	Variable POT	500k	02	040
09	Optocoupler	4N35 DIP6 30V	01	030
10	OP-AMP	LM358	03	045
11	OP-AMP	741	01	020
12	Resistor	8.2k	05	006
13	Resistor	180	10	018
14	Resistor	180k	05	009
15	Resistor	3.9k	05	009
16	Instrumentation Amplifier	AD620	01	459
17	Breadboard	-	02	200
18	Jumper Wire	Male to male	1 set	40
			Total:	1162

Impact on Society & Environment:

1. **Improved Quality of Life for Individuals with Motor Disabilities:**
    - The circuit's successful development can lead to the creation of advanced assistive technologies, such as brain-computer interfaces, providing a transformative impact on the daily lives of individuals with motor disabilities.
2. **Enhanced Healthcare Accessibility:**
    - By offering a cost-effective solution for extraction of gamma band EEG signals, the project contributes to accessible healthcare, ensuring that individuals with motor disabilities have timely and efficient diagnostic tools.

3. **Reduced Healthcare Burden:**
    - Early detection of motor disabilities through the circuit can lead to proactive healthcare interventions, potentially reducing the overall burden on healthcare systems by addressing issues at their onset.
4. **Technological Advancements in Medical Sectors:**
    - The project paves the way for technological advancements in the medical field, promoting the integration of innovative tools and technologies for improved patient care, diagnosis, and treatment.
5. **Environmental Considerations:**
    - The development of a cost-effective circuit aligns with sustainability goals by minimizing the resources required for implementing assistive technologies, contributing to a more environmentally conscious approach in the healthcare sector.

Discussion:

1. **Discrepancy Between Simulation and Practical Implementation:**
    - The observed variance in input voltage between the simulation (100uV) and real-life scenario (0.01 V) highlights a critical disparity that may contribute to the lack of proper output during practical implementation. This emphasizes the importance of calibrating simulations to closely mirror real-world conditions for accurate results.
2. **Component Availability Challenges**:
    - The non-availability of all components specified in the simulation circuit within the market poses a significant challenge. This issue underscores the necessity of adapting the circuit design to incorporate readily accessible components without compromising the intended functionality.
3. **Calculation of Compatible Resistance and Capacitance Values:**
    - The calculated resistance and capacitance values play a pivotal role in determining the circuit's performance. Discrepancies between calculated and practical values signal the need for a more comprehensive assessment of component characteristics, taking into account tolerances and practical limitations.
4. **Implementation Challenges on Breadboard:**
    - Translating the circuit design from simulation to practical implementation on the breadboard introduces additional challenges. Factors such as parasitic capacitance,

signal degradation, and interference may affect the circuit's behavior, necessitating careful consideration during the transition from theory to practice.

Conclusion:

In conclusion, this project aimed to develop a gamma-band EEG signal extraction circuit with specific objectives focusing on detection, simulation, and practical implementation. The observed discrepancies between simulation and practical results underscore the complexity of translating theoretical designs into real-world applications.

The challenges encountered, including input voltage disparities and component availability issues, highlight the need for a more meticulous approach in designing circuits that are robust and adaptable to practical constraints. The discussion on voltage gain, resistance, and capacitance values emphasizes the importance of fine-tuning the circuit parameters for optimal performance.

References:

1.https://www.igi-global.com/chapter/accessibility-in-e-government/184062

2.https://www.telerik.com/blogs/motor-disabilities-and-what-you-need-for-accessibility

3. https://www.who.int/news-room/fact-sheets/detail/disability-and-health

4. https://ieeexplore.ieee.org/document/6746942

5. https://components101.com/ics/ad620-instrumentation-amplifier

6. https://www.techtarget.com/searchnetworking/definition/optoisolator

7. https://components101.com/ics/mct2e-phototransistor-optocoupler-ic

8.https://www.utmel.com/components/op07-operational-amplifier-pinout-datasheet-op07-vs-lm308?id=995

Signature of Student 1: ……………………………………… Date: …………………………….

Signature of Student 2: ……………………………………… Date: …………………………….

Signature of Supervisor: …………………………………….. Date: ……………………………