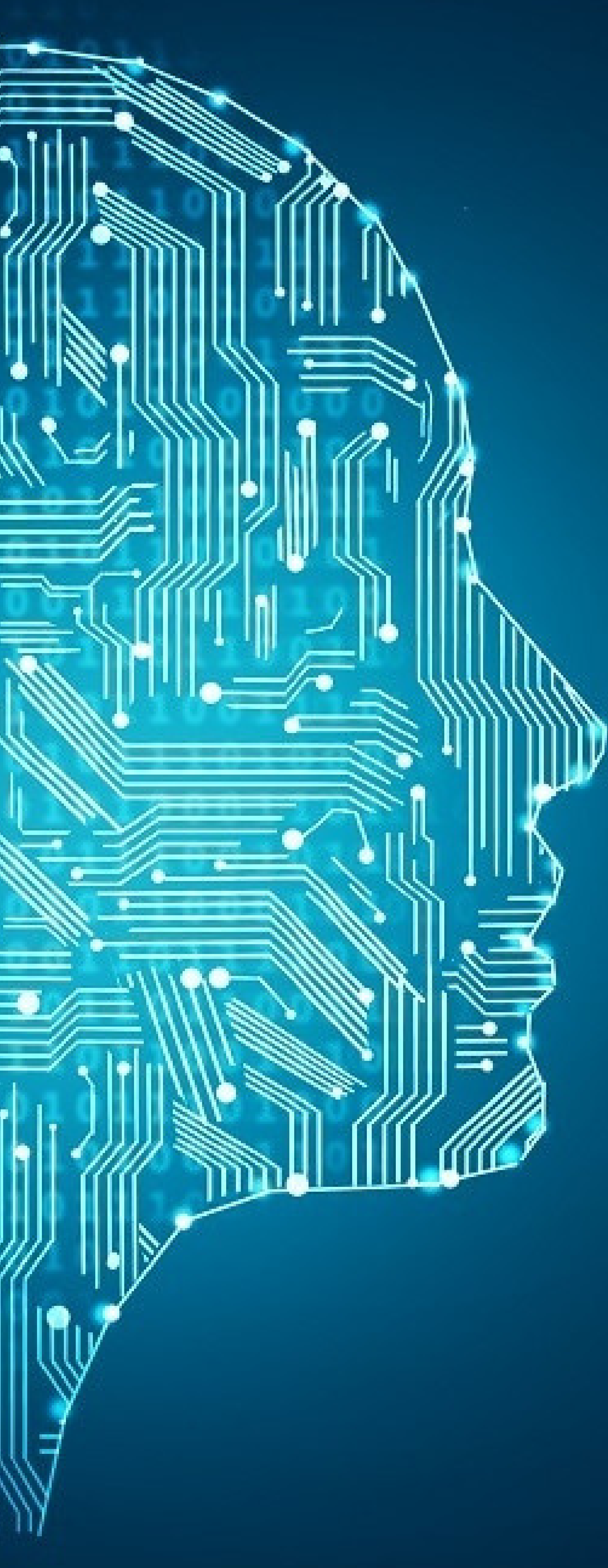

INTRODUCTION TO BIOMEDICAL ENGINEERING LAB - MCT-401L

LAB REPORTS

SUBMITTED BY:

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2015-MC-167

SUBMITTED TO:

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- Design an analog high pass filter.

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- Plot and comment on the response.

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- Plot and comment on the response.

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- Introduction to bio instrumentation.
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Lab # 1

Objectives:

To get familiarize with the type of filters used in signals.

Filters

In **signal** processing, a **filter** is a device or process that removes some unwanted components or features from a **signal**. **Filtering** is a class of **signal** processing, the defining feature of **filters** being the complete or partial suppression of some aspect of the **signal**.

Filters may be classified as either digital or analog.

1. **Analog Filters:** Analog filters are used to filter out unwanted bands of frequency. It may be classified as either passive or active and are usually implemented with R, L, and C components and operational amplifiers.
2. **Digital Filters:** Digital filters are implemented using a digital computer or special purpose digital hardware. A digital filter, in general, is a computational process, or algorithm that converts one sequence of numbers representing the input signal into another sequence representing the output signal. Accordingly, a digital filter can perform functions as differentiation, integration, estimation, and, of course, like an analog filter, it can filter out unwanted bands of frequency.

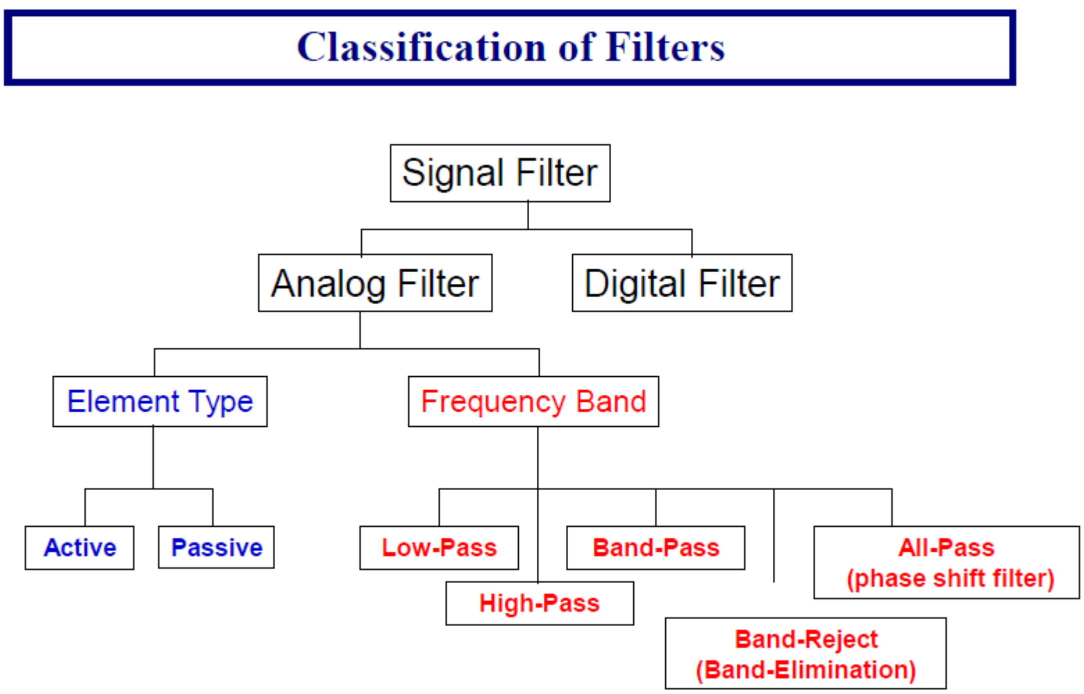


Figure 1: Classification of filters

Analog Filters:

Analog filters are classified with respect to element type.

1. **Active Filter:** An active filter is one that, along with R, L, and C components, also contains an energy source, such as that derived from an operational amplifier.
2. **Passive Filter:** A passive filter is one that contains only R, L, and C components. It is not necessary that all three be present. L is often omitted (**on purpose**) from passive filter design because of the size and cost of inductors – and they also carry along an R that must be included in the design.
   It will be shown later that the ideal filter, sometimes called a “brickwall” filter, can be approached by making the order of the filter higher and higher. The order here refers to the order of the polynomial(s) that are used to define the filter.

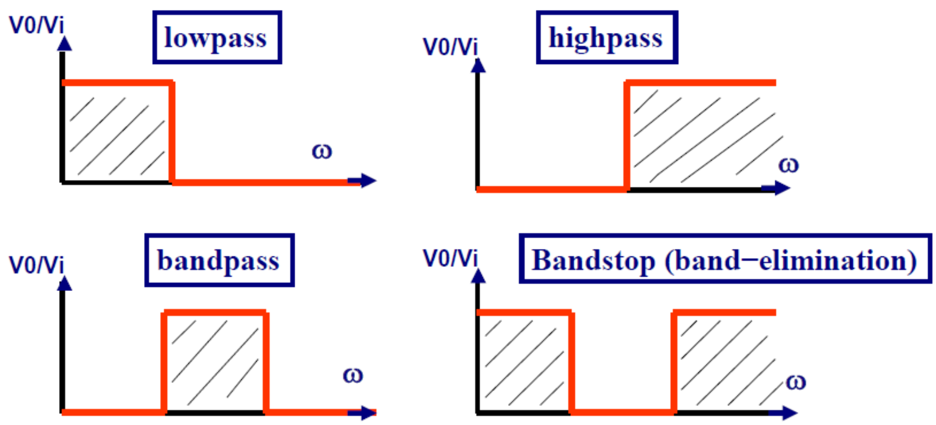


Figure 2: Ideal filters

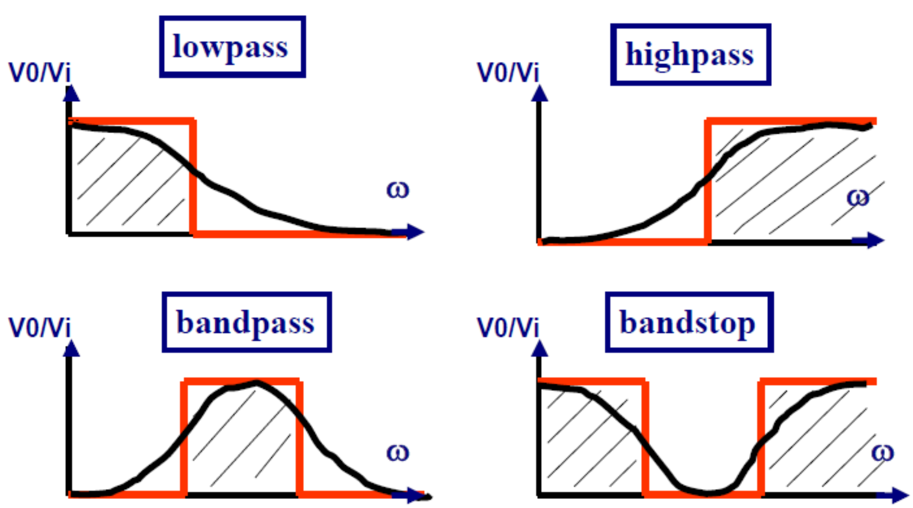


Figure 3: Realistic filters

Passive Analog Filters:

1. **Lowpass Filter:** Lowpass (LP) filters select low frequencies up to the cut-off frequency f_c and attenuate frequencies higher than f_c.

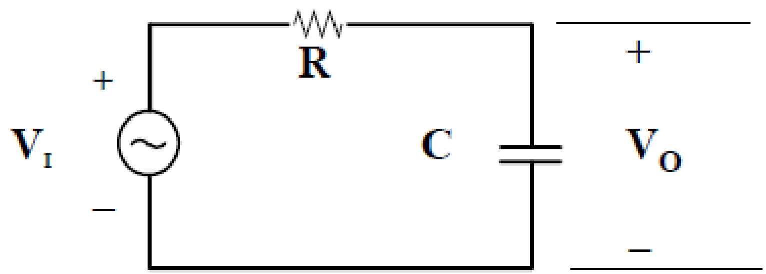


Figure 4: Lowpass filter circuit Diagram

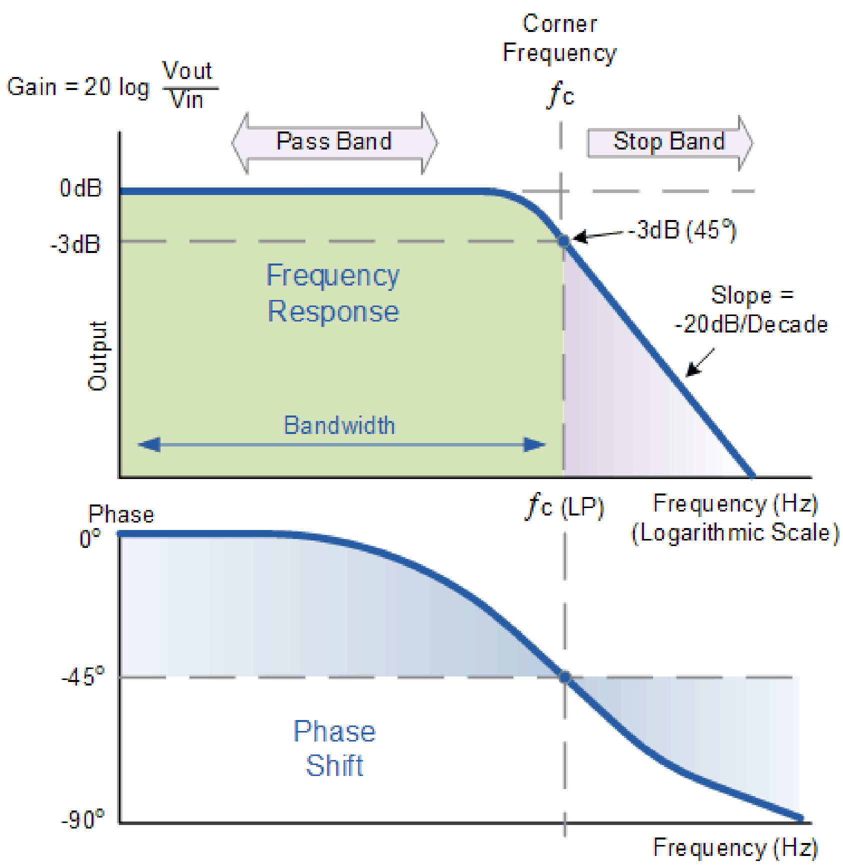


Figure 5: Lowpass filter bode plot

2. **Highpass Filter:** Highpass (HP) filters select frequencies higher than f_c and attenuate frequencies below f_c.

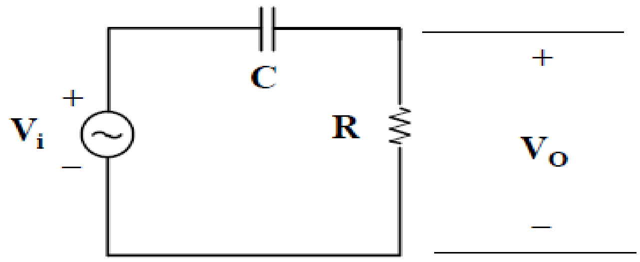


Figure 6: Highpass filter circuit Diagram

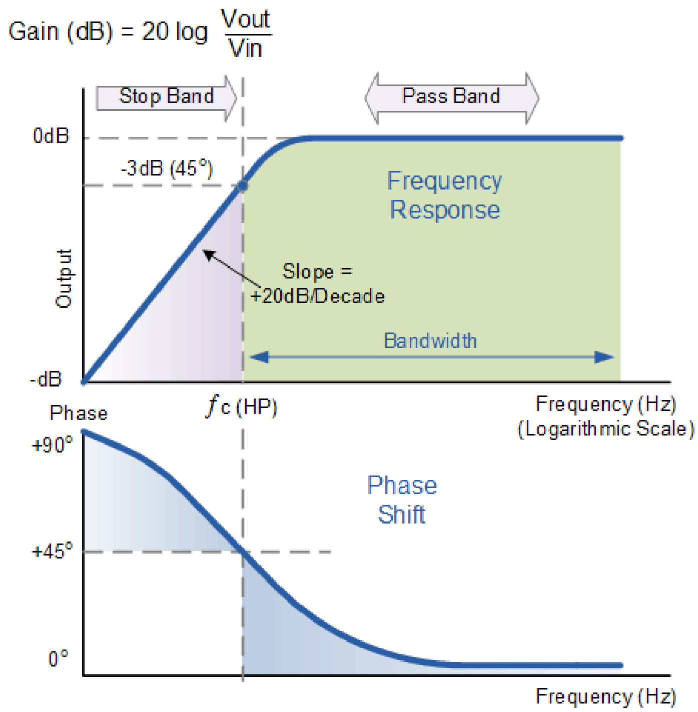


Figure 7: Highpass filter bode plot

3. **Bandpass Filter:** Bandpass (BP) filters select frequencies between a lower cut-off frequency f_{cl} and a higher cut-off frequency f_{ch}. Frequencies below f_{cl} and frequencies higher than f_{ch} are attenuated.

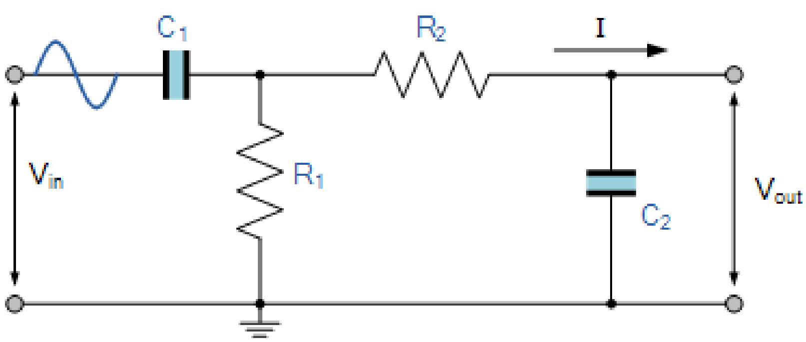


Figure 8: Bandpass filter circuit Diagram

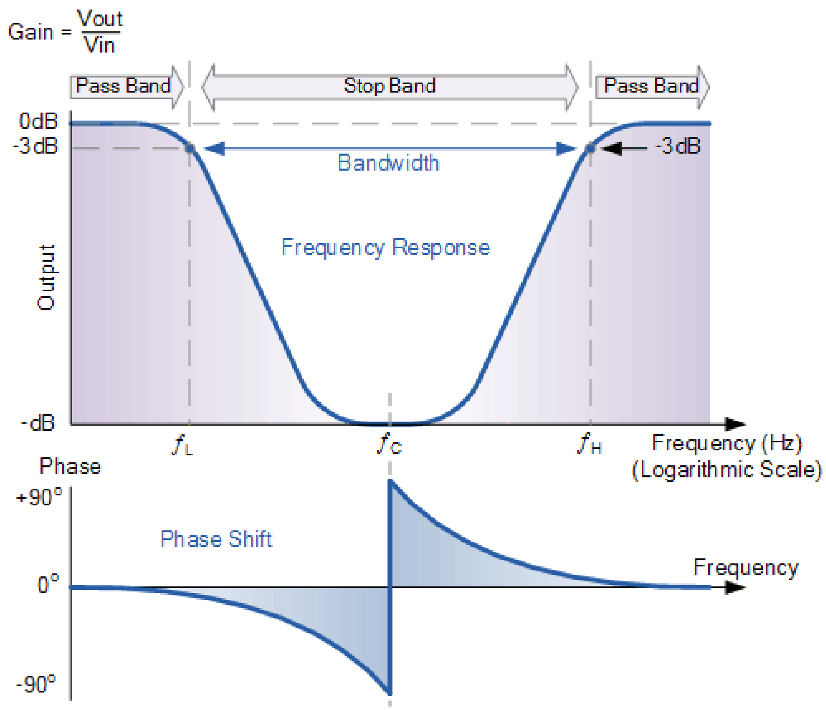


Figure 9: Bandpass filter bode plot

4. **Bandstop (Bandreject) Filter:** Bandreject (BR) filters attenuate frequencies between a lower cut-off frequency f_{cl} and a higher cut-off frequency f_{ch}. Frequencies below f_{cl} and frequencies higher than f_{ch} are passed.

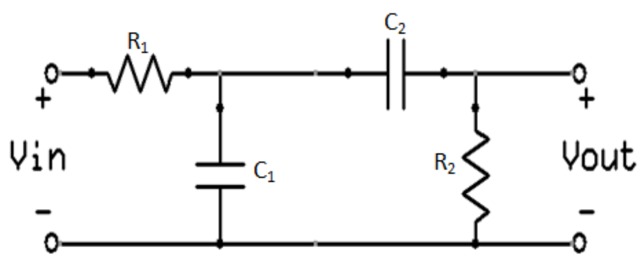


Figure 10: Bandstop filter circuit Diagram

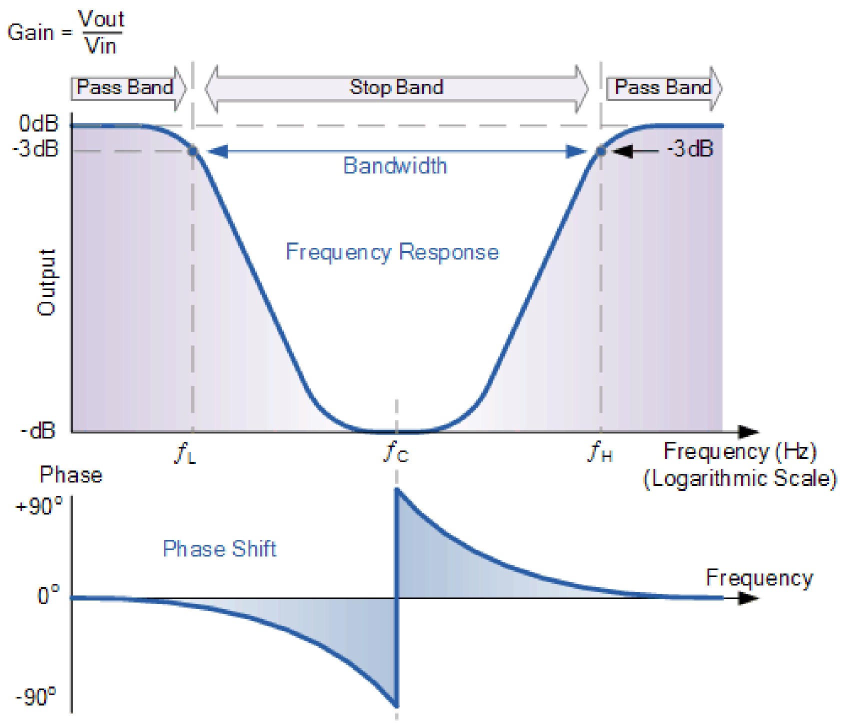


Figure 9: Highpass filter bode plot

Applications:

- Lowpass filters are used in Audio Applications for Equalization purposes.
- Highpass filters are used in the loud speakers to reduce the low level noise.
- BPFs (Bandpass filters) are extensively used in wireless transmitters and receivers.
- In telephone technology, these filters are used as the telephone line noise reducers and DSL internet services. It will help to remove the interference on the line which will reduce the DSL performance.

Lab # 2

Objectives:

- Derive transfer function of an analog low pass filter
- Design an analog low pass filter

Introduction:

A simple passive RC Low Pass Filter or LPF, can be easily made by connecting together in series a single Resistor with a single Capacitor as shown below. In this type of filter arrangement the input signal (V_{IN}) is applied to the series combination (both the Resistor and Capacitor together) but the output signal (V_{OUT}) is taken across the capacitor only.

This type of filter is known generally as a "first-order filter" or "one-pole filter", why first-order or single-pole? Because, it has only "one" reactive component, the capacitor, in the circuit.

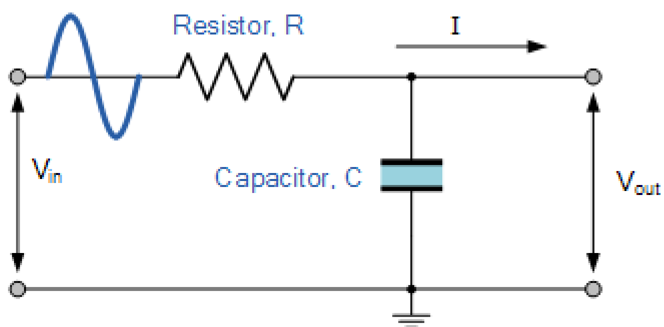


Figure 1: Lowpass filter circuit

Transfer Function Derivation:

$$V_{IN} = R*i(t) + (1/C)\int_0^t i(t)\,dt$$

$$V_{IN} = R\frac{dq}{dt}(t) + (1/C)\,q(t)$$

Where $q=CV_{OUT}$

$$V_{IN} = RC\frac{dVout}{dt}(t) + (1/C)\,V_{OUT}(t)$$

Taking Laplace

$$V_{IN}(s) = RC*V_{OUT}(s) + V_{OUT}(s)$$

$$\boxed{\frac{Vout(s)}{Vin(s)} = \frac{1}{RCs+1}}$$

Also well-known is the equation for calculating the -3dB (aka, half-power) cutoff frequency of the RC low pass filter:

$$f_C = \frac{1}{2\pi RC}$$

Simulink and Table:

>> R = 10e3; C = 1e-6

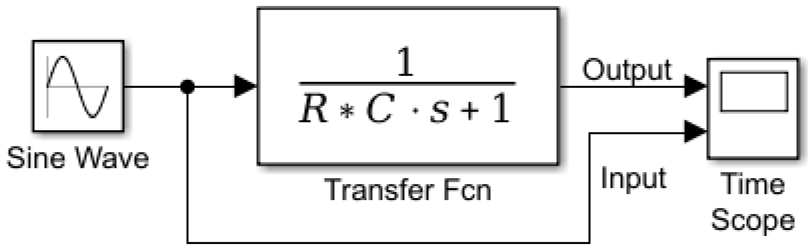


Figure 2: Lowpass filter Simulink

$w_C = 2\pi f_C = \frac{I}{R*C} = 100$

#	Cut-off frequency	Applied Voltage	Output Voltage	Vo/Vi	20log(Vo/Vi) db
e.g	w /wc=1	10	7.055	0.7055	-3.03
1	w /wc=10	10	1.015	0.1015	-19.87
2	w /wc=20	10	0.858	0.0858	-21.33
3	w /wc=30	10	0.6	0.06	-24.44
4	w /wc=40	10	0.492	0.0492	-26.16
5	w /wc=50	10	0.356	0.0356	-28.97

Graphs:

$\frac{w}{w_c} = 1$

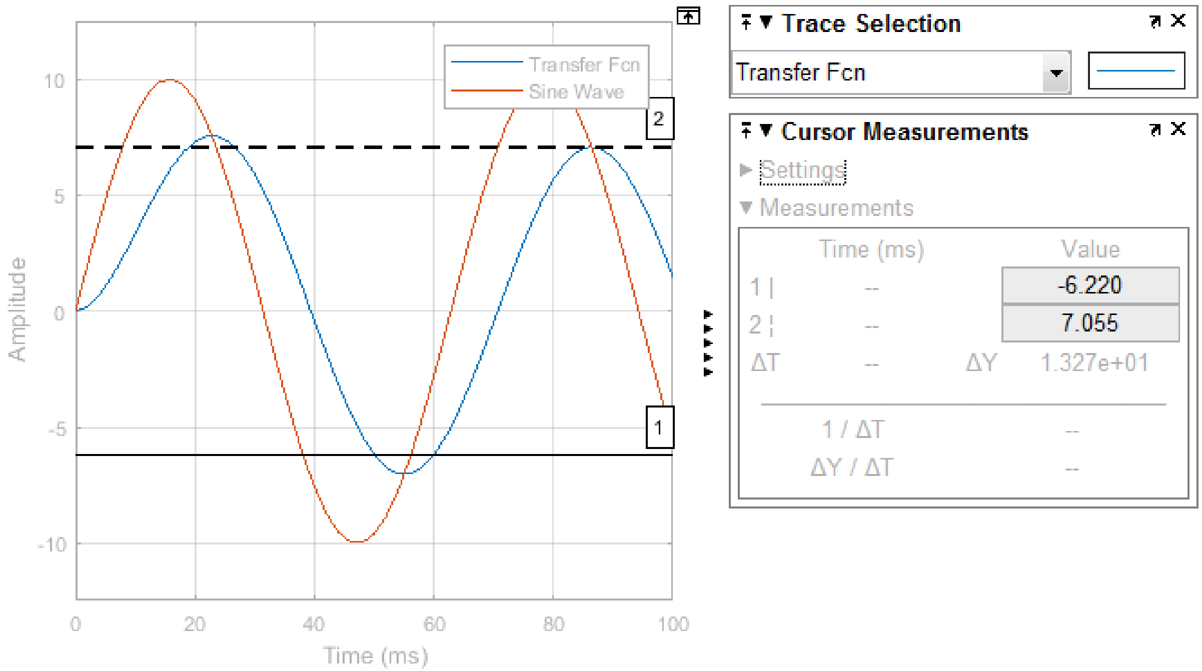


Figure 3: Graph at w = 100

$$\frac{w}{w_c} = 10$$

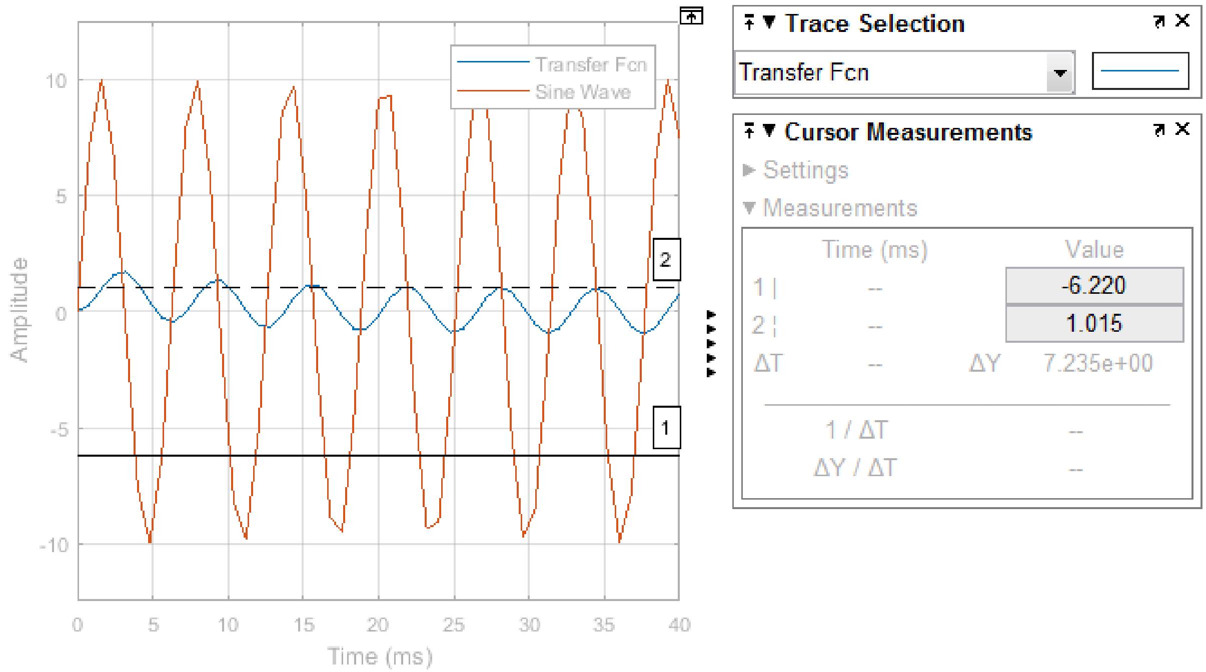


Figure 4: Graph at w = 1000

$$\frac{w}{w_c} = 20$$

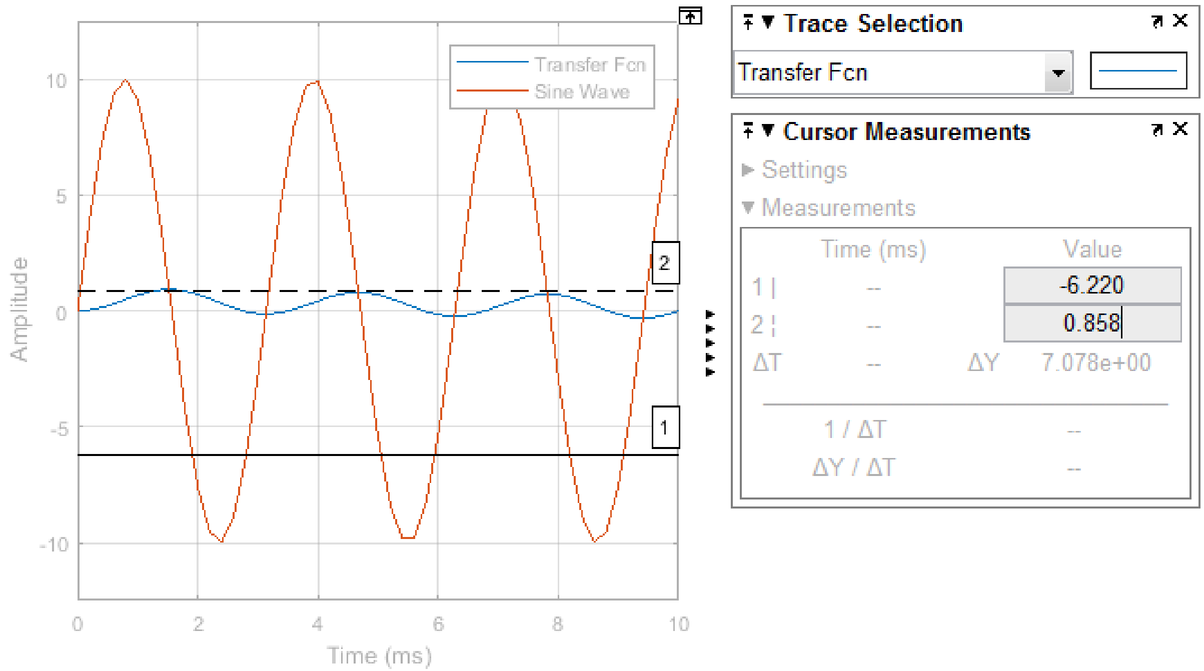


Figure 5: Graph at w = 2000

$$\frac{w}{w_c} = 30$$

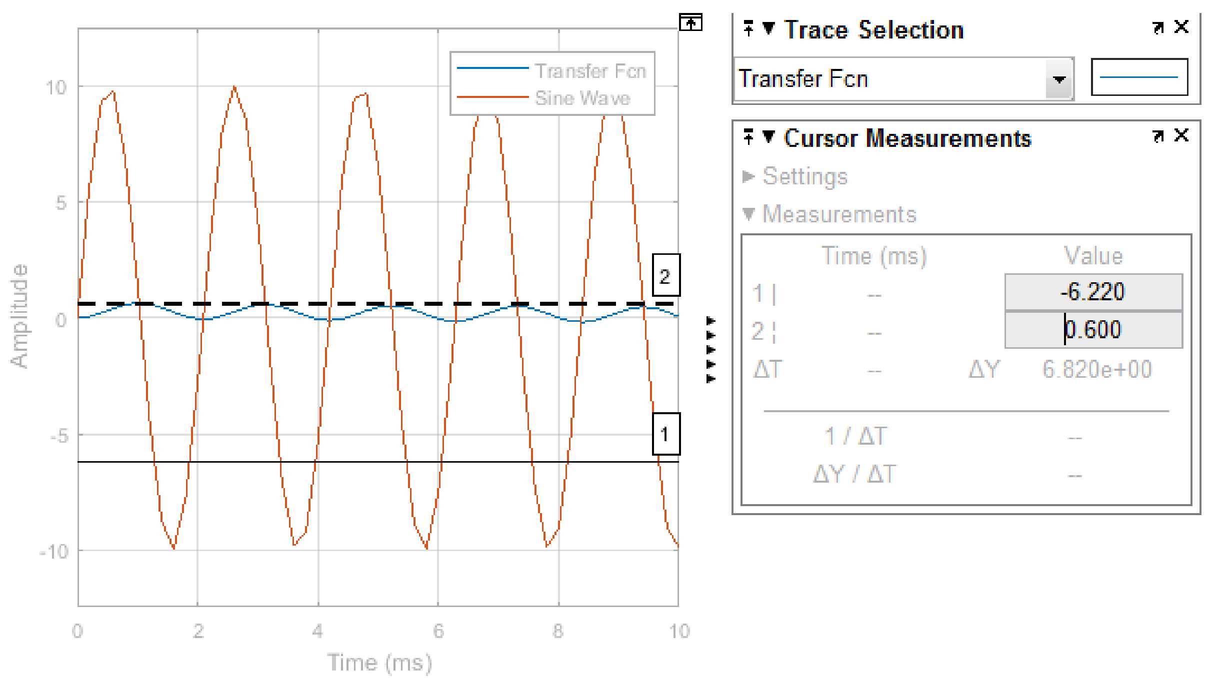


Figure 6: Graph at w = 3000

$$\frac{w}{w_c} = 40$$

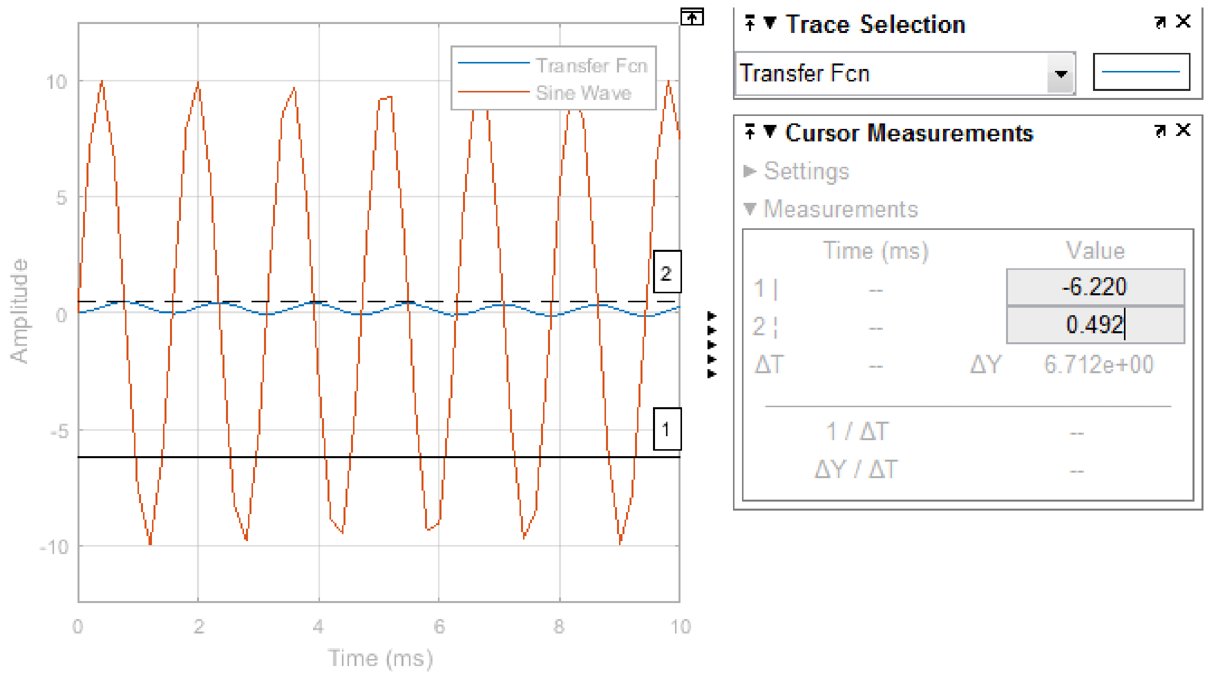


Figure 7: Graph at w = 4000

$$\frac{w}{w_c} = 50$$

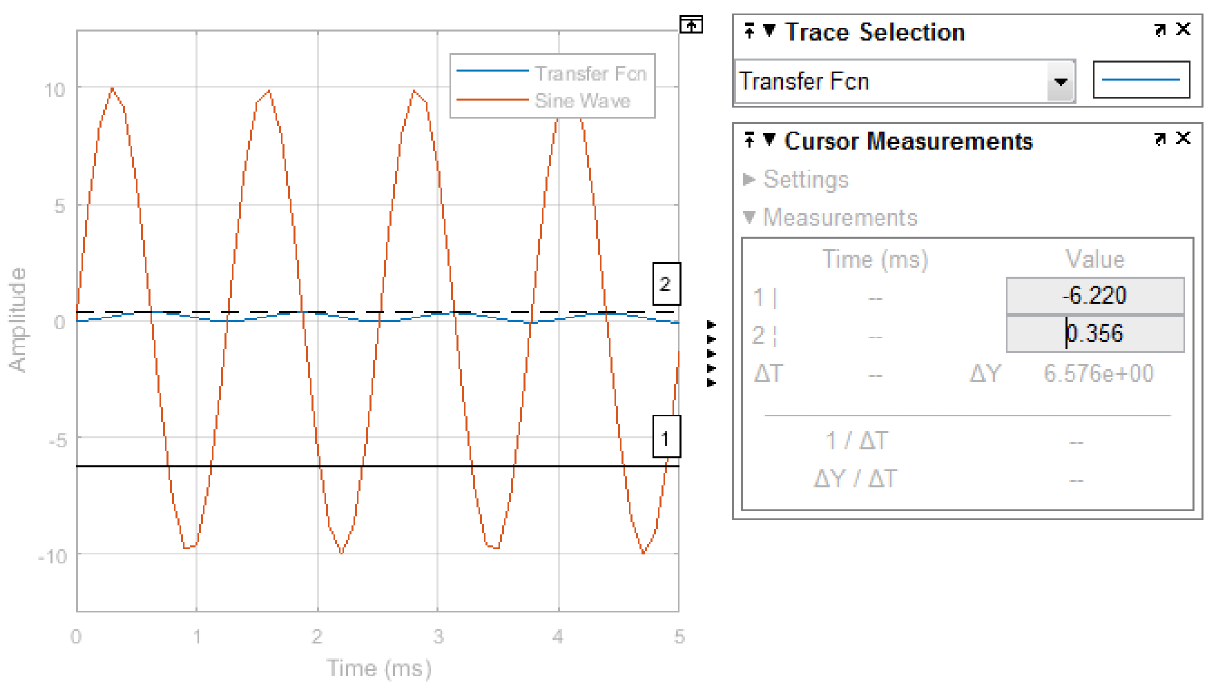


Figure 8: Graph at w = 5000

Conclusion:

- As natural frequency (w) increases, output decreased.
- As natural frequency (w) increases, magnitude of bode plot (db value) decreased.

Lab # 3

Objectives:

- Derive transfer function of an analog high pass filter
- Design an analog high pass filter

Introduction:

A High Pass Filter is the exact opposite to the low pass filter circuit as the two components have been interchanged with the filters output signal now being taken from across the resistor.

In this circuit arrangement, the reactance of the capacitor is very high at low frequencies so the capacitor acts like an open circuit and blocks any input signals at V_{IN} until the cut-off frequency point (f_C) is reached. Above this cut-off frequency point the reactance of the capacitor has reduced sufficiently as to now act more like a short circuit allowing the entire input signal to pass directly to the output as shown below in the filters response curve.

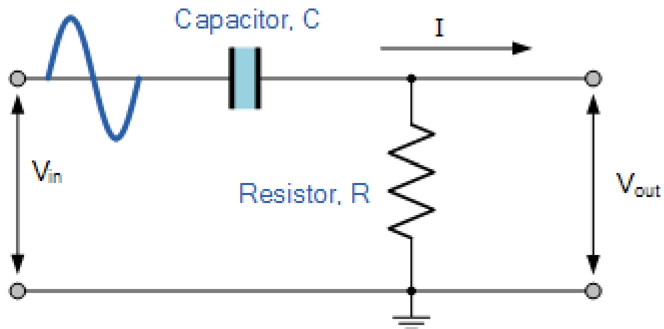


Figure 1: Highpass filter circuit

Transfer Function Derivation:

$$V_{IN} = R*i(t) + (1/C)\int_0^t i(t)\,dt$$

Where $i = \frac{V_{OUT}}{R}$

$$V_{IN} = V_{OUT}(t) + (1/C)\int_0^t \frac{V_{OUT}}{R}\,dt$$

Taking Laplace

$$V_{IN} = V_{OUT}(s) + (1/RCs) * V_{OUT}(s)$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{\frac{1}{RCs} + 1}$$

$$\frac{Vout(s)}{Vin(s)} = \frac{RCs}{RCs + 1}$$

Also well-known is the equation for calculating the -3dB (aka, half-power) cutoff frequency of the RC low pass filter:

$$f_C = \frac{1}{2\pi RC}$$

Simulink and Table:

>> R = 10e3; C = 1e-6

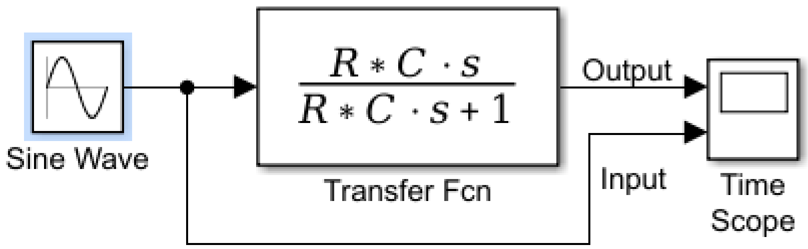


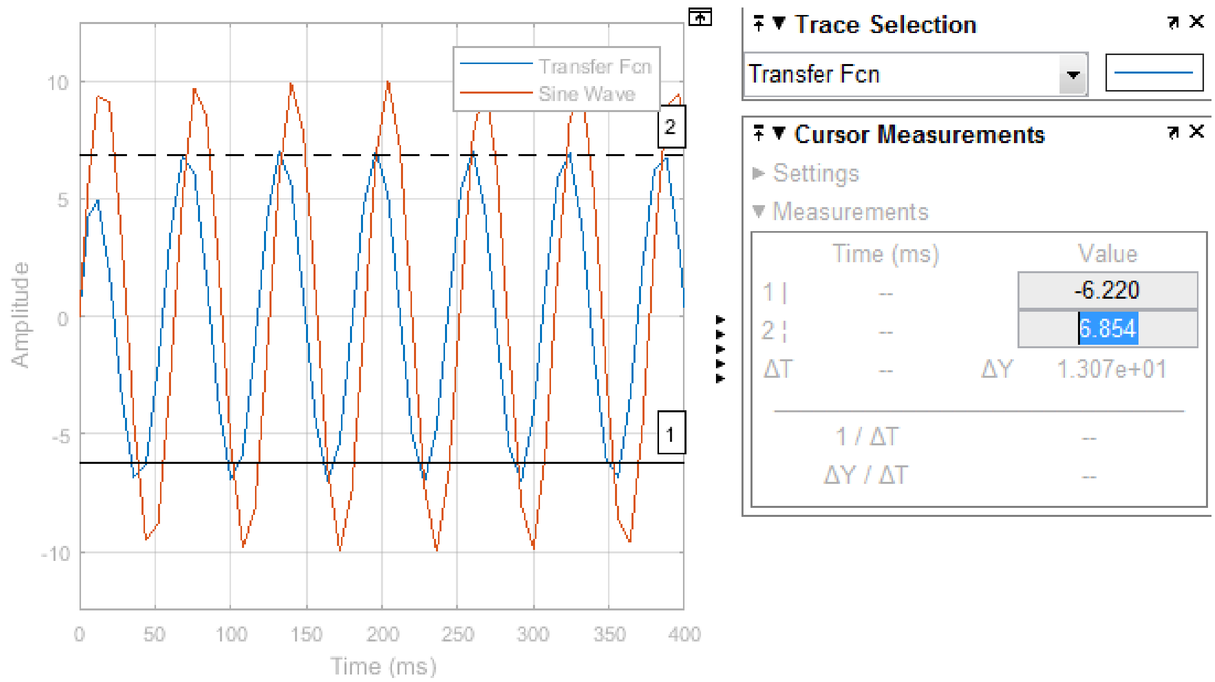
Figure 2: Highpass filter Simulink

$w_C = 2\pi f_C = \frac{I}{R*C} = 100$

#	Cut-off frequency	Applied Voltage	Output Voltage	Vo/Vi	20log(Vo/Vi) dB
e.g	w /wc=1	10	6.854	0.6854	-3.28
1	w /wc=10	10	9.083	0.9083	-0.83
2	w /wc=20	10	9.629	0.9629	-0.33
3	w /wc=30	10	9.789	0.9789	-0.19
4	w /wc=40	10	9.805	0.9805	-0.17
5	w /wc=50	10	9.808	0.9808	-0.16

Graphs:

$\frac{w}{w_c} = 1$



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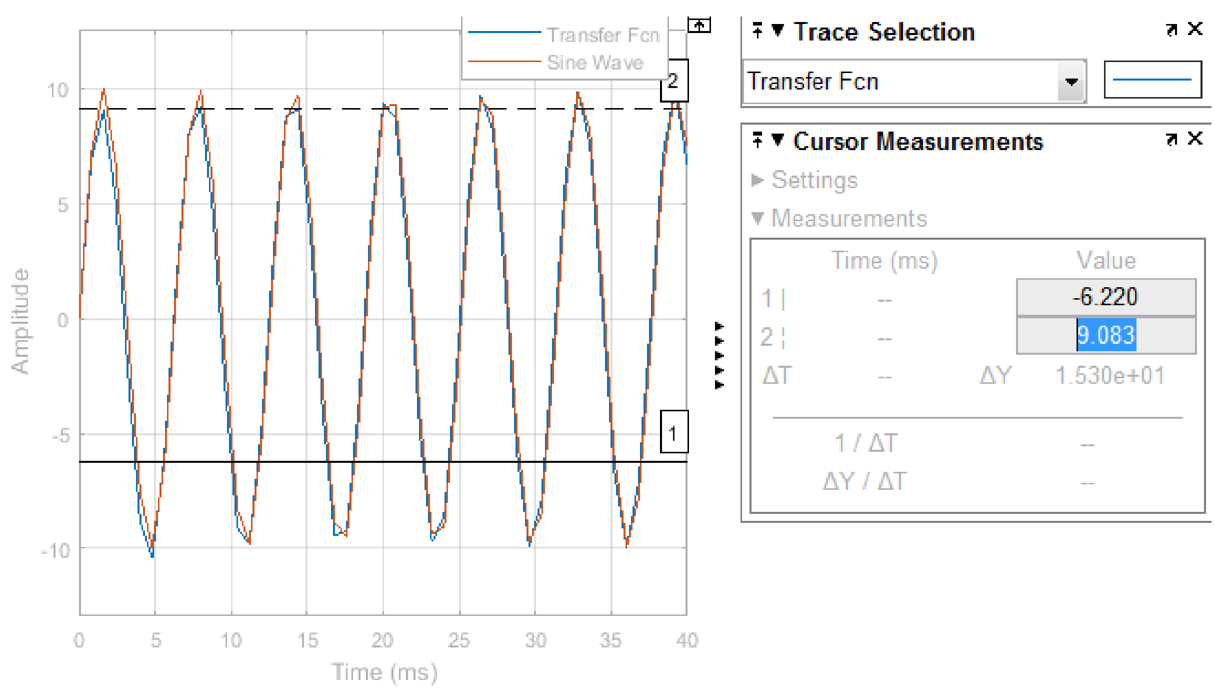


Figure 4: Graph at w = 1000

$$\frac{w}{w_c} = 20$$

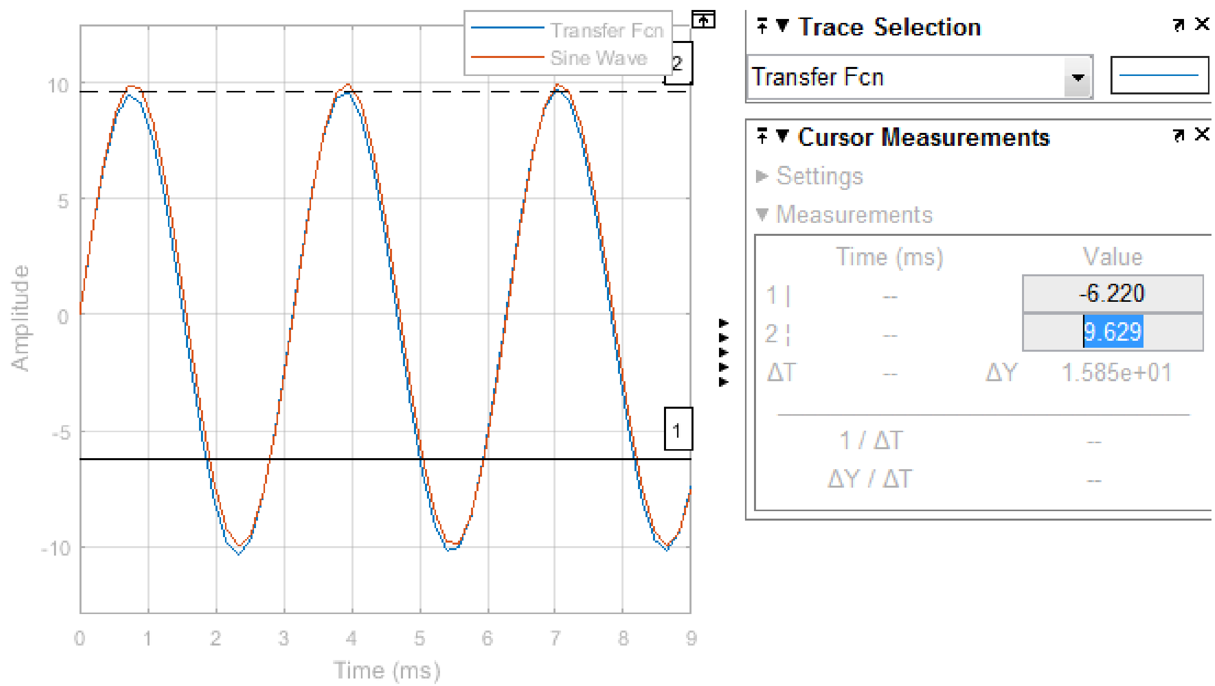


Figure 5: Graph at w = 2000

$$\frac{w}{w_c} = 30$$

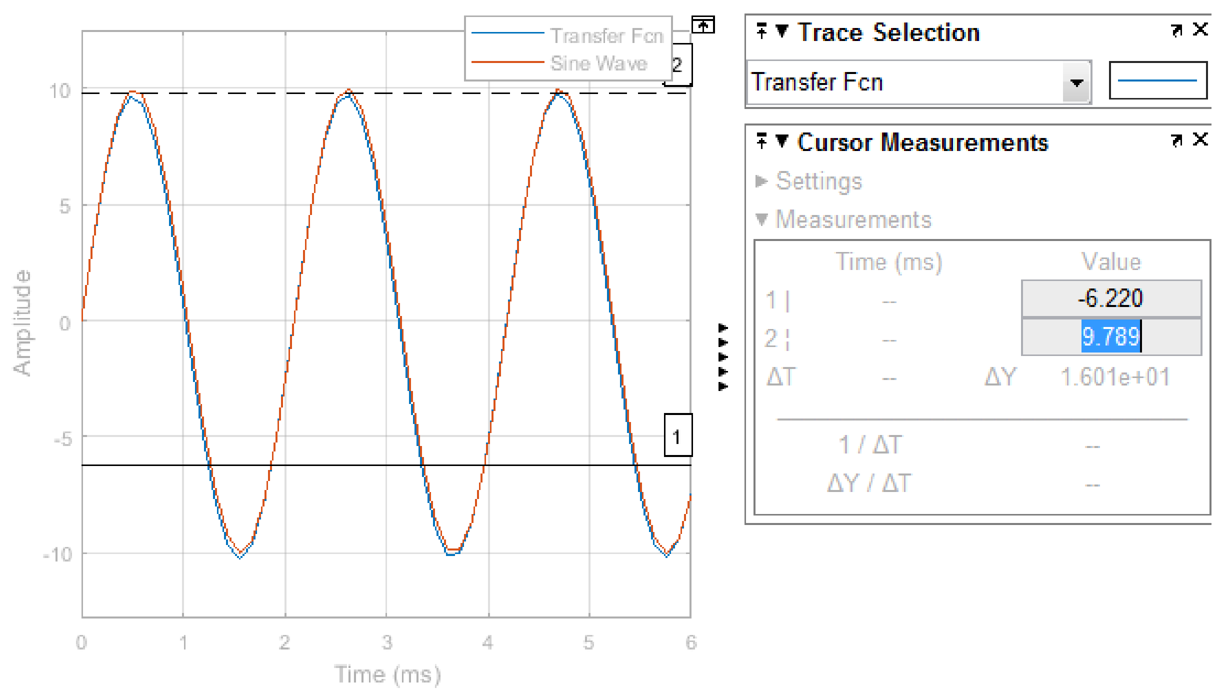


Figure 6: Graph at w = 3000

$$\frac{w}{w_c} = 40$$

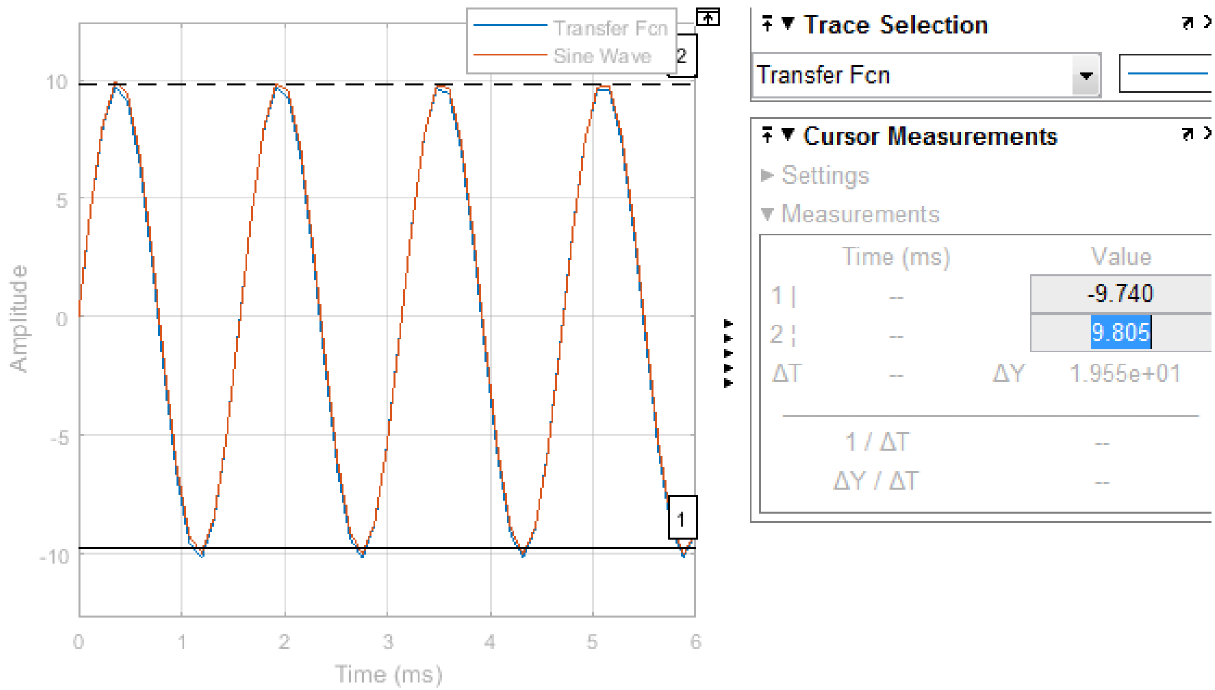


Figure 7: Graph at w = 4000

$$\frac{w}{w_c} = 50$$

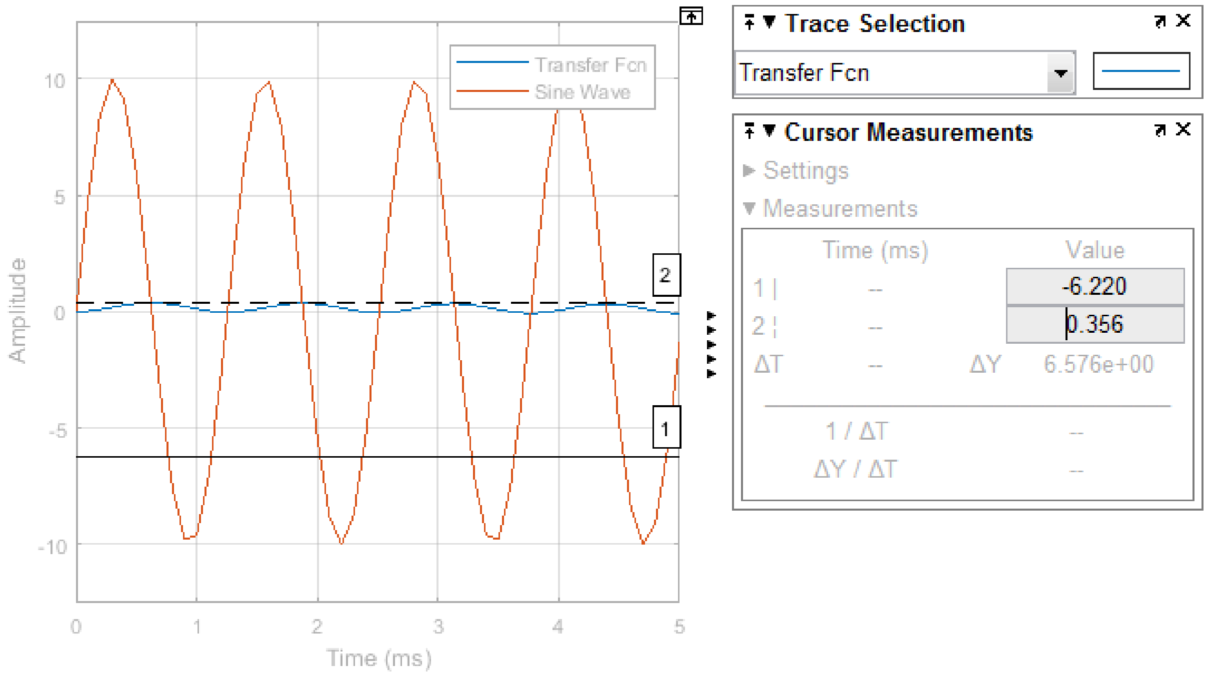


Figure 8: Graph at w = 5000

Conclusion:

- As natural frequency (w) increases, output decreased.
- As natural frequency (w) increases, magnitude of bode plot (db value) decreased.

Lab # 4

Objectives:

- Comparison of analog low pass filters as instructed in the class.
- Plot and comment on the response/output of each filter type.

Introduction:

Butterwoth:

The first, and probably best-known filter approximation is the Butterworth or maximally-flat response. It exhibits a nearly flat passband with no ripple. The rolloff is smooth and monotonic, with a low-pass or highpass rolloff rate of 20 dB/decade (6 dB/octave) for every pole. Thus, a 5th-order Butterworth low-pass filter would have an attenuation rate of 100 dB for every factor of ten increase in frequency beyond the cutoff frequency. It has a reasonably good phase response.

Chebyshev:

The Chebyshev response is a mathematical strategy for achieving a faster roll-off by allowing ripple in the frequency response. As the ripple increases (bad), the roll-off becomes sharper (good). The Chebyshev response is an optimal trade-off between these two parameters. Chebyshev filters where the ripple is only allowed in the passband are called type 1 filters. Chebyshev filters that have ripple only in the stopband are called type 2 filters , but are are seldom used. Chebyshev filters have a poor phase response.

Elliptic:

The cut-off slope of an elliptic filter is steeper than that of a Butterworth, Chebyshev, or Bessel, but the amplitude response has ripple in both the passband and the stopband, and the phase response is very nonlinear. However, if the primary concern is to pass frequencies falling within a certain frequency band and reject frequencies outside that band, regardless of phase shifts or ringing, the elliptic response will perform that function with the lowest-order filter.

Bessel:

- Maximally flat response in both magnitude and phase.
- Nearly linear-phase response in the passband.

You can use Bessel filters to reduce nonlinear-phase distortion inherent in all IIR filters. High-order IIR filters and IIR filters with a steep roll-off have a pronounced nonlinear-phase distortion, especially in the transition regions of the filters. You also can obtain linear-phase response with FIR filters.

Code:

M-file code is attached at the end of this experiment.

Graph:

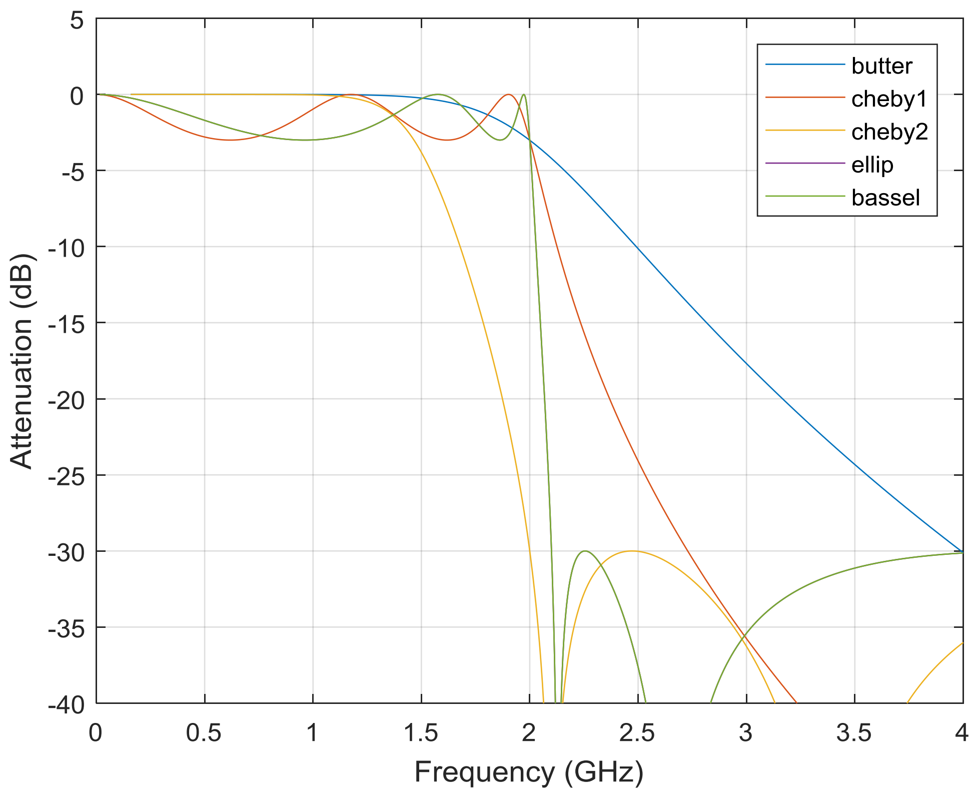


Figure 1: Output graph of analog lowpass filters

Comments and Results:

Butterworth Lowpass Filter:

- Flattest pass-band but a poor roll-off rate.

Chebyshev I Lowpass Filter:

- Sharper transition band compared to Butterworth (for the same number of poles).
- Poorer group delay compared to Butterworth.
- More ripple in passband poorer phase response.

Chebyshev II Lowpass Filter:

- No ripple in passband.
- Nulls or notches in stopband.

- Sharper transition band compared to Butterworth.
- Passband phase more linear compared to Chebyshev I.

Elliptic Lowpass Filter:

- Ripple in passband.
- Nulls in the stopband.
- Sharper transition band compared to Butterworth & both Chebyshevs.
- Poorest phase response.
- Worst roll-off rate of all four filters but the best phase response. Filters with a poor phase response will react poorly to a change in signal level.

Lab # 5

Objectives:

- Design an analog bandpass butterworth filter using Matlab.
- Derive transfer function.
- Determine the values of w_{low} and w_{high}.
- Order of the filter centre frequency and bandwidth can be varied.
- Plot and comment on the response.

Introduction:

Passive Band Pass Filters can be made by connecting together a low pass filter with a high pass filter.

By connecting or "cascading" together a single Low Pass Filter circuit with a High Pass Filter circuit, we can produce another type of passive RC filter that passes a selected range or "band" of frequencies that can be either narrow or wide while attenuating all those outside of this range. This new type of passive filter arrangement produces a frequency selective filter known commonly as a Band Pass Filter or BPF for short.

Unlike the low pass filter which only pass signals of a low frequency range or the high pass filter which pass signals of a higher frequency range, a Band Pass Filters passes signals within a certain "band" or "spread" of frequencies without distorting the input signal or introducing extra noise. This band of frequencies can be any width and is commonly known as the filters Bandwidth.

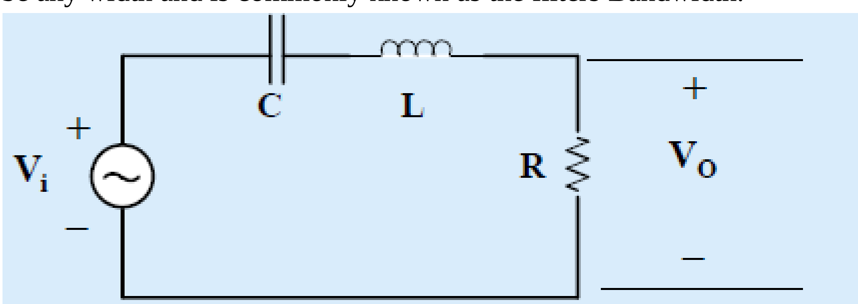


Figure 1: Bandpass filter circuit

Transfer Function Derivation:

$$V_{IN} = R*i(t) + (1/C)\int_0^t i(t)\,dt + L\frac{di(t)}{dt}$$

Where $i(t) = \frac{V_{OUT(t)}}{R}$

$$V_{IN}(t) = V_{OUT}(t) + (1/C)\int_0^t \frac{V_{OUT}(t)}{R}\,dt + (L/R)\frac{dV_{OUT}(t)}{dt}$$

Taking Laplace

$$V_{IN} = V_{OUT}(s) + (1/RCs) * V_{OUT}(s) + (L/R)s * V_{OUT}(s)$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{\frac{1}{RCs} + \frac{L}{R}s + 1}$$

$$\boxed{\frac{Vout(s)}{Vin(s)} = \frac{\frac{R}{L}s}{s^2 + \frac{R}{L}s + \frac{1}{LC}}}$$

Also well-known is the equation for calculating the -3dB (aka, half-power) cutoff frequency of the RC low pass filter:

$$\boxed{f_C = \frac{1}{2\pi RC}}$$

Code:

M-file code is attached at the end of this experiment.

Result and Comment:

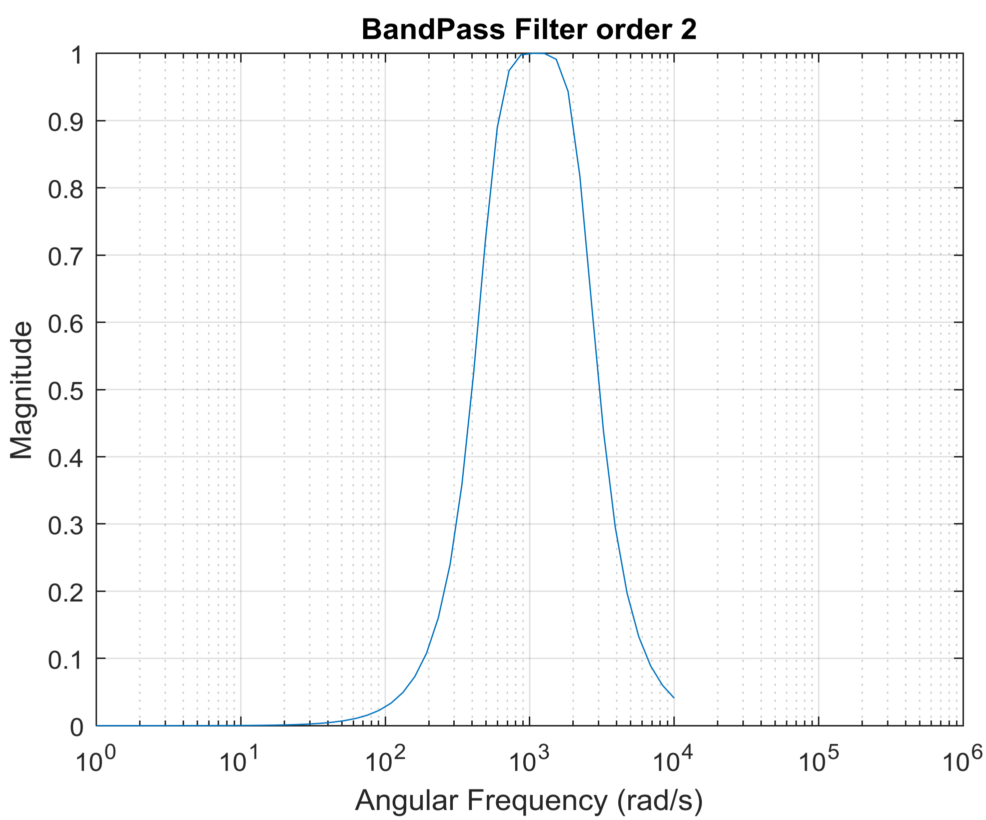


Figure 2: Bandpass filter output plot

- As you showed, it passed the band in between values 100 to 2100 and stopped the remaining bands. This is not an ideal case, that is why, it look liked that.

Lab # 6

Objectives:

- Design an analog bandstop butterworth filter using Matlab.
- Derive transfer function.
- Order of the filter centre frequency and bandwidth can be varied.
- Plot and comment on the response.

Introduction:

A band Stop Filter known also as a Notch Filter, blocks and rejects frequencies that lie between its two cut-off frequency points passes all those frequencies either side of this range.

By combining a basic RC low-pass filter with a RC high-pass filter we can form a simple band-pass filter that will pass a range or band of frequencies either side of two cut-off frequency points. But we can also combine these low and high pass filter sections to produce another kind of RC filter network called a band stop filter that can block or at least severely attenuate a band of frequencies within these two cut-off frequency points.

The Band Stop Filter, (BSF) is another type of frequency selective circuit that functions in exactly the opposite way to the Band Pass Filter we looked at before. The band stop filter, also known as a band reject filter, passes all frequencies with the exception of those within a specified stop band which are greatly attenuated.

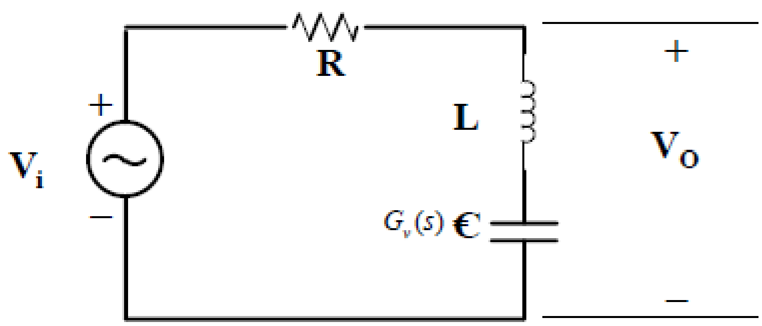


Figure 1: Bandsto filter circuit

Transfer Function Derivation:

$$V_{IN} = R*i(t) + (1/C)\int_0^t i(t)\,dt + L\frac{di(t)}{dt}$$

$$\boxed{\frac{Vout(s)}{Vin(s)} = \frac{s^2+\frac{1}{LC}}{s^2+\frac{R}{L}s+\frac{1}{LC}}}$$

Also well-known is the equation for calculating the -3dB (aka, half-power) cutoff frequency of the RC low pass filter:

$$\boxed{f_C = \frac{1}{2\pi RC}}$$

Code:

M-file code is attached at the end of this experiment.

Result and Comment:

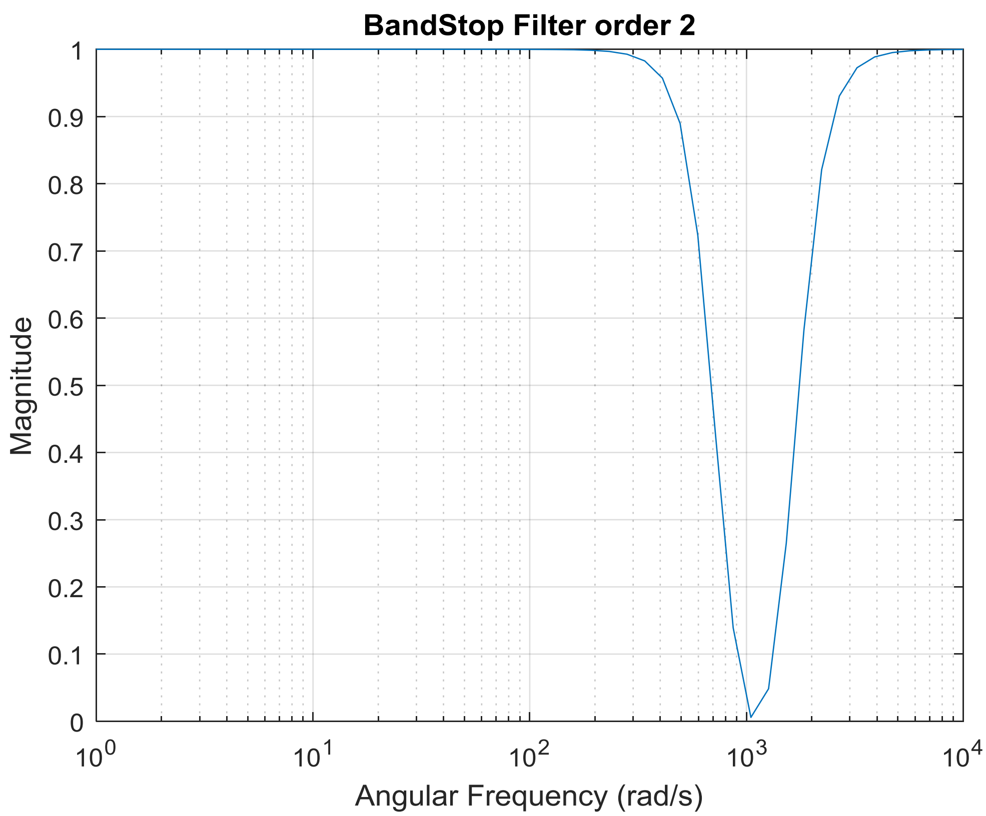


Figure 2: Bandpass filter output plot

- As you showed, it stopped the band in between values 400 to 1800 and passed the remaining bands. This is not an ideal case, that is why, it look liked that.

Lab # 7

Objectives:

- Lowpass filter design in MATLAB.
- Design a lowpass FIR filter for data sampled at 48 kHz. The passband-edge frequency is 8 kHz. The passband ripple is 0.01 dB and the stopband attenuation is 80 dB. Constrain the filter order to 120.

Introduction:

When designing a lowpass filter, the first choice you make is whether to design an FIR or IIR filter. You generally choose FIR filters when a linear phase response is important. FIR filters also tend to be preferred for fixed-point implementations because they are typically more robust to quantization effects. FIR filters are also used in many high-speed implementations such as FPGAs or ASICs because they are suitable for pipelining. IIR filters (in particular biquad filters) are used in applications (such as audio signal processing) where phase linearity is not a concern. IIR filters are generally computationally more efficient in the sense that they can meet the design specifications with fewer coefficients than FIR filters. IIR filters also tend to have a shorter transient response and a smaller group delay. However, the use of minimum-phase and multirate designs can result in FIR filters comparable to IIR filters in terms of group delay and computational efficiency.

FIR Lowpass Designs - Specifying the Filter Order:

There are many practical situations in which you must specify the filter order. One such case is if you are targeting hardware which has constrained the filter order to a specific number. Another common scenario is when you have computed the available computational budget (MIPS) for your implementation and this affords you a limited filter order. FIR design functions in the Signal Processing Toolbox (including fir1, firpm, and firls) are all capable of designing lowpass filters with a specified order. In the DSP System Toolbox, the preferred function for lowpass FIR filter design with a specified order is firceqrip. This function designs optimal equiripple lowpass/highpass FIR filters with specified passband/stopband ripple values and with a specified passband-edge frequency. The stopband-edge frequency is determined as a result of the design.

Code:

M-file code is attached at the end of this experiment.

Result and Comment:

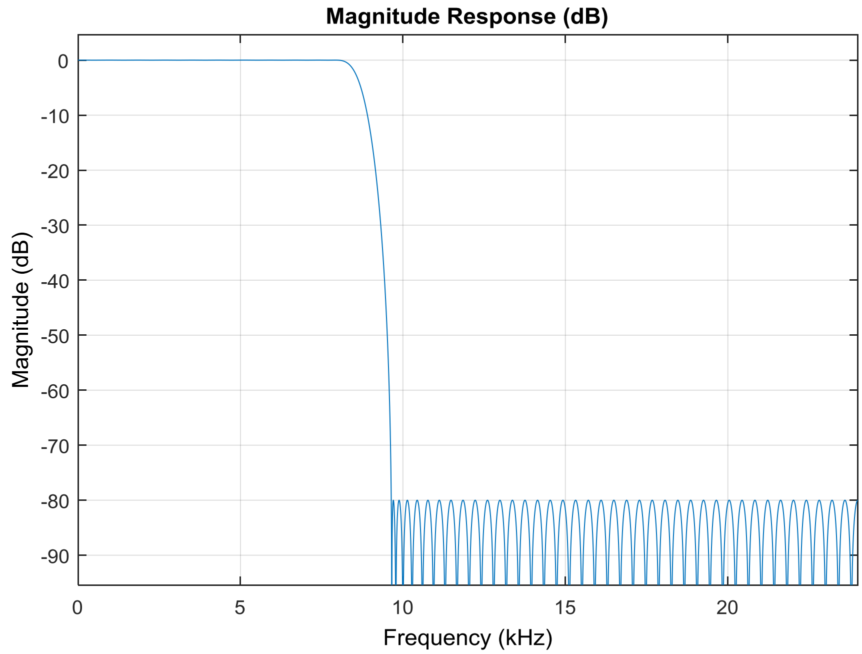


Figure 1: stop band frequency is 9.6 kHz

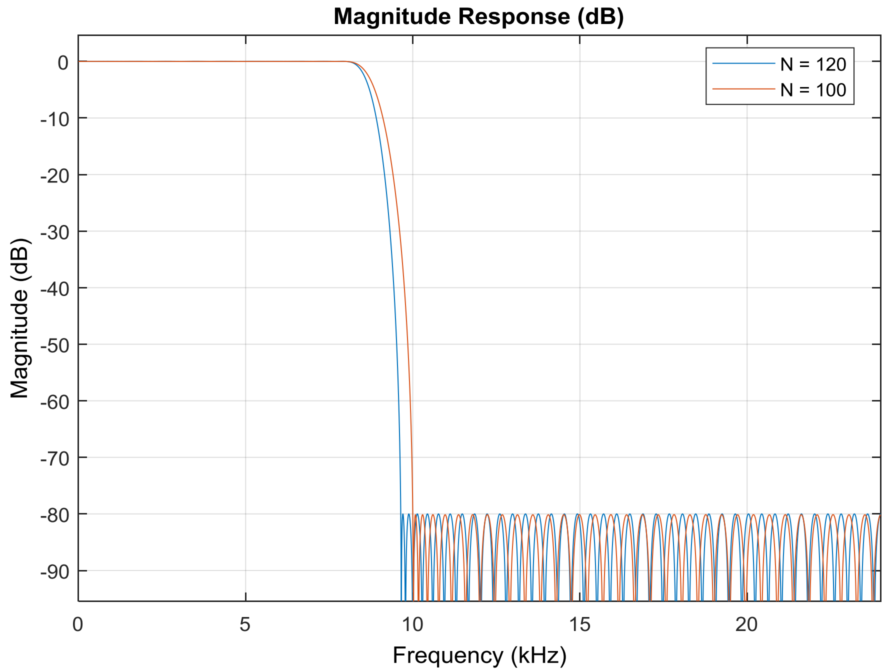


Figure 2: 100 and 120 ordered filter

- By increasing filter order, stop band frequency become 10 kHz.

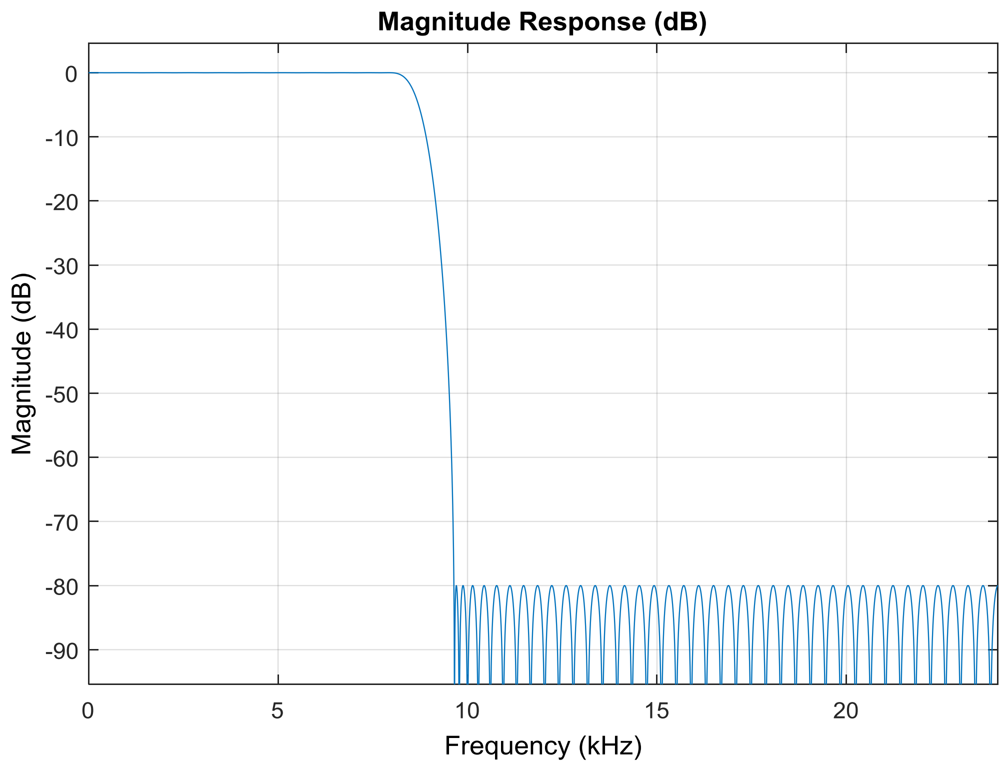


Figure 3: stop band frequency is 9.6 kHz

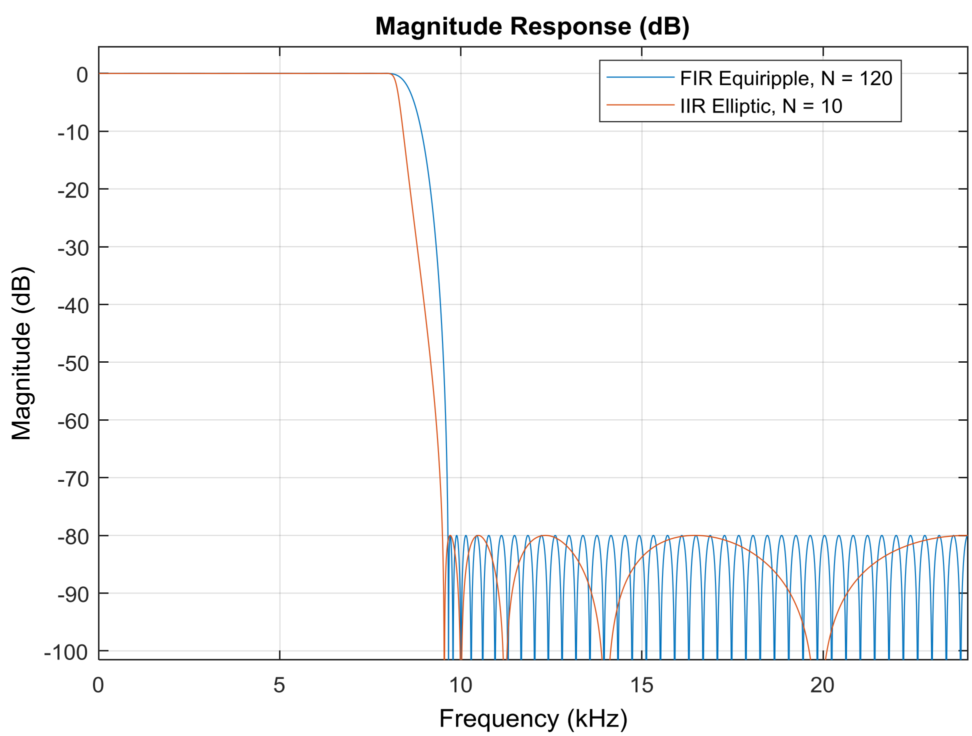


Figure 4: 120 (FIR Equiripple) and 10 (IIR Elliptic) ordered filter

- As you showed, Elliptic filter response is good than FIR Equiripple

Lab # 8

Objectives:

Implementation of digital filters on data captured using an inertial measurement unit (IMU) during level ground walking activities.

Introduction:

Human walking is formulated as a predictive dynamics problem in this chapter. Details of the walking cycle are described: single support phase, double support phase, swing phase, heel strike, toe-off, etc. The concept of a zero-moment point constraint is imposed in the formulation for dynamic stability. Constraints on the joint ranges of motion, joint torques, ground penetration, and self-avoidance are formulated and demonstrated in an example. Calculation of the ground reaction forces is explained. First, the one step formulation for the gait problem is formulated and solved. With this formulation only the symmetric gait can be simulated. Subsequently, the full stride problem is formulated and solved. With this formulation asymmetric gait can be simulated. Cause-and-effect of the predictive dynamics formulation is illustrated by restricting joint range of motion, changing loads, changes in anthropometry and other parameters. Normal walking kinematics and dynamics are validated with available experimental data.

Code:

M-file code is attached at the end of this experiment.

Result and Comment:

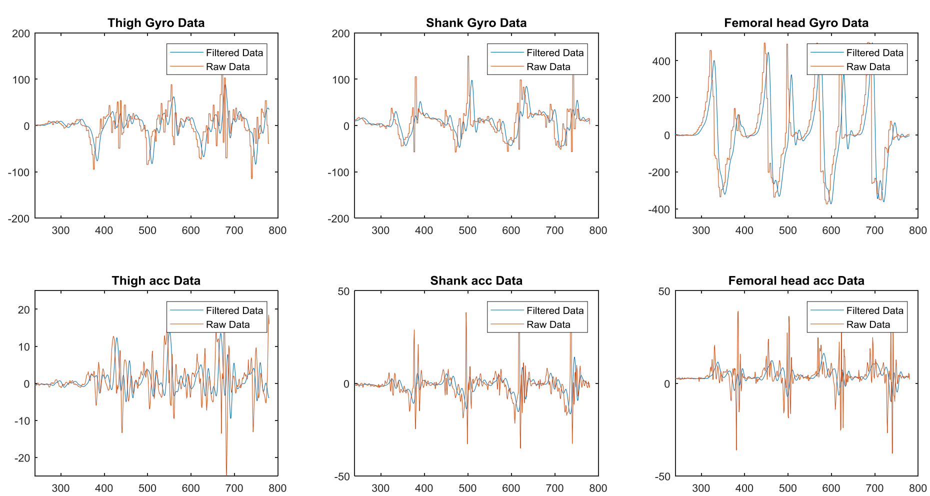


Figure 1: Normal place LGW data

- By increasing the filter order, ripples increased and by decreasing filter order, curve smoothed for low pass filter case.
- Cutoff frequency should be double than human frequency.

Lab # 9

Objectives:

Simulate visco-elastic models in Matlab Simulink.

Code for Figure 4.18:

```
x=[0:0.01:0.06];
N=x.*0+376;
V=x.*0+137;
M=137.*x-8.22;
figure
subplot(3,1,1),plot(x,N,x,N,'x')
xlabel('x [m]')
ylabel('N [N]')
title('Axial Force V')
subplot(3,1,2),plot(x,V,x,V,'x')
xlabel('x [m]')
ylabel('V [N]')
title('Shear Force V')
subplot(3,1,3),plot(x,M,x,M,'x')
xlabel('x [m]')
ylabel('M [N-m]')
title('Bending Moment M')
```

Results and: comment:

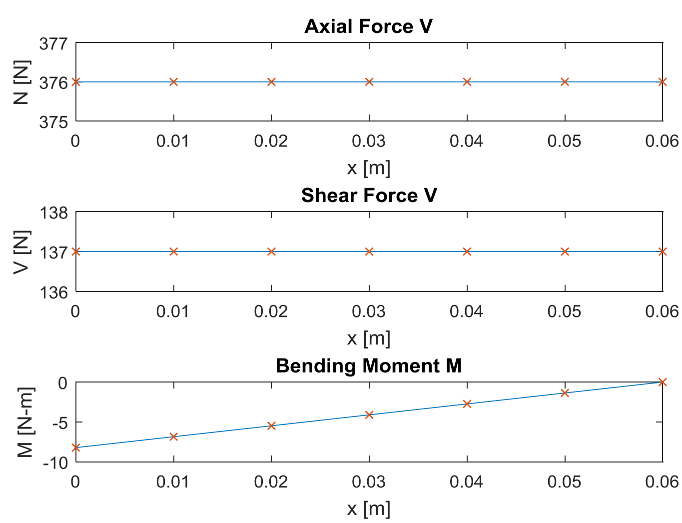
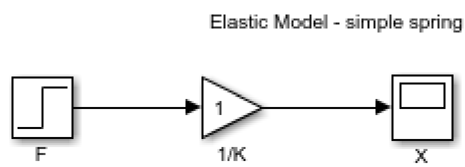


Figure 1: Output Graphs

- Distance isn't affecting on Axial and Shear force but, directly proportional to Bending moment.

Simulink for Figure 4.20:



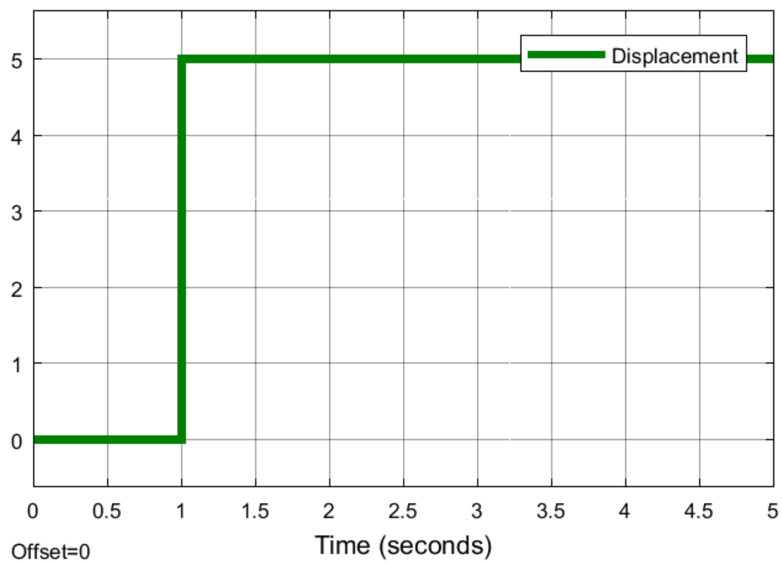
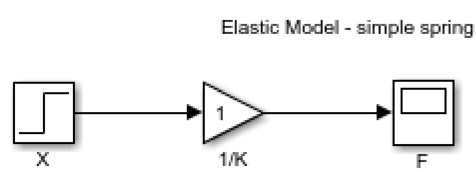


Figure 2: Creep

- A step change in force F to measure the resulting Change in length or position x is called Creep.

Simulink for Figure 4.21:



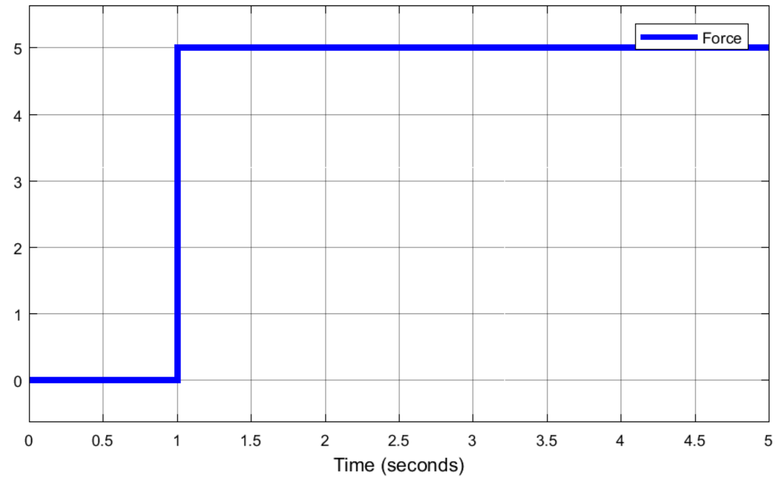
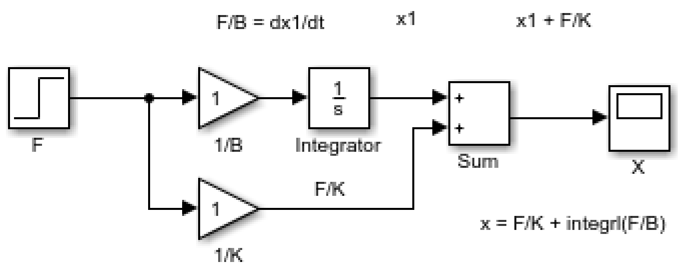


Figure 3: Stress Relaxation

- A step change in position x to measure the resulting Change in force F is called Stress Relaxation.

Simulink for Figure 4.22:



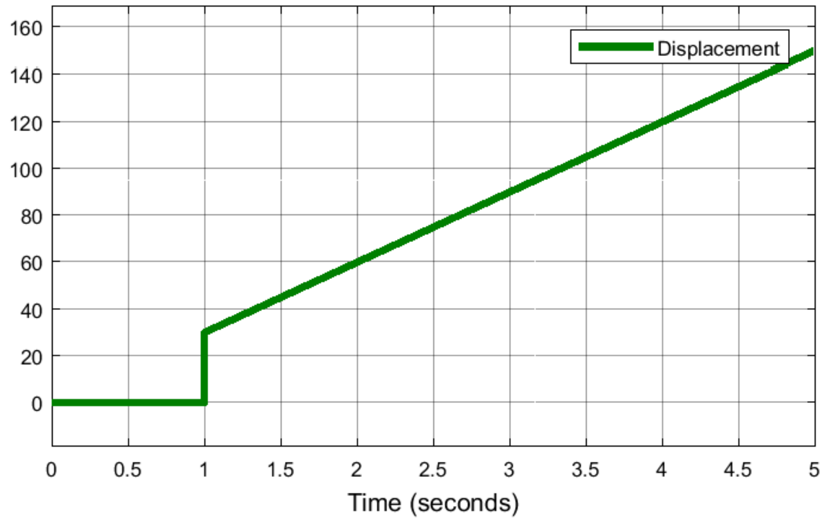


Figure 4: Creep of Maxwell model

- The creep response shows that this model is not bounded in displacement since an ideal dashpot may be extended forever

Lab # 10

Objectives:

- Introduction to Biomedical instrumentation lab.
- Introduction to Biomaterial lab.

Introduction:

Bioinstrumentation:

Bioinstrumentation is an application of biomedical engineering, which focuses on the devices and mechanics used to measure, evaluate, and treat biological systems. It focuses on the use of multiple sensors to monitor physiological characteristics of a human or animal. Such instrumentation originated as a necessity to constantly monitor vital signs of Astronauts during NASA's Mercury, Gemini, Apollo missions.

Bioinstrumentation is a new and upcoming field, concentrating on treating diseases and bridging together the engineering and medical worlds. The majority of innovations within the field have occurred in the past 15-20 years. Bioinstrumentation has revolutionized the medical field, and has made treating patients much easier. The instruments/sensors convert signals found within the body into electrical signals. There are many subfields within bioinstrumentation, they include: biomedical options, creation of sensor, genetic testing, and drug delivery. Other fields of engineering, such as electrical engineering and computer science, are related to bioinstrumentation.

Bioinstrumentation has since been incorporated into the everyday lives of many individuals, with sensor-augmented smartphones capable of measuring heart rate and oxygen saturation, and the widespread availability of fitness apps, with over 40,000 health tracking apps on iTunes alone. Wrist-worn fitness tracking devices have also gained popularity, with a suite of on-board sensors capable of measuring the user's biometrics, and relaying them to an app that logs and tracks information for improvements.

Biomaterial:

A biomaterial is any substance that has been engineered to interact with biological systems for a medical purpose - either a therapeutic (treat, augment, repair or replace a tissue function of the body) or a diagnostic one. As a science, biomaterials is about fifty years old. The study of biomaterials is called biomaterials science or biomaterials engineering. It has experienced steady and strong growth over its history, with many companies investing large amounts of money into the development of new products. Biomaterials science encompasses elements of medicine, biology, chemistry, tissue engineering and materials science.

Note that a biomaterial is different from a biological material, such as bone, that is produced by a biological system. Additionally, care should be exercised in defining a biomaterial as biocompatible, since it is application-specific. A biomaterial that is biocompatible or suitable for one application may not be biocompatible in another.

Bioinstrumentation

Bioinstrumentation lab instruments:

Mini-shaker for immunology:

Operating ambient temperature range 4– 45 degree celicius, speed range 150-1000rpm, analogue/digital timer, different capacity.
Use: For regulated shaking of micro test plates.

Figure 1: Mini Shaker

Centrifuge/Vortex Multi spin:

Multi-spin, automatic, averagely collecting 12 tubes at a time, spin regulation: 1000-3500 rpm, spintime: 1sec-99min.

Use: For collecting microvolumes of reagents on the microtube bottom, must have instrument in PCR.

Figure 2: Centrifuge

Universal water thermostat:

Temperature range up to 100oC , weight not more than 8 kg, optional flowing water cooler.

Use: For maintaining stable temperature.

Figure 3: Universal water thermostat

Magnetic Stirrers:

Speed range: 0-3000 rpm, stainless steel working plate, stand height up to 320mm.

Figure 4: Magnetic Stirrers

Laboratory microscope

4X,10X,40X, 100X objective, 10X,16X wide field eyepiece, sliding binocular head, double layer mechanical stage.

Figure 5: Laboratory microscope

Blood Bank Centrifuge:

Control panel with stepless speed control, digital speed indicator, and 0-99min digital timer, dynamic brake, zero start interlock, lid locking switch and safety cutoff.

Use: For centrifuging larger volume centrifuge tubes, bottles, blood bags etc.

Figure 6: Blood Bank Centrifuge

Hot Air Oven:

Free convenction electricity 220v and 50hz, chamber made of stainless steel sheet, circulating fan, temperature controller, temperature range 500C to 1800C.

Use: For drying and air sterilization of medical instruments, glasses, dishes and syringes.

Figure 7: Hot Air Oven

Biological Safety Cabinets:

Different classes class I/II 100 gradient in the front panel, reserved timer for 30 min, motor, front panel alarm device, heap filter efficiency 99.99%.

Use: provides clean air.

Figure 7: Biological Safety Cabinets

Shaking incubator:

Double walled construction with regular modes, replaceable air tubular heater, temperature controller, temperature range 5-600C.

Figure 8: Shaking incubator

Bacteriological Incubator:

Microprocessor based temperature controller having temperature range 50C to 600C, duly powder coated.

Figure 9: Bacteriological Incubator

Immersion Water Bath:

Water bath size of different in liters, mostly with open reservoir and immersion circulator.

Use: For heating temperature sensitive samples.

Figure 10: Immersion Water Bath

Lab # 11

Objectives:

- Introduction to biomechanics.
- Study of ECG.
- Study of EMG.
- Study of pulse Meter Module.

Introduction:

Biomechanics:

Biomechanics is the science of movement of a living body, including how muscles, bones, tendons, and ligaments work together to produce movement. Biomechanics is part of the larger field of kinesiology, specifically focusing on the mechanics of movement. It is both a basic and applied science, encompassing research and practical use of its findings.

Biomechanics includes not only the structure of bones and muscles and the movement they can produce, but also the mechanics of blood circulation, renal function, and other body functions. The American Society of Biomechanics says that biomechanics represents the broad interplay between mechanics and biological systems. Biomechanics studies not only the human body but also animals and even extends to plants and the mechanical workings of cells.

For example, the biomechanics of the squat includes consideration of the position and/or movement of the feet, hips, knees, back and shoulders and arms.

Elements of Biomechanics:

- **Statics:** Studying systems that are in equilibrium, either at rest or moving at a constant velocity.
- **Dynamics:** Studying systems that are in motion with acceleration and deceleration.
- **Kinematics:** Describing the effect of forces on a system, motion patterns including linear and angular changes in velocity over time. Position, displacement, velocity, and acceleration are studied.
- **Kinetics:** Studying what causes motion, the forces and moments at work.

Piezoelectric:

Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The word Piezoelectric is derived from the Greek piezein, which means to squeeze or press, and piezo, which is Greek for "push". One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (the generation of electricity when stress is applied) also exhibit the converse piezoelectric effect (the generation of stress when an electric field is applied).

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material. The piezoelectric effect is very useful within many applications that involve the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, and ultra-fine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, such as scanning probe microscopes (STM, AFM, etc). The piezoelectric effect also has its use in more mundane applications as well, such as acting as the ignition source for cigarette lighters.

Figure 1: Piezoelectric sensor

Lab Activity # 01

Objectives:

- To understand the functionality of EMG signals.

Apparatus:

- EMG Sensor
- Pc
- Power lab
- Lab tutor
- EMG connectors
- Dry band

Introduction:

Electromyography (EMG) is a technique for recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyography, to produce a record called an electromyogram. An electromyography detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, to analyze the biomechanics of human or animal movement. The electrical source is the muscle membrane potential of about -90 mV. Measured EMG potentials range between less than 50 μV and up to 20 to 30 mV, depending on the muscle under observation. Typical repetition rate of muscle motor unit firing is about 7–20 Hz, depending on the size of the muscle (eye muscles versus seat muscles), previous axonal damage and other factors. Damage to motor units can be expected at ranges between 450 and 780 mV.

This is very easy method to observer the movement of muscles and different problem and illness related to muscles contraction and relaxation.

Procedure:

1. First of all to perform the practical the patient body muscles relaxed.
2. Different color electrode attached on the arm muscle on biceps and triceps positions.
3. The other side of the electrode connector attached on the lab tutor.
4. Now click on the start button on LCD with the help of mouse.
5. Patient bends their arm the contraction of biceps muscles and relaxes the triceps muscles in this condition.
6. Now the patient arm in straight and in this condition the biceps muscles in relax condition and triceps muscle contract condition.
7. Measure the signal on LCD in graphically signals and click on stop.

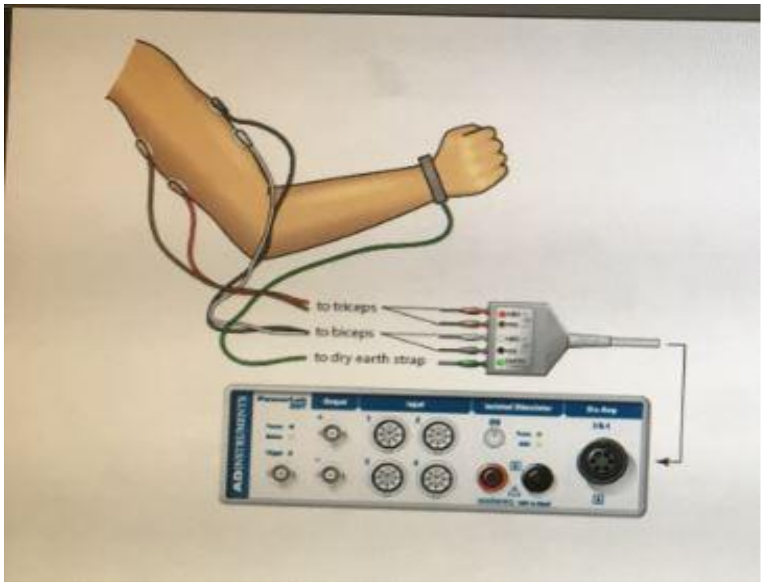


Figure 2: EMG_Connections

Results:

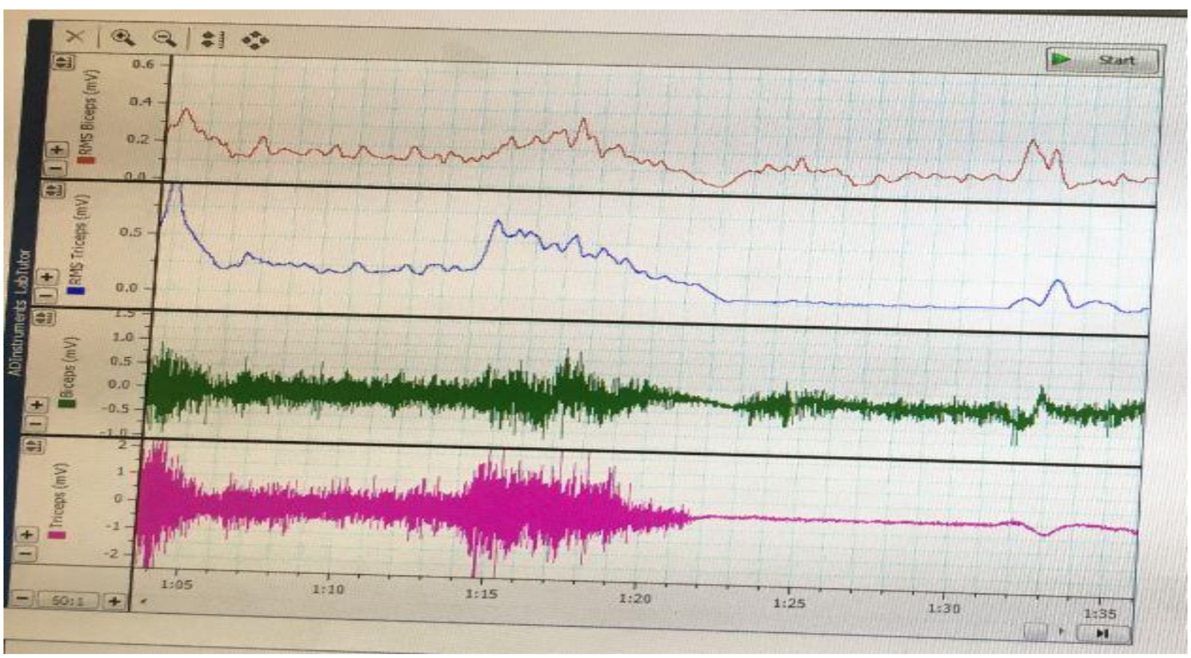


Figure 3: EMG Output waves

Conclusion:

When biceps is contract then triceps is relax and when triceps is contract then biceps is relax.

Lab Activity # 02

Objectives:

- To understand the basic operation of CAPSTONE and interfacing Goniometer sensor with Use to measure the angle of joints.

Apparatus:

- Goniometer Sensor
- PC with Capstone software

Introduction:

We are using the CAPSTONE software made by PASCO company and it is used to measure different forces output with the help of force sensor and gives us the measurement in graphical. On the two axis measure forces many points with respect to time change.

PRE-processor is a device which we use one side is connect with PC to get signal the signal is very poor and in analog form. In PRE-processor proper circuit is use. Signal is come in analog form and convert into Digital form with the help of ADC. Signal is week amplifier also used for make the signal strong and make it readable for computer.

Goniometer is a sensor which we use for check the joint angles movement or angle of freedom. Mostly use when body joints is fractured. Basically goniometer measure the joint angle movement around **0 to 180 degree**.

Gyroscope is use mostly in mobiles for angular rotation or angular acceleration measurement, here are two types of the gyroscopes use;

1. Angular acceleration gyroscope
2. Linear acceleration gyroscope

Linear acceleration:

Linear acceleration is process to measuring how fast the velocity of an objects. The formula to calculate velocity is just distance/time. This gives how fast an object is moving at a certain time. However, speed is not always the same.

Angular acceleration:

Angular acceleration, also called rotational acceleration, is a quantitative expression of the change in angular velocity that a spinning object undergoes per unit time. It is a vector quantity, consisting of a magnitude component and either of two defined directions or senses.

The magnitude, or length, of the angular acceleration vector is directly proportional to the rate of change of angular velocity, and is measured in radian s per second squared (rad/s^2 or $rad \cdot s^{-2}$). Alternatively, the angular acceleration magnitude can be expressed in degrees per second squared (deg/s^2 or $deg \cdot s^{-2}$). The direction of the angular acceleration vector is perpendicular to the plane in which the rotation takes place. If the increase in angular velocity appears clockwise with respect to an observer, then the angular acceleration vector points away from the observer. If the increase in angular velocity appears counterclockwise, then the angular acceleration vector points toward the observer.

Procedure:

1. Goniometer sensor which we use in this experiment. Orthopedic is used this sensor or measuring the angle of joints for during the fracture.
2. Goniometer connected with the PRE-processor and other side is connected with PC.
3. Make sure conform PC is connected if not connect then restart.
4. Now start the **CAPSTONE** software with press on start button and measure the angle of movement with the goniometer sensor.
5. If injured the radius, ulna joint then sensor is connected with joint and check the joint how much movement. After some again performs this procedure and check how much recover the joint movement.
6. We measure some joint in graphical representation in positive form and some time in negative form. Like radius, ulna joint movement in positive direction and knee joint measure the negative side.
7. Now go on graph and right click on x-axis select the time option and same action performs on y-axis and selected the angle of radius.
8. If sensor pushes upward the points go on graph upper side on reference line this time graph will change again repeated and measure the different angle values.
9. When change the graph position on reference line the automatically vale enter in the table.
10. Now print that graph and stop the software.

Results:

- We have checked how much angle change with respect to time.
  Figure 3: EMG Output waves

S=rQ if,
Q=r/S find the angle using this formula.

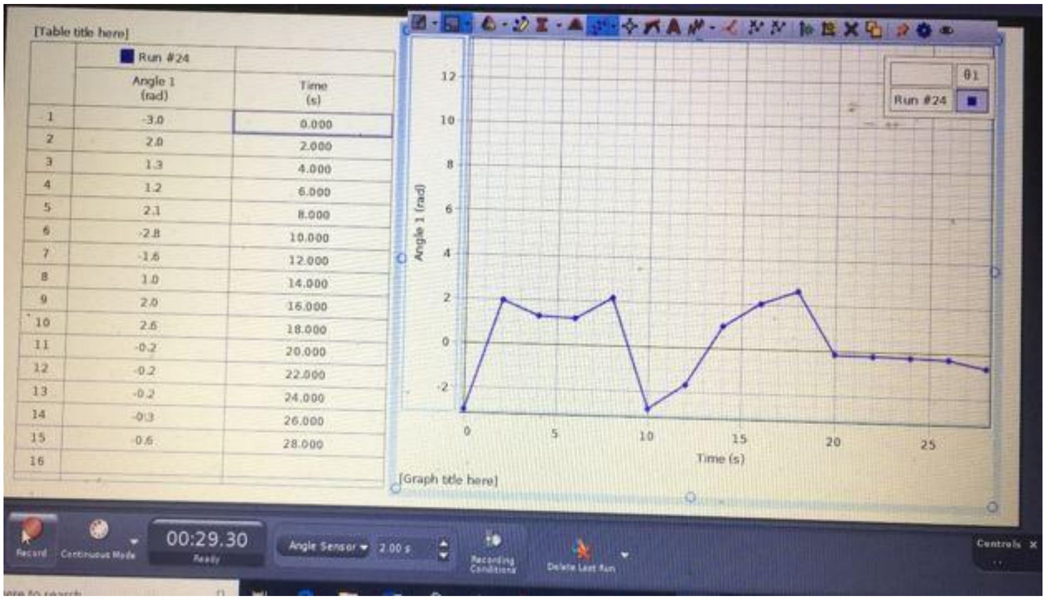


Figure 4: Goniometer sensor Output waves

Conclusion:

We can measure the different angle with respect to radius change the value at reference point.

Lab Activity # 3

Objectives:

- To understand the functionality of EEG (Electroencephalography) signals.

Apparatus:

- EEG Sensor
- Pc
- Power lab
- Lab tutor
- EEG connectors
- Dry band

Introduction:

Electroencephalography (**EEG**) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasive, with the electrodes placed along the scalp, although invasive electrodes are sometimes used, as in electrocardiography. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. Clinically, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp.[1] Diagnostic applications generally focus either on event-related potentials or on the spectral content of EEG. The former investigates potential fluctuations time locked to an event, such as 'stimulus onset' or 'button press'. The latter analyses the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals in the frequency domain.

EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, depth of anesthesia, coma, encephalopathies, and brain death. EEG used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders, but this use has decreased with the advent of high-resolution anatomical imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis. It is one of the few mobile techniques available and offers millisecond-range temporal resolution which is not possible with CT, PET or MRI.

Procedure:

- **Results:**

- **Conclusion:**

- First of all, place the EEG Sensor two electrodes on Forehead.
- sPlace the third reference electrode on bone.
- Now open the Lab Tutor software**.**
- Open analysis of tables.
- Now open the alpha and beta outputs rhythm.
- AND blink your eye and check the graphs.

Positioning of Electrode:

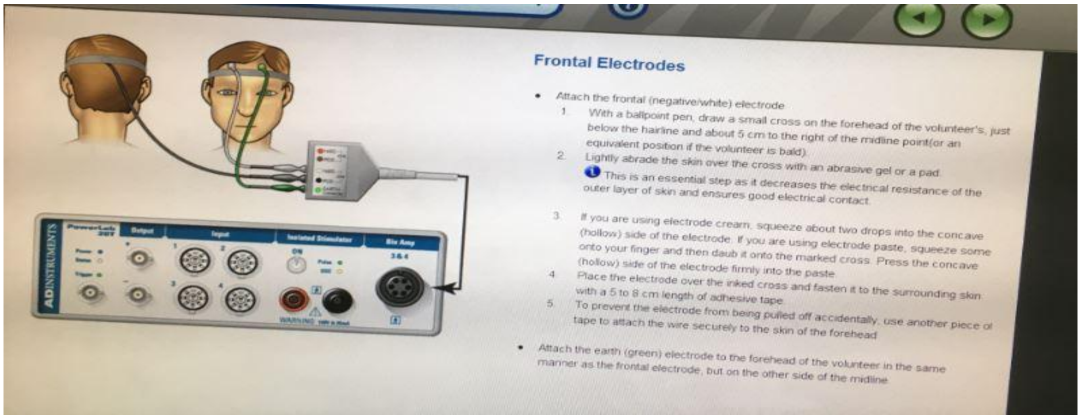


Figure 5: Positioning of Electrode

Occipital Electrode:

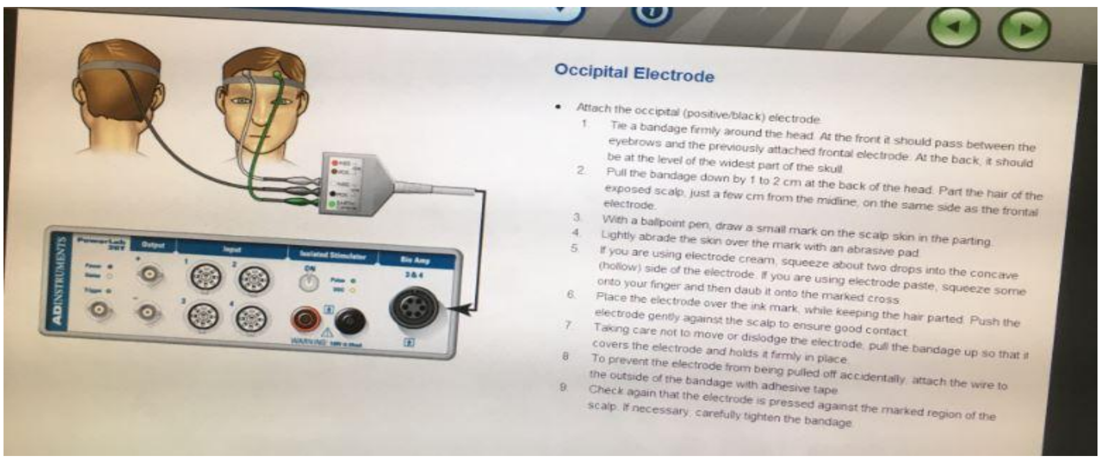


Figure 6: Occipital Electrode

Volunteer Positioning:

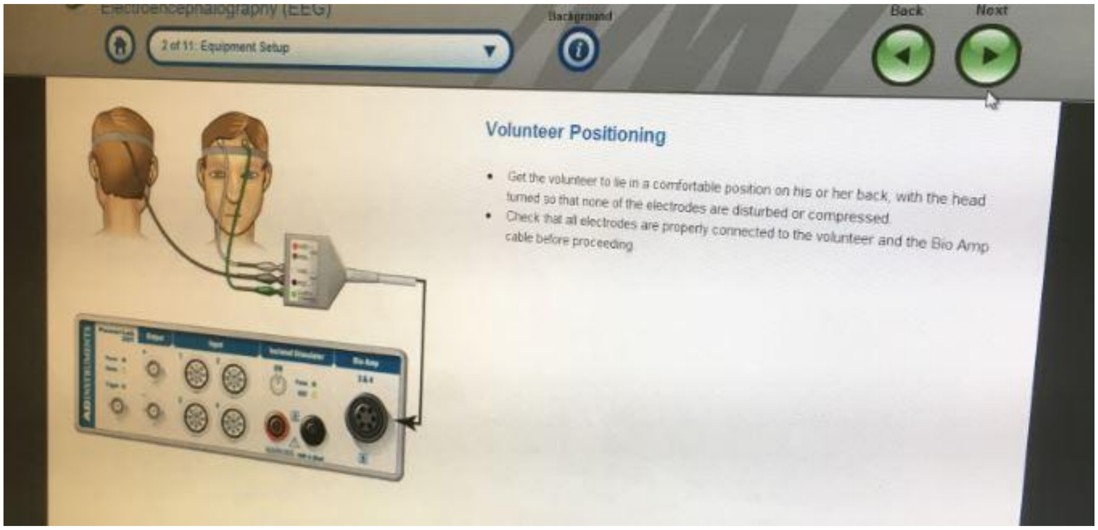


Figure 7: Volunteer Positioning

Results:

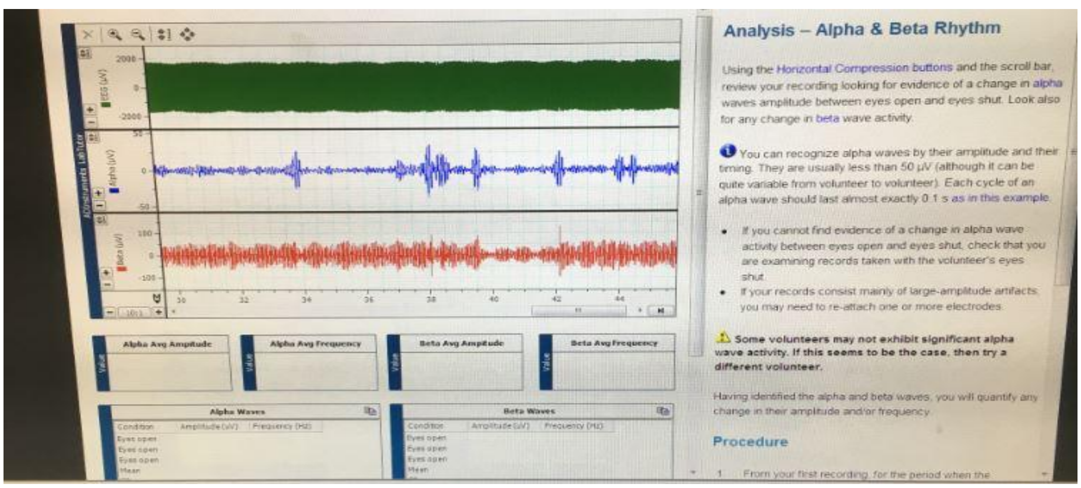


Figure 8: Analysis of Alpha & Beta Rhythm

Lab # 12

Objectives:

- Introduction to bio instrumentation.
- Study of ECG.
- Study of EMG.
- Study of pulse Meter Module.

Introduction:

Bioinstrumentation:

Bioinstrumentation is an application of biomedical engineering, which focuses on the devices and mechanics used to measure, evaluate, and treat biological systems. It focuses on the use of multiple sensors to monitor physiological characteristics of a human or animal. Such instrumentation originated as a necessity to constantly monitor vital signs of Astronauts during NASA's Mercury, Gemini, Apollo missions.

Bioinstrumentation is a new and upcoming field, concentrating on treating diseases and bridging together the engineering and medical worlds. The majority of innovations within the field have occurred in the past 15-20 years. Bioinstrumentation has revolutionized the medical field, and has made treating patients much easier. The instruments/sensors convert signals found within the body into electrical signals. There are many subfields within bioinstrumentation, they include: biomedical options, creation of sensor, genetic testing, and drug delivery. Other fields of engineering, such as electrical engineering and computer science, are related to bioinstrumentation.

Bioinstrumentation has since been incorporated into the everyday lives of many individuals, with sensor-augmented smartphones capable of measuring heart rate and oxygen saturation, and the widespread availability of fitness apps, with over 40,000 health tracking apps on iTunes alone. Wrist-worn fitness tracking devices have also gained popularity, with a suite of on-board sensors capable of measuring the user's biometrics, and relaying them to an app that logs and tracks information for improvements.

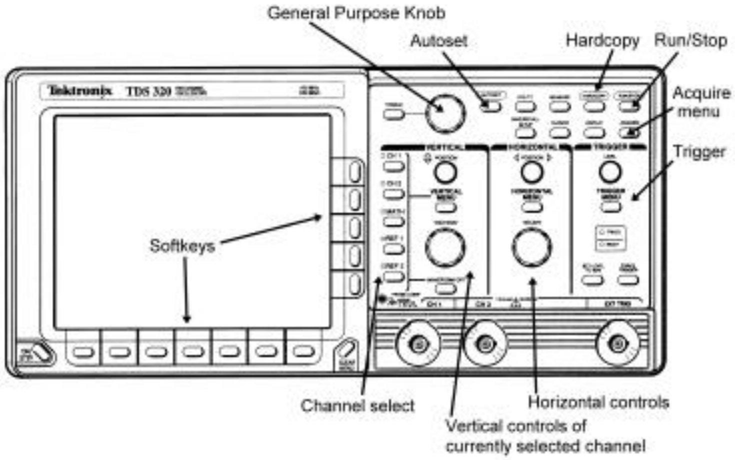
Oscilloscope basics:

All oscilloscopes share certain basic features. Refer to Fig. 1 to see where typical controls may be found.

- The most recognizable feature: a screen. On older analog scopes this is a cathode-ray tube or CRT; the signal creates a moving dot or \trace" across the screen. On newer digital scopes the screen is a CRT or at-panel display that operates like a computer monitor. The basic use of the screen is to display the signals in a voltage versus time graph. The screen usually has a graticule on it of about 1 cm squares.
- At least two (maybe more) signal inputs, or "channels", typically called "CH1", "CH2", etc., and one external "trigger" input, typically called "EXT TRIG".

- A collection of controls related to vertical part of the display associated with the input signals. These control the kind of coupling to the input: direct “DC", through a capacitor “AC", or disconnected “GND". The amount of amplification applied to the signal is controlled by a knob, and is specified in terms of screen units: a “10mV/div" setting means that a 10 millivolt change in the input signal will move the trace vertically by one major division.
- A collection of controls related to the horizontal part of the display. These controls set the time axis and are calibrated in seconds per division, e.g., 1μs/div means that one major division corresponds to 1 microsecond. The horizontal controls are sometimes called the “timebase" and the setting is called the “sweep rate".
- A collection of controls called the “trigger" that are used to synchronize the input signal to the horizontal display. Because there is no fixed relationship between an external signal and the internal timebase, the trigger makes the scope wait until some prescribed level in an input is reached before beginning its display.

In addition to the above features which are common to both analog and digital varieties, digital oscilloscopes typically come with the ability to save data and control settings to memory, perform mathematical operations on data traces, average many cycles together to reduce the effect of random fluctuations, and carry out automatic measurements of frequency and amplitude of the input signals. One can also make printouts of the display screen to keep a paper record of the measurement. The basic and advanced features of oscilloscopes will be explored in the following exercises.



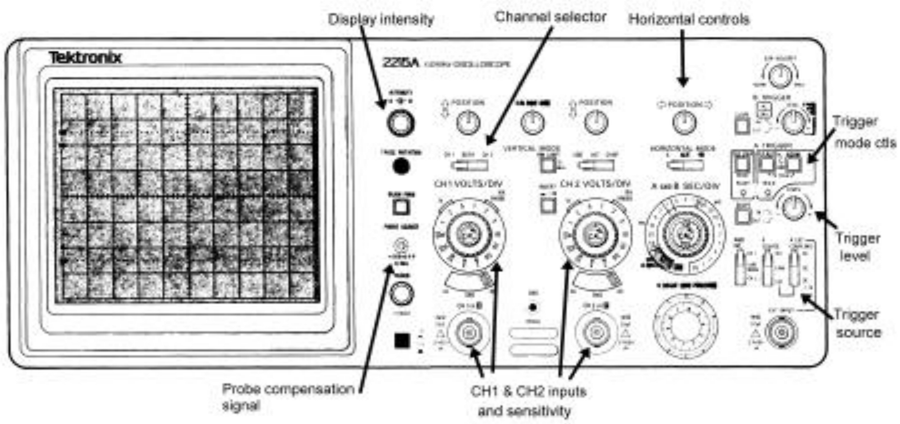


Figure 1: oscilloscope

Function generator basics:

Function generators, whether the old analog type or the newer digital type, have a few common features:

- A way to select a waveform type: sine, square, and triangle are most common, but some will give ramps, pulses, “noise", or allow you to program a particular arbitrary shape.
- A way to select the waveform frequency. Typical frequency ranges are from 0.01 Hz to 10 MHz.
- A way to select the waveform amplitude.
- At least two outputs. The “main" output, which is where you find the desired waveform, typically has a maximum voltage of 20 volts peak-to-peak, or $\pm$10 volts range. The most common output impedance of the main output is 50 ohms, although lower output impedances can sometimes be found. A second output, sometimes called “sync", “aux" or “TTL" produces a square wave with standard 0 and 5 volt digital signal levels. It is used for synchronizing another device (such as an oscilloscope) to the possibly variable main output signal.

A wide variety of other features are available on most modern function generators, such as “frequency sweep" the ability to automatically vary the frequency between a minimum and maximum value, “DC offset" a knob that adds a specified amount of DC voltage to the time-varying waveform, and extra inputs or outputs that can be used to control these extra features by other instruments.

Figure 2: Function generator

Lab Activity 1

Objectives:

- To understand the functionality of ECG signals.

Equipment Required:

- KL-72001 Main Unit
- KL-75001 Electrocardiogram
- ECG Module Digital Storage
- Oscilloscope ECG Simulator
- KL-79101 5-Conductor Electrode Cable
- Alcohol Prep Pads
- Lead Clamps
- Electrode Leads
- DB9 Cable
- BNC Cable
- RS-232 Cable
- Connecting Wires
- 10-mm Bridging Plugs
- Trimmer

Theory:

Electrocardiography is the process of producing an electrocardiogram (ECG or EKG), a recording - a graph of voltage versus time - of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat). Changes in the normal ECG pattern occur in numerous cardiac abnormalities, including cardiac rhythm disturbances (such as atrial fibrillation and ventricular tachycardia), inadequate coronary artery blood flow (such as myocardial ischemia and myocardial infarction), and electrolyte disturbances (such as hypokalemia and hyperkalemia).

In a conventional 12-lead ECG, ten electrodes are placed on the patient's limbs and on the surface of the chest. The overall magnitude of the heart's electrical potential is then measured from twelve different angles ("leads") and is recorded over a period of time (usually ten seconds). In this way, the overall magnitude and direction of the heart's electrical depolarization is captured at each moment throughout the cardiac cycle.

There are three main components to an ECG: the P wave, which represents the depolarization of the atria; the QRS complex, which represents the depolarization of the ventricles; and the T wave, which represents the repolarization of the ventricles.

During each heartbeat, a healthy heart has an orderly progression of depolarization that starts with pacemaker cells in the sinoatrial node, spreads throughout the atrium, passes through the atrioventricular node down into the bundle of His and into the Purkinje fibers, spreading down and to the left throughout the ventricles. This orderly pattern of depolarization gives rise to the characteristic ECG tracing. To the trained clinician, an ECG conveys a large amount of information about the structure of the heart and the function of its electrical conduction system. Among other things, an ECG can be used to measure the rate and rhythm of heartbeats, the size and position of the heart chambers, the presence of any damage to the heart's muscle cells or conduction system, the effects of heart drugs, and the function of implanted pacemakers.

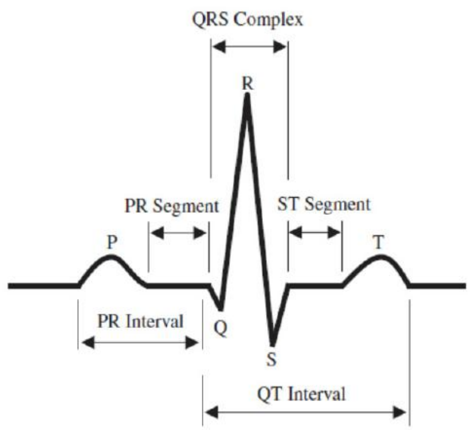


Figure 3: ECG signal

Procedure:

- Set the KL-75001 ECG module on the KL-72001 main unit. Then, complete the connection.
- On KL-75001 ECG module, insert bringing plugs in position 1,2,3,4,5 and 6 (HPF cutoff frequency = 1HZ), 9, 10, 11 and 12 or 13 (BRF center frequency 50 or 60Hz in accordance with local line frequency).
- Connect the outputs of ECG Simulator to the lead side of KL-79101 5-Conductor electrode cable as follows: RA-1, LA-2, LL-3, RL-5. Connect the module side of KL-79101 5-conductor electrode cable to J1 connect on KL-75001 ECG module. According to the message shown in LCD module, choose an output of 60 beats per minute and amplitude of 1. Then, ECG simulator produces standard ECG signals.
- Turn Power on. Select module: KL-75001 item for the LCD display by pressing the select button of main unit. Set mode select switch to the lead 1 position. Record the Vo1 waveform displayed on CH1 trace. Make sure that the amplifier VR1 has been adjusted for maximum undistorted output amplitude. Repeat step 5 for the signals of the lead II, lead III, aVr, aVl and aVf by switching mode select to the corresponding position and recording the waveform. Remove bridging plugs from position 5 and 6 to position 7 and 8. This change the cutoff frequency of HPF from 1Hz to 0.1Hz. Repeat step 5 to 7. Turn power off and disconnect circuit.

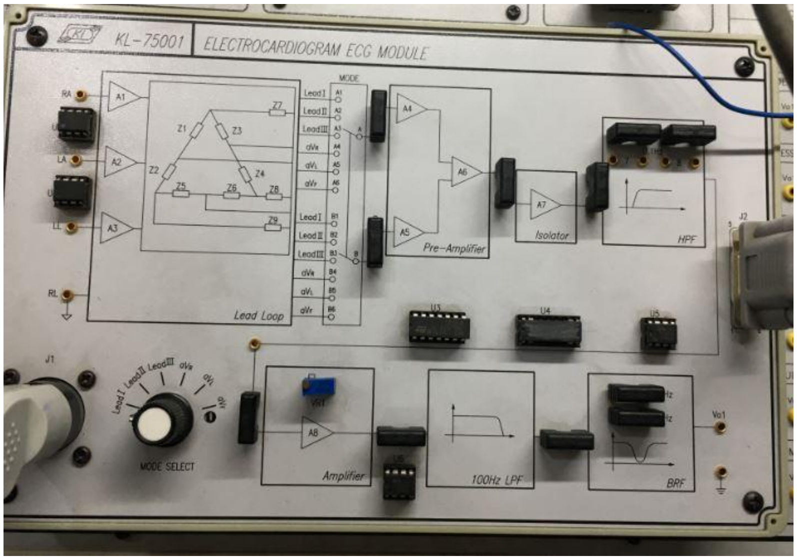


Figure 4: ECG Module

Results:

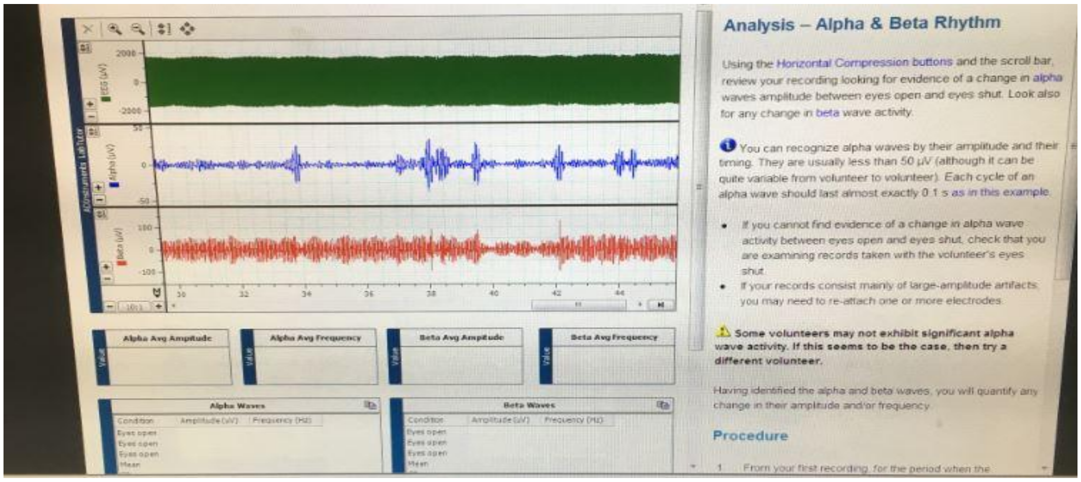


Figure 8: Analysis of Alpha & Beta Rhythm

Lab Activity # 02

Objective:

- To understand the functionality of EMG signals.

Equipment Required:

- KL-72001 Main Unit
- KL-75002 Electromyogram EMG Module
- Digital Storage Oscilloscope
- Body surface electrode
- KL-79101 5-Conductor Electrode Cable
- Alcohol Prep Pads
- 5-kg dumbbell
- Electrode Leads
- DB9 Cable
- BNC Cable
- RS-232 Cable
- Connecting Wires
- 10-mm Bridging Plugs
- Trimmer

Procedure:

- Set the KL-75002 EMG module on the KL-72001 main unit. Then, complete the connection.
- On KL-75002 EMG module, insert bringing plugs in position 1, 2, 4 (line frequency = 60HZ), 5, 6, 8 (gain = 100) 9, 10 and 11.
- Ask subject to take away watch and ornament from his hand.
- Ask subject to stand and relax naturally his right hand (finger tips to the ground) and turn the palm to face towards.
- Ask the subject to hold 5-ks dumbbell, then lift it by bending his elbow. Clear the skin of biceps with alcohol prep pads in order to reduce resistance. Then, place two electrodes on arm.
- Use alcohol prep pads to clear the skin on the upper left arm for reducing skin resistance. Place the reference electrode on. Since it just a reference point, you can choose anywhere you want to the left arm.
- Connect electrodes to the lead side of KL-79101 5-Conductor electrode cable. Connect the other side of KL-79101 5-Conductor electrode cable to J1 connector on the KL-75002 EMG module.
- Turn power on. Select module KL-75002 (EMG) from LCD by pressing select button of KL-72001 main unit.

- Set the VOLT/DIV controls of CH1 and CH2 to 1 V/div and set the Time/DIV control to 500 mS/div.

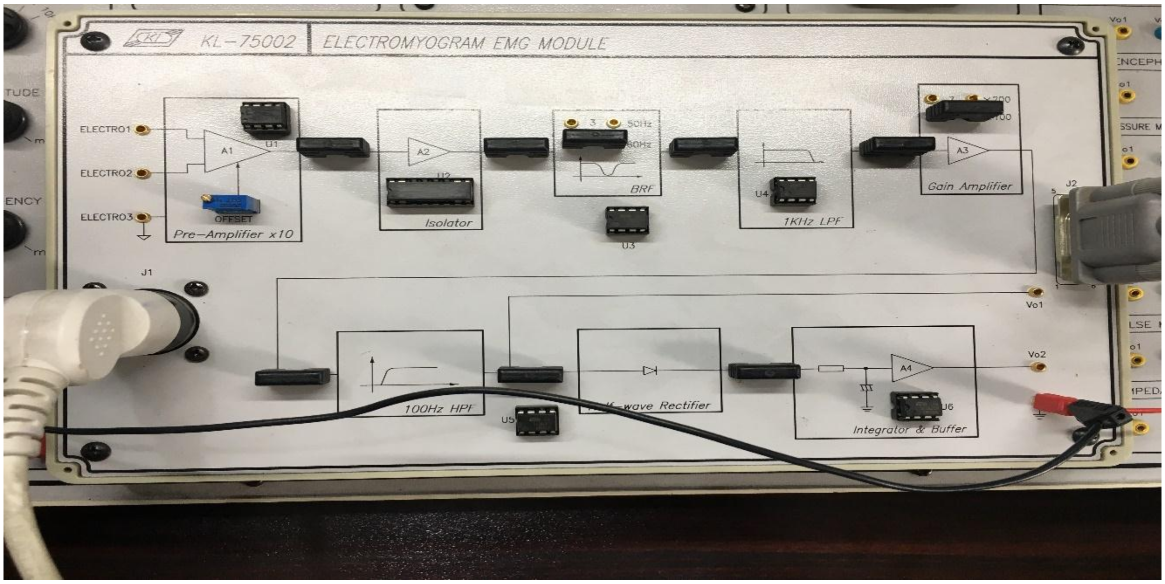


Figure 5: EMG Module

Results:

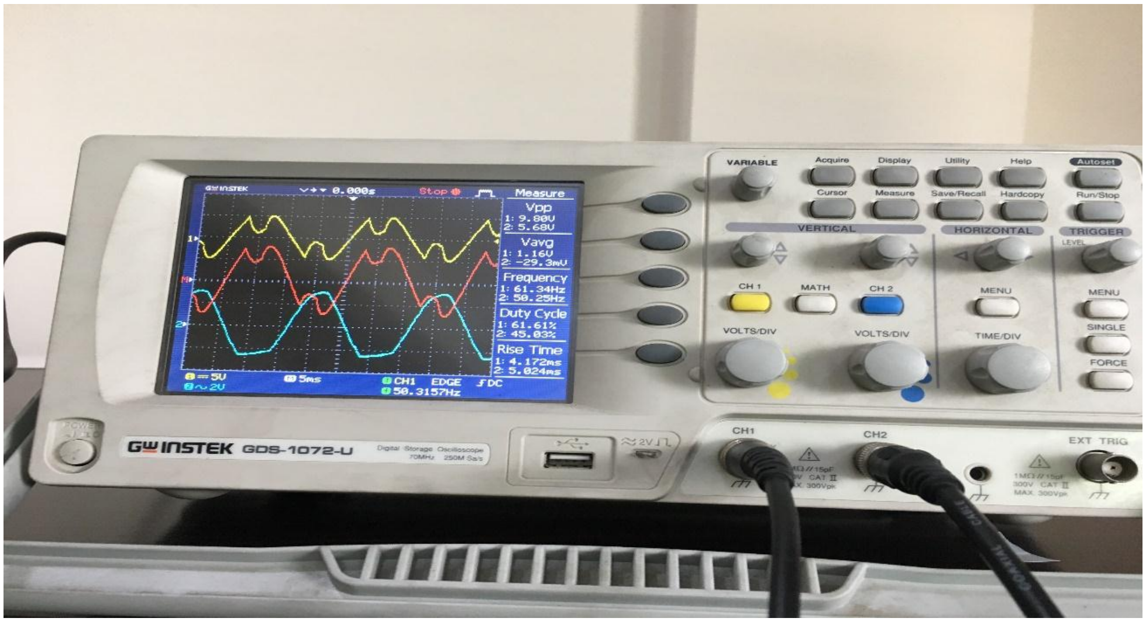


Figure 6: EMG waves output

Lab Activity # 03

Objective:

- Study of incubator

Theory:

Incubator is a device used to grow and maintain microbiological cultures or cell cultures. The incubator maintains optimal temperature, humidity and other conditions such as the CO (CO2) and oxygen content of the atmosphere inside. Incubators are essential for a lot of experimental work in cell biology, microbiology and molecular biology and are used to culture both bacterial as well as eukaryotic cells.

Louis Pasteur used the small opening underneath his staircase as an incubator. Incubators are also used in the poultry industry to act as a substitute for hens. This often results in higher hatch rates due to the ability to control both temperature and humidity. Various brands of incubators are commercially available to breeders.

The simplest incubators are insulated boxes with an adjustable heater, typically going up to 60 to 65 °C (140 to 150 °F), though some can go slightly higher (generally to no more than 100 °C). The most commonly used temperature both for bacteria such as the frequently used E. coli as well as for mammalian cells is approximately 37 °C (99 °F), as these organisms grow well under such conditions. For other organisms used in biological experiments, such as the budding yeast Saccharomyces cerevisiae, a growth temperature of 30 °C (86 °F) is optimal.

Figure 7: Incubator

More elaborate incubators can also include the ability to lower the temperature (via refrigeration), or the ability to control humidity or CO2 levels. This is important in the cultivation of mammalian cells, where the relative humidity is typically >80% to prevent evaporation and a slightly acidic pH is achieved by maintaining a CO2 level of 5%.

Incubator is used for the pre mature babies to maintain the body temperature and make environment which is required for the baby. Air is provide from different sides and distribute it uniformly. For setting the temperature we have two modes

- Skin temperature control
- Air temperature control

At the end if it require humidity it will be provide from the water.

Ultra sound:

By ultra sound we can get the body part image, even, we also check the motion of fetus.

Figure 8: Ultra Sound

Conclusion:

We perform different experiment like ECG, EMG and also study about the Incubator and procedure of ultra sound.