EXPERIMENT 3 ELECTRO-OCULOGRAM(EOG) MEASUREMENT

3.0 OBJECTIVE

The goal of the experiment is to help students understand the electrical alteration in the muscles that control the eyeball motion. In this experiment, the electrical activities in six bundles of muscle regulating the eyeball motion will be measured. And, students can observe how different eye muscles act when the eyeball moves in horizontal or vertical way. It helps them comprehend the response of the brain cortex.

3.1 PHYSIOLOGICAL PRINCIPLE

The eye movements are controlled by three separate pairs of muscles, including the medial and lateral recti, and the superior and inferior recti and oblique as shown in Figure 3.1. The medial and lateral recti contract reciprocally, it enables the eyeballs to move from side to side. The superior and inferior recti contract reciprocally to move the eyeballs upward or downward. And the oblique muscles operate mainly to rotate the eyeballs for keeping the visual fields in the upright position. Distribution of the muscles for controlling the two eyes is symmetrical. Figure 3.2 indicates the four-direction motion of the eyes and their corresponding eye muscle activities. The three pairs of ocular muscles are controlled by the third, fourth, and sixth cranial nerves. Either by way of this medial longitudinal fasciculus or by way of other closely associated pathways, each of the three sets of muscles to each eye is reciprocally innervated so that one muscle of the pair relaxes while the other contracts.

The most important movements of the eyes are those that cause the eyes to “fix” on a discrete portion of the field of vision. The fixation mechanism is primarily controlled by the secondary visual areas of the occipital cortex. Visual fixation can lock the target on the central area of the retina. When the object image moves from the center of the fovea to the fovea edge, the reflex response through the negative

feedback mechanism will regulate the three pairs of ocular muscles to move the object image back to the center of the fovea. Thus, as the image moves upwards, the eyeballs will move downwards; when the image moves to the left, the eyeballs will move to the right. Both actions as described above will finally move the image back to the center of the fovea. Therefore, the locked object will be always kept, by means of the eye movements, on the center of the fovea in order to obtain the clearest image.

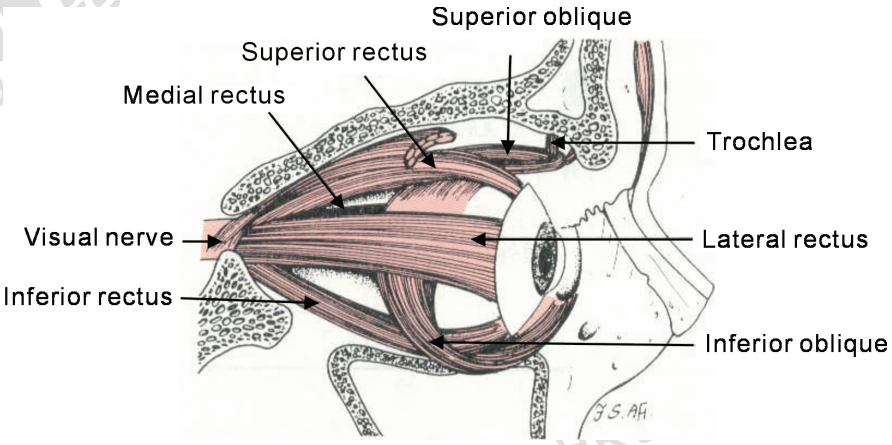


Figure 3.1 Three pairs of extraocular muscles and their positions.

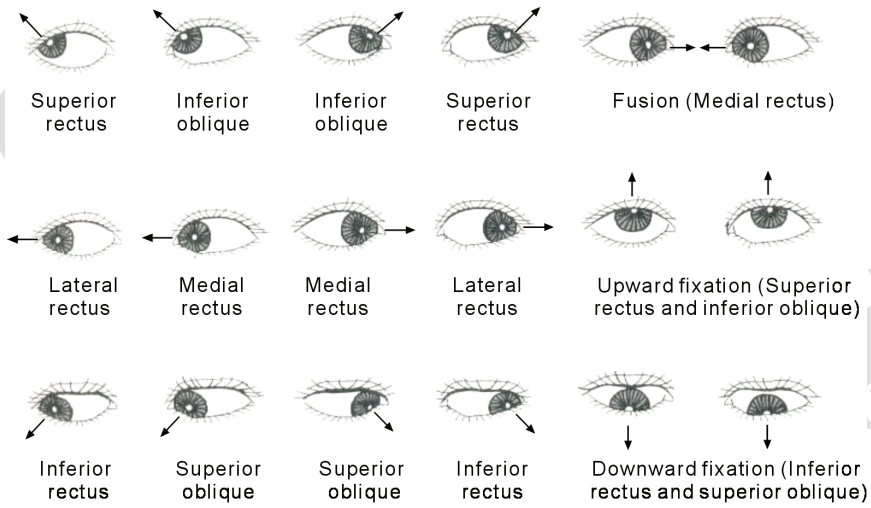


Figure 3.2 Four-direction eye movements and their corresponding ocular muscles

3.2 PRINCIPLE OF CIRCUIT DESIGN

1. Block Diagram of EOG Measurement Circuit

As described in the previous section, the eye movements are mainly controlled by the three pairs of ocular muscles. The stimulation from cerebral nerves will result in potential alteration of the ocular muscles. As shown in Figure 3.2, when eyeballs move to different directions, the corresponding ocular muscles will be stimulated. Therefore, the vertical and horizontal components of the eye movement can be observed simultaneously in the experiment. Four electrodes are placed at the upper, lower, right and left areas of the eye, respectively, and the reference electrode at the frontal lobe. Further, to avoid the electrical shock caused by leakage from the power supply or measuring instrument, the isolation concept must be incorporated in designing a circuit for the EOG detection.

Figure 3.3 shows the block diagram of the EOG measurement circuit. There are two sets of circuit for simultaneously measuring the horizontal and vertical components of the ocular movement, respectively. With the arrangement, as the eye moves to right or left (upper or lower), the corresponding components of the muscular force will be obviously changed. An instrumentation amplifier with a gain of 5 is applied as the preamplifier for picking up the unipolar component of the EOG signals. The function of the isolation circuit is to isolate the signal and line power source, and can be implemented by using either an optical or voltage-transformed method. The bandwidth of the band-pass filter is from 0.05 to 30 Hz, and the amplifier with an amplification factor of 50 can magnify the weak signal that has passed through the filter. Then, the amplified EOG signals can be directly sent to the oscilloscope for display.

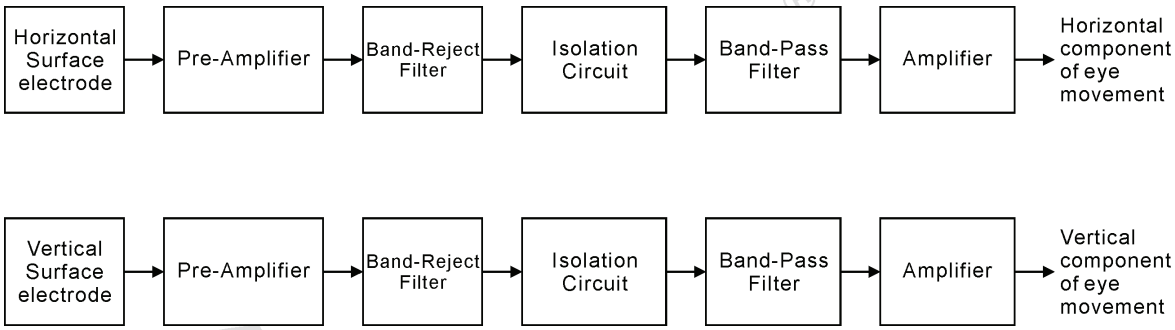
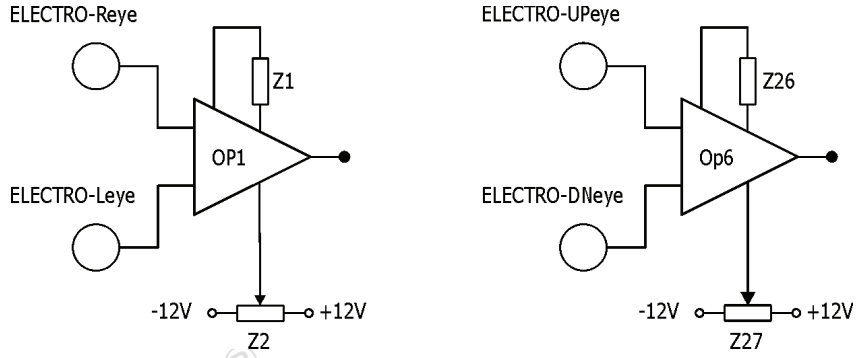


Figure 3.3 Block diagram of EOG measurement circuit.

2. Preamplifier Circuit



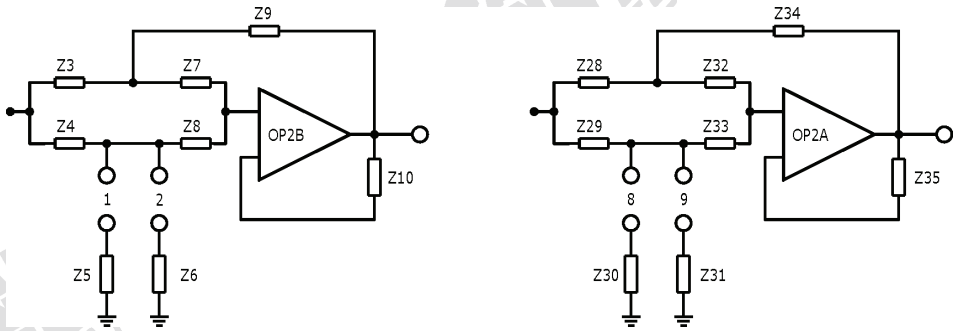
(a) Horizontal electrode (b) Vertical electrode

Figure 3.4 Preamplifier circuits.

Figure 3.4 shows the preamplifier circuits, each composed of an instrumentation amplifier OP1 or OP6. They are used to detect the horizontal and vertical components of the muscular force, respectively. The gain of each preamplifier can be determined with Equation (3.1). The potential to the reference terminal (pin 5) defines the zero output voltage. The compensation potential from Z_2 or Z_{27} can be used to adjust the drift level of the output voltage.

$$Av = \frac{49.4k\Omega}{Z_1} + 1 \quad \& \quad Av = \frac{49.4k\Omega}{Z_{26}} + 1 \tag{3.1}$$

3. Band-Reject Filter



(a) BRF1 (b) BRF2

Figure 3.5 Band-reject filters.

Figure 3.5 shows twin-T band-reject filers. The band-reject filter 1 shown in Figure 3.5(a) is constructed by OP2B, Z_3, Z_4, Z_5 (or Z_6), Z_7, Z_8 and Z_9. If $Z_3 = Z_7$, $Z_4 = Z_8$, $Z_5 = 0.5Z_3$ (or $Z_6 = 0.5Z_3$) and $Z_9 = 2Z_4$, the center frequency can be calculated by Equation (3.2).

$$f = \frac{1}{2\pi Z_3 Z_4} \tag{3.2}$$

The band-reject filter 2 shown in Figure 3.5(b) is constructed by OP2A, Z_{28}, Z_{29}, Z_{30} (or Z_{31}), Z_{32}, Z_{33} and Z_{34}. If $Z_{28} = Z_{32}$, $Z_{29} = Z_{33}$, $Z_{30} = 0.5Z_{34}$ (or $Z_{31} = 0.5Z_{34}$) and $Z_{34} = 2Z_{29}$, the center frequency can be calculated by Equation (3.3).

$$f = \frac{1}{2\pi Z_{28} Z_{29}} \tag{3.3}$$

4. Isolation Circuit

Figure 3.6 shows the isolation circuits that are constructed by OP3 and OP8. Here, the isolation function is carried out by means of an optical approach.

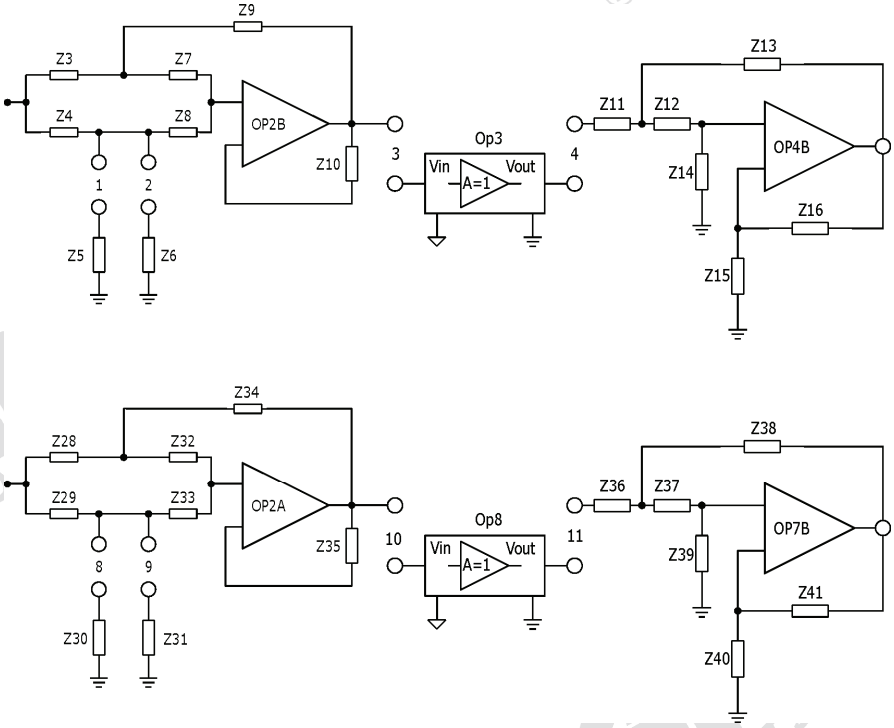


Figure 3.6 Isolation circuits.

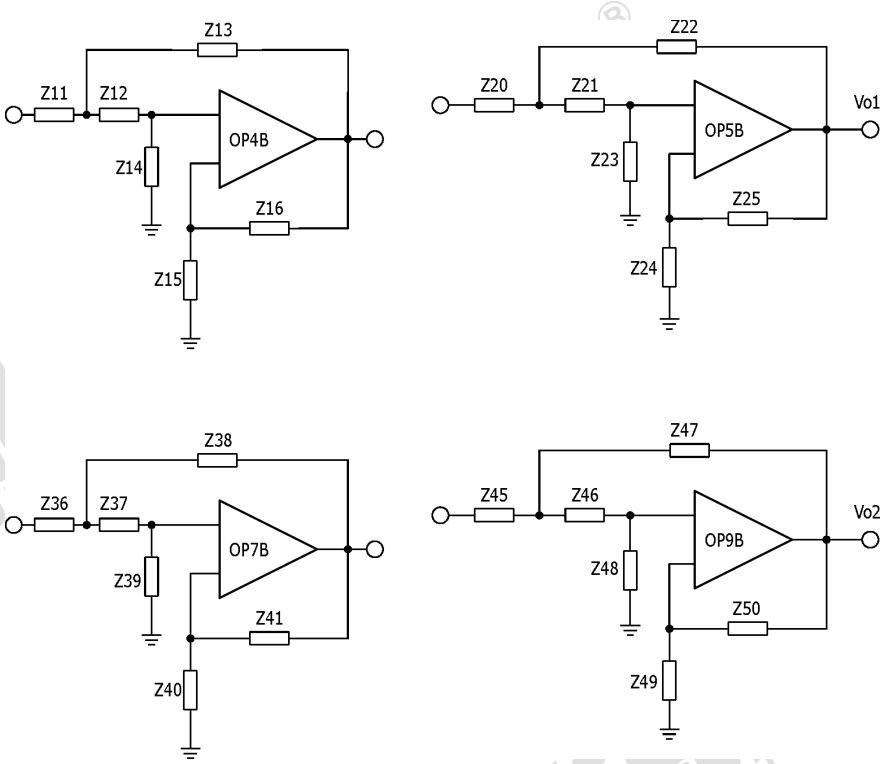
5. Band-Pass Filter Circuit

In designing the EOG measurement circuit, OP4B and OP7B are used to construct two active 2nd-order high-pass filters, respectively, as shown in Figure 3.7(a). The cutoff frequency (f_L) of each filter is set at 0.05 Hz, and can be calculated using Z_{11}, Z_{12}, Z_{13} and Z_{14}, or Z_{36} Z_{37}, Z_{38} and Z_{39} as expressed in Equation (3.4),

$$f_L = \frac{1}{2\pi\sqrt{Z_{11}Z_{12}Z_{13}Z_{14}}} \quad \& \quad f_L = \frac{1}{2\pi\sqrt{Z_{36}Z_{37}Z_{38}Z_{39}}} \tag{3.4}$$

And, each passband gain is explained in Equation (3.5).

$$\frac{Z_{15}+Z_{16}}{Z_{15}} = 1.56 \quad \& \quad \frac{Z_{40}+Z_{41}}{Z_{40}} = 1.56 \tag{3.5}$$



(a) 2nd-order high-pass filters (b) 2nd-order low-pass filters

Figure 3.7 Filter circuits.

Figure 3.7(b) shows two active 2nd-order low-pass filters that are constructed by OP5B and OP9B, respectively. The cutoff frequency (f_H) of each filter is set at 30 Hz, and can be determined using Z_{20}, Z_{21}, Z_{22} and Z_{23}, or Z_{45}, Z_{46}, Z_{47} and Z_{48} as expressed in Equation (3.6),

$$f_H = \frac{1}{2\pi\sqrt{Z_{20}Z_{21}Z_{22}Z_{23}}} \quad \& \quad f_H = \frac{1}{2\pi\sqrt{Z_{45}Z_{46}Z_{47}Z_{48}}} \tag{3.6}$$

And, each passband gain is explained in Equation (3.7).

$$\frac{Z_{24}+Z_{25}}{Z_{24}} = 1.56 \quad \& \quad \frac{Z_{49}+Z_{50}}{Z_{49}} = 1.56 \tag{3.7}$$

6. Amplifier Circuit

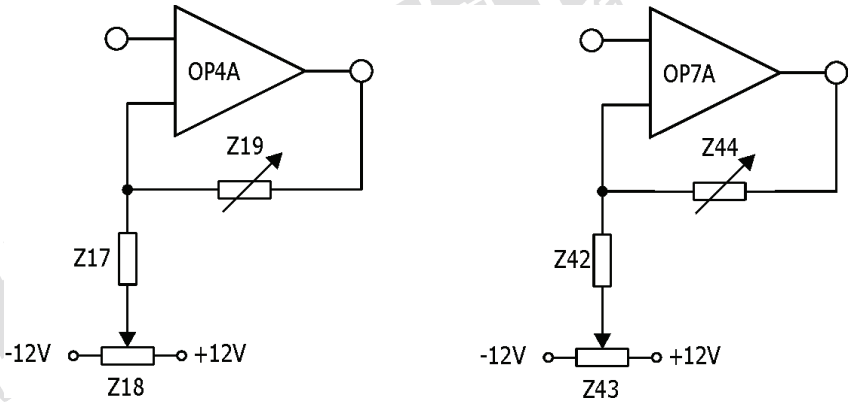


Figure 3.8 Amplifier circuits.

Figure 3.8 shows two non-inverting amplifiers constructed by OP4A and OP7A, respectively. In each amplifier, Z_{19} or Z_{44} is used for the gain adjustment as expressed in Equation (3.8), and Z_{18} or Z_{43} is used for adjusting the drift voltage level.

$$A_V = \frac{Z_{17} + Z_{19}}{Z_{17}} \quad \& \quad A_V = \frac{Z_{42} + Z_{44}}{Z_{42}} \tag{3.8}$$

3.3 EQUIPMENT REQUIRED

1. KL-72001 Main Unit
2. KL-75003 Electrooculogram EOG Module
3. Digital Storage Oscilloscope
4. Digital Voltmeter (DVM)
5. KL-79101 5-Conductor Electrode Cable
6. Body Surface Electrodes
7. Alcohol Prep Pads
8. Electrode Leads
9. DB9 Cable
10. BNC Cables
11. RS-232 Cable
12. Connecting Wires
13. 10-mm Bridging Plugs
14. Trimmer

3.4 PROCEDURE

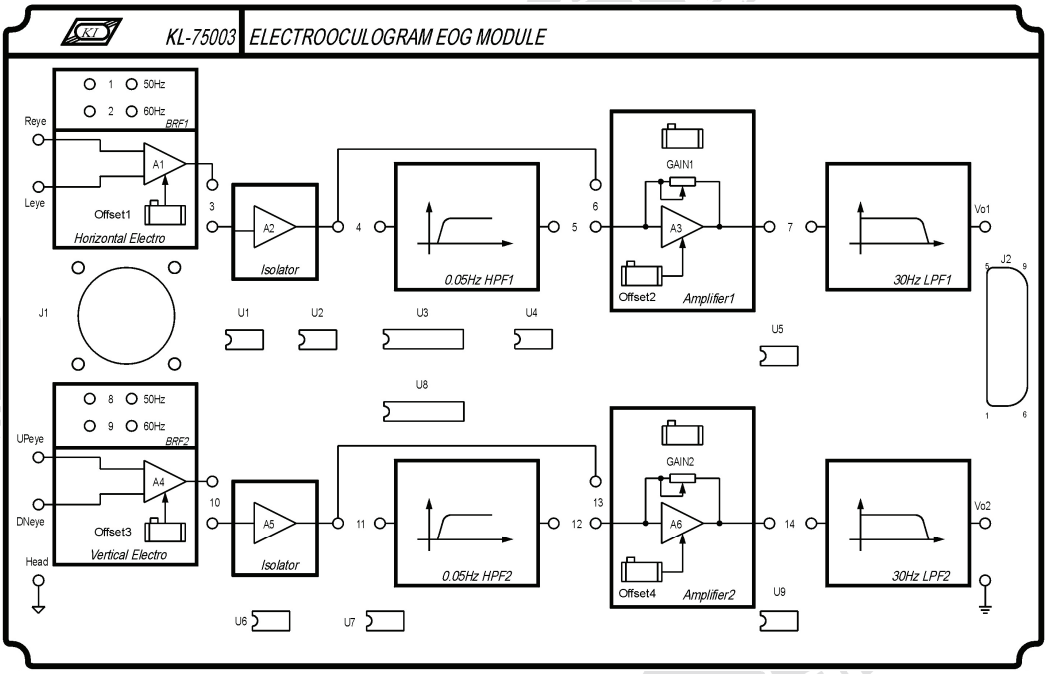


Figure 3.9 Front panel of KL-75003 EOG Module.

A. Calibrating Horizontal Surface Electrode Circuit

1. Set KL-75003 EOG Module on the KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Horizontal Electro	Reye	→	Horizontal Electro	Leye
Horizontal Electro	Leye	→	Vertical Electro	Head

2. Turn power on.
3. Connect the positive probe of DVM to the output terminal of the Horizontal Electro and the negative probe to the ground labeled Head.

4. Adjust Offset1 potentiometer to make the output DC voltage indicated by DVM equal to 0 V.
5. Turn power off and disconnect circuit.

B. Measuring the Characteristics of Band-Reject Filter 1 (BRF1)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	Horizontal Electro	Reye
FUNCTION GENERATOR	--	GND	→	Horizontal Electro	Leye
SCOPE ADAPTOR	--	CH2	→	Horizontal Electro	Output

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Horizontal Electro	Leye	→	Vertical Electro	Head

2. Insert a bridging plug into position 1 or 2 to set the center frequency of BRF1 to 50 or 60 Hz (according to local line frequency).
3. Turn power on.
4. Apply a 1 Hz, 1 Vpp sine signal to the Horizontal Electro input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on the oscilloscope screen.
5. Observe BRF1 output signal displayed on CH2 trace, and then record the amplitude in Table 3.1.

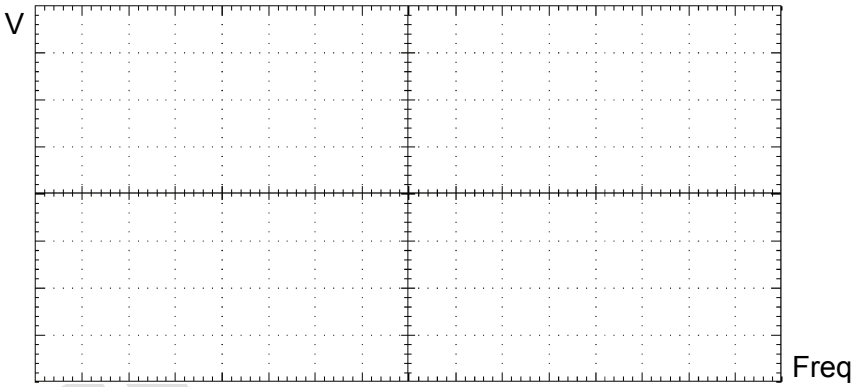
6. Without changing the amplitude of input sine signal, repeat Steps 4 and 5 for other frequency values listed in Table 3.1.

Table 3.1 Measured output amplitude of BRF1.

Input Freq	5Hz	10Hz	20Hz	30Hz	50 or 60Hz	100Hz	200Hz	500Hz	1KHz
BRF1 Output (Vpp)									

7. According to the recorded data in Table 3.1, plot the characteristic curve of BRF1 in Table 3.2.

Table 3.2 Characteristic curve of BRF1.



8. Turn power off and disconnect circuit.

C. Measuring the Characteristics of High-Pass Filter 1 (HPF1)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	0.05Hz HPF1	Input
FUNCTION GENERATOR	--	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	--	CH2	→	0.05Hz HPF1	Output

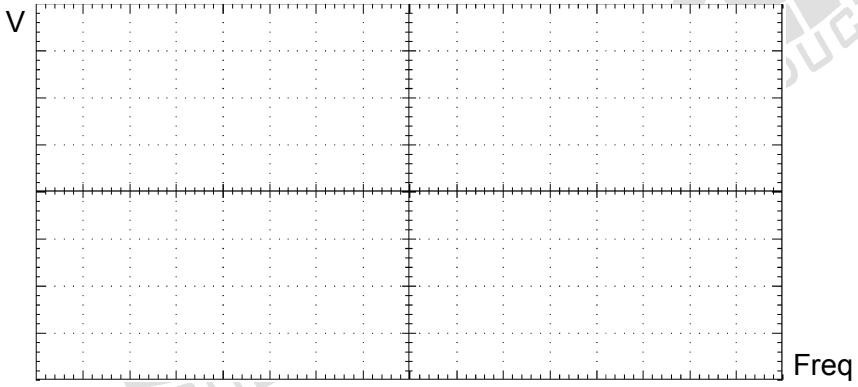
2. Turn power on.
3. Apply a 1 KHz, 1 Vpp sine signal to HPF1 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.
4. Observe HPF1 output signal displayed on CH2 trace and record the amplitude in Table 3.3.
5. Without changing the amplitude of input sine signal, repeat Steps 3 and 4 for different frequency values listed in Table 3.3.

Table 3.3 Measured output amplitude of HPF1.

Input Freq	1KHz	500Hz	100Hz	10Hz	5Hz	1Hz	0.3Hz	0.2Hz	0.1Hz
HPF1 Output (Vpp)									

6. According to the recorded data in Table 3.3, plot the characteristic curve of HPF1 in Table 3.4.

Table 3.4 Characteristic curve of HPF1.



7. Turn power off and disconnect circuit.

D. Measuring the Characteristics of Amplifier 1

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Amplifier1	input	→	--	Ground (in the bottom right corner)

2. Turn power on.
3. Connect the positive probe of DVM to the Amplifier1 output, and connect the negative probe to the ground terminal located at the bottom-right of KL-75003 EOG Module.
4. Adjust Offset2 potentiometer to make the output of DC voltage indicated by DVM equal to 0 V.
5. Remove the connecting wire from the KL-75003 EOG Module.
6. Complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	Amplifier1	Input
FUNCTION GENERATOR	--	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	--	CH2	→	Amplifier1	Output

7. Apply a 100 Hz, 100 mVpp sine signal to Amplifier1 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.
8. Adjust GAIN1 potentiometer to the minimum counterclockwise position (with clicks at the end). Record the minimum amplitude of Amplifier1 output signal displayed on CH2 trace in Table 3.5.
9. Adjust GAIN1 potentiometer clockwise to obtain maximum undistorted output. Record the output peak-to-peak voltage in Table 3.5.

Table 3.5 Measured output amplitude of Amplifier1.

GAIN1 Position	Amplifier Output Voltage (Vpp)
Minimum counterclockwise	
Maximum undistorted output	

10. Adjust GAIN1 to make the output peak-to-peak voltage equal to 5 Vpp. In this situation, the voltage gain of Amplifier1 is set to 50 (5 Vpp/100 mVpp).
11. Turn power off and disconnect circuit.

E. Measuring the Characteristics of Low-Pass Filter 1 (LPF1)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, Complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	30Hz LPF1	Input
FUNCTION GENERATOR	--	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	--	CH2	→	30Hz LPF1	Output (Vo1)

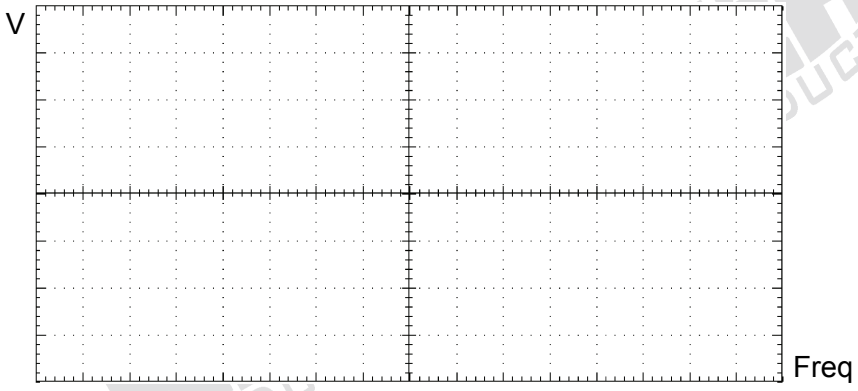
2. Turn power on.
3. Apply a 1 Hz, 1 Vpp sine signal to the LPF1 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.
4. Observe LPF1 output signal displayed on CH2 trace and record the amplitude in Table 3.6.
5. Without changing the amplitude of input sine signal, repeat Steps 3 and 4 for different frequency values listed in Table 3.6.

Table 3.6 Measured output amplitude of LPF1.

Input Freq	1Hz	10Hz	20Hz	25Hz	30Hz	35Hz	40Hz	50Hz	100Hz
LPF1 Output (Vpp)									

6. According to the recorded data in Table 3.6, plot the characteristic curve of LPF1 in Table 3.7.

Table 3.7 Characteristic curve of LPF1.



7. Turn power off and disconnect circuit.

F. Calibrating Vertical Surface Electrode Circuit

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Complete the following connections:

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Vertical Electro	UPeye	→	Vertical Electro	DNeye
Vertical Electro	DNeye	→	Vertical Electro	Head

2. Turn power on.
3. Connect the positive probe of DVM to the output terminal of the Vertical Electro and the negative probe to the ground labeled Head.
4. Adjust Offset3 potentiometer to make the output DC voltage indicated by DVM equal to 0 V.
5. Turn power off and disconnect circuit.

G. Measuring the Characteristics of Band-Reject Filter 2 (BRF2)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	Vertical Electro	UPeye
FUNCTION GENERATOR	--	GND	→	Vertical Electro	DNeye
SCOPE ADAPTOR	--	CH2	→	Vertical Electro	Output

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Vertical Electro	DNeye	→	Vertical Electro	Head

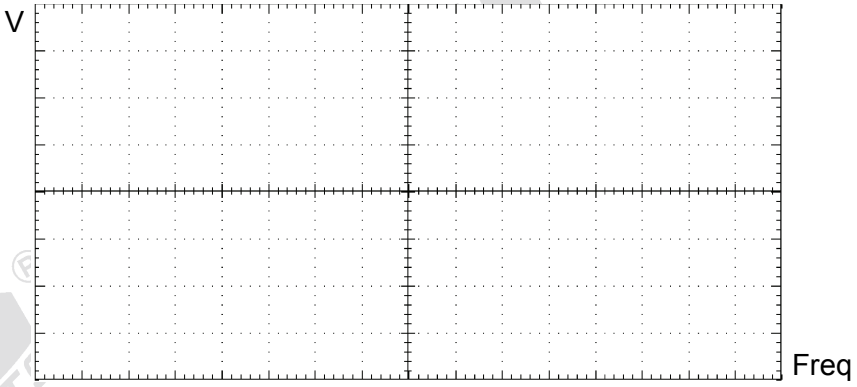
2. Insert a bridging plug into position 8 or 9 to set the center frequency of BRF2 to 50 or 60 Hz (according to local line frequency).
3. Turn power on.
4. Apply a 5 Hz, 1 Vpp sine signal to the Vertical Electro input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on the oscilloscope screen.
5. Observe BRF2 output signal displayed on CH2 trace and record the amplitude in Table 3.8.
6. Without changing the amplitude of input sine signal, repeat Steps 4 and 5 for other frequency values listed in Table 3.8.

Table 3.8 Measured output amplitude of BRF2.

Input Freq	5Hz	10Hz	20Hz	30Hz	50 or 60Hz	100Hz	200Hz	500Hz	1KHz
BRF2 Output (Vpp)									

7. According to the recorded data in Table 3.8, plot the characteristic curve of band-reject filter in Table 3.9.

Table 3.9 Characteristic curve of BRF2.



8. Turn power off and disconnect circuit.

H. Measuring the Characteristics of High-Pass Filter 2 (HPF2)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	0.05Hz HPF2	Input
FUNCTION GENERATOR	--	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	--	CH2	→	0.05Hz HPF2	Output

2. Turn power on.
3. Apply a 1 KHz, 1 Vpp sine signal to HPF2 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.

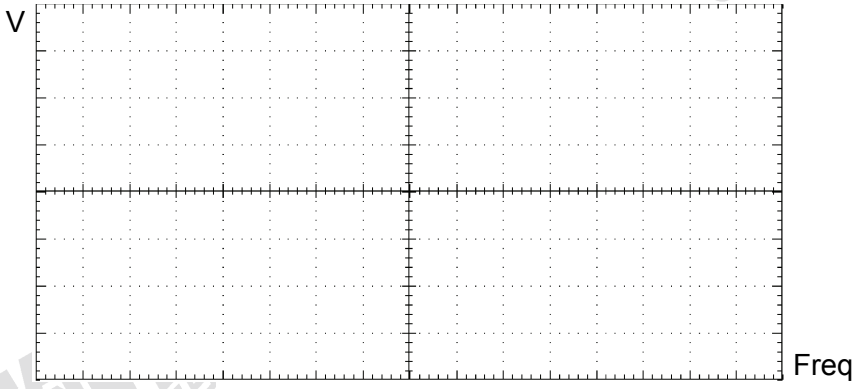
4. Observe HPF2 output signal displayed on CH2 trace and record the amplitude in Table 3.10.
5. Without changing the amplitude of input sine signal, repeat Steps 3 and 4 for different frequency values listed in Table 3.10.

Table 3.10 Measured output amplitude of HPF2.

Input Freq	1KHz	500Hz	100Hz	10Hz	5Hz	1Hz	0.3Hz	0.2Hz	0.1Hz
HPF2 Output (Vpp)									

6. According to the recorded data in Table 3.10, plot the characteristic curve of the high-pass filter 2 in the space provided in Table 3.11.

Table 3.11 Characteristic curve of HPF2.



7. Turn power off and disconnect circuit.

I. Measuring the Characteristics of Amplifier 2

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Complete the following connections:

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

KL-75003 EOG Module				
Block	Terminal	To	Block	Terminal
Amplifier2	input	→	--	Ground (in the bottom right corner)

2. Turn power on.
3. Connect the positive probe of DVM to Amplifier2 output, and connect the negative probe to the ground terminal located at the bottom-right of KL-75003 EOG Module.
4. Adjust Offset4 potentiometer to make the output DC voltage indicated by DVM equal to 0 V.
5. Remove the connecting wire from KL-75003 EOG Module.
6. Complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	–	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	–	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	–	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
FUNCTION GENERATOR	–	OUTPUT	→	Amplifier2	Input
FUNCTION GENERATOR	–	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	–	CH2	→	Amplifier2	Output

7. Apply a 100 Hz, 100 mVpp sine signal to Amplifier2 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.
8. Adjust GAIN2 potentiometer to the minimum counterclockwise position (with clicks at the end). Record the minimum amplitude of the Amplifier2 output signal displayed on CH2 trace in Table 3.12.
9. Adjust GAIN2 potentiometer clockwise to obtain maximum undistorted output signal. Record the output peak-to-peak voltage in Table 3.12.

Table 3.12 Measured output amplitude of Amplifier2.

GAIN2 Position	Amplifier Output Voltage (Vpp)
Minimum counterclockwise	
Maximum undistorted output	

10. Adjust GAIN2 to make the output peak-to-peak voltage be equal to 5 Vpp. In this situation, the voltage gain of Amplifier2 is set to 50 (5 Vpp/100 mVpp).
11. Turn power off and disconnect circuit.

J. Measuring the Characteristics of Low-Pass Filter 2 (LPF2)

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
FUNCTION GENERATOR	--	OUTPUT	→	SCOPE ADAPTOR	--	CH1
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2
FUNCTION GENERATOR	--	OUTPUT	→	30Hz LPF2	Input
FUNCTION GENERATOR	--	GND	→	--	Ground (in the bottom right corner)
SCOPE ADAPTOR	--	CH2	→	30Hz LPF2	Output (Vo2)

2. Turn power on.
3. Apply a 1 Hz, 1 Vpp sine signal to LPF2 input by adjusting FREQUENCY and AMPLITUDE knobs of FUNCTION GENERATOR, and observe CH1 trace on oscilloscope screen.
4. Observe LPF2 output signal displayed on CH2 trace and record the amplitude in Table 3.13.

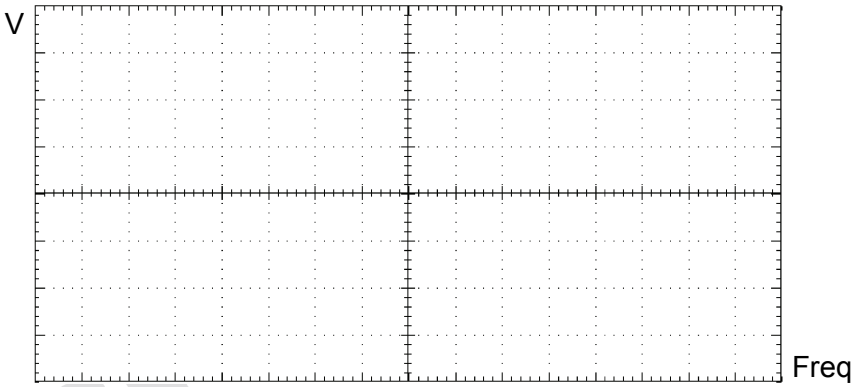
5. Without changing the amplitude of input sine signal, repeat Steps 3 and 4 for different frequency values listed in Table 3.13.

Table 3.13 Measured output amplitude of LPF2.

Input Freq	1Hz	10Hz	20Hz	25Hz	30Hz	35Hz	40Hz	50Hz	100Hz
LPF2 Output (Vpp)									

6. According to the recorded data in Table 3.13, plot the characteristic curve of LPF2 in Table 3.14.

Table 3.14 Characteristic curve of LPF2.



7. Turn power off and disconnect circuit.

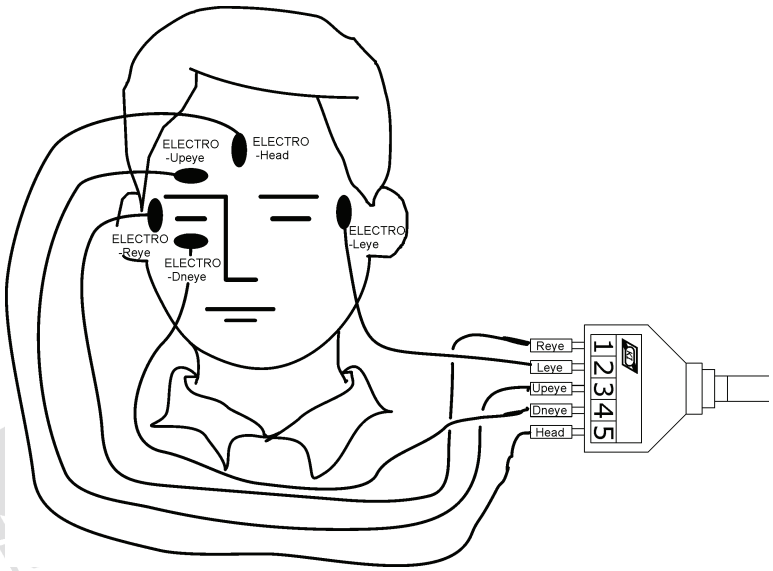
K. EOG Measurement using Oscilloscope

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connections:

KL-72001 Main Unit				KL-72001 Main Unit		
Section	Area	Terminal	To	Section	Area	Terminal
SCOPE ADAPTOR	--	CH1	→	OUTPUT	ELECTRO-OCULOGRAM	Vo1
SCOPE ADAPTOR	--	CH2	→	OUTPUT	ELECTRO-OCULOGRAM	Vo2
SCOPE ADAPTOR	--	CH1 (BNC)	→	CH1 input of the oscilloscope		
SCOPE ADAPTOR	--	CH2 (BNC)	→	CH2 input of the oscilloscope		

KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

2. On KL-75003 EOG Module, insert bridging plugs in positions 1 or 2 (according to local line frequency), 3, 4, 5, 7, 8 or 9 (according to local line frequency), 10, 11, 12, 14.
3. Refer to the electrode placement shown below, clean the skin with alcohol prep pads and apply four electrodes on the upper, lower, right and left of the eye, and the reference electrode on the frontal lobe.



4. Connect the electrodes to the lead side of KL-79101 5-Conductor Electrode Cable as shown above. Connect the module side of KL-79101 electrode cable to J1 connector on KL-75003 EOG Module.
5. Turn power on. Select MODULE:KL-75003 (EOG) from LCD display by pressing the SELECT button of KL-72001 Main Unit.
6. Ask the subject to sit down comfortably, to look forwards, and to keep quiet.
7. Observe the oscilloscope screen and adjust Offset2 and Offset4 potentiometers to make the dc voltages of CH1 and CH2 signals equal to 0 V approximately.
8. Set VOLT/DIV controls of CH1 and CH2 to 1 V/div, and set the TIME/DIV control to 500 ms/div.

9. Make sure that the gains of Amplifier1 and Amplifier2 have been set to 50 (refer to Procedures D and I).

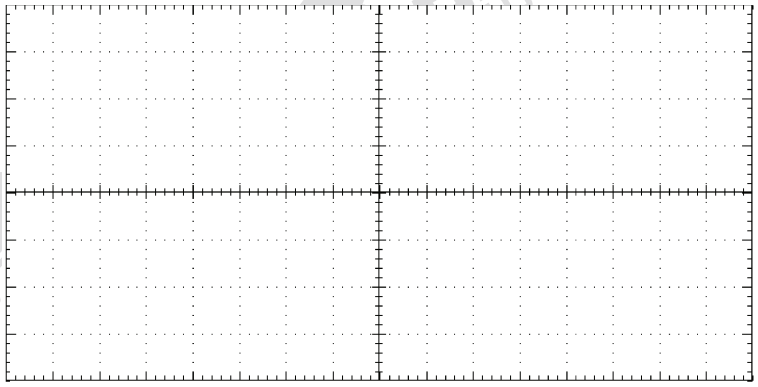
Notes:

a. During the experiment, ask the subject not to blink, and keep quiet.

b. If the noise on the measured signal is too large, it may be caused by the high impedance existed between the skin and electrode. Use alcohol prep pads to remove the skin oil to reduce the impedance before re-applying the electrodes.

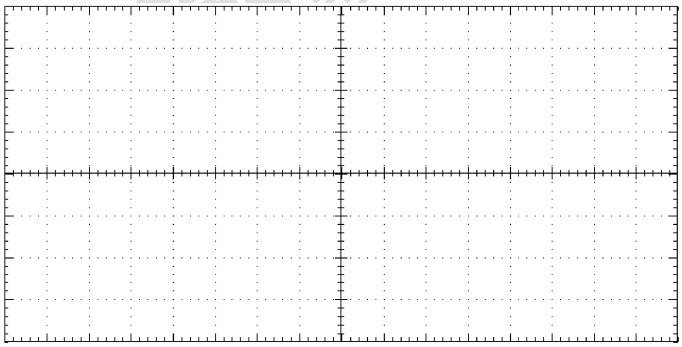
10. Ask the subject to blink five times at intervals of one second. Observe and record the waveforms of blinking test in Table 3.15.

Table 3.15 Measured EOG waveforms.

Condition	CH1 (horizontal component) / CH2 (vertical component)
Blink 5 times	

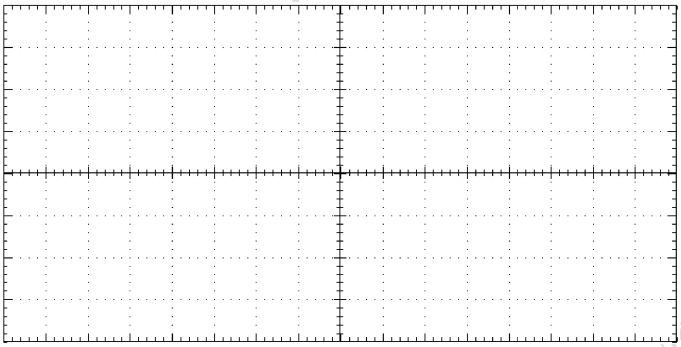
11. Another student is asked to hold a pen 60 cm away from and in front of the subject. Ask the subject to watch the pen.
12. Slowly move the pen to the left of the eye and then back to its original position. Observe and record the waveforms of EOG in Table 3.16.

Table 3.16 Measured EOG waveforms.

Condition	CH1 (horizontal component) / CH2 (vertical component)
Left movement of eyes and then return	

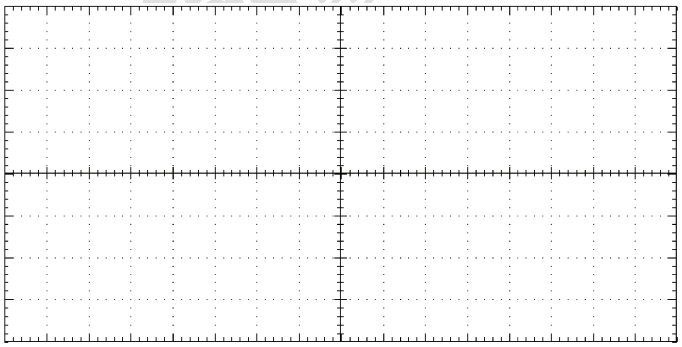
13. Slowly move the pen to the right of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms of EOG in Table 3.17.

Table 3.17 Measured EOG waveforms.

Condition	CH1 (horizontal component) / CH2 (vertical component)
Right movement of eyes and then return	

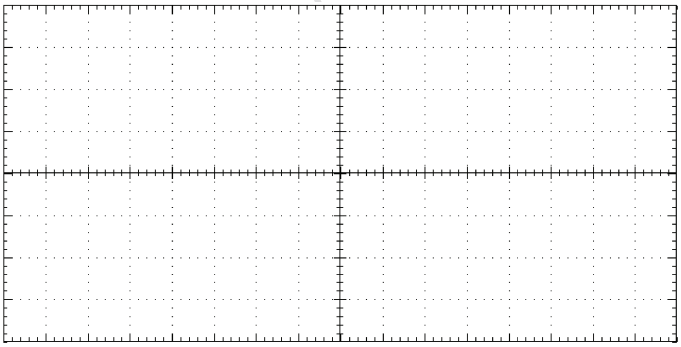
14. Slowly move the pen to the upper location of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms of EOG in Table 3.18.

Table 3.18 Measured EOG waveforms.

Condition	CH1 (horizontal component) / CH2 (vertical component)
Upper movement of eyes and then return	

15. Slowly move the pen to the lower location of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms of EOG in Table 3.19.

Table 3.19 Measured EOG waveforms.

Condition	CH1 (horizontal component) / CH2 (vertical component)
Lower movement of eyes and then return	

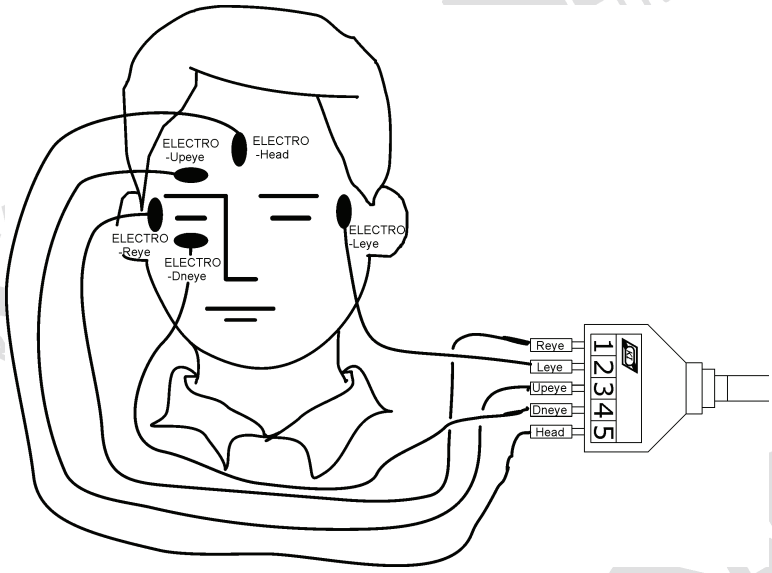
16. Turn power off and disconnect circuit.

L. EOG Measurement using KL-720 Software

1. Set KL-75003 EOG Module on KL-72001 Main Unit. Then, complete the following connection:

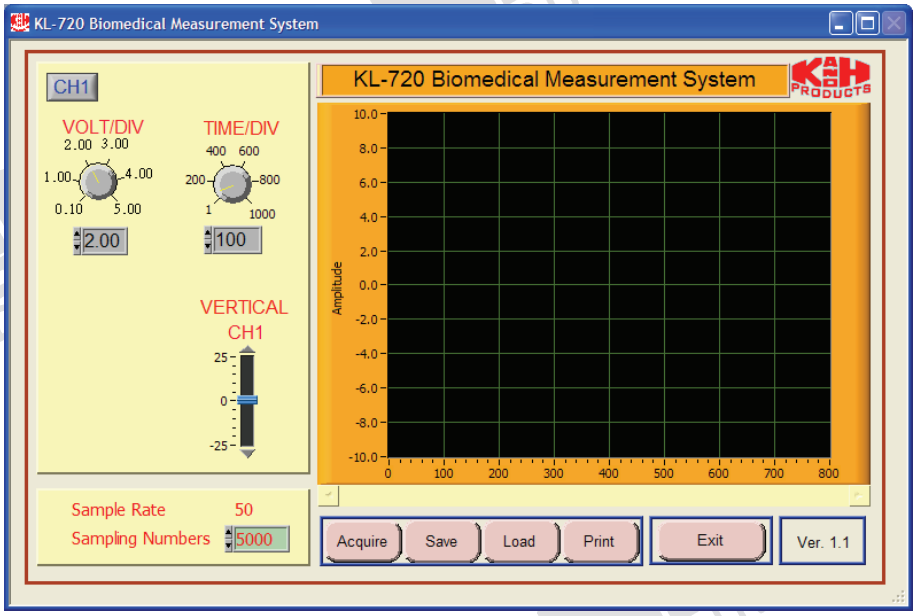
KL-72001 Main Unit				KL-75003 EOG Module	
Section	Area	Terminal	To	Block	Terminal
MODULE OUTPUT	--	9-Pin	→	--	J2

2. On KL-75003 EOG Module, insert bridging plugs in positions 1 or 2 (in accordance with local line frequency), 3, 4, 5, 7, 8 or 9 (in accordance with local line frequency), 10, 11, 12, 14.
3. Refer to the electrode placement shown below, clean the skin with alcohol prep pads and apply four electrodes on the upper, lower, right and left of the eye, and the reference electrode on the frontal lobe.

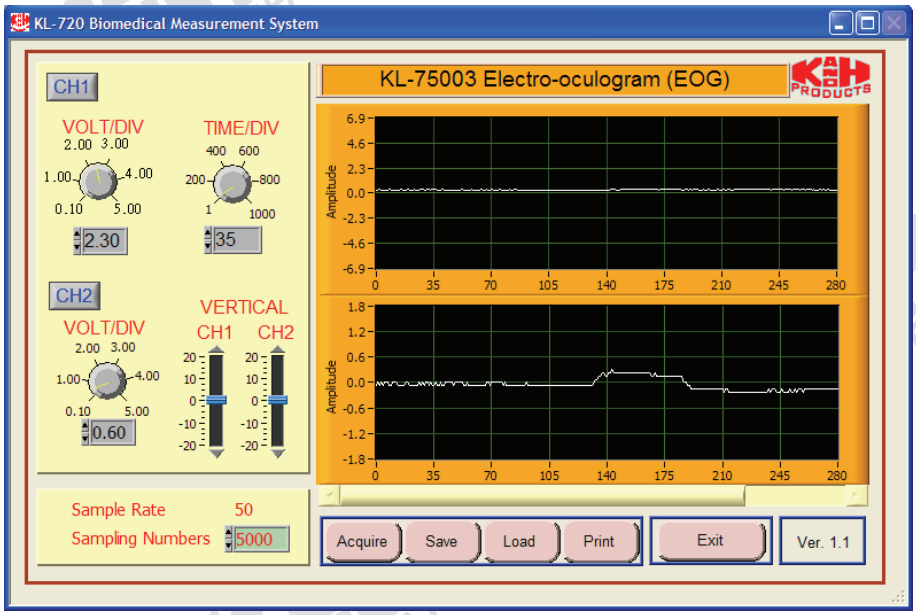


4. Connect the electrodes to the lead side of KL-79101 5-Conductor Electrode Cable as shown above. Connect the module side of KL-79101 5-Conductor Electrode Cable to J1 connector on KL-75003 EOG Module.
5. Connect RS-232 OUTPUT connector of KL-72001 Main Unit to RS-232 port on computer using RS-232 cable.
6. Turn power on. Select MODULE:KL-75003 (EOG) item from LCD display by pressing SELECT button of KL-72001 Main Unit.

7. Boot the computer.
8. Execute KL-720 program. The window of KL-720 Biomedical Measurement System appears as shown below.



9. Click the Acquire button. The system begins to acquire the measured data via RS-232 port and shows the waveforms on KL-75003 Electro-oculogram (EOG) waveform windows.



Note: If the message "time out, please check the COM port was connected the device" appears, check the connection and setup of the RS-232 port.

10. Adjust VOLT/DIV and TIME/DIV knobs, so the signals can be read accurately.
11. Make sure that the gains of Amplifier1 and Amplifier2 have been set to 50 (refer to Procedures D and I).

Notes:

a. During the experiment, ask the subject not to blink, and keep quiet.
b. If noise is still too large, it may be caused by the high impedance existed between the skin and electrode. Use alcohol prep pads to remove the skin oil before re-applying the electrodes.

12. Ask the subject to blink five times at intervals of one second. Record the waveform of blinking test on disk.
13. Another student is asked to hold a pen 60 cm away from and in front of the subject. Ask the subject to watch the pen.
14. Slowly move the pen to the left of the eye and then back to its original position. Record the waveforms of EOG on disk.
15. Slowly move the pen to the right of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms on disk.
16. Slowly move the pen to the upper location of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms on disk.
17. Slowly move the pen to the lower location of the eye and then return to its original position. Ask the subject to watch the pen and record the waveforms on disk.
18. Exit KL-720 Biomedical Measurement System, turn power off and disconnect circuit.