1. Define the following terms (20') (名词解释)

(1) Dynamic Characteristics: Describe the input-output relation for **time-varying** inputs.

(2) Precision and Accuracy: Precision measures **the consistency** of the measurement, i.e., the ability of a sensor or an instrument to give the SAME output for equal inputs applied over some period of time. Accuracy measures the difference that exists between **the actual value** (which must be measured by a primary or good secondary standard) and the indicated value at the output of the sensor.

(3) Linearity: describe how close the input-output relationship of an instrument is to a straight-line.

(4) Absolute refractory period: the portion of the refractory period when a nerve or muscle fiber cannot respond to a stimulus, as contrasted with the relative refractory period.

(5) Action potential: An action potential is a rapid rise and subsequent fall in voltage or membrane potential across a cellular membrane with a characteristic pattern.

(6) motor unit: the unit of motor activity formed by a motor nerve cell, its axon and innervated muscle fibers.

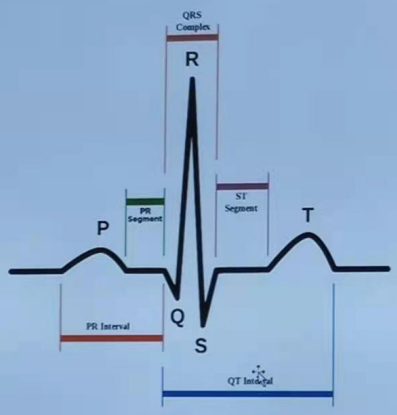
2. Draw a typical lead II electrocardiogram and label all waves (P, QRS, T) and intervals. Explain what is happening electrically within the heart during P, QRS, T waves, P-R interval

innervated muscle fibers

2. Draw a typical lead II electrocardiogram and label all waves (P, QRS, T) and intervals. Explain what is happening electrically within the heart during P, QRS, T waves, P-R interval and S-T segment. (10')

Answer: The lead II waveform is illustrated below.

- P wave represents the electrical depolarization of the atria.
- QRS complex represents the depolarization of the ventricles.
- T wave represents the repolarization of the ventricles.
- P–R interval is measured from the onset of the P wave to the onset of the QRS complex. The majority of the P–R interval is contributed by conduction delay in the AV node (this has the effect of separating the mechanical contraction of the atria and ventricles).
- QT interval represents ventricular depolarisation and repolarisation.
- ST Segment represents the interval between ventricular depolarization and repolarization.



3. List at least three factors that would influence ECG recording and describe the way to reduce them. (10')

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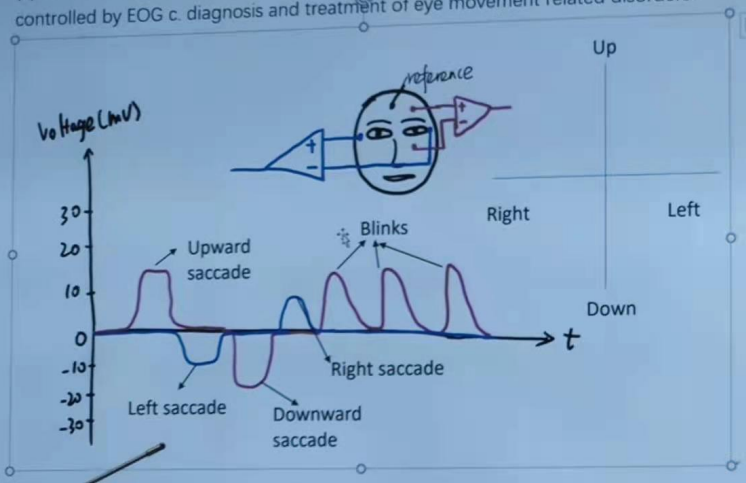
Answer:

- Frequency Distortion: choose/design the right frequency band for ECG recording according to specific applications
- Saturation or Cutoff Distortion: design appropriate static work point for the amplifier.
- Artefact from Large Electric Transients: keep the subject as static as possible during the measurement and use switch to fast discharge the capacitor to ensure the Electric Transients quickly get back to the normal baseline.
- Interference from Other Electrical Devices and Signals: use notch filter to filter powerline interference and EMG signals

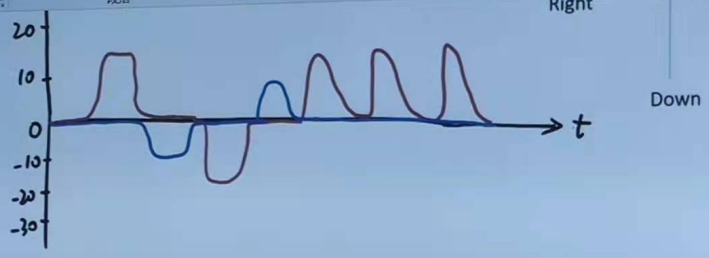
4. Answer the following questions about electro-oculographic (EOG) technique (20')
   (1) Describe the principle of EOG technique.
   (2) List three influential factors of this technique.
   (3) List three applications of this technique.
   (4) Analyze the eye movement according to the EOG signals measured below.

over long period of use c. Susceptible to movement of facial muscles or ...

(3) a. recording eye movements in sleep and dream research b. motorized wheelchairs controlled by EOG c. diagnosis and treatment of eye movement related disorders



5. An excitable cell is stimulated by a micropipette, and an extracellular electrode is placed at the outer-membrane surface. Explain how the polarity and amplitude of the stimulating



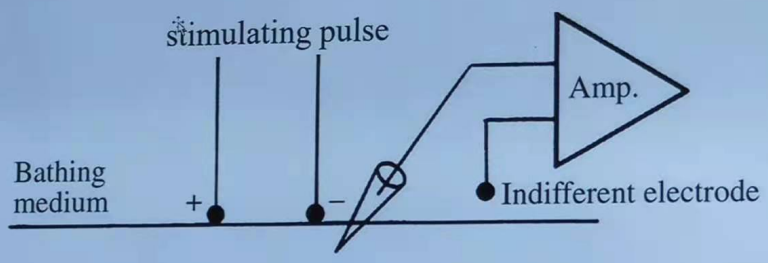
Answer:

(1) the cornea of the eye is electrically positive relative to the back of the eye. The human eye can be modelled as an electrical dipole with the positive terminal in front at the cornea, and the negative terminal behind at the retina of the eyeball. Eye movements thus produce a moving (rotating) dipole source.

(2) a. the corneoretinal potential is not fixed, and can be affected by light, fatigue, and other qualities. b. susceptible to baseline drift due to minor electrode/skin offset potential changes over long period of use c. Susceptible to movement of facial muscles or jaw

(3) a. recording eye movements in sleep and dream research b. motorized wheelchairs controlled by EOG c. diagnosis and treatment of eye movement related disorders

5. An excitable cell is stimulated by a micropipette, and an extracellular electrode is placed at the outer-membrane surface. Explain how the polarity and amplitude of the stimulating pulse influence the membrane potential of the excitable cell. (20')



Cell

Whether membrane potential is increased or decreased simply depends on the polarity of applied voltage. With current flowing outward through the membrane (i.e., with the micropipette as the anode and the extracellular electrode as the cathode) the potential drop has a polarity opposite to that of the resting transmembrane potential and therefore the magnitude of the resting potential decreases (this is called depolarization). With current flowing into the membrane, the ohmic potential drop is of similar polarity to that of the resting transmembrane potential and the magnitude of the resting potential is

medium + −

Cell

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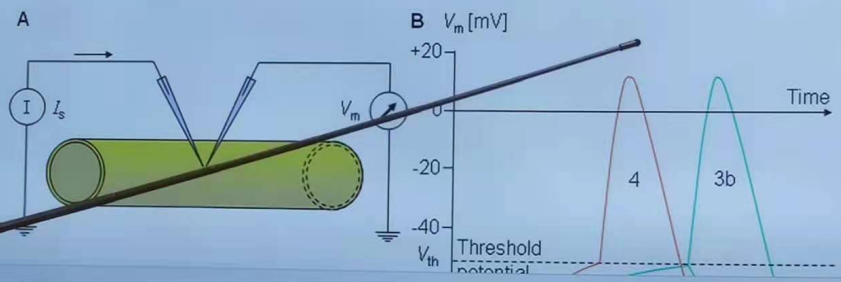

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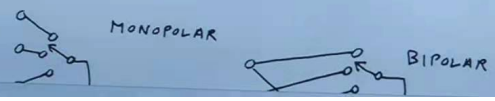
6. Use switches (开关) and differential amplifier (差分放大器) to record EEG signals from four sites of the scalp (头皮) using monopolar and bipolar electrode setups (20').

Answer:

Differential amplifier has 3 inputs (positive, negative and ground). The ground is used for common mode rejection. The primary purpose of the ground is to prevent power line noise from interfering with the biopotential signals. A ground electrode for EEG recordings is often placed on the forehead (but could be placed anywhere else on the body; the location of the ground on the subject is generally irrelevant).

In a unipolar setup, there will be one reference electrode, and the potential difference between this electrode (connected to Vin-) and every other electrode on the head (connected to Vin+) will be measured.

For bipolar recordings, each active (Vin+) electrode will have its own reference (Vin-) connection.



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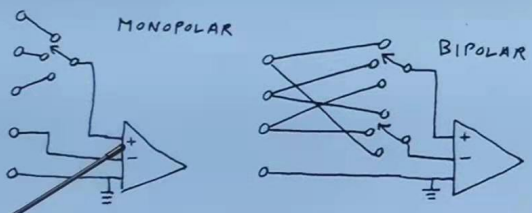

Reference:
https://www.biopac.com/knowledge-base/ground-vs-reference-for-eeg-recording/