EKG-set

Amplifier, Electrodes and Cream

Description D028

Figure 1. EKG Set

Short description
The EKG set is designed to measure electrical signals produced by the heart. The set consists of a pair of electrodes, a filter and an amplifier. It is supplied with bands for attaching the electrodes to arms, conductive gel and a 9 V battery.
The amplifier receives signals from the electrodes via an LED. The light sensor is used to convey the LED signal to the voltage signal. The optical coupling guarantees the safety of the person attached.
A 9V battery supplies the EKG amplifier.

The EKG amplifier consists of three main components; a differential amplifier, a filter section and an LED-driver.

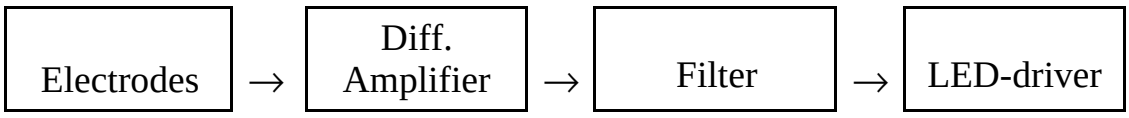

Figure 2. Circuitry of the EKG amplifier

The EKG amplifier has an LED that indicates the condition of the battery. When the battery voltage is lower then 7V, the LED blacks out. The battery should be replaced.

The EKG set can be used (via the light sensor (014)) with following interfaces:

- UIA / UIB through Measuring console
- SMI
- CoachLab
- CoachLab II
- Texas Instruments CBL™ data-logger.

The name of the EKG set in the sensor library of Coach 5 program is **EKG sensor (028) (CMA).**

Connection of the EKG amplifier
The measurement system consists of the EKG-set (two electrodes and an EKG amplifier), the light sensor and an interface.
The amplifier is in the measurement system between the electrodes on the body and the light sensor, which conducts the signal to the interface.
Figure 3 shows example of connection of the light sensor to the Measuring Console (UIB-interface).

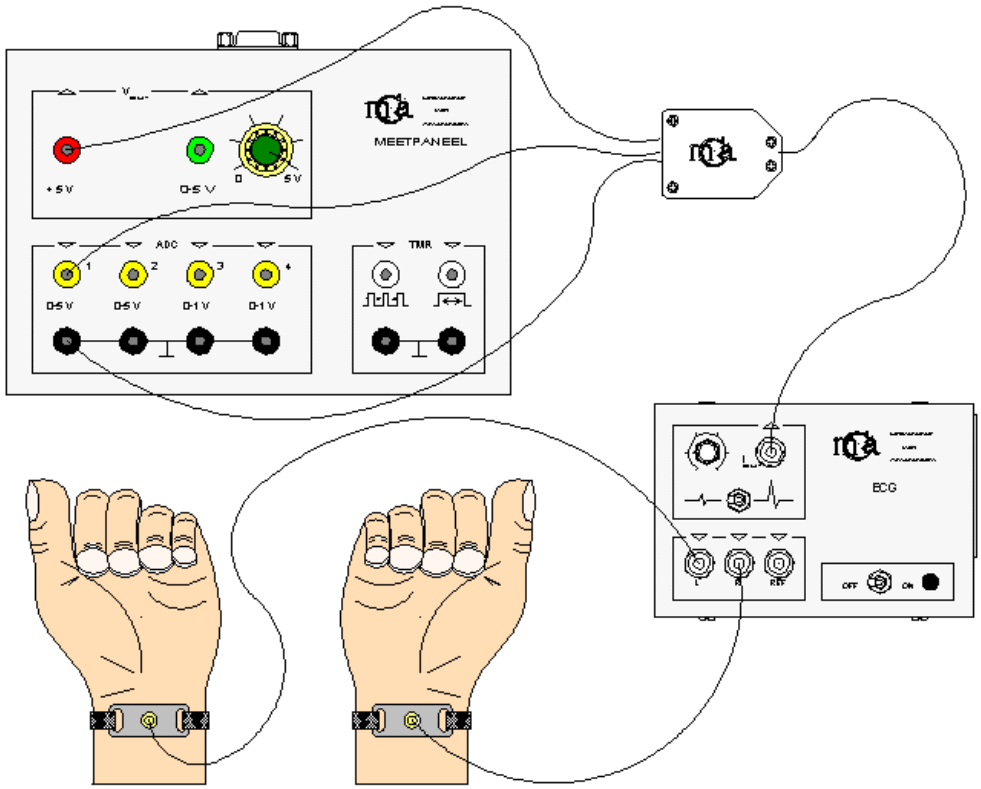

Figure 3. The measuring system, EKG amplifier with the Measuring Console

Recording Electrocardiogram

- Switch the amplifier-box ON (the ON/OFF switch at the right).
- Switch the filter and amplifier by moving the switch (at the left) to the right.
  The EKG amplifier is connected to an interface via a light sensor.
  The output connection on the EKG amplifier (on the right of the text I_{out}) is specially designed for a connection of a CMA light sensor (014).
- Start a measurement and regulate (with the knob on the amplifier) until the sensor generates a signal of 2 Volts, when no EKG is produced. Avoid voltages higher than 3 V (when no EKG is produced), because of technical restrictions of the light sensor results will be poor.
- When an EKG is produced, the signal varies between 1 and 3 Volts.
- Place the electrodes on the body (on the left and right wrist) and connect the electrodes to the inputs on the amplifier.
- A measurement can be started now.

The third input (Black, REF) is for the connection of a reference electrode that can be placed for example on the leg. In this way, the influence of

distortion signals can be reduced. However, the use of a reference electrode is unnecessary in most cases.

Warning
The input for the reference electrode should never be connected with the analog ground. Doing this the electrical separation between the body and the equipment, which is made for safety reasons, is undone.

Suggestions for experiments
- Monitoring EKG in rest. The person whose EKG is being recorded should remain calm and relaxed.
- Monitoring EKG after mild exercises.
- Studying the EKG pattern (meaning of P, Q, R, S and T waveforms).
- Combining the EKG registration with a heart tone measurement using a microphone.

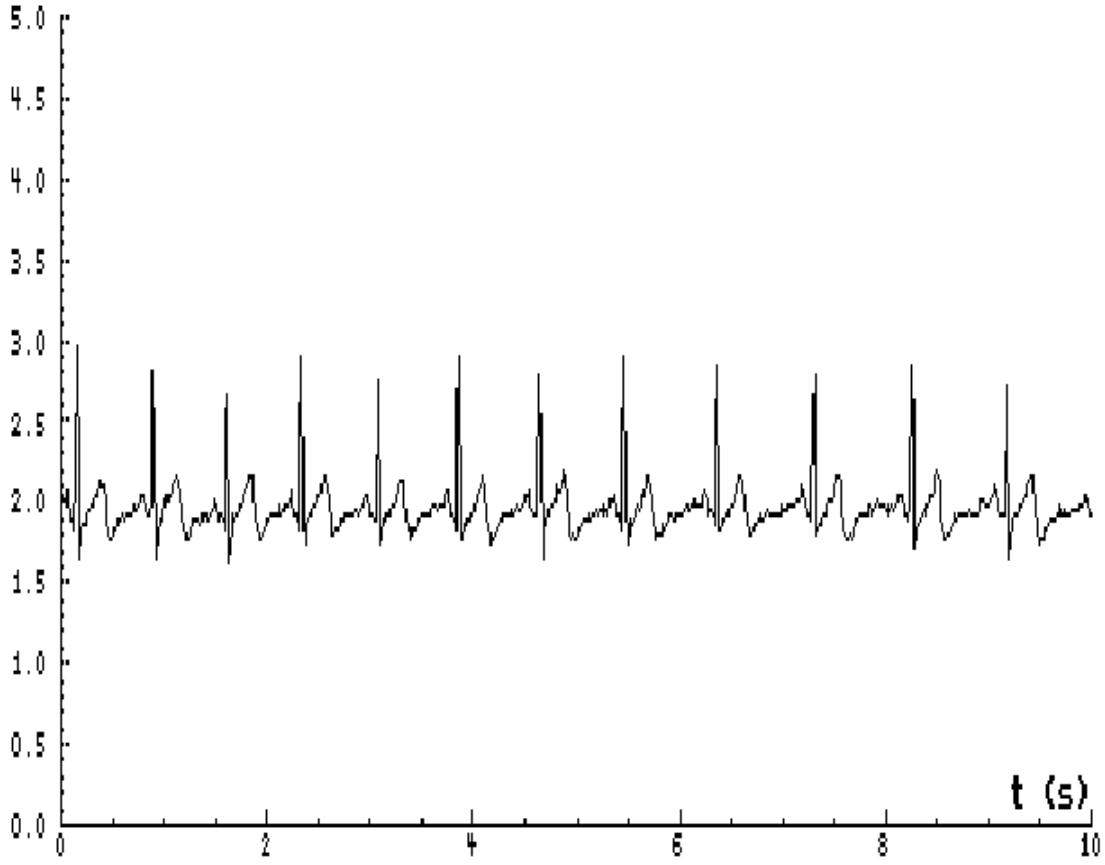

Figure 4. Typical measurement result

The Electrocardiogram

A characteristic EKG of one heartbeat is shown in figure 5. Every (normal) heartbeat is composed of a P-wave, a QRS-complex and a T wave.
The P wave is caused by depolarization of the atrial tissue prior to contraction.
The QRS-waves are generated by currents when the ventricular tissue depolarize, prior to contraction.
The T wave is caused by currents generated as the ventricle recovers from depolarization.
The P-R interval is about 0.16 seconds for most persons. The length of this interval is independent of the heartbeat rate (see figure 6).

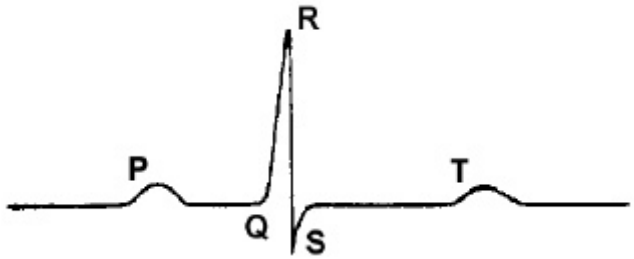

Figure 5. Typical EKG

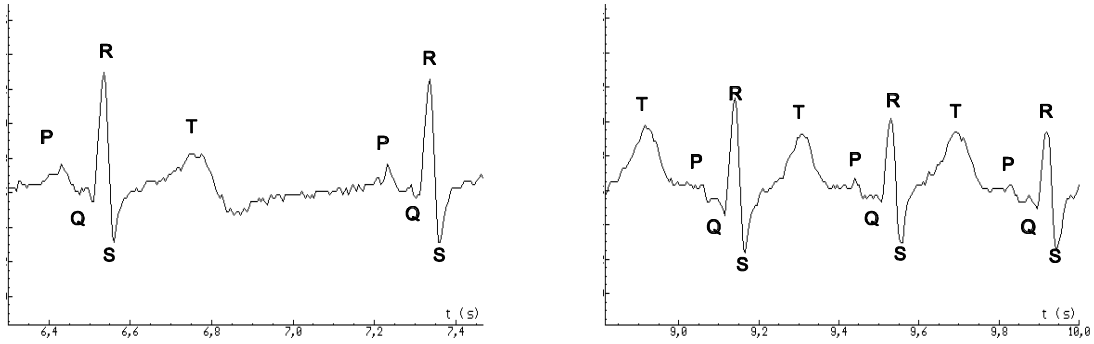

Figure 6. Two registration of an EKG from the same person, on the left at a heartbeat of 80, on the right at a heartbeat of 162 beats per minute.

In general EKG's produced with the CMA EKG amplifier and light sensor will show this pattern. However no EKG, produced with this equipment is the same. Specially, the height of the P wave and the length of the S wave may differ from the pattern shown in medical books (compare figure 5 and figure 6). Figure 5 is taken from a medical book, figure 6 are EKG's made with CMA equipment). This might be due to the method of measuring (the electrodes are placed on the wrists instead of on the breast), but also to the fact that the CMA EKG amplifier is an instrument that doesn't meet medical quality standards.
Note: This product is to be used for educational purposes only. It is not appropriate for medical or research applications. Specifically, it may not be used for patient diagnosis.

Better results
In order to obtain a signal free of interference make sure that the cables between electrodes and amplifier are short (about 10 cm). The amplifier should be near the body (or on the body), and electrode cream should be used in order to minimize contact-resistance of skin and electrodes. Electrode cream is delivered with the EKG amplifier and available as an accessory (CMA foundation).
The amplifier should not be near transformers (computers!) when a measurement is made. The amplifier is extremely sensitive for the field that is produced by the transformers.

Muscles in the arm also produce electrical signals. These signal are much stronger than the potential produced by the heart; The (under)arms of the person whose EKG is produced should not move his arms. Placing the arms on the arms of a chair gives the best results.

Life-duration and replacement of the battery
The duration of life of the battery (9V) is between 25 and 60 hours. Because of the short duration of life, it is important to switch the amplifier of, when it is not used. Replacement is necessary when the indication-LED (bottom right) blacks out. This happens when the voltage supplied by the battery is below 7 volts. When the voltage-supply is 8 volts, the LED produces visibly less light. Opening the flaps on the side of the amplifier and replace the battery. The amplifier itself does not have to be opened.

More technical information about EKG amplifier

The differential amplifier contains three op-amps. The amplification can be adjusted, to a factor of 5x, with a potentiometer in the amplifier. Regulation of the modulation depth is not necessary, because the voltage range of the EKG from different persons, is quite the same. The sensitivity for interference on both inputs at the same time is very low (the common-mode suppression is high). This of importance; this facility reduces the influence of interference (especially 50 Hz noise).

The filter section contains two op-amps. The filter also amplifies the signal. Amplification in the band pass is about 200. Low frequencies are filtered, as well as high frequencies. The crossover points are 0.7 Hz and 50 Hz. Beyond the crossover points signal suppression increases with 12 dB per octave. The amplitude of a sinus-shaped signal of a frequency 2 times higher (above 50 Hz) or a frequency 2 times lower (under 0.7 Hz) is suppressed by a factor 4.

Filtering can be (de)selected by turning a switch on the amplifier to the left. This might be of use when you want to demonstrate the conditioning of signals. When deselected, the differential amplifier is connected directly with the LED-driver. In this case, the signal remains unconditioned. The signal will not be filtered and the modulation depth (percentile variation of intensity) is 200 x weaker. Variations in voltage, produced by the light sensor, connected with the amplifier will be about 10 mV.

The LED-driver converts the electrical signal into an optical signal. The LED is sent a DC current, on which the EKG signal is modulated. The DC current can be regulated with the potentiometer on the front of the EKG amplifier. The modulation depth is not affected by changing the DC current. The modulation depth can be enlarged or reduced by changing the amplification of the comparation amplifier (see above).
Regulation of the DC current on the LED is necessary for the adaptation of the output signal to the sensitivity of the light sensor, which is different for each sensor.

Technical data

Inputs REF Output	Input resistance 10 MΩ Works fine 0.3 V plus or minus V_{REF} Limited to 0.7 V (by diodes) plus or minus and resists voltages 40 V plus or minus V_{REF} Reference input. **Never** connect this input to the analog ground Optical signal for CMA light sensor ∅ 3.0 mm
Amplification	At a voltage, produced by the light sensor of 2 V: - with filter: between 500 and 2400 x - without filter: between 2.3 and 11 x adjustable with (internal) potentiometer.
Filter	Amplification 200 x Band pass: 0.7 - 50 Hz; beyond crossover points reduction = -12 dB per octave (De)selectable by switch
Supply	9 V battery, indication LED for ON/OFF also indicates battery-condition.
Consumption of current	Max. 8 mA (depending on LED-current)
Dimensions	12 cm x 8 cm x 4 cm. 250 gr (incl. Battery).
Delivered with:	3 electrodes, tube electrode cream and battery.

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