

Faster and better diagnosis of heart problems:

Contactless ECG system for emergencies

With a new system, doctors and paramedics can diagnose heart diseases faster and better. The multi-channel electrocardiography system, developed by researchers at the Institute of Electrical Measurements and Fundamental Electrical Engineering, offers significant advantages over conventional electrocardiography. An electrocardiogram can, almost in passing, be recorded through the clothes without contact. Since the new system can be carried similar to a notebook, it can make the quick diagnosis in the field easier in emergency cases and, in particular cases, it can even save lives.



Contactless ECG system with electrode array and tablet PC on the back

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Electrocardiography is a medical routine procedure for diagnosing heart diseases. An electrocardiogram (ECG) is made, which records the heart activity in form of electric impulses. The intensity and the time structure allow conclusions about possible heart diseases. The new method is also based on this technology. Other than the conventional ECG, the electrodes do not have to be applied laboriously with conductive gel or held by vacuum to the skin. The contactless ECG system only has to be held on the body surface to measure the heart signals.

At the same time, the recordings are much more detailed than the previous separate curves. The new machine thus acts as a "window to the heart". It can record films of the electrical heart activity with up to 80 images per second. The measurement results are represented two-dimensionally, similar to a map. Such an illustration is called Body Surface Potential Mapping, where the measured voltages are colored (s. figure). Due to the special array of the electrodes, the doctor can immediately identify the signals spatially and assign them to the

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appropriate body regions. Hence, the heart activity is directly shown above the body surface. This method thus reveals additional, medically relevant information at a glance.

The integrated tablet PC is used for data acquisition. The devices can therefore be immediately available for rescue operations.

How does the new ECG work?

The method uses the effect that the heart activity also causes charge displacement on the body surface. If the charge in the body changes, it can in turn influence the charge on a metal plate close to the body. This plate does not require direct electrical contact to the skin. Measurement is therefore possible through layers of clothing. A supersensitive signal amplifier is connected to the plate which amplifies the body signal and processes it, so it can be displayed on the screen later on. Plate, amplifier and further signal processing electronic systems are integrated in the compact electrodes (30 mm in diameter, approx. the size of a 2 euro coin). The electrodes are only slightly larger than standard ECG electrodes. These new, intelligent electrodes contain essential parts of signal processing electronic systems. They are called capacitive electrodes, from which the term capacitive ECG (cECG) is derived. Researchers at the Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik developed them in cooperation with Prof. G. Curio of the Charité in Berlin and Prof. K.-R. Müller of the Fraunhofer Institute FIRST, Berlin.

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BACKGROUND INFORMATION

- cECG 01** **Electrocardiography (ECG)**
- cECG 02** **Electrodes für ECG Measurements**
- cECG 03** **Capacitive Electrodes for the cECG**
- cECG 04** **Body-Surface-Potential-Mapping**
- emg** **The "Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik"**

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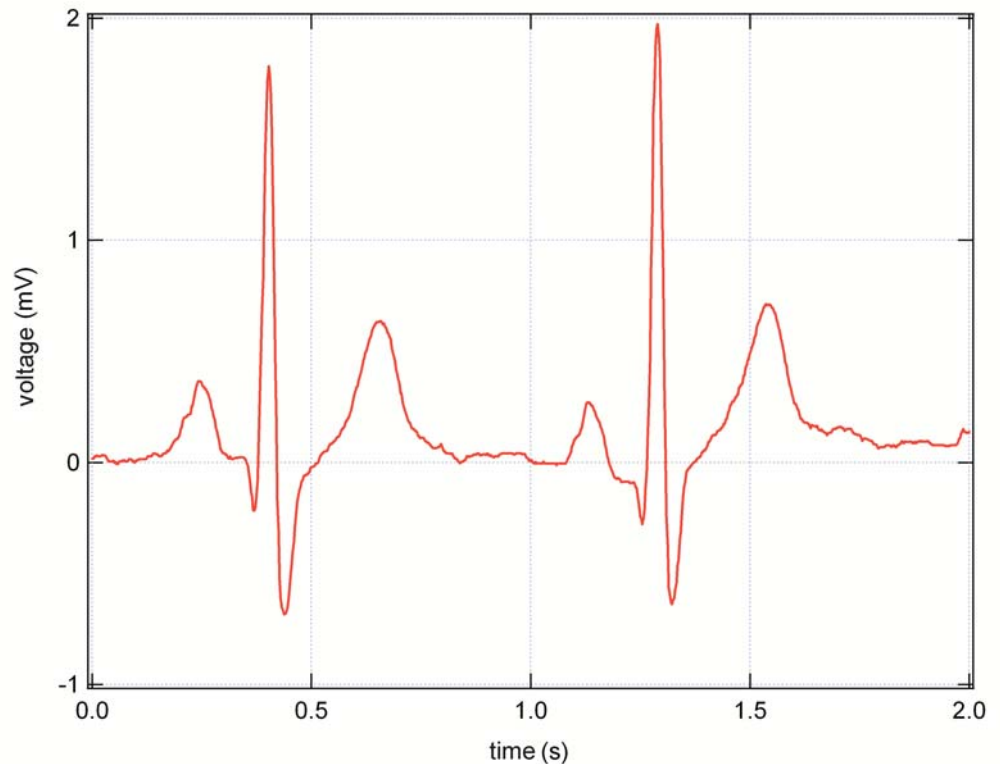
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BACKGROUND INFORMATION



Electrocardiogram of a healthy man

Electrocardiography is a routine method of medical diagnostics for assessing the function of the human heart. The electrical activity of cardiac nerves is measured. The electrical impulses cause contractions of the muscles, which pump the blood through the body and the lung and thus supply the organs with blood.

These electrical processes occur deep in the body on the myocardial muscle and can be measured on the skin due to accompanying voltages. Four electrodes are usually applied to record the electrocardiogram, by means of which voltages distant from the heart can be measured. These voltages amount to a thousandth volt.

The signals are represented as voltage related to time for routine evaluation (s. fig.). Due to the time-dependent representation, the doctor derives diagnosis by comparing the signals of the ill person with the normal signals of healthy ones.

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Suction and adhesive electrode of a conventional ECG system

Electrodes that minimize the contact resistance between electrode and skin surface and guarantee a stable, reliable contact are usually used for ECG measurement. So-called silver / silver-chloride electrodes meet these demands best. The derivation of the ECG can be optimised by using a special conductive gel which is applied between electrodes and skin; modern electrodes are already equipped with the gel in a reservoir. Since **adhesive electrodes** can in general only be used once, there are **suction electrodes** in addition which are held to the skin by vacuum and can easily be removed afterwards. This form of ECG measurement is especially used in doctor's surgeries and hospitals.

BACKGROUND INFORMATION



Electrode with aluminium housing

The effect of charge displacements on the body surface due to the body potentials are used for the capacitive measurement of the ECG. This change of the charge on the body surface can in turn affect the charge on a metal plate close to the body. This electrical plate does not require direct electrical contact to the body, so it is isolated from the body. Therefore, the measurement of the capacitive ECG (cECG) is also possible through layers of clothing. A supersensitive signal amplifier is connected to the plate which amplifies the body signal and processes it, so it can be displayed on the screen later on. Plate, amplifier and further signal processing electronic systems are integrated in the compact electrodes of 30 mm in diameter. The electrode is thus only slightly larger than a standard ECG electrode.

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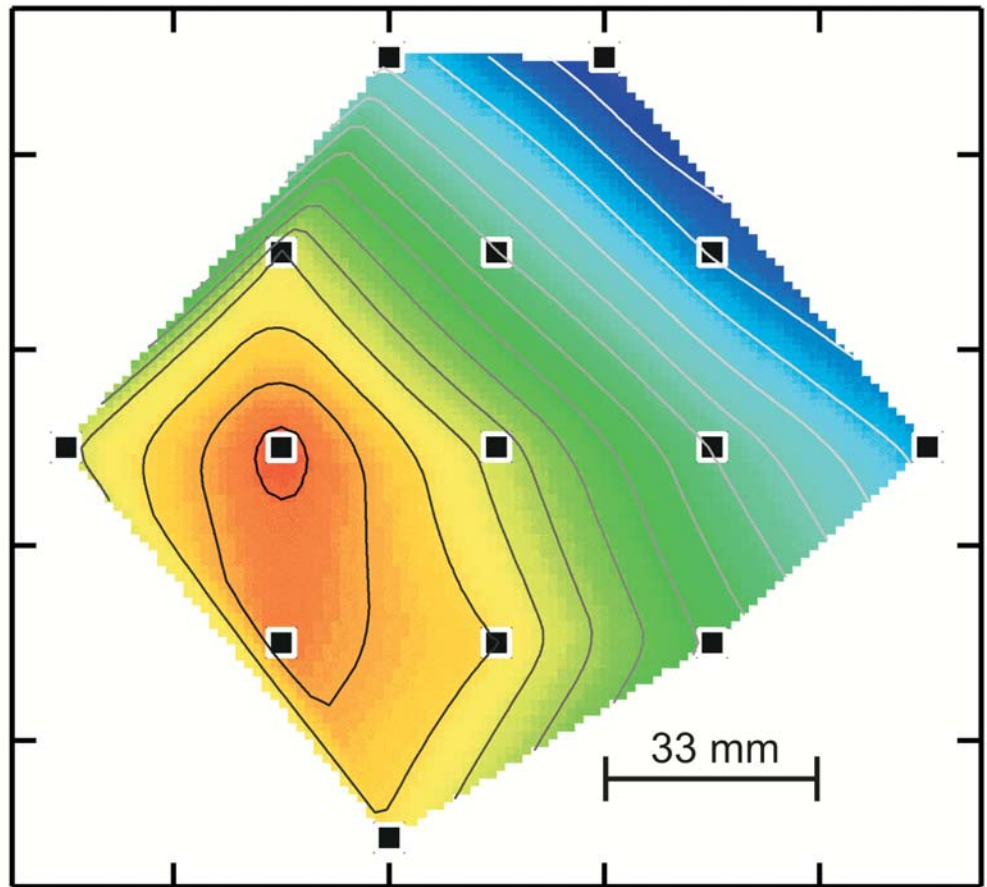
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*Body Surface Potential Map, recorded by cECG
Positive voltages are coded red, negative ones blue.*

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Apart from the usual display of the ECG signal as a voltage curve related to time, the representation of the spatial potential distribution of the electrical signal on the body surface can provide important medical information. Such a representation is called Body Surface Potential Mapping. Due to the special array of electrodes of the cECG presented here, the signals can be displayed immediately during data recording as well. For this purpose, the measured voltages are colour-coded and plotted in a coordinate system in line with their position in the electrode array (s. figure above). The heart activity is thus shown directly on the body surface. The new cECG machine thus acts as a "window to the heart", with the possibility of recording films of the electrical heart activity with up to 80 images per second.

The "Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik"

BACKGROUND INFORMATION



At home and in cars, as well as in industry and economy: Everywhere electrical sensors are at work for many kinds of instruments. The "Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik" of the TU Braunschweig headed by Prof. Dr. rer. nat. Meinhard Schilling investigates how sensors can be manufactured smaller, more precise and more reliable. Also new metrological concepts are developed. The sensors are produced in a modern cleanroom by means of nanotechnology and are attached to analog and digital measurement systems. These systems are employed for magnetic field measurements, biochemical/medical applications and for the analysis of microchips working at the highest frequencies up to more than 1000 GHz. In all these areas close cooperations with industry and international research institutes are maintained and extended.

The **magnetic sensors and systems** are tested in a magnetically shielded room. There also is a SQUID magnetometer system for biomagnetical measurements of the heart and the brain located.

For the development and testing of **biochemical sensors** a bioreactor is placed in a S1-laboratory, which guarantees the secure handling of microorganisms.

For analysis of microchips at **ultrahigh frequencies** a microwave laboratory is maintained with a far infrared laser-system, where also the novel terahertz-microscope has been developed.

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