Acquisition of Corneal Electrical Signals by a Simple Method

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RADIO TECHNOLOGY
IN BIOMEDICAL INVESTIGATIONS

ACQUISITION OF CORNEAL ELECTRICAL SIGNALS BY A SIMPLE METHOD

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Conventional systems for electroretinography (ERG) use complex electronic circuit to get electrical corneal signals (ECS), they usually use dedicated data acquisition hardware to acquire the signal over the cornea's eye. In this paper we proposed a simple method to acquire the ECS using the computer sound card to put into the PC the ECS. We show the results of the signals acquired from the cornea through microphone's port.

KEY WORDS: *retina, cornea, map of vision, electric stimulator*

1. INTRODUCTION

Typical multi focal electroretinography equipment generate random spots patterns, each spot goes to a specific point over the retina`s surface. Detection levels of each electrical signal measured at the cornea´s patient lets the physician a map of vision performance of the patient. The measured procedure on the cornea's eye is done by special electrode [1]. The electrode carries the signal to a low noise amplifier to eliminate undesired noise, transmitting the signal to a computer [2] (Fig. 1), to show them graphically to the physician for an easy understanding of the levels of sight of each retina´s point.

2. TYPICAL SYSTEM FEATURES

2.1 Electrodes

The contact lens electrodes has an inner gold ring connected by a copper cable to acquire the signals from the cornea´s surface. The reference electrode is attached to the forehead, or to the ear's lobe [1]. Both electrodes are connected to instrumentation amplifier designed to provide a high input's impedance and a high common mode rejection ratio [3].

2.2 Amplifier

The low noise amplifier must fulfill certain minimum features to amplify properly the cornea´s signal [4]; these features are indicated on the Table 1.

Some multifocal electroretinography equipment, like RETI scan version 3.1 [5], use a 1000 gain preamplifier to obtain the signal from electrodes, a pass band filter to reduce noise. The output signal of the preamplifier is sent to an acquisition card placed on a slot computer, amplifying again the signal until reaching a gain of 100,000 to 200,000 [4]; later the signal is filtered by pass band filter and then the signal is converted from analog to digital, finally, the information is processed by dedicated software .

TABLE 1: Amplifier features

Feature	Specification
Bandwidth	3 Hz to 300 Hz
Gain	100.000 to 200.000
Input impedance	10 MΩ minimum
CMRR	100 dB minimum

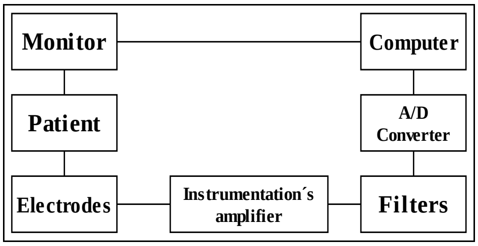

FIG. 1: Block diagram of the Electroretinography's equipment

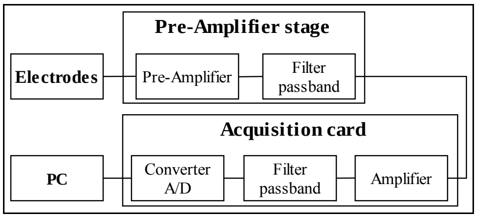

FIG. 2: Block diagram of the RETIscan system

Another electroretinography equipments, like that designed by Metrovision [2], use an amplifier whose input has a preamplifier with a gain of 2500; this stage is followed by a passband filter with a bandwidth of 0.1 Hz to 1200 Hz; later the signal is sent to another amplifying stage with adjustable gain of 1.5 to 5; after that the signal goes through an adjustable programmable filter to deliver a clean signal to the conversion stage from analog to digital; finally the signal is sent to the PC's parallel port where the information is processed (Fig. 3).

It is important to mention that both equipments have floating stages whose function is to protect the physical integrity of the patient [4], isolating electrically the cornea of the leakage currents that could be generated in the components interconnected to the amplifier; to avoid this undesired effect the amplifiers use floating sources, opto-insolated or DC to DC converters [2].

Typical commercial equipments acquire signals on the cornea's surface by complex A/D circuits like data acquisition cards and signal pre-processing consoles. This paper proposes the use of a simple PC sound card to acquire the analogical signal. We use the PC sound card for analog to digital conversion, to process the signal and to put it ready for final software manipulation (Fig. 4).

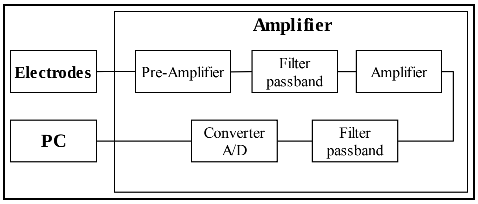

FIG. 3: Block diagram of Metrovision's system

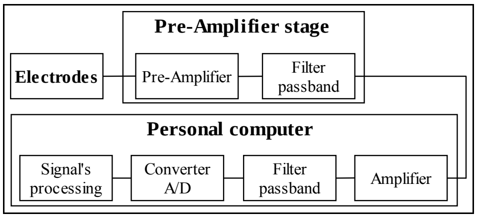

FIG. 4: Block diagram of proposed system

3. PROCEDURE

To carry out this work, a simple MatLab program was developed to acquire the signal from the PC sound card. Some cards have only one channel to acquire the audio signal (mono), but others have two channels (stereo). We must be careful to select the adequate channel by which the signal will be captured [6]. Software has a flag to set the selected port. The cornea´s signal acquired has a low maximum frequency component that is in the order of 250 Hz (see Fig. 5) [1]. Most PC sound card takes samples between 8000 Hz and 44100 Hz, then the sampling audio PC port is more than enough to convert to digital samples the ECS. We must be very careful to read to the audio port immediately after the spot light on the screen is over and for a time no longer than the next light spot will come again [7]. The maximum value of the ECS is represented as a data correlated with its spot position in the cornea to let a dedicated software display set of values with n colors representing the amplitude of the (ECS) and its position.

The gain of the sound card is controlled by software, by varying the intensity of the volume with the recording control; the input signal can be changed with a minimum gain of 0.31 and a maximum gain of 150.

3.1 Corneal electric stimulator

In order to do the necessary tests to our ERG system, without having the need to stimulate a patient we used a set of ERG patterns generated by our own Corneal Electrical Stimulator (CES). [1,8,10-12]. The CES generates real ERG signals from previously synthesis waveforms of recorded signals patterns taken from human cornea after spot stimulation. The CES signals are generated by a friendly adaptive filter.

The control's software of the CES is a program developed under the Matlab 7.0 environment by means of the parallel port that sends codified digital information to generate a voltage waveform with frequency and amplitude desired, Fig. 5 shows the appearance of the graphical software user interface. The graphical environment shown allows the user to manipulate the voltage (F), the frequency (G), and the number of stimulus (E) of the CES.

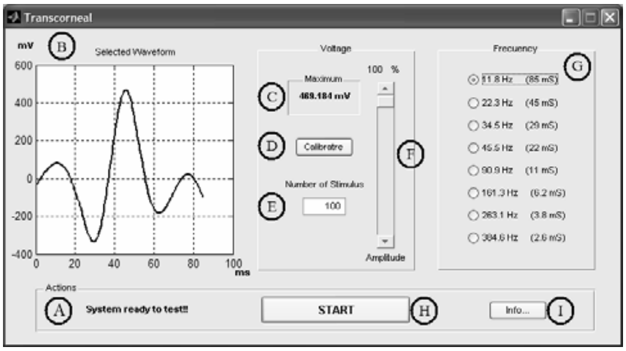

FIG. 5: Wavelet Graphical environment appearance

3.2 Pattern generator

In order to stimulate the retina we use not only traditional light spots, but also a set of predefined patterns that can be implemented on diverse easy forms by the physician. We generate over the screen a random sequence of hexagons to stimulate the cones [7]; to stimulate the rods a sparkle of blue light is used. In both cases the retina must be adapted to darkness by twenty minutes [4].

We show in Fig. 6 the spot light generator over the PC screen. The dedicated software let us get sets of (Fig. 7) [7] different pixel arrangement in a cathode ray tube monitor (CRT), controlling the size and the position of the spot. We also can stimulate with different wavelength to investigate the effects of the wavelength into the photoreceptors' response. We can obtain too the accumulated response of all the photoreceptors (cones and rods), by a sparkle of white light impacted over all the retinas` patient.

To acquire the ERG signal we use a low noise preamplifier (SR560 model, Stanford Research System) its features are shown on Table 2 [9].

The PC port was adjusted with a function generator (GF8056 model, ELENCO), which was set to a frequency of 50 Hz and a voltage of 1 Vp-p; an oscilloscope (THS720P model, Agilent Tektronix), was used to acquire and compare the obtained signal, which has two acquisition channels to 100 MHz with isolated channel.

TABLE 2: Specifications of the amplifier SR560

Feature	**Specification**
Bandwidth	Adjustable 0.03 Hz to 1 MHz
Gain	1 to 50000
Input impedance	100 MΩ
CMRR	> 90dB to 1 kHz

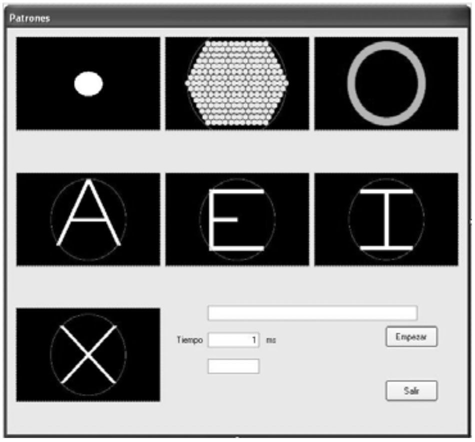

FIG. 6: Software generator of luminous patterns

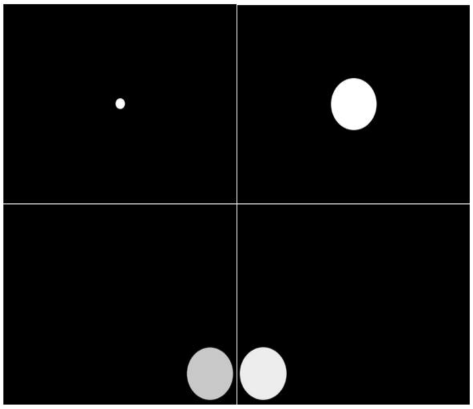

FIG. 7: Pattern with size, color and position variable

4. RESULTS

For testing we use a commercial biomedical amplifier SR560 with a minimum 100 mV pp signal at its input, see Fig. 8. Figure 9 shows the preamplifier output signal, we can see the filter effectiveness to eliminate all the high frequency noise components; the Fig. 10 shows the signal captured by the computer port with a gain of 1.

Afterward, an ERG signal of 100 mV_{p-p} is at the input of the SR560 amplifier with an increased frequency of 161.3 Hz. Figure 11 shows the SR560 amplifier output and Fig. 12 shows output at the sound card. We can appreciate the flexibility of the sound card to different input signals.

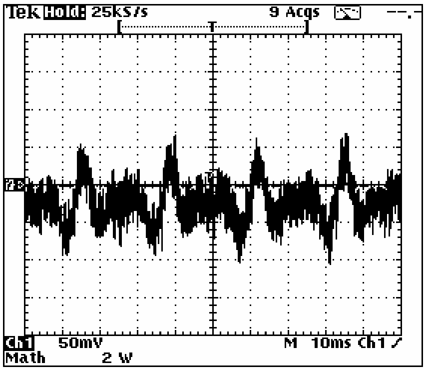

FIG. 8: ERG signal obtained with the oscilloscope from the generator

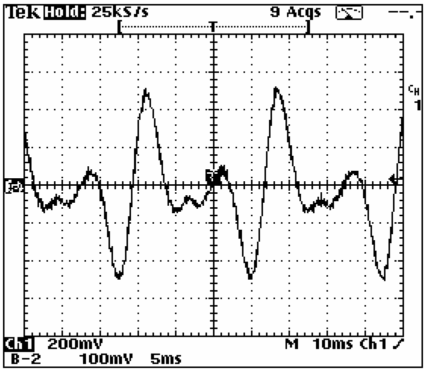

FIG. 9: ERG signal obtained with the oscilloscope from the amplifier

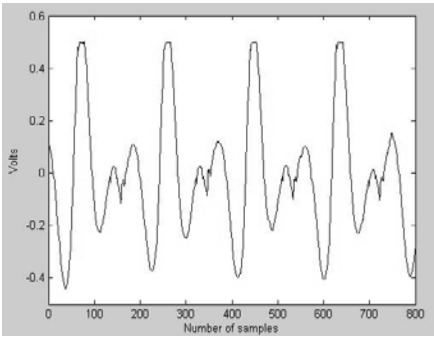

FIG. 10: ERG signal captured with the sound card obtained from the amplifier

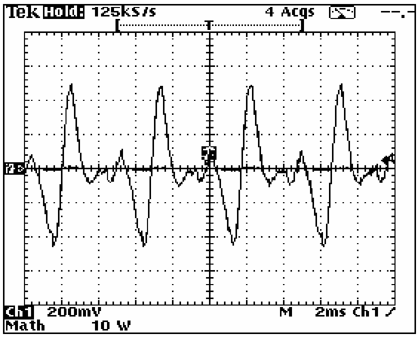

FIG. 11: ERG signal obtained with the oscilloscope from the amplifier

5. CONCLUSIONS

We conclude that sound card PC works properly to acquire ECS signals. The sound card is usually integrated in almost all computers, then it is possible to acquire ophthalmology signals by an easy and low prices procedures. We conclude that an analog PC port has good enough filters to acquire ophthalmology signals over the cornea. The software needed to manipulate the signals by the analog port of the PC are low demanding., but we must take care of that the interface between the amplifier and the PC, must be really electrically isolated. Results let us be optimistic to new possibilities for biological data acquisition systems by the audio port in PC equipment. The system can generate sets of pre-defined patterns to study the retina electrical answer not only to spots but also complex patterns.

Our ECS generator is capable to reproduce exact ophthalmology signals for Calibration proposes.

6. ACKNOWLEDGMENT

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