EYE MOVEMENT CONTROLLED MOUSE POINTER

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ABSTRACT

This paper proposes the design of a reconfigurable mouse pointer controlled by movement of the eyes. The system uses the biopotential signal related to the eye movement to send commands through a PS2 mouse interface to a microcomputer. The controller responsible for interpreting the digital representation of the biopotential signals is synthesized in a reconfigurable device (FPGA).

It is an ongoing project and currently, we already have experimental results demonstrating the main features of the desired system.

1. INTRODUCTION

The biopotential is an electric signal measured in a living organism. The bioelectric phenomena may involve the generation of electric fields or currents resulted from the biological processes. Their origin comes from the difference of internal and external membrane ions's concentration [1].

The eye movement biopotentials are often recorded by an instrument called electrooculogram (EOG) [2], used for diagnosis purposes. On the other hand, several works report the use of the electrooculogram (EOG) for different classes of applications [3][4]. Wearable smart devices, as special glasses, can be used for allowing people with motor dysfunctions to control the mouse pointer of a microcomputer [5].

In the laboratory of Microelectronics and Embedded Systems, we are currently developing a wearable sensor network for serving as a platform of a class of wearable instruments. One of them aims at helping physically disabled people to have access to information through the internet [6], using an eye-movement-controlled mouse pointer [5]. In this paper, we present the initial steps on this research, developed in the framework of a scientific initiation program. We have developed the front-end of the desired device, which includes a biopotential sensor (instrumentation amplifier), an analog-to-digital converter (ADC), a digital controller and a PS2 interface. This prototype is for concept proof purposes and will guide the specification of an integrated circuit which will include all circuits.

This paper is organized as follows: after this introduction, in section 2, we describe the proposed system operation. Then, in section 3 we develop the description of the adopted architecture. In section 4 we present the obtained results and provide comments on them. Finally, in section 5, we draw some concluding remarks.

2. DESCRIPTION OF THE SYSTEM OPERATION

The developed prototype uses a mechanical PS2 mouse as a starting point. Its operating principle is very simple and is based on the movement of a small sphere rolling over a table. The sphere's movement is captured by an optoelectronic circuit and is reproduced by a moving sprint on the screen of a microcomputer. In our circuit, we measure the EOG signal and after some signal processing, we emulate the mechanical mouse sphere's movement.

The biopotential of the eye is generated between the cornea and the retina, and measures from of 10 to 100 µV [2]. It is captured using AgCl electrodes (silver chloride) [2], which are arranged on the face of the individual as shown in Figure 1.

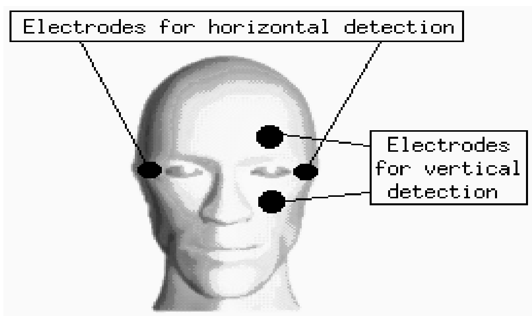

Figure 1. Arrangement of electrodes on the face

The electrodes are connected to instrumentation amplifiers, which present high differential gain, high input common mode rejection and high input impedance. The frequency band of interest spans from 0 to 10 Hz [2]. After amplification, the signal is digitized, using an analog-to-digital converter.

The digital signal is processed by a digital circuit in order to detect the direction of the eyes' movement and to generate signals that emulate the mechanical mouse behavior. The digital circuit was modeled in Verilog Hardware Description Language [7][8]. The circuit is detailed in the next section.

3. DESCRIPTION OF ARCHITECTURE

In Figure 2, the block diagram of the system is illustrated. The device's architecture is composed of two EOG amplifiers (one for each direction, vertical and horizontal) [2][4][5], a A/D converters (one for each amplifier) and a FPGA.

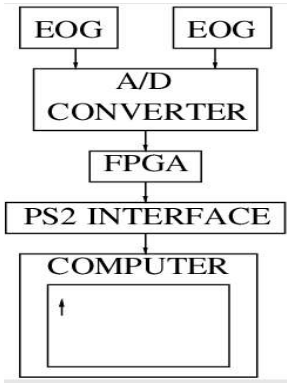

Figure 2. Diagram of the architecture

The instrumentation amplifiers are standard instrumentation circuits [9], adding up low-pass filters (with a cutoff frequency of 11 Hz, since the frequency range of the signal eye is from 0.1 to 10 Hz [2]) and control of DC offset. The amplifier (Figure 3) has two stages of gain: the first has 33.51 dB gain and the second 58.27 dB gain, resulting a total gain of 92 dB.

The device proposed will replace the system of the sphere of the mechanic mouse. For this purpose, it was done a system that produces signals equal to those generated in the mechanical device.

A signal used in mechanic mouse is produced using a FPGA implementation [10][11], replacing the system of the sphere (Figure 4).

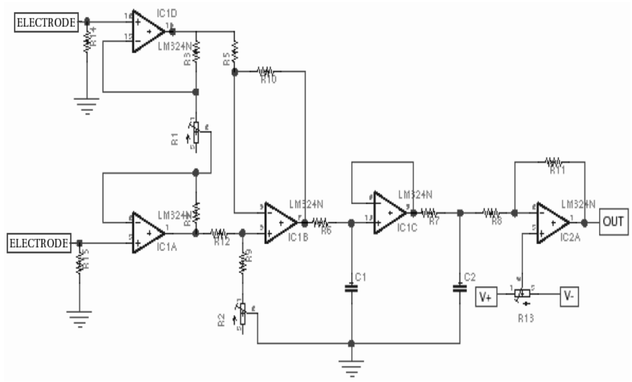

Figure 3. Biopotential amplifier circuit diagram (EOG)

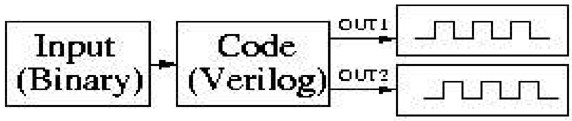

Figure 4. Diagram of the model behavior

When the mouse is moved, two signals delayed by 90° are generated (Figure 5). From this delay the chip processor distinguishes the sense that the individual is moving the mouse (top-down, right-left).

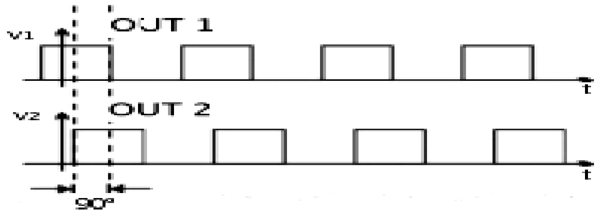

Figure 5. Signal generated in the movement of the mechanic mouse

The FPGA was used as a link between the eye movement device and the PS2 interface. It is through this that we can control the outputs on the basis of inputs, which are the biopotentials signals already scanned. The EOG circuit also provides the control of the digital signal level by the offset adjustment on the input signal.

4. RESULTS AND DISCUSSIONS

The test results showed that the magnitude of the signal varies accordingly to the direction of eye movement (from top to down, from right to left), as expected. Another observation made was the increasing of the signal's magnitude as the eye movement's frequency goes up. The potential obtained was around 50 μV. The EOG signal (shown in Figure 6) was measured on the output of the first stage of the amplifier.

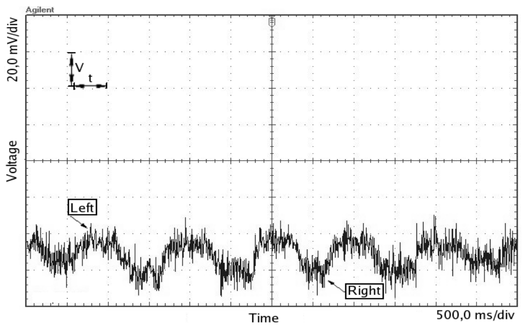

Figure 6. EOG Signal

The result of simulation code in Quartus II is showed in Figure 7. Three-bit code were used (a, b, c), since the aim was only to test the description. The combination between them, simulated the direction to which the person was looking, for example: 110 > right, 111 > left. The outputs were specified as out_e (left) and out_d (right). The clock is specified as clk. Based on the simulation, we observe that the outputs to are not outdated 90° to each other.

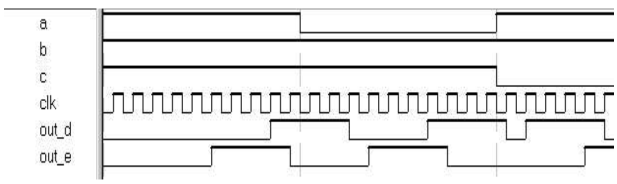

Figure 7. Result of simulation in Quartus II

The description implemented in FPGA is the behavioral model of system of mechanic mouse, but the signals outputs aren't delayed of 90º to each other. However, it was found that a gap of 90° is not necessary to between the signals so that the chip can distinguish the direction of movement. The results of the analysis are shown in Figure 8.

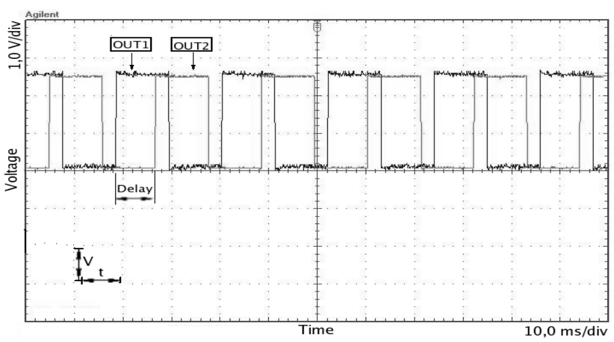

Figure 8. Outputs of the FPGA

The FPGA used was the Altera Cyclone EP1C12Q240C8. This provided great flexibility for adjustments in the system, since any modifications that need to be done was through it, only modifying the description of the hardware. The oscilloscope used to measure the signal was the model DSO3202A of Agilent.

5. CONCLUSIONS AND PERSPECTIVES

This paper proposed an architecture for building a reconfigurable mouse pointer controller, using amplifiers and EOG and FPGA. The use of FPGA made the system adaptable to the mode of operation desired by the user. The device is being developed with the aim of benefiting physically disabled, who may not have the same form of adaptation to the device, then, lends itself to the user system.

The system continues to be developed and the next step is to integrate all the circuits in a printed circuit board. Then, we will develop specifications for an integrated circuit and in a long term, we expect to build a wearable sensor network platform for developing devices for use in human body.

6. ACKNOWLEDGMENTS

We would like to acknowledge CNPq for supporting this work, also the Propesq, and all the volunteers who helped in search.

7. REFERENCES

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