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DESIGN AND IMPLEMENTING AN INSTRUMENT FOR PSYCHOPHYSIOLOGYCAL DIAGNOSIS (CASE OF ELECTRODERMAL ACTIVITY

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I. Introduction

The observation that changes in electrical activity of the skin can be produced by various physical and emotional stimuli was reported in 1888 by Charles Fere. Since then, EDA (Electrodermal activity) measures have been applied to a wide variety of questions ranging from basic research examining attention, information processing, and emotion, to more applied clinical research examining predictors and/or correlates of normal and abnormal behavior. Currently, different types of devices exist for EDA detection. They consist of PIC microcontroller or DSP, analog to digital converter, precision operational amplifiers, etc. By using an Atmega168 microcontroller, we reduce the number of component and propose a circuit easy and cheaper to implement.

II. Conditioning circuit for EDA and Implementation

Figure 1 shows the conditioning circuit for EDA. The circuit uses three Op amps: first of them (U1A) together with R3 and skin resistance build up a non-inverter assembly which maintains a constant voltage of 500 mV applied to the subject; The second (U1C) together with resistances R4 and R5 build up a differential amplifier which allows to obtain an output voltage (VS2) directly proportional to the skin conductance (1/skin resistance). U1B is used as a follow assembly. R6 together with C1 build up an order 1 low-pass filter. The output of the filter gives the analog voltage (Vanalog) which will be sampled. R1 together with R2 build up a voltage divider assembly which produces 500 mV from a 5 V precision voltage generator.

The equations of V_{REF}, V_{S1}, V_{S2} and V_{analog} are:

$$V_{analog} = \frac{1}{1 + J\omega \cdot R_6 C_1} V_{S2} \quad (1)$$

$$V_{S2} = \frac{R5}{R4} \cdot \frac{R3}{R_{skin}} \cdot VREF \quad (2)$$

$$V_{S1} = V_{REF} \cdot \left(1 + \frac{R3}{R_{skin}}\right) \quad (3)$$

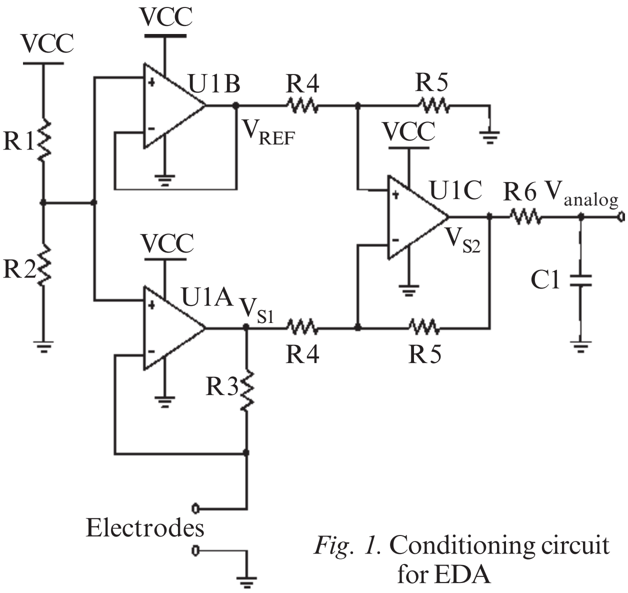

Fig. 1. Conditioning circuit for EDA

$$V_{REF} = \frac{R_2}{R_1 + R_2} \quad (4)$$

Where VCC is a constant voltage equals to 5V, R_{skin} is the skin resistance, R1, R2, R3, R4 and R5 are resistances.

In order to determine the range of the resistance that the circuit can measure with a negligible error, Rskin is replaced by a test resistance whose values are presented in Table 1.

Table 1

Measurements errors

Rskin (kΩ)	VS1 calculated (V)	VS1 measured (V)	Err_1 (%)	VS2 calculated (V)	VS2 measured (V)	Err_2 (%)
4.3	4.34	4.12	1.12	1.74	1.68	0.21
10	2.15	2.20	0.12	0.75	0.78	0.12
20	1.325	1.359	0.09	0.375	0.394	0.09
91	0.681	0.702	0.06	0.082	0.088	0.04
220	0.575	0.589	0.03	0.034	0.037	0.03
330	0.55	0.565	0.04	0.023	0.0256	0.03
560	0.529	0.544	0.04	0.013	0.016	0.07
1000	0.5165	0.531	0.04	0.0075	0.0099	0.08
2200	0.5075	0.522	0.04	0.0034	0.0061	0.21

Where circuit in which it is added the microcontroller and the adaptation circuits. The microcontroller is an Atmega168 which consist of an integrated 10 bit ADC and an USART (Universal Synchronous and Asynchronous serial Receiver and Transmitter). The pin 28 of Atmega168 receives the analog signal which is then sampled at 1500 Hz. After computing the digital value, it is then sent to the transmitter pin of the USART (pin 3). By using an adaptation circuit (max232), it is easy to convert TTL output of the microcontroller to EIA-232 voltage levels used by serial ports. Pin 3 of Atmega168 is connected to pin 11 of max232 and its pin 14 is connected to the transmitter pin (pin 2) of DB9 serial connector.

Vcc (5V) is obtained by using a 5 V precision regulator which is itself supplied by a 9 V battery.

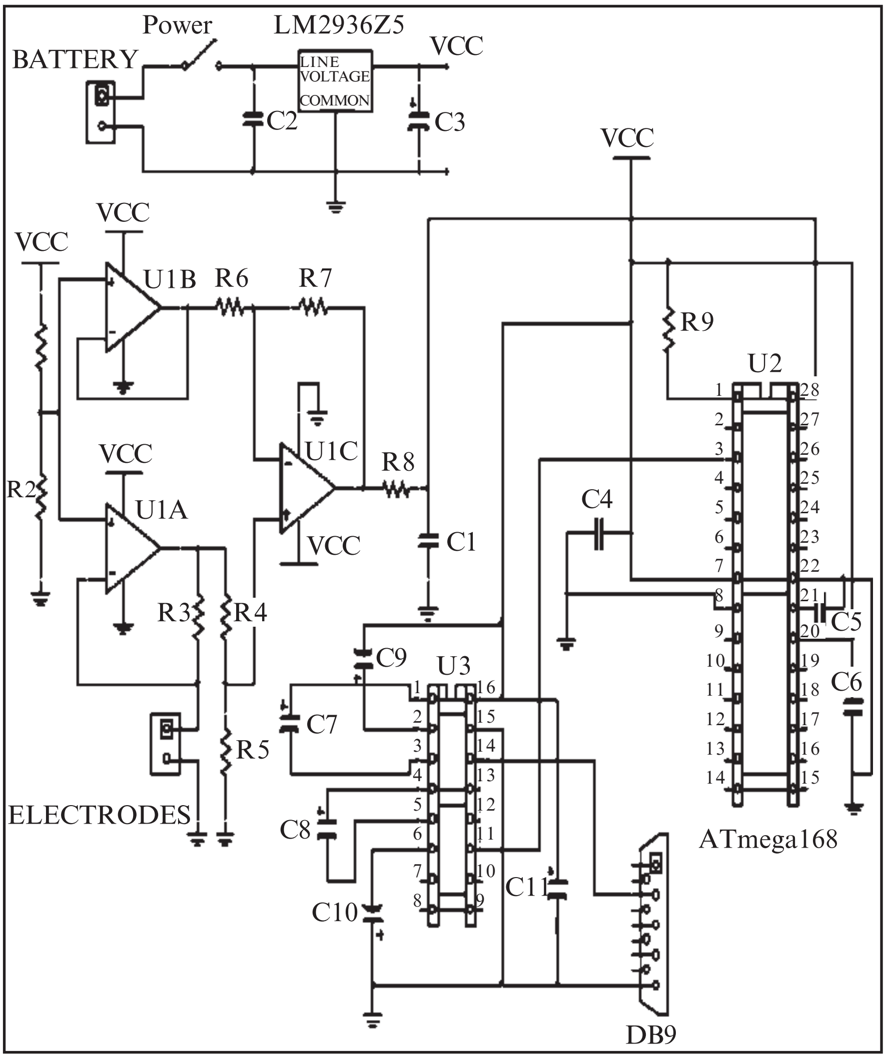

Fig. 2. MV Circuit for EDA detection

III. Results

Once the implementation is completed, it was experimented on five people during the first minutes of their thesis defense. There were chosen assuming that there were under stress.

By recalling equation (2), we can find the value of skin conductance (Y_{skin}), knowing that conductance is the inverse of resistance. So

$$Y_{skin} = \frac{1}{R4} \cdot \frac{V_{S2} \cdot R4}{V_{REF} \cdot R3 \cdot R5}$$

In this equation, R3, R4, R5 and V_{REF} are known. V_{S2} is the value measured by the ADC (because $V_{S2} \approx V_{analog}$). This value of Y_{skin} is static. However, skin conductance values vary as a function of the arousal level of the subject, electrode size and contact with the skin, humidity, temperature, and a number of other variables. These variables vary with time. This allows us to model these parameters by introducing the term θ (t) in formula (6) which becomes:

$$Y_{skin}(t) = \frac{V_{S2} \cdot R4}{V_{REF} \cdot R3 \cdot R5} \cdot \theta(t)$$

Table 2 below summarizes the results of the measures.

The average conductance is between 2 and 20 μSiemens. From an emotional context, the candidate CA3 appears to be the less emotional or less stressed in the current context as Figure 3 (C) shows little fluctuation (peak) around its average value (2.51 мS). In fact, graph of the conductance is relatively stable around the mean value. Similarly, the candidate CA4 also presents a relatively flat curve around its average value (2.55 мS). During the first minutes of the recording time (up to 100 seconds or 120 seconds), the conductance is low (2.8 мS to 3 мS) but after the one hundred twentieth second (120th seconds) it decreases and remains fairly stable, with little oscillations around 2.5 мS. However, the evolution of EDA for candidates CA1, CA2 and CA5 are less stable than that of CA3. They appear to be more stressed

Table 2

Record of EDA observations in the first 5 minutes of candidate defense

Candidate ID	Age	Y_{skin}_moy
CA1	23	1.92E-06
CA2	27	4.18E-06
CA3	23	2.51E-06
CA4	26	2.55E-06
CA5	23	1.76E-06

Note. Y_{skin}_moy = Conductance mean in Siemens (S).

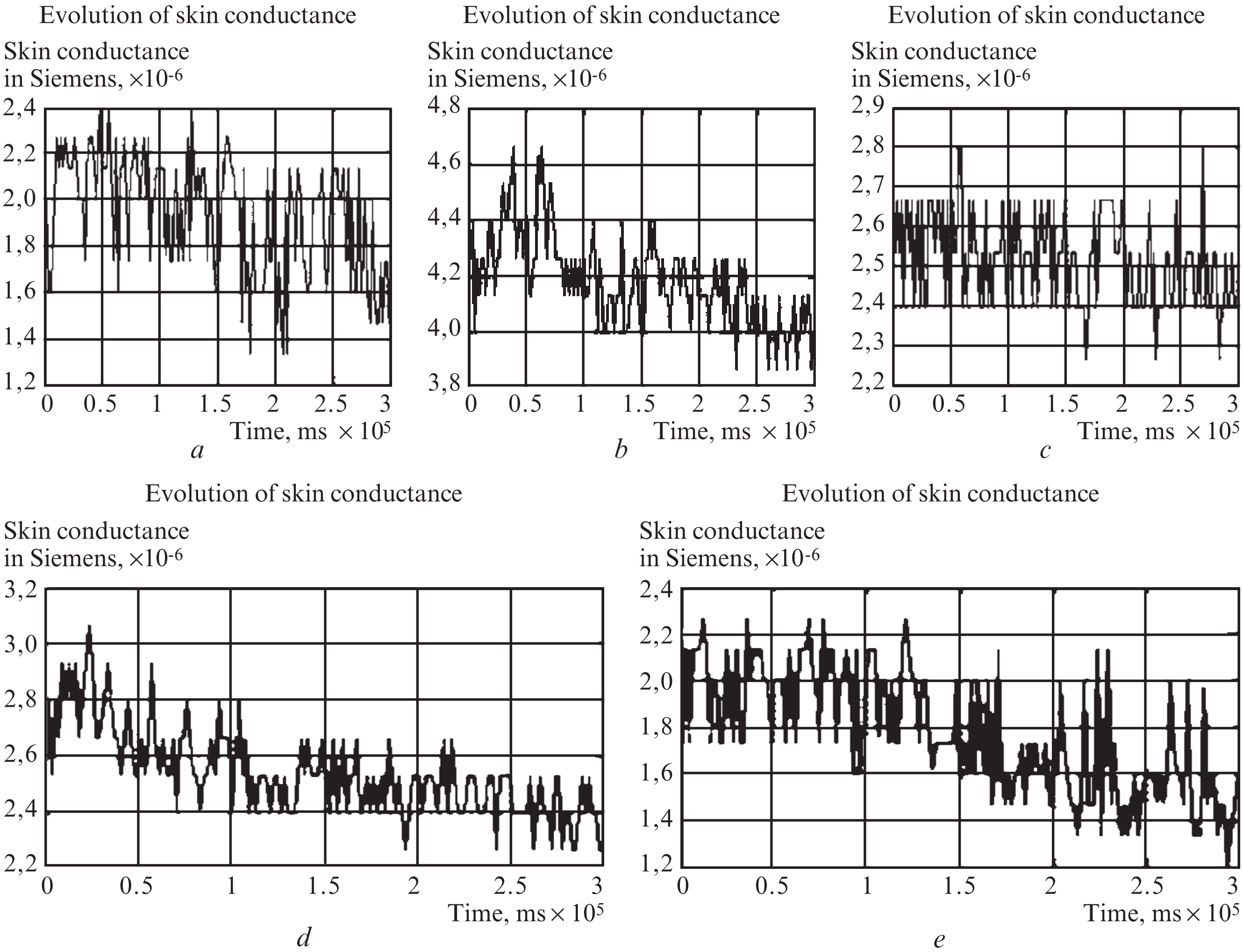

Fig. 3. Electrodermal activity of candidates

than CA3. However, despite the emotional state of CA2, the graph of its conductance shows some stability over candidates CA1 and CA5.

Then a correlation study was performed and the results are presented in Table 3, where p_values are probabilities for correlation between skin conductance and a particular characteristic be significant.

The analysis of these results reveals a positive correlation and significant at 10% between skin conductance and age of candidates. In other words electrodermal conductance increases while age increases. Similarly, there is a positive and significant correlation at 1% between electrodermal conductance and body mass of candidates. Thus, the conductance increases while age and/or body mass of the candidate increase.

Table 3

Correlations between electrodermal conductance and personal characteristics

Individual Characteristics	Skin Conductance (Y_{skin}_Moy)
Age of candidates	0.841 (0.074)*
Size	0.482 (0.411)**
Body mass	0.967 (0.007)***

Note. p_values are in brackets; (*), (**), (***) significant at 10%, 5%, 1%.

IV. Conclusion

This paper presented a circuit able to record electrodermal activity and the results obtained after experiencing the device. The proposed circuit is built around FERE's model and conductance measures are ranging between 1 мS and 100 us. Electrodermal activity is a good indicator of stress level. It is based on the variation of dermal conductivity, which is dependent on the emotional state of the person and his age.

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ДИЗАЙН І ЗАСТОСУВАННЯ ОБЛАДНАННЯ ДЛЯ ПСИХОФІЗІОЛОГІЧНОЇ ДІАГНОСТИКИ (ЕЛЕКТРОДЕРМАЛЬНА АКТИВНІСТЬ)

Досягнення в електроніці, й особливо в інструментарії, зробили можливою модернізацію медичного обладнання та появу нейровізуалізації. Однак незважаючи на грунтовну роботу, яка проводилася Фере і Тархановим з 1888 р., у галузі психофізіології у подальшому спостерігалося відставання. У цій статті ми описуємо нове обладнання, засноване на методі Фере, спроектоване і впроваджене для реєстрації та аналізу показників електродермальної активності. Усі частини цього обладнання зроблені на основі мікроконтролера ATmega168.

Ключові слова: електродермальна активність, ендосоматичний метод, метод Фере, ATmega168, психофізіологія.

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DESIGN AND IMPLEMENTING AN INSTRUMENT FOR PSYCHOPHYSIOLOGYCAL DIAGNOSIS (CASE OF ELECTRODERMAL ACTIVITY EDA)

Advances in electronics, and particularly in instrumentation have made possible the modernization of medical equipment and the emergence of neuroimaging. However despite the groundwork laid by Fere and Tarchanoff since 1888, a delay occurs in the field of psychophysiology. In this paper we describe a new instrument based on FERE's method, designed and implemented for EDA's record and analysis. The hard and soft parts of the instrument are based on the skills of microcontroller ATmega168. An amplitude analysis achieves the diagnosis skills of the instrument.

Key words: EDA, endosomatic method, FERE method, ATmega 168, psychophysiology.
