Microcontroller Based Device for Cranial Electrotherapy Stimulation

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Abstract – "**A Cranial Electrotherapy Stimulation (CES) device includes: a low frequency generator, frequency generator controller, current generator, output mode module, output trigger module and a frequency status display. To compose each module as a separate part will make the device too complex, difficult to extend and moreover not cost effective. Taking in mind today's progress of microcontroller technology, leaded by the tendency to migrate as much as possible to software than hardware, most of the modules can be software realized and uploaded to a microcontroller. This case is solved by using a PIC Microchip microcontroller which covers the needed resources such as sufficient number of inputs and outputs, enough memory and a good clock speed rate."**

Keywords-**low frequency, frequency generator, icrocontroller, electrotherapy.**

I. INTRODUCTION

There are different ways of realizing a device for Cranial Electrotherapy. Taking in mind the fast progress of the development of new microcontrollers and the possibility of further development of the device, the most suitable method is using microcontrollers.

A simplified overview of a device for CES is shown on Fig.1. As it is shown there it consists of seven modules where three of them can be grouped in one and realized using a microcontroller. To suite the needs of the grouped modules a software program should be written and uploaded to the microcontroller.

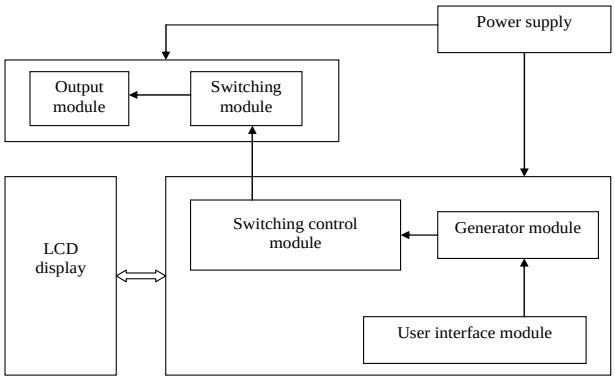

Fig.1.Block diagram of a microcontroller based device for Cranial Electrotherapy Stimulation

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II. MODULES DESCRIPTION

In the devices generator module an uninterrupted series of impulses with a square form and in range from 0 to 150 Hz are generated, in conform to the prescripted therapy and the physiological characteristic of the human body and the effects on it.

This module calculates the delay that has to be generated by the microcontroller before switching the output state and so to generate the requested output frequency on the electrodes.

A program that has the possibility of generating different delays, with which impulses with different parameters can be generated, has been written. To implement this it has been taken in mind that in the used microprocessor the execution of all single word instructions consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1 μs. If a conditional test is true, or the program counter is changed as a result of an instruction, the instruction execution time is 2 μs. Two-word branch instructions (if true) would take 3 μs.

The power supply module is divided into two circuits. One for the patient's circuit (to the electrodes) and one circuit for the microcontrollers power supply. This division is necessary, because the right microcontrollers working voltage has to be ensured, which is significantly lower than the rest of the device.

In the switch control module a process of switching the generated impulse sequences to the right output is accomplished. The switching can be performed in tree ways:

- Output in Series
- Output in Parallel
- Static mode

In the Output in Series mode the output impulse sequence is switched between both electrodes, so that only one electrode is active at a certain time Fig2.

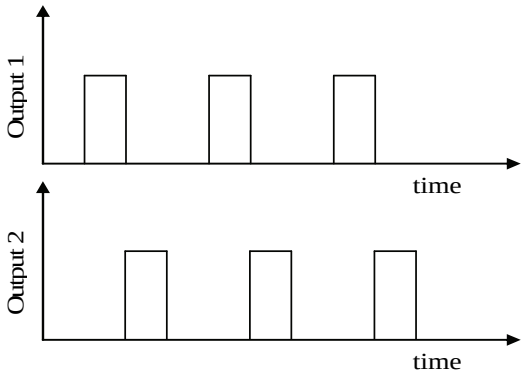

Fig.2. Output in Series

In the Output in Parallel mode the output impulse sequence

is passed to both output electrodes, no that both electrodes are active at a certain time Fig.3.

In both cases the output sequence is provided by the generator module.

In the Static mode the device is acting as a galvanostat. In this case the only active output is output 1 and a zero Hz frequency is generated by the generator module.

The switch module is acting as a bridge between the microcontroller and the patients' circuit. It is controlled by the switch control module and powered by the output current module, so that the impulses with the right parameters will be passed to the electrodes.

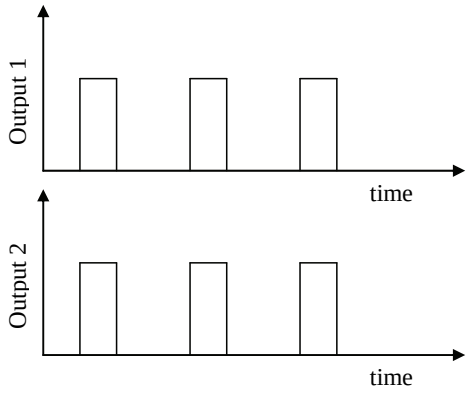

Fig.3. Output in Parallel

The user interface module gives the user the possibility to set the desired operation mode of the device, according to the prescribed therapy. The user can change the output frequency that will be generated by the generator module in the rage from 0 Hz to 150 Hz, as well as to set the sequence mode.

As feedback from the device to the user a LCD display is chosen instead of other alternative ways of realization – using LEDs or personal computer. In the development of the device providing the information to the user via a personal computer was on purpose omitted. The reason is that in this case the user will be restricted to use the full capabilities of the device if he doesn't have a suitable computer with the right parameters and operation system. This will also affect the portability of the device and will reflect on the devices price, if a suitable computer has to be provided.

The LED indication is not suitable as well, due to the limitation of information that can be displayed to the user.

A LCD display has been chosen, because besides visualizing the current output frequency it can be used to display information, in form of helping messages, which will assist the user to use the device.

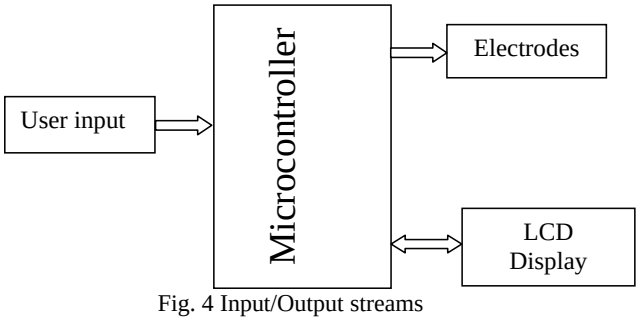

Fig. 4 Input/Output streams

To realize device 1 input and 2 output stream to the microcontroller ware used (Fig 4). To accomplish the input stream 2 digital inputs of the microcontroller are used. For the 2 output streams 11 digital outputs of the microcontroller are used. For all the streams 13 input/outputs of the microcontroller are used. The above described microcontroller is PIC18F1320 and it has 16 input/outputs, so it is suitable for the task and still have 3 spare input/outputs, that can be used in future extension. A realized device with the above described structure and functions is shown on Fig.4.

Fig.4. Cranial Electrotherapy Stimulation device

III. Conclusion

1.Various modules that can be realized with a microcontroller has been shown in the paper.

2. Necessary input output streams has been discussed in the paper.

3. Form and sequence of signals used for a Cranial Electrotherapy device has been applied in the paper.

4. The realization with a specific microcontroller (PIC18f1320) has been shown in the paper.

5. The obtained results, described in the paper can be used for further research and development of another Cranial Electrotherapy device.

References

[1] http://www.doc.ic.ac.uk/~ih/doc/pic/

[2] http://www.seattlerobotics.org/encoder/sep97/basics.html

[3] Limoge A, Robert C, Stanley T: Trancutaneous cranial electrical stimulation (TCES): A review 1998 . *Neuroscience and Behavioral Reviews* , 23:529-538, 1999.

[4] http://www.dynamind.com/ces.htm

[5] http://www.depressiontreatmentnow.com/cranial_electrotherapy_stimulation.html

[6] Stinus L, Auriacombe M, Tignol J, Limoge A, Le Moal: Transcranial electrical stimulation with high frequency intermittent current (Limoge's) potentiates opiate-induced analgesia: blind studies, *Pain* , 42: 351-363, 1990.

[7] http://ww1.microchip.com/downloads/en/DeviceDoc/39605F.pdf

[8] http://users.bart.nl/users/pouweha/lcd/lcd2.shtml

[9] http://www.piclist.com/techref/io/lcd/pic.htm

[10]http://ourworld.compuserve.com/homepages/steve_lawther/t6963c.htm