Biomedical Physiotherapeutic Complex

Valerian DOROGAN, Vitalie SECRIERU, Tatiana VIERU, Stanislav VIERU, Andrei DOROGAN,
Eugeniu MUNTEANU, Ştefan Balica
Technical University of Moldova
dorogan_lme@yahoo.com

***Abstract* – The paper describes the biomedical physiotherapeutic complex elaborated in Laboratory of Micro-Optoelectronics of the Technical University of Moldova. The elaborated complex includes the implementation of a large range of realizations of microelectronics and modern nanotechnologies and of medicine research. A concept of realizing a physiotherapeutic complex is described in the paper.**

***Index Terms* – aero ionization, laser therapy, trans-coetaneous electrical nerve stimulator, millimeter waves, module structure.**

I. INTRODUCTION

The authors had been involved in the elaboration and implementation of physiotherapeutic complex, because Republic of Moldova has lack of medical and physiotherapeutic devices in regional and ambulatory centers. The paper presents the obtained results.

II. BIOMEDICAL PHYSIOTHERAPEUTIC DEVICE CONCEPT

A new physiotherapeutic complex system was elaborated during study and experimental elaboration in the field of modern technologies. It assures a complex physiotherapeutic treatment using the methods: trans-coetaneous electrostimulation of nerves (TENS), laser radiation therapy in the visible and IR range, ultraviolet radiation therapy, therapy using ionized air.

The therapeutic complex system is consisted of an electronic block (Main Module) based on an advanced microcontroller, which assures the functionality of all elements, working regime setup, patients and operating regimes' information storage. The system is connected to the netbook through a USB interface, equipped with specialized software, which permits to guide the output ports and their functionality control. The netbook usage permits to graphically visualize the selected parameters for therapy.

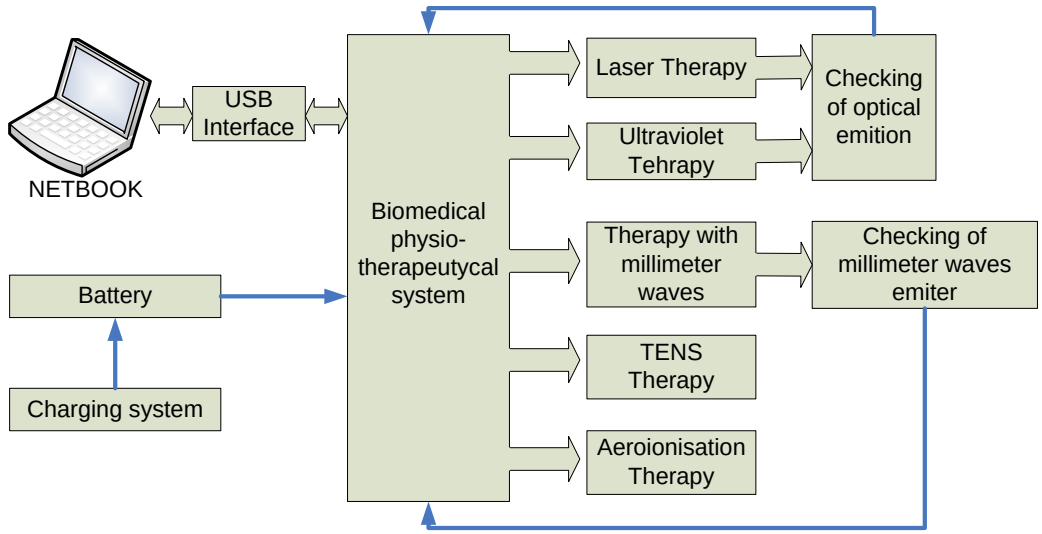

Fig. 1. Block scheme of the physiotherapeutic complex.

The supply is made from the network and from an autonomous supply system, which assures the system's mobility and excludes the electrical power network jamming. The system permits to use 5 independent ports (peripheral modules) designated for laser therapy in IR, ultraviolet therapy, millimetric waves therapy, therapy through trans-coetaneous electrostimulation of nerves and therapy with ionized air.

III. OPERATING MODE OF THE PHYSIOTHERAPEUTYCAL SYSTEM

The execution program of the physiotherapeutic complex has a model alike an operating system. The structure of program functioning of the physiotherapeutic complex is represented in figure 2.

The linkage between peripheral modules is made by the program core, which controls the functioning state of these modules. The interaction with the PC (user) is assured at the same time.

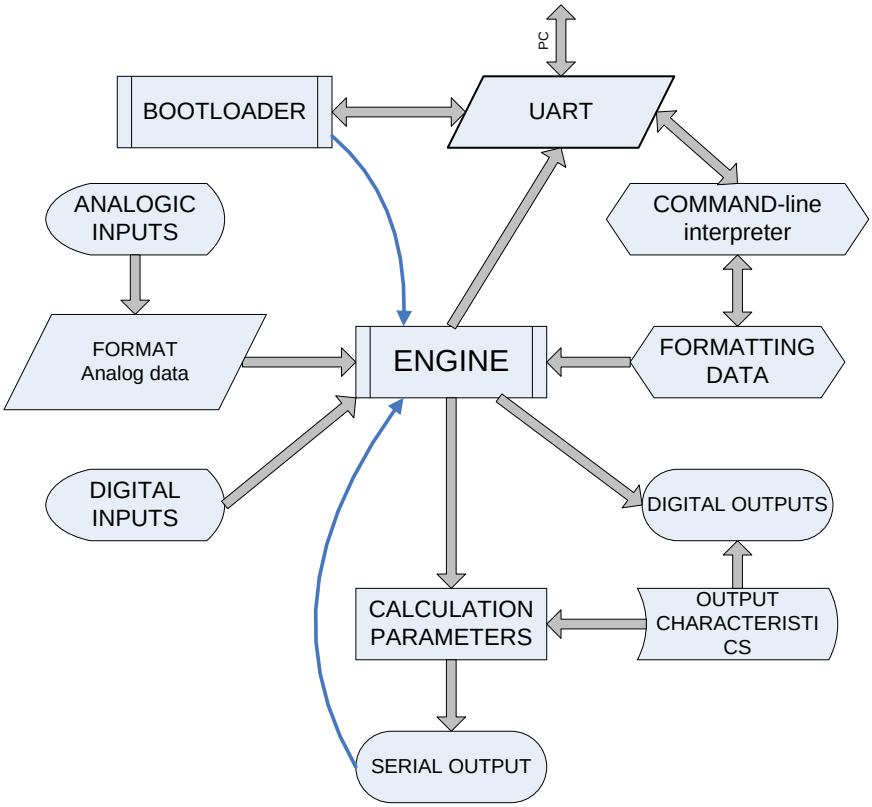

Fig..2. Operating scheme of the firmware

IV. COMMUNICATION OF COMMAND-LINE WITH THE SYSTEM

The data obtained from PC through the asynchronous bus is interpreted through a command-line. The used command-line has the following advantages:

- usage commodity;
- increased flexibility;
- extended data operating possibilities;
- autonomous functioning.

The command-line will search the word, which will correspond to a command from the PC part, at the beginning of the received data sequence, for example "PTC_TEMP". In this case, the core will determine the execution of temperature read function, will prepare the answer for PC and will order the transmission of data. After existent data transmission towards calling stack, the results about the current temperature inside the physiotherapeutic complex will be transmitted towards.

The command-line represents a standby module, which has lots of received data operating possibilities. One of the possibilities is the determination of command parameters. For example the PC sent the command "TENS_D 100". The respective command has to setup the time duration for the TENS module to 100 μs. The command-line will determine the parameters of the income command, which has the value 100 in our case.

Although, the command-line usage imposes some impediments during operation caused by the following shortcomings:

- the closed structure does not permit the operation with all data inside the command-line system;
- high execution time and big program volume;
- high volume of the used operating memory.

V. MAIN MODULE

It has to be mentioned that not only peripheral modules can be modernized, but, also, the main module. At the moment the most popular idea is to equip any kind of device with the possibility of firmware update. This is why the device possesses an "update port", or uses one of the general use ports. The update procedure is different from the general communication one of the selected port. The program frequency that is responsible for update is named bootloader and is run in a special way. The physiotherapeutic complex is also equipped with a bootloader making the update and device modernization possible at a maximum range. The update is performed from PC through the communication interface of the device (USB) using a special program.

The execution of bootloader is made immediately after the complex turns on. If the linkage between bootloader and PC is stabilized in 2 seconds, the bootloader starts up the update regime of the basic program. The firmware updates in sequences, each sequence being verified using a sum control. After finishing the update the program control turns into the execution sequence of the complex. If the linkage was not setup after 2 seconds, the basic program will be executed.

VI. INTERACTION OF MODULES OF THE PHYSIOTHERAPEUTIC COMPLEX

The operation with the physiotherapeutic complex modules is made using the following components:

- Digital inputs;
- Analog inputs;
- Digital outputs;
- Analog outputs;

The digital inputs are used to visualize some states for the respective module. The state of the button placed on the optic head can serve as example for the laser module. The button is used for an easier interaction of the user with complex during the procedures.

The analog inputs of the main module are used for monitoring the output circuits' state of the complex. The analog signal converted into digital one demands a special formatting, because different modules have different output parameters. The read analog signal is represented in a special

form, the final representation in voltage would be for the TENS module. The core will determine the module stop for protecting against an eventual output shortcut if the output voltage value would be lower on ¾ than the setup voltage value.

The digital outputs possess 2 functions: signal creation and module connection. Initially, the module is turned on in standby state. After that the output signal is generated and the module turns form standby state into functioning regime. In order to simplify the module stop it is necessary that the PC would indicate the stop command of the output signal.

Digital potentiometers of 8 bits are used to form the analog outputs. The guidance of a digital potentiometer is made using the synchronous bus TWI. Two digital potentiometers are coupled in serial mode in order to increase the precision up to 9 bits. The nonlinearity of the output signal has also increased, but remained in acceptable limits.

VII. OPERATION EXAMPLE FOR THE LASER THERAPY MODULE.

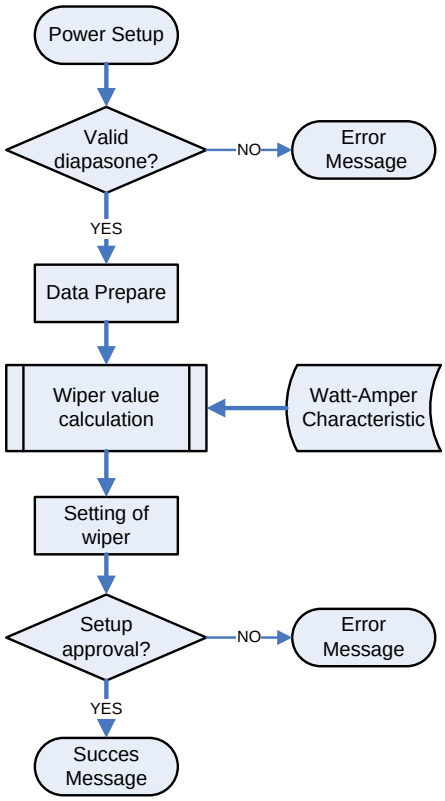

Fig. 3. Block scheme of laser's power setup.

Conforming to the functioning specifics of the quantum therapy module it is necessary to setup the laser output power by making the PC query the execution of power setup.

The block scheme of laser emission power setup is presented in figure 3. The core will verify if the if the power corresponds to the 5-50 mW diapason. Further, data preparation and the calculus of potentiometer values will be done, which will correspond to the laser watt-ampere characteristic. The watt-ampere characteristic of the laser is positioned in a data array from the address space of the internal EEPROM of the microcontroller. The calculus of the potentiometer value is coming after calculating the laser's work current. The potentiometer will form the reference voltage, which corresponds to the laser's current source. characteristics.

VIII. PC APPLICATION

A PC application was created for communicating with the physiotherapeutic system.

The main requirements for the application are reflected by the USE-CASE diagram (figure 4) and the program functionalities by the classes' diagram.. A driver for RS232 device was installed, for controlling the module from USB port, and will contain a dll file with a set of API commands, which will be used by the PC to execute the commands.

The program controls a medical device though the USB port, which has a graphical interface with access for modifying and deleting patients' data into a database, represented in Access data file. This way the doctor will be able to visualize and control the technical regimes for each person, configure the TeraLaser or other device. The program provides a display control of the module's response to the queries applied through USB port.

IX. CONCLUSIONS

A prototype of a complex system for physiotherapy was elaborated as a result of the activity in the frame of a project, which will contain different modules like: main module, communication module with the PC, Teralaser module, air-ion-therapy module, and trans-coetaneous electrostimulated therapy module of the nervous terminations (TENS).

Principles that vise the Visual Studio medium, C# language were engaged for PC connection and guidance. The connection of one peripheral device through the USB port was realized using this language (RS232 driver). Different libraries were also used such as ADO.NET for registering, modifying and deletion of patients' data in the Access type files. The commands' transmission towards the periphery and response receiving was realized in the program. The program guides the peripheral equipment using a set of commands, such as "help/r/n", "TENSVOLTAGE 40 mW/r/n" ect. Each module has its own properties and table in database. Any king of database registration vises the properties selected by the doctor.

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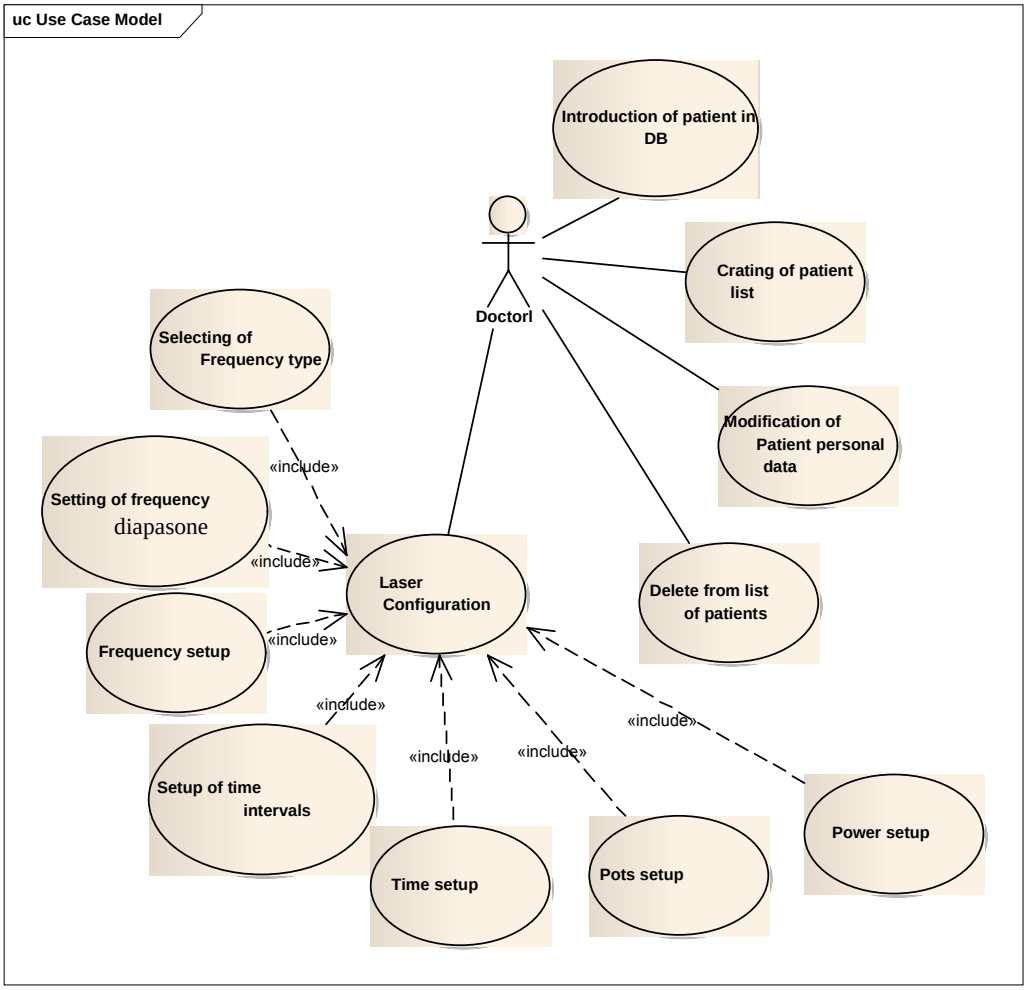

Fig. 4 USE-CASE diagram of the PC application