„Dunărea de Jos" University of Galaţi
Doctoral School of Engineering

ABSTRACT
PhD Thesis

RESEARCH ON THE DEVELOPING OF SPECIALIZED SOFTWARE IN DESIGNING OF FISH FACILITIES

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Most likely, the results of research conducted in this thesis, there had never been a purposeful and put on final papers unless there was a Man above all, who encouraged me always in everything I did, professional and scientific, a Man who was with me in everything I have done, even when everything seemed hopeless and guided my steps right way of development of quality ideas. I want to thank in this way to the Man, Prof. Dr. Eng. Victor Cristea.

Never, I will never be erased from my memory, echoes the exhortations "Youth, go!" that Mr. Rector, Prof. Dr. Eng. Gabriel-Iulian Bârsan address them to me every time I see the halls of the University. I thank once again and every time, you will be hard, I will mobilize these words.

Even if time, as the physics units was not always by my side, I always found understanding from Mr. Prof. Dr. Phys. Adrian Cîrciumaru who supported me when things were an unexpected turn and I thank you for all their support.

Words would be superfluous in thanking to the ladies Assoc. Prof. Eng. Iulia Grecu and Assoc. Prof. Eng. Lorena Dediu for having accepted the invitation to participate as members of this thesis guidance committee.

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Not lastly, I would like to thank my wife, Tatiana-Ioana for all those days where I could not go together wherever we wanted and that I understand the states of discontent mine were at odds maximum because things in this research did not go as I wanted and "carefully avoided" modules, parts and cables across our house.

Ing. Inf. Geode. Ciprian-Mugurel Enache

Galati July 2016

KEYWORDS:

-aquaculture
-systems recirculating
-increase intensive fish
-water quality parameters
-automatic -systems
-monitored water quality parameters
-direct interface
-away interface
-SMS
-GSM
-EEPROM
-calibration
-microcontroller
-ATMEGA32
-real time clock (RTC)
-alarming
-printed-circuit

TABLE OF CONTENTS:

PhD THESIS STRUCTURE:

This PhD thesis contains 210 pages, in which the documentary part is 25 pages and the experimental part has 144 pages. This paper contains 105 figures and graphs and nine tables. In developing the thesis were used 87 bibliography references.

INTRODUCTION

Nowdays, the administrative situation in our country makes the status of land to have an uncertain status due to the repeated claims in whatever form, the body of water or agricultural land but also because of damages caused by the lack of land reclamation works aquaculture seek other alternatives for its development required to ensure adequate food for a population which is in a continuous growth as globally speking.

Meanwhile, technology-based business systems and computer science is an evolving and involving them in everyday life, is becoming greater, to the detriment of traditional methods. This provides added safety, rapidity in decision making by optimizing things that translate goals led processes and savings in raw material costs involved.

PhD thesis presented here, entitled "Research on the development of specialized software in the design of fish facilities" is an interdisciplinary and started from the idea of applying the benefits of modern technology intensive fish farming systems, modern aquaculture-specific systems.

The work is mainly aimed to mainly design of viewpoints functional hardware and software of an automatic device to monitor quality parameters of water in recirculating systems and other external parameters of the system greatly influences its activity, such as networks voltages or relative humidity in rooms with pools culture.

The original elements of the work presented here are contituied by customizing parameters monitored with the beneficiary's request, the possibility to check and remotely control these parameters, realization of this automated using technology elements less expensive given that kept soundness measurements and safety.

The research was conducted in laboratories departments of Aquaculture, Environmental Science and Cadastre (Faculty of Food Science and Engineering) and Science General (Faculty Border of Humanities, Economics and Engineering), both from the "Dunărea de Jos" University of Galați and direct labor.

The paper is divided into five chapters, as follows:

-The First chapter is devoted to the study of the importance of fisheries products in feeding the globe population and use of these in non food economy, the way the world has ensured over time these products, advantages of using recirculating aquaculture systems for these purposes their contribution the total amount of fishery products worldwide. At the same time, an overview of their current state of development.

-The Second chapter is a synthesis of physical, chemical and biological water tanks along with the importance of monitoring their culture. Their influences on the growth rate of the fish and their health are presented displaying the fish while the optimum values are not respected, the limits of minimum and maximum of them, depending on the requirements of crop species. For each parameter, the quality of the water is shown the possible source of its appearance in water basins of culture and the way of returning to the optimum values. Such research is essential to understand the need for accuracy in maintaining water quality.

The experimental part of this thesis is divided into two stages represented by chapters three and four.

-The Chapter Three of this thesis contains the main elements of research made to the physical development of the automation system. In the first phase, it described the design of the automated system, based on traditional principles of automated processes, describing the functional blocks of its market study microntrollere and microcontroller model selection to be able to ensure achievement of goals. At the same time, emphasis was placed on designing other functional blocks automatic system in its purpose and the practical realization of all modules, from the design of printed circuit boards, through their implementation and ending with planting components and assembling boxes protection thereof. Also in chapter three are shown how to design direct interface menu, algorithm design and realization of software source code, compiled, it led to the development of machine code for the microcontroller.

-The Four Chapter of the thesis shows how the automatic system was installed and put into operation in the recirculated water system. Under his achievements are given the necessary calibrations and data collection experiment. Evolution of water quality parameters of river culture culture is presented for an experimental period of one month, along with related charts for all parameters monitored by remote query, three times each day. Also in the fourth chapter of the thesis it is detailed and direct interface menu system with its functions and automatic operation mode.

-The Last chapter of the thesis comprises the final conclusions drawn up by design, development and implementation of the automated system, presenting the thesis objectives achieved and those which could not be fulfilled. Here they are listed some of the possible directions of further development of the system.

Design and implementation of automatic process control monitoring and maintaining quality parameters of water in recirculating systems were made in an original manner, well documented.

CHAPTER 3

ASPECTS OF AUTOMATIC MONITORING SYSTEM DESIGN

Given the importance of maintaining water parameters cultural comfort zone for fish species reared intensively in them, but also the desire to automatically monitor these factors in order to reduce staff costs and maximize the rigor of doing measurements the control system of the recirculating system is one of the most important parts thereof. Therefore, it must be reliable, have moments of "down-time" (downtime) as low as possible.

3.2. The designing of automatically monitoring system in recirculating aquaculture systems

In designing the surveillance system of this material was gone, based on discussions with experts in fisheries, from monitoring the voltage on the three phases of the network (R, S and T) as circulating pumps are powered phase, monitoring water temperature, pH, electrical conductivity, water temperature thereof, the light intensity of the basin areas of culture and the relative humidity of the room where they are. These parameters are added and battery monitoring system for maintaining operation between lack of electricity from the grid.

A block diagram of the system can be found in Figure 3.5. The signal captured by the sensors are in the process of intensive aquaculture are sent to an amplifier for linearization. It aims to bring beach 0..5V standard of keeping these signals, possibly, a linear feature with their response. These are reproduced on the analog-digital converters (ADC) of the logical unit command and analyzed for decision-making. The logic unit also has an interface for communication with the user. Through its manual system parameters can be monitored at a certain time and can be done and setting optimum values beaches. This allows anyone, even without specialized studies can adjust these parameters.

All logic unit is connected through communication ports telecommunication unit enabling remote viewing parameters, and alerting users when their intervention is required. The transmission parameters can be done remotely via GSM communication in the form of SMS or data transmission via the internet, GPRS, 3G or 4G. If opting for the transmission of data, this can be done directly internet without the need to resort to mobile networks.

To maintain a real-time value as true, the logical unit read this from a dedicated circuit, piloted by quartz with high precision. Knowing the exact point in time, allowing logical unit will analyze the best possible input parameters while maintaining an exact value time as much time without user input and decisions at certain points in time, as accurate (fish feeding, for example).

All direct logical drive is connected and a memory EEPROM allows storing all the parameters needed by the control unit in decision making. Here are stored beaches optimal parameter settings required for operation of the system but can store and sudden events.

Orders adopted by the decision are transmitted in digital format, Boolean logic - ON / OFF, Pulse Width Modulation - PWM or analog via a Digital-Analog Converter (DAC).

The role of central logic control unit can be achieved either by a computer system as a desktop or laptop, a microcontroller or a PLC PLC type, with minor changes to the proposed scheme. Using a computer system in higher expenses related to hardware architecture of that system, data acquisition boards and ensuring optimal operating climate conditions. We know that culture ponds in the vicinity humidity is high which means that the air in the room where the computer system should be dehumidified to avoid oxidation of the security features of the computer system.

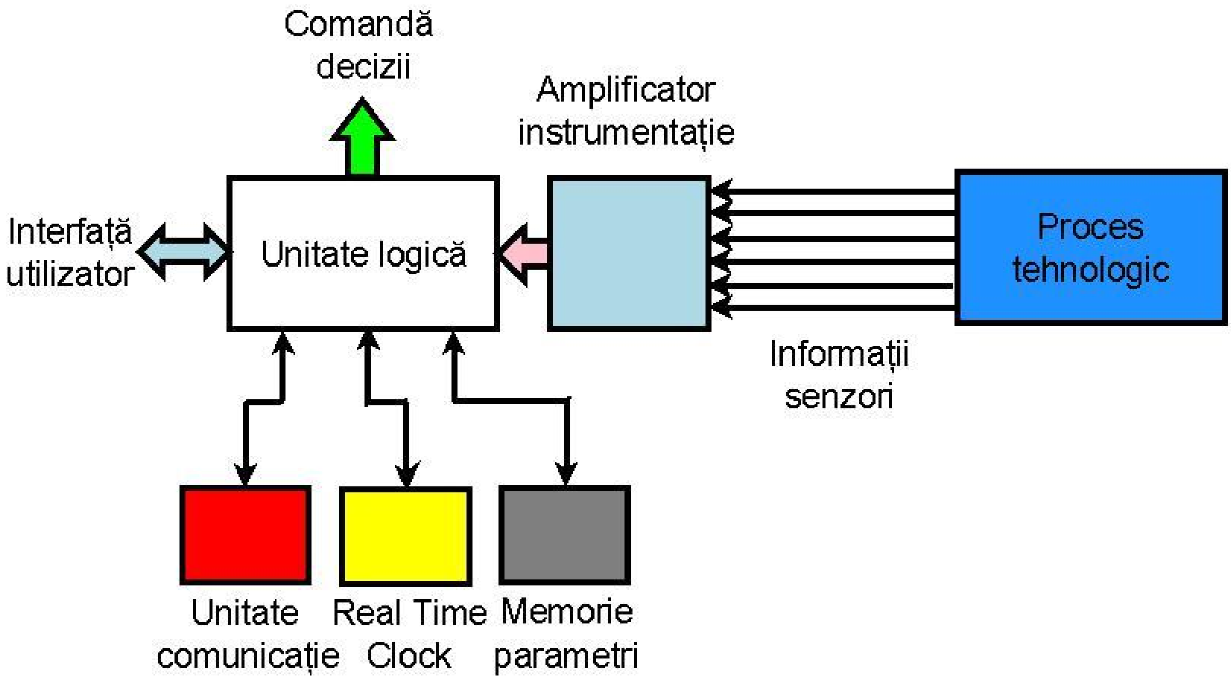

Figure 3.5. Block diagram of automated system for process technologic management.

3.4. ATMEGA32 microcontroller

Following discussions with colleagues in aquaculture specialists from the department Aquaculture, Environmental Science and Cadastre from the "Dunarea de Jos" University of Galati, was concluded to monitor, through this project, the following parameters:

-main voltages from electricity network
-water temperature
-the level of pH in water
-electric water conductivity
-light intensity near river culture
-air relative humidity to the development of further projects like acvapony.

This information was defining in choosing the optimal microcontroller relative to its price. Initially, we chose microcontroller ATMEGA16 only after application development by its complexity, the large number of arithmetic and the large number of variables to be used was found excess capacity flash memory where it was stored program (107%) and exceeded SRAM.

Because it is similar in architecture and method of operation, but with double capacity of flash memory, it was chosen for implementation of the same microcontroller family, ATMEGA 32.

According catalog sheet presented by its producer, Atmel, he has the following properties:

-RISC architecture (reduced instruction machine code number) which means that the written instructions into machine code directly executed without being decomposed into microinstructions, as is the case CISC architecture);

-a powerfull set of machine code instructions - 131, most executables in a single clock cycle;

-32 Registers of 8-bit general purpose registers;

-static-operation, meaning there are no moving parts in the design thereof;

-a clock frequency up to 16MHz, which implies execution of up to 16 million instructions per second (16MIPS)

-the possibility of introducing a 2x multiplier clock (dubbing).

-the memory of the microcontroller segments involving non-volatile memory with high endurance, organized as follows:

-32 KB flash memory is stored with instructions for the program;

-1024 KB EEPROM memory;

-memory is 2KB RAM (the only volatile area);

-memory flash allows guaranteed 10,000 cycles erase / write while FLASH memory allows around 100 000 such cycles;

-they can be arrested -information of 20 years at a temperature of 85 ° C and 100 years at a temperature of 25 ° C;

-an Optional Boot Code Section area with the possibility of data protection through Fuse Lock Bits Bits;

Choosing microcontroller suitable for the proposed application is closely related to knowledge of the functionality of its pins.

3.5. The functional blocks of the designed system

From a functional perspective, the system was designed to retrieve information from a variety of sensors, analog or digital transmission to their processing by the control logic unit represented by board ATMEGA32 microcontroller. Because the information from the sensors are different as analog voltage levels and microcontroller supports a wide voltage analog digital converters of its 0-5 V interleaving is necessary in this chain of an instrumentation amplifier. This, in addition to the role of translating beach voltages for each sensor separately accepted ranges of microcontroller has meant to keep linearization of information from these and to correct any deviations from it. Nonlinearities correction of these sensors can be made by arithmetical calculations performed by the microcontroller with data from readings of eight of its ADC.

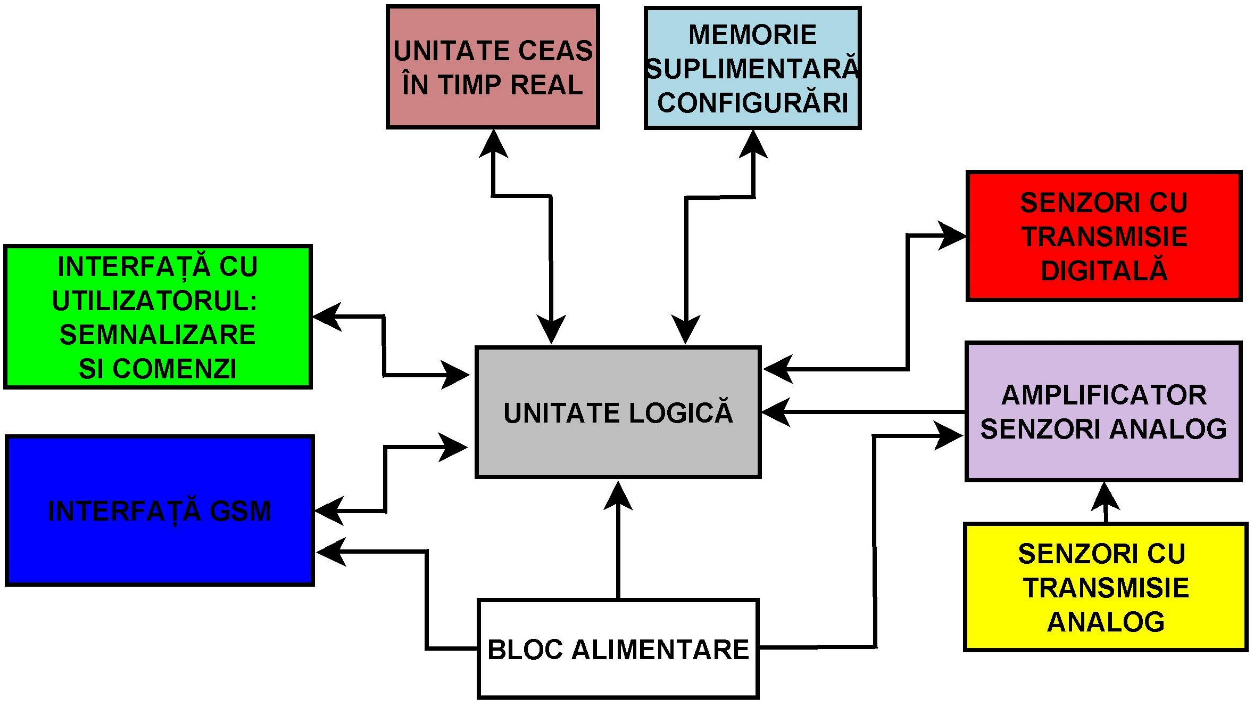

Figure 3.25. Diagram designed with functional blocks of the automatic driving

Sensors that provide readable information digitally, as a rule, embedded in the firmware own all information related to calibration and correction of any deviation from linearity. Due to its compatibility with TTL protocol could be interrogated directly by the microcontroller, so communication with them was marked as bidirectional.

Communication with user interfaces are of two kinds:

-**direct interface** consists of a LCD display that can be read system states and can make adjustments to its controls for this and LED for signaling alarms. The latter are more visible from a distance;

-**remote interface** communication with the user. This allows the recipient to remotely monitor system activity and be alarmed if things get out of control microprocessor or an external intervention is needed on the aquaculture system. Communication with the user can be done via Internet by GPRS protocol, specific mobile or via SMS sent. The second option is much easier from the point of view of cost of subscriptions for mobile and by the fact that user wishing to communicate with the system should be fitted with a smart device communication, smartphone, tablet, computing system etc.

To better monitor the parameters time and for decisions on automatic feeding fish after a graphic, for example, the system needs to know the exact time during which an event occurs. Because multiple interventions in activity led process could cause delays in the timing of time and avoid overcrowding processor and this function was chosen for inclusion in this diagram of an external power supply unit time. It can communicate bidirectionally with the central unit via the I2C protocol. RTC have bidirectional communication unit wich is interrogated as to the timing of time and adjustment time it is done by writing the values of time from when the adjustment. RTC also has the advantage of a perpetual calendar, useful when calculating the time periods of adverse events, for example.

Even if microcontroller provides a nonvolatile memory, EEPROM, it has a capacity of only 1 KB, insufficient complexity detained parameters and access to it is difficult because of the time delay in dealing with it. To remedy this situation, the system was implemented in an external EEPROM memory, aiming to keep vital information for the system, initial parameter and configuration. In case of accidental interruption of the power microcontroller, and its return program initialization information related to its last state and configuration parameters are reloaded into its internal memory, without losing. Bidirectional communication with all memory is made via I2C bus, memory and real time clock unit having different addresses. These are specific to each type of component separately and, in case the bus more components of the same type can be set by making meal hardware or Vcc pin of their configuration.

Next, design issues are dealt for each functional block in part in terms of hardware.

3.6. The design of scheme of the logic board electronic management system

In this work, the entire port of microcontroller ATMEGA32 has the mission of reading analog values from sensors. Their bit distribution is as follows:

-PA0 - R phase main voltage network;
-PA1 - S phase main voltage network;
-PA2 - T phase main voltage network;
-PA3 - Voltage of back-up battery in case of loss of power supply system;
-PA4 - Water pH;
-PA5 - Electrical conductivity of water;
-PA6 - Humidity;
-PA7 - Light intensity in the basin areas.

Entries of port A in the microcontroller are protected by the introduction between them and the mass of diode Zenner 5V6, aiming to open if the voltage exceeds this value and the voltage in this case is done by variable resistances RV1-RV8 (Figure 3.27). They also act as resistive dividers to be also able to adjust the voltage on port A, during calibration. For example, tensions from the network phase voltage sensors may have a value of up to 8 V. The resistive divider created such tension that reaches the microcontroller's inputs will not exceed 4.5 V.

The port B of microcontroller is dedicated to communication with the LCD display, backlight control and upon its alternative functions can be done and microcontroller programming through ISP (In System Programming). LCD display type HD44780 is an alphanumeric display that contain two lines with 16 characters per line. For its operation, it needs the following six connections.

PC0 and PC1 port pins of the microcontroller ATMEGA32 C are used in this application with their alternative functions namely TWI communication, they SCL and SDA playing the role of this type of communication. They communicate with two devices PCF8583 (Real Time Clock) and a memory 24LC256.

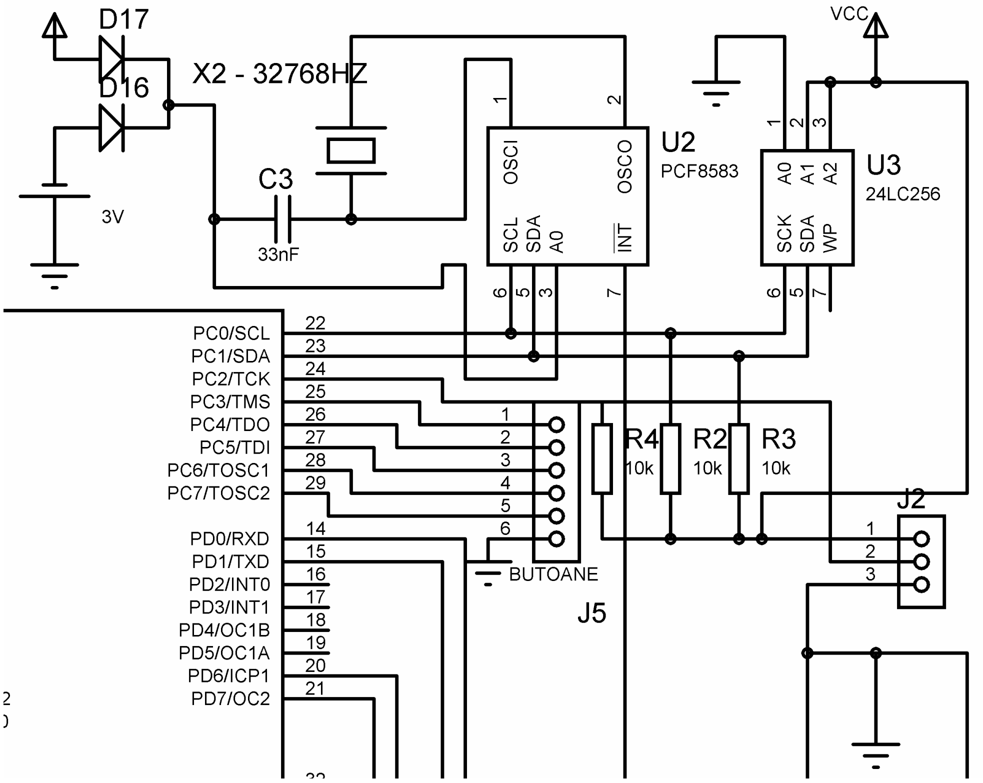

Figure 3.30. Extract from scheme electronic logic board port C of microcontroller connections.

Alternative functions of PD0 and PD1 pins, port D of the microcontroller were previously presented as USART communication. In this case, through these pin (RXD and TXD) microprocessor interface will communicate with GSM. It has an RS232 serial communication port to receive and send AT commands type, values etc.

PD2-PD5 microcontroller pins you were thinking as output ports, to implement decisions in future developments of the system.

Electronic schematic control board can fully consulted in Annex 1 to this paper.

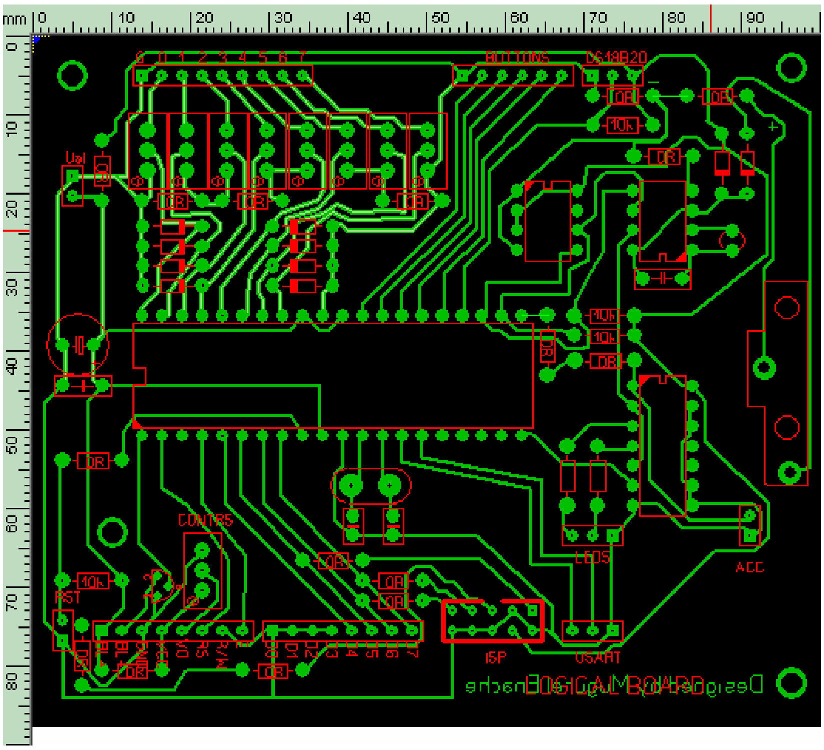

Figure 3.34. PCB unit in the design phase. Screenshot.

The end result of design and practical realization can be seen in the figure below.

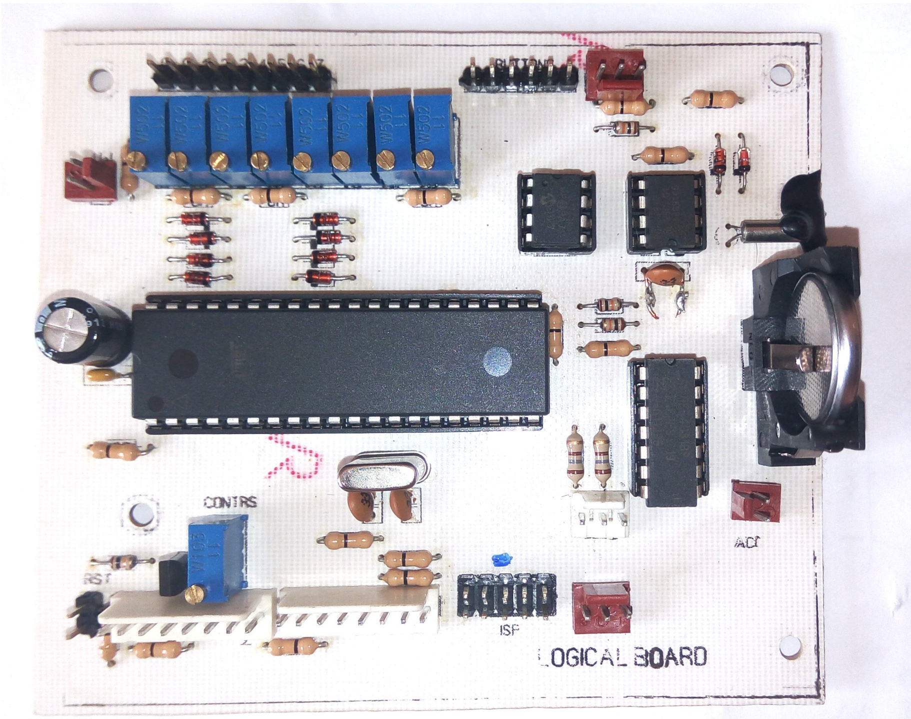

Figure 3.35. Logic board of the microcontroller with all components implemented.

Next, it proceeded to designing schemes for electronic sensors from the mains voltage and pH probes corresponding amplifiers, relative humidity, water conductivity, light intensity. In this summary, is briefly only water conductivity sensor design.

3.9. Water conductivity sensor and its signal amplifier

This method requires the immersion into the liquid whose conductivity is to be determined to two electrodes, in order to determine the resistance of the liquid between two points, given by the movement of ions derived from the dissolution of mineral salts. Where between the two electrodes there is an electrical voltage continuous measurement would produce water electrolysis and the result would be wrong. Therefore, a good result of the determinations is made between the two electrodes when there is a voltage that periodically changes its polarity - AC and not allowing ions to adhere to the electrodes.

The first module includes U2: A group of resistors R1, R2, R3, R4, RV1 and capacitor C1. It is designed to generate a frequency of around 10 kHz and amplitude measurements required output is approximately 21 Vpp. The frequency of oscillation is given by $f_{out} = \frac{1}{2\pi R v C_1}$. Further, after the date variable resistence RV2, some of it is applied to non-inverting input of U2 are operational: B and part returns to its electrodes entry through the loop resistance represented by R5. In the pact, it was found that its value resulting from the calculations had decreased to a value of 6.8 kilohms, for the proper functioning of the way, amplification U2: B are correlated with the contact surface of the electrodes with water.

The module represented by U2 C and the rectifier bridge is intended to move the negative side of the amplified signal of U2: B in the positive voltage to the microcontroller may be taken in the range 0-5 V.

The last part of the scheme represent the output buffer, intended to correct the offset signal and integrate signal from the signal pulses debris alternative to the measurements.

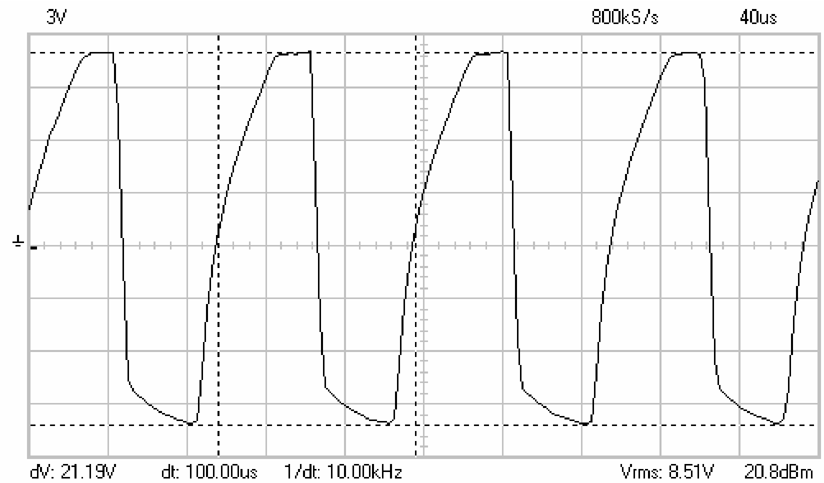

Figure 3.42. Oscillations from the output of frequency generator viewed by the oscilloscope

Conductivity is microsiemens basic unit of measurement is the inverse of resistance, so that a microsiemens is 1 / 1MOhm. Other alternatives for measuring conductivity units are EC ppm and TOS, framed by the relationships:

$$PPM = \frac{EC}{500}$$

$$R = \frac{1}{EC * 10^{-6}}$$

PPM or parts per million synthetic may be represented as where the conductivity of the water in one liter of pure water (distilled) is added 1 mg of salt.

Functional purpose of this module is to get to the amplifier output of 0 V when the electrodes in the water with conductivity 0 ppm and 5 V when the electrodes are immersed in water having conductivity of 2000 ppm, a value considered coverings in aquaculture.

Electrodes for measuring conductivity were built two screws Θ = 4mm stainless steel treated to avoid their oxidation. To limit their contact surface of the water, the electrodes were dressed with termocontractil tube, leaving only available to a length of 1 cm each for water contact. They were caught with the nuts on a plate textolit at a distance of 15 mm between their axes.

Both plates were fixed in a box of ABS for mechanical grip and protection and the box was provided with ventilation slots and cooling. In front of it were provided two DB9 connectors for input and output amplifier sensor, an LED for signaling power but also a parent input BNC probe for measuring pH. On the back of the box was mounted power fuse 0.25 A at 250 V protection installation.

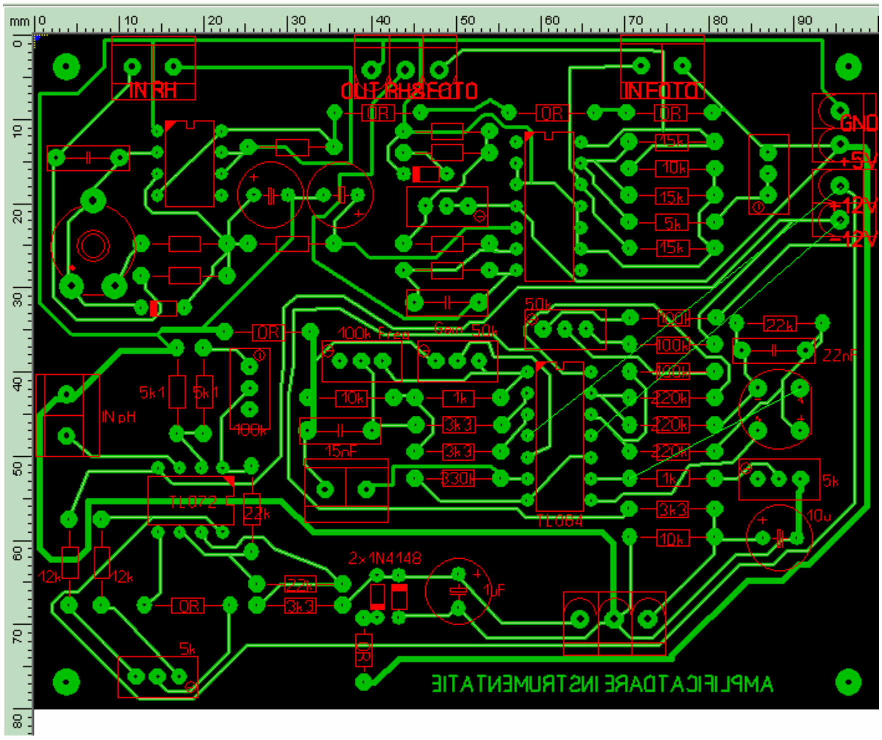

Figure 3.48. PCB of instrumentation amplifier that brings together four measuring modules. Screenshot during design.

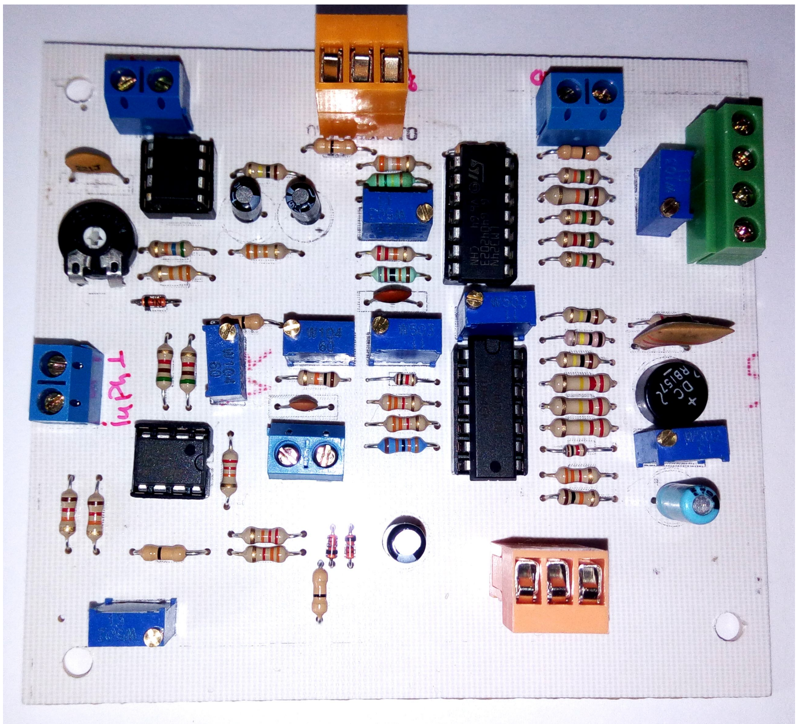

Figure 3.49. Board instrumentation amplifier and planted components once built

The GSM interface is assembled with the logic board on which the microcontroller and its annexes in a ABS box fitted with cooling fans (Fig. 3.55) on whose face is positioned elements interface, direct (buttons and display) (Figure 3.56). In order not to interfere with microcontroller, GSM interface has installed an external antenna.

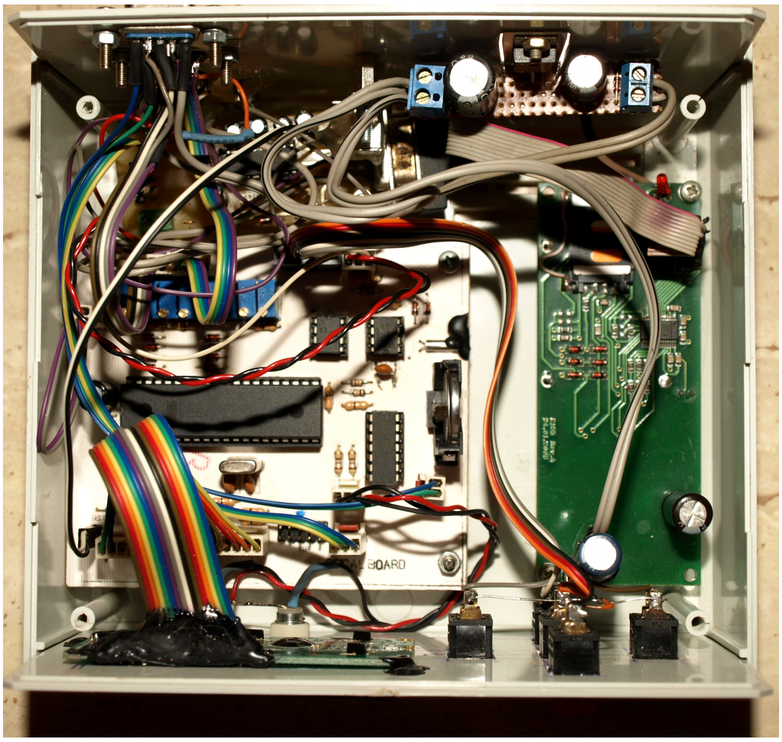

Figure 3.55. Box logic board interface mounted with GSM interface and its annexes

Figure 3.56. The front cover with direct interface elements installed.

3.15. Design of software algorithm for monitoring

After knowing and dependencies of the chosen microcontroller hardware, initially as a model for the proposed primary objectives, and after design all the extensions it can proceed to design the actual software.

An algorithm must meet three main rules:

-to be generally

-to have an end or more ends

-to be unique.

In the automated system shown below, the algorithm software must include the following problems:

-reading values from the sensors;

-integration of them if necessary and calculation of actual measured values;

-comparing read values with minimum and maximum limits imposed via direct interface;

-trigger an alarm, if applicable;

-sending SMS to the list of authorized persons;

-take a decisions for correction parameters that are out of the range of measurement;

-treating queries from GSM dial interface;

-if they come from approved numbers, reply by SMS verification;

-if the call comes from numbers that are not in the list of authorized, it is ignored;

-treating interruptions that have the source pressing some buttons on the direct interface;

-display appropriate application interface menus directly on the LCD display;

-starting battery test sequence is completed when the time dedicated to this;

-management configuration parameters;

-storing configuration parameters in EEPROM memory and read them to reset after a reset or power supply return;

-stocarea of logs in EEPROM.

Implementing these functions in the microcontroller is done taking into account its memory capacity, the components included within it and its external connections, connections clearly addressed in the previous sections. Being a miniaturized device capabilities, flash memory has a limited capacity for storing. Occupied memory capacity can not be estimated but can only be determined experimentally. Initially, in this project, it opted for ATMEGA16, the same family as ATMEGA32 but only with half the memory. After compiling the application, it found that it exceeded its capacity by approximately 14%, which does not leave room for further developments.

3.17. Configuration of CodeVisionAVR application for this case

Through CodeWizardAVR tool within CodeVisionAVR was done the following configuration parameters used microcontroller (Figure 3.62):

-microcontroller Used: ATMEGA32

-frequency of the clock: supplied externally via a 16MHz quartz crystal

-type of compilation: app.

-customisable steering pin ports A, B, C and D of the microcontroller was done by following the next stage, Ports, as shown in Figure 3.63:

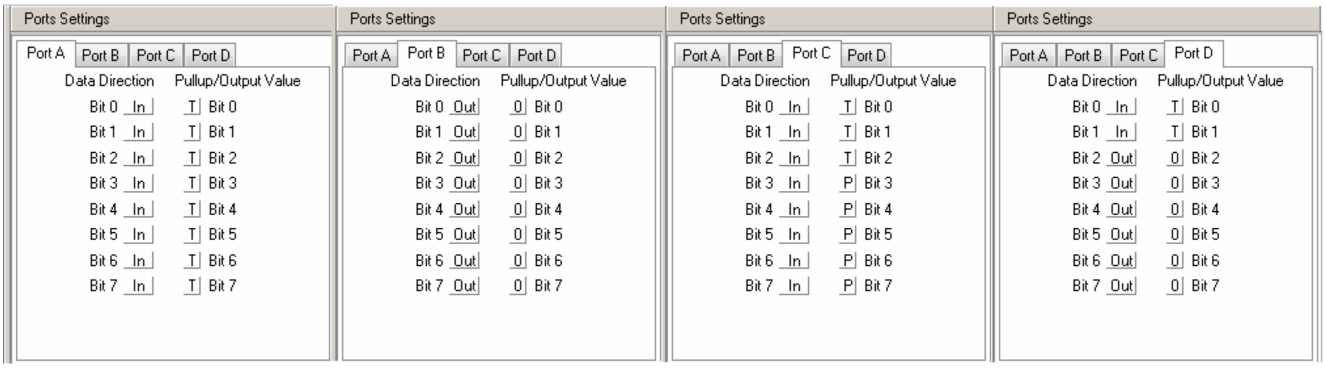

Figure 3.63. Screenshots of CodeWizardAVR when configuring I/O of the microcontroller

-customisation os watchdog;

-customisation of communication ports USART, I2C and 1wire;

-customisation of interruptions;

-customisation of ADCs;

A very important section in this chapter is the reading of the vector corresponding external EEPROM people to be alarmed if a failure occurs. As with corresponding text messages direct interface menus, saving flash memory microcontroller, was done writing all text strings in external EEPROM memory, strings dialed by their address. The same applies to falls and textual commands GSM interface receives through USART port after situation. Retention of these strings is one character has ASCII value of each character written in base 16 (hexadecimal).

Such allotment can be seen below, with the explanation that the first column represents the memory address of the location, the following eight are actual values written in base 16 and the last column is "translated" into ASCII values.

```
0000: 0030 0031 002E 0053 0065 0074 0061 0072  01.Setar
0008: 0065 0020 0074 0069 006D 0070 003A 0020  e.timp:.
0010: 0030 0032 002E 004E 0075 006D 0061 0072  02.Numar
0018: 0020 0070 0072 006F 0070 0072 0069 0075  .propriu
0020: 0030 0033 002E 0043 0072 0065 0064 0069  03.Credi
0028: 0074 0020 0063 0061 0072 0074 002E 003A  t.cart.:
.....
0120: 0031 0039 002E 0056 0065 0072 0069 0066  19.Verif
0128: 002E 0052 0065 006C 0048 0075 006D 003A  .RelHum:
0130: 0032 0030 002E 0056 0065 0072 0069 0066  20.Verif
```

```
0138: 002E 0049 002E 004C 0075 006D 002E 003A  .I.Lum.:
0140: 0000 0000 0000 0000 0000 0000 0000 0000  ........
0148: 0000 0000 0000 0000 0000 0000 0000 0000  ........
0150: 0041 0054 002B 0043 0050 0042 0052 003D  AT+CPBR=
0158: 0031 0031 002C 0031 0031 000D 00FF 00FF  11,11.ÿÿ
0160: 0041 0054 002B 0043 0043 0049 0044 000D  AT+CCID.
.....
01C8: 0061 006C 006C 0069 006E 0067 0043 0061  allingCa
01D0: 006C 006C 0020 0069 006E 0020 0070 0072  ll.in.pr
01D8: 006F 0067 0072 0065 0073 0073 0053 006C  ogressSl
01E0: 0065 0065 0070 0069 006E 0067 004E 0065  eepingNe
01E8: 0069 006E 0072 0065 0067 0069 0073 0074  inregist
01F0: 0072 0061 0074 0021 0049 006E 0072 0065  rat!Inre
01F8: 0067 002E 0072 0065 0074 0065 0061 00FF  g.reteaÿ
.....
0228: 0063 0069 0074 0069 0074 0061 0044 006F  cititaDo
0230: 0061 0072 0020 0061 0070 0065 006C 0020  ar.apel.
0238: 0075 0072 0067 002E 004C 0069 0070 0073  urg.Lips
0240: 0061 0020 0073 0065 006D 006E 0061 006C  a.semnal
0248: 0000 0000 0000 0000 0000 0000 0000 0000  ........
0250: 004D 0055 0047 0055 0052 0045 004C 0031  MUGUREL1
0258: 0020 0020 0020 0020 0020 0020 0020 0020  ........
0260: 0043 004C 0049 0045 004E 0054 0020 0032  CLIENT.2
0268: 0020 0020 0020 0020 0020 0020 0020 0020  ........
.....
0350: 0030 0037 0030 0030 0030 0030 0030 0030  07000000
0358: 0030 0030 0000 0000 0000 0000 0000 0000  00......
```

Memory address assignment was done in order to implement them in source code. Adresses between 0000h-0138h are elected, on two occasions (16-character) messages on a row of display for direct entry into the menu interface.

Alarms configuration parameters are retained in the memory EEPROM 0500h-0540h, as shown in Table 3.2.

Table 3.2. Organization EEPROM memory configuration parameters and alarms in their original values

Parametrul	**Adresa memorie Alarmă DA/NU**	**Valoare minimă**		**Valoarea maximă**	
		Adresă	**Valoare inițială**	**Adresă**	**Valoare inițială**
R main voltage	0510h	0520h	AFh=175V	0530h	F5h=245V
S main voltage	0511h	0521h	AFh=175V	0531h	F5h=245V
T main voltage	0512h	0522h	AFh=175V	0532h	F5h=245V
U batt	0513h	0523h	50h=8,0V	0533h	96h=15,0V
pH	0514h	0524h	41h=6,5	0534h	5Dh=9,3
TDS	0515h	0525h	0h=0	0535h	C8h=800
RH	0516h	0526h	0h=0%	0536h	64h=100%
I light	0517h	0527h	0h=0luxi	0537h	78=1200luxi
Water temperature	0518h	0528h	11h=17°C	0538h	20h=32°C

CHAPTER 4

THE COMMISSIONING OF AUTOMATION SYSTEM. EXPERIMENTAL DATA

4.1. Real Time Clock calibration

In this operation, real time clock circuit, PCF8583, needs a clock signal to retain a certain time basis. This signal can be derived from the intercalation in the loop of a quartz crystal oscillator with 32768 Hz or the frequency of application to the oscillator input of a signal with frequency of 50 Hz (most often, it is provided by the mains). In its interior, the integrated circuit divides the signal with 2^{16} (65536) in the first case and divides it by 10, for the second case.

In order to make the necessary corrections and measure time basis connected to the terminal 7 (INT) of the integrated circuit a digital oscilloscope, brand Velleman Instruments, model PCS-100A and measured waveform at its output (Figure 4.1.)

Oscillator frequency adjustment value based on quartz crystal was made by exploratory capacitor values of C3 Card scheme logic. It has gone from a value of 1 nF and a waveform to have as accurately as 500 ms between impulses (as in Figure 4.1.) Was obtained when the value of 33 nF capacitor mentioned above. Deviations clock, whose frequency was fixed so were -23 seconds in the 30 days of continuous operation acceptable deviation.

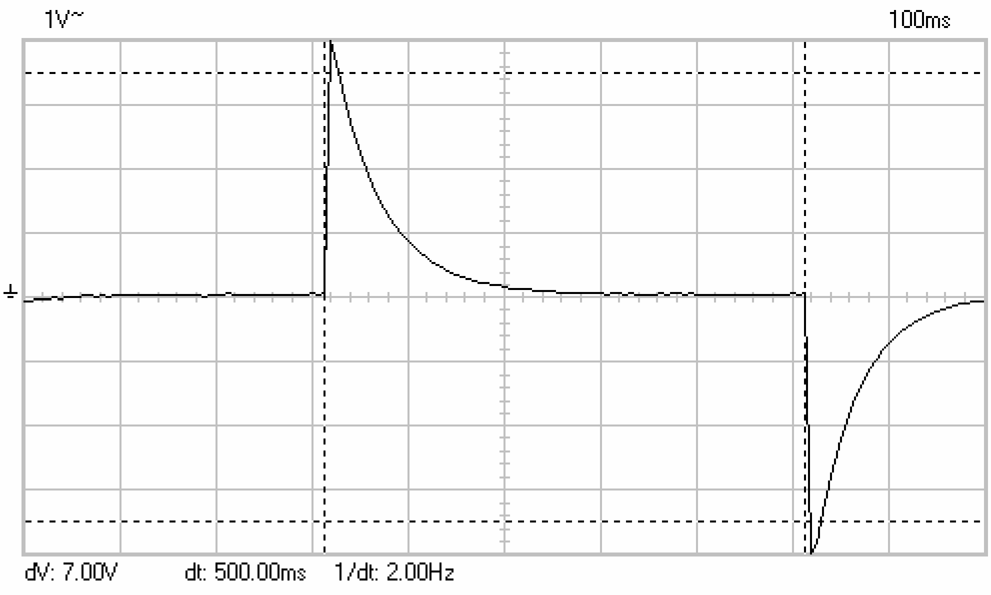

Figure 4.1. The oscilloscope waveform from the output of PCF8583 (INT pin)

4.2. Sensor calibration for the voltages of the mains

Because of high voltages that can cause electric shock to measure voltage on the three phases of the electricity network was chosen option by voltage transformers. They retain the proportion between the primary and secondary voltage ratio given them by the number of windings of the transformer which is a constant value.

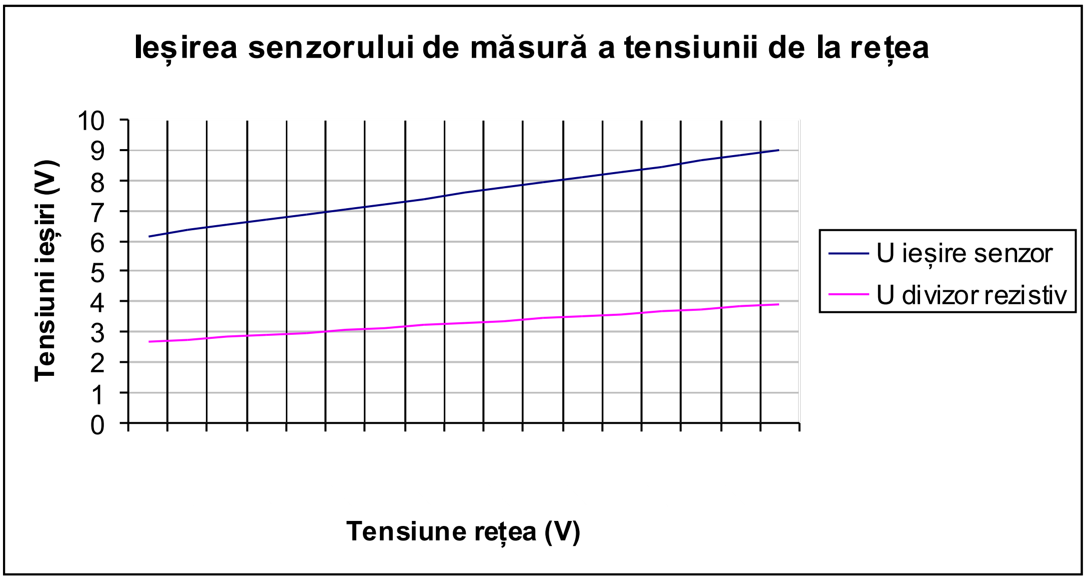

Figure 4.2. The graph values from the output voltage of the sensor grid.

4.4. pH sensor calibration

To perform these tests in order to calibrate were purchased three containers with standard solutions (buffers) of 4, 7 and 10 pH units (figure 4.4), which is within the maximum of acidity / alkalinity to the present application, respectively neutral value 7. To perform repeated tests without hurting the values of standard solutions for laundering probe pH sensor in the shift from value to another, to use a container with a liter of distilled water to rinse the probe and then wiped with tissue paper. In parallel, was used as a control and a digital pH meter, produced by WTW, model WTW, pH 340 model.

After repeated tests, the following were considered optimal values obtained from output (analog input of the microcontroller)

-for a pH 4, Uout = 0.730 V;

-for a pH 7, Uout = 2.406 V;

-for a pH of 10 Uout = 4.08 V.

Reported on a graph, the values emphasizes amplifier linearity response measured on the pH range between 4 and 10.

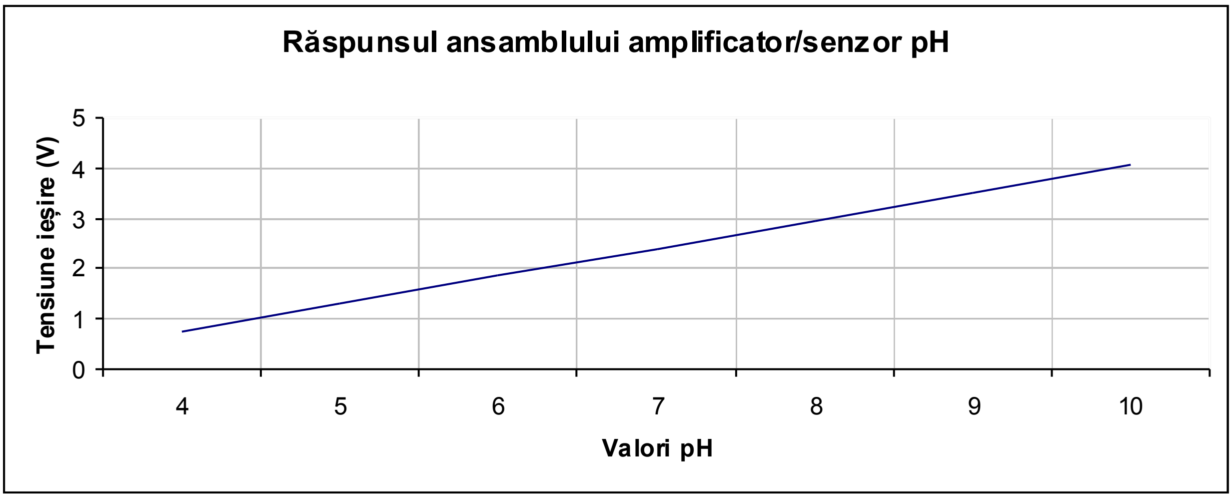

Figure 4.6. Response voltage probe amplifier assembly in pH measurement

In order for the microcontroller to be able to calculate the actual values of the pH on the basis of the voltage supplied to the input, calculate two coefficients, the gain and the offset on the basis of which the actual value from the value read results:

Real value= the ADC value * x + y,

where ADC is the reading of analog-digital converter, x and y is scaling coefficient is offset coefficient.

Given the experimental values obtained from calibration equations can be written system to help determine the coefficients x and y:

$$\begin{cases} 0{,}730 * x + y = 4 \\ 2.406 * x + y = 7 \\ 4.08 * x + y = 10 \end{cases}$$

By solving the system, taking two and two equations and mediation results are obtained the two values of coefficients, x = 1.791 and y = 2.6925. Here longer keep in mind that the reading of ADC is in the range 0 ... 1023 units for input voltages between 0 and 5 V and x and y values are ultimately used multiplied by the ratio 5/1024, ie 0.004941.

4.8. Installing the SIM

Through direct interface, was introduced telephone number of the author in the list of authorized numbers and the first tests were carried out, questioning the system parameter values.

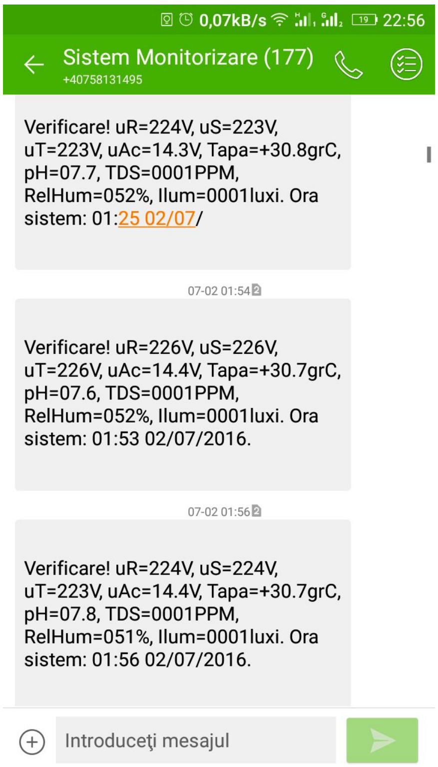

Figure 4.14. Screenshot from mobile phone when receiving SMS from GSM system interface

4.11. Data collection

Experimental verifications were conducted during a calendar month, while the system has operated continuously and without the need for any intervention on his or any reset. This confirmed and demonstrated the reliability and safety of its operation, a positive response to one of the design requirements.

Parameter monitoring was done remotely and the results have been entered into a database every day at 8:00, 16:00 to 22:00. The results can be seen in the graphs in Figures 4.19 - 4.24 for each trait.

Table 4.1. Thresholds value writed on the automated system

Parameter	Triggered?	Min value	Max value
Main voltage R	YES	175 V	245 V
Main voltage S	YES	175 V	245 V
Main voltage T	YES	175 V	245 V
Batt voltage	YES	11,0 V	14,8 V
Water temperature	YES	20 ^{0}C	28 ^{0}C
pH	YES	6,5	9,4
TDS conductivity of water	YES	0ppm	850 ppm
Relative humidity	YES	40%	65%
Light intensity	NO	-	-

If the mains voltage power supply, we noted variations between day and night time moments of the evening, their growth over the maximum threshold of 245 V led to repeated alarms. The mains voltage was only parameter that triggered alarms repeated throughout this period and its relatively high values resulted in failure of the air conditioning and decoupling repeated fuses in the electrical panel.

The water temperature was relatively constant around 25,5^{0}C, with higher values during the day and low at night due to lack functioning air conditioning system. In fact, in its start date 25.06 determined, as can be seen from the graph, decreased by almost 2,5^{0}C it and return to higher values after being adjusted the thermostat temperature to a higher value. This was done after analyzing data collected by the system automatically.

The evolution of the pH values of culture water from the basin was a relatively constant with small changes (increases of 0.1-0.2 units) at 2-3 hours post meal and fish are given the replacement decreases a small amount water or low temperature. There were no reported alarms due to exit from this parameter limits.

Neither evolution of total water conductivity values had large variations, it is a veiled average 650ppm. They found small variations in moments completing its water system and increases after serving fish feed.

Relative humidity in the room recirculating river was around 50%, and did not trigger any alarm. They found an increase it up to a peak of 62% while the windows were closed and the room door and the ventilation / air conditioning did not work, on 06/22/2016. Starting climate led to dehumidification, on 06/28/2016, which is signaled by lowering the relative humidity to 44%.

The light intensity around pools known culture of daily cycles of 0 lux 1000-1100 lux night until noon, when the sun enters the room windows. Depending on the state of the weather that day, peak of the day varies between 800 and 1100 lux. By overlaying graphics, we have not found significant changes in pH or TDS of the water in relation to the light which confirms that the algae from ponds is very low.

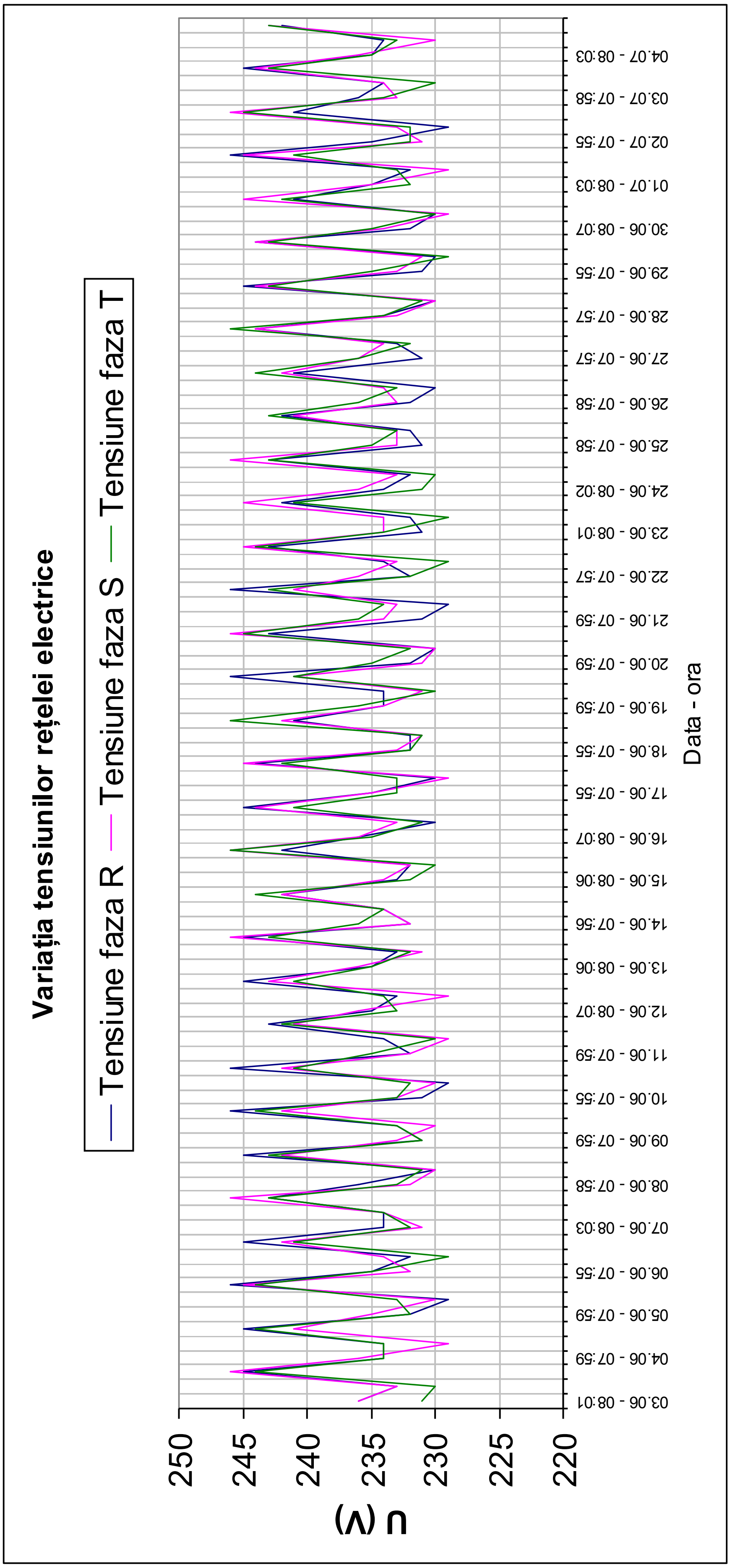

Figure 4.19. The graph evolution supply voltages from power supply for one month based on data collected by the automated system.

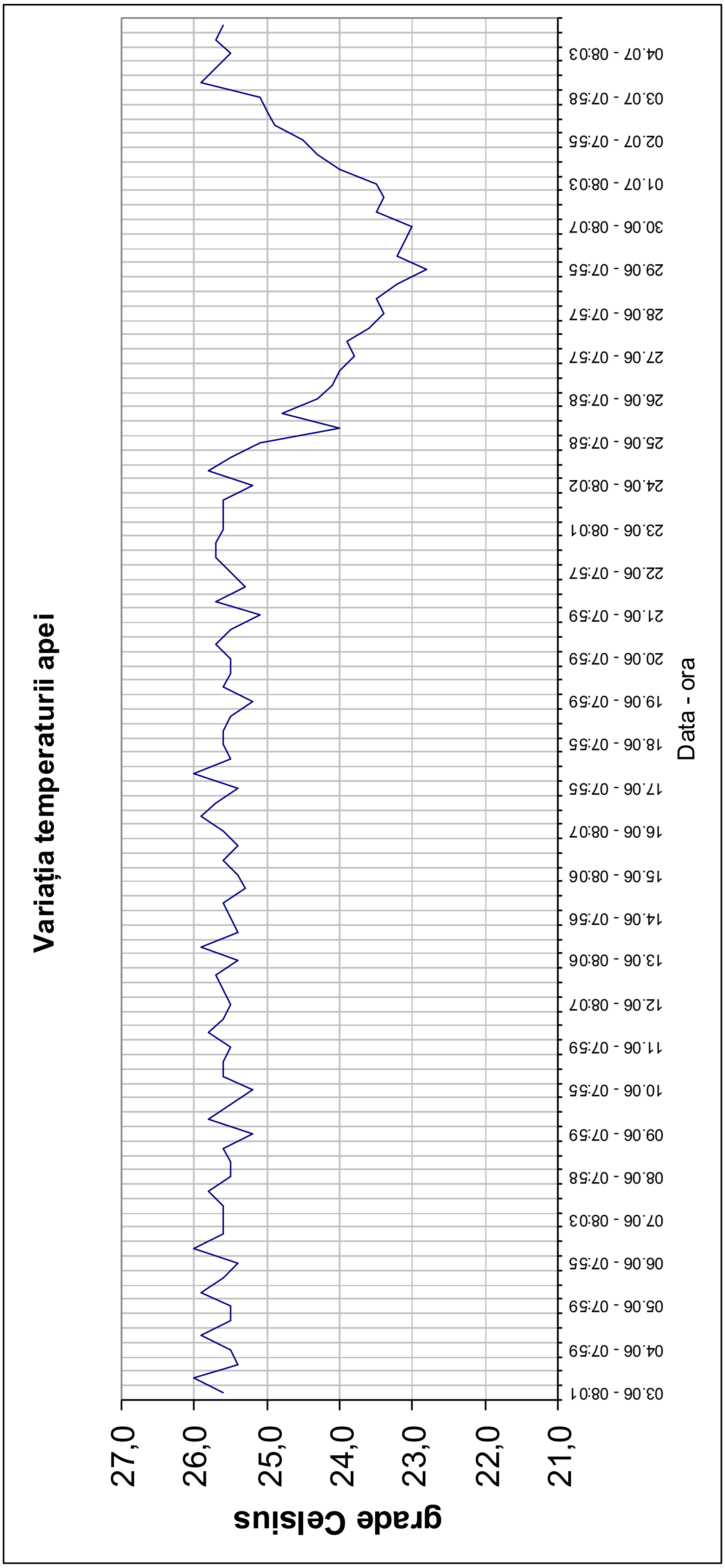

Figure 4.20. Water temperature evolution graph for one month based on data collected by the automated system.

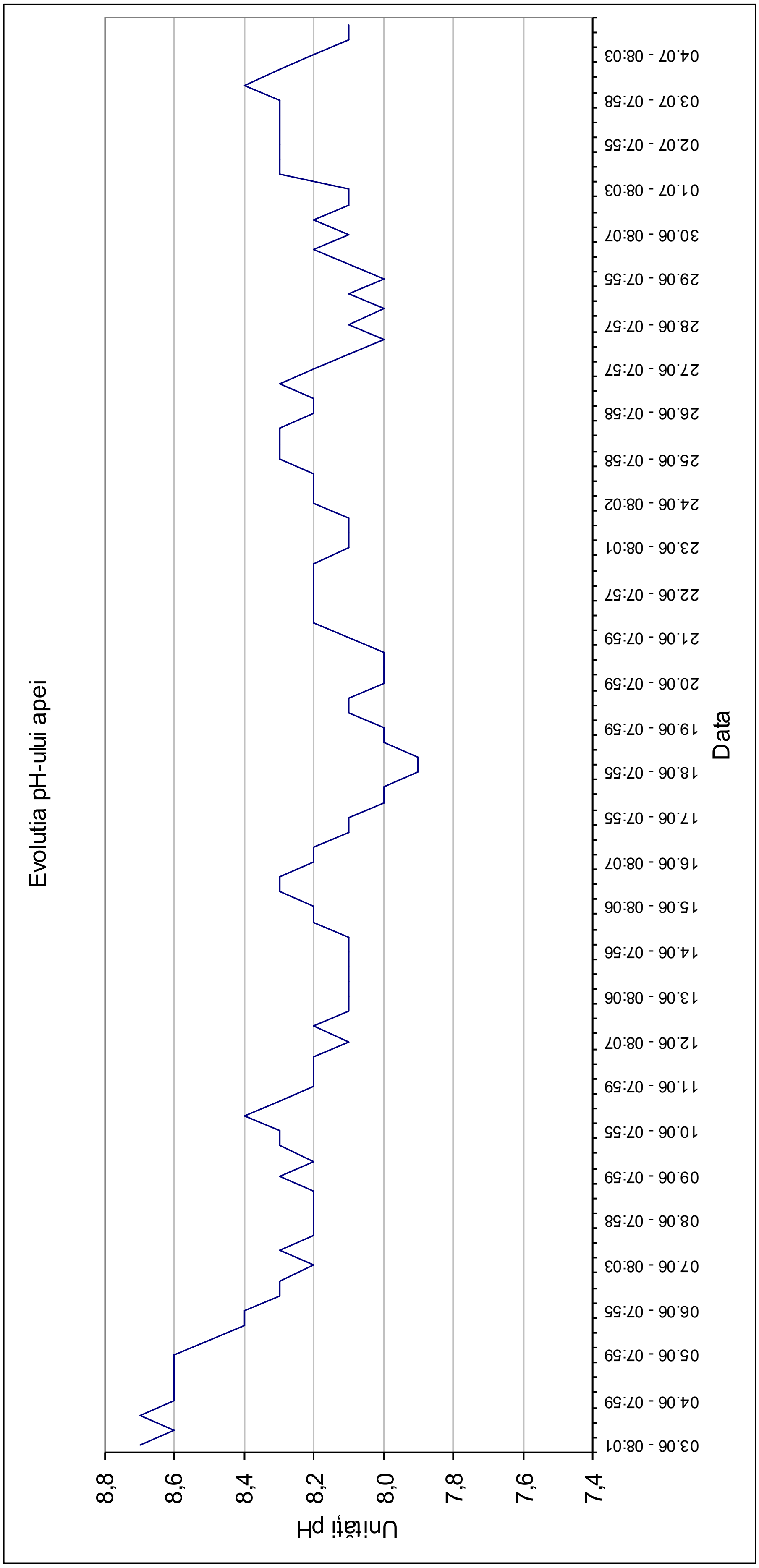

Figure 4.21. The graph evolution pH of the water for one month based on data collected by the automated system.

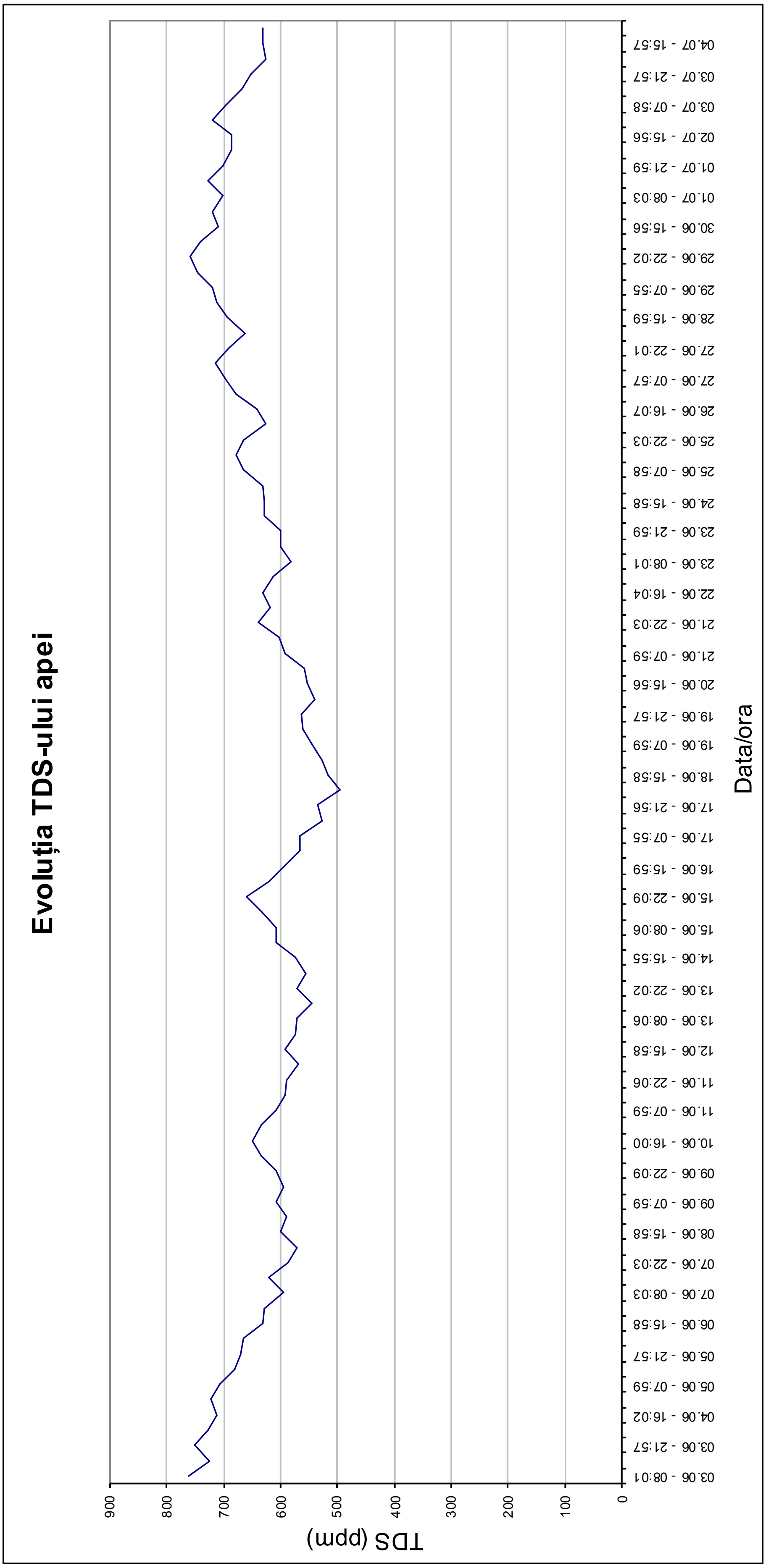

Figure 4.22. The graph evolution total conductivity of water for a month based on data collected by the automated system.

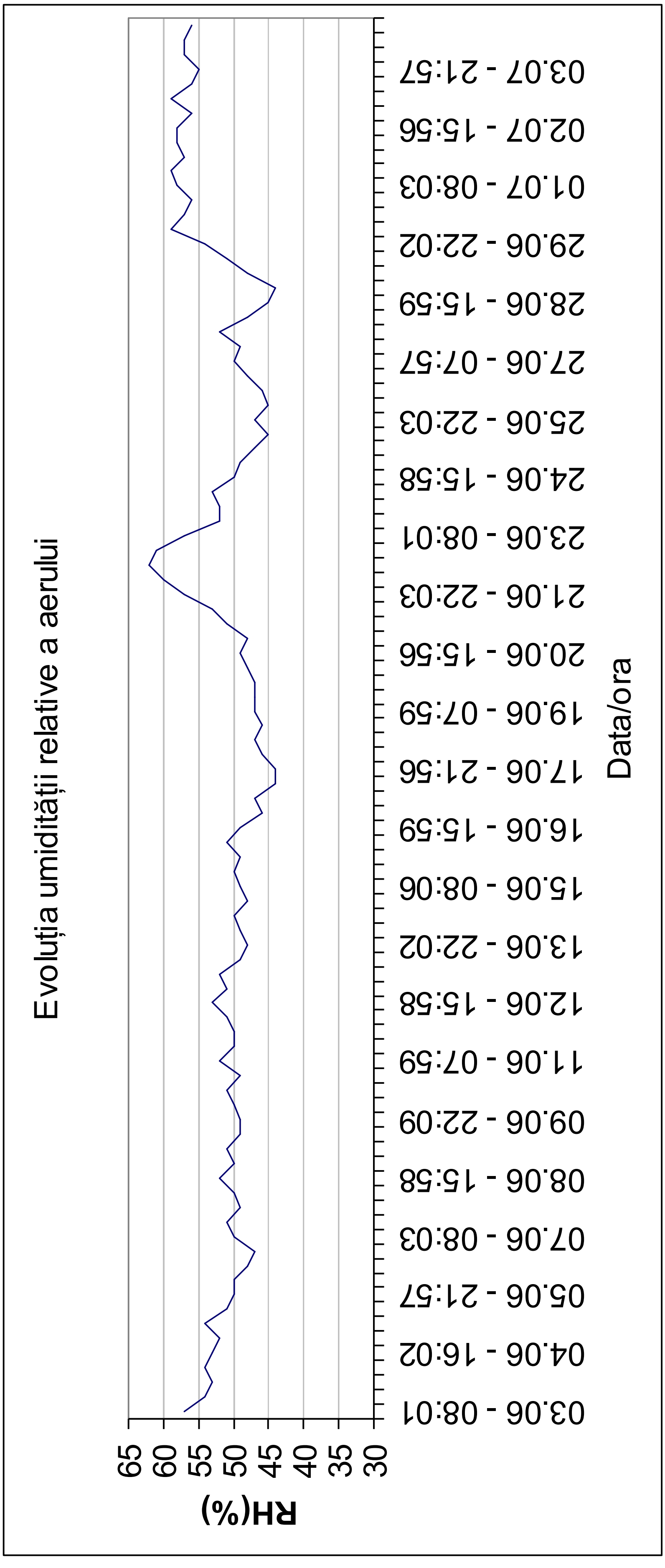

Figure 4.23. The graph developments relative humidity in the room with pools of culture for one month based on data collected by the automated system

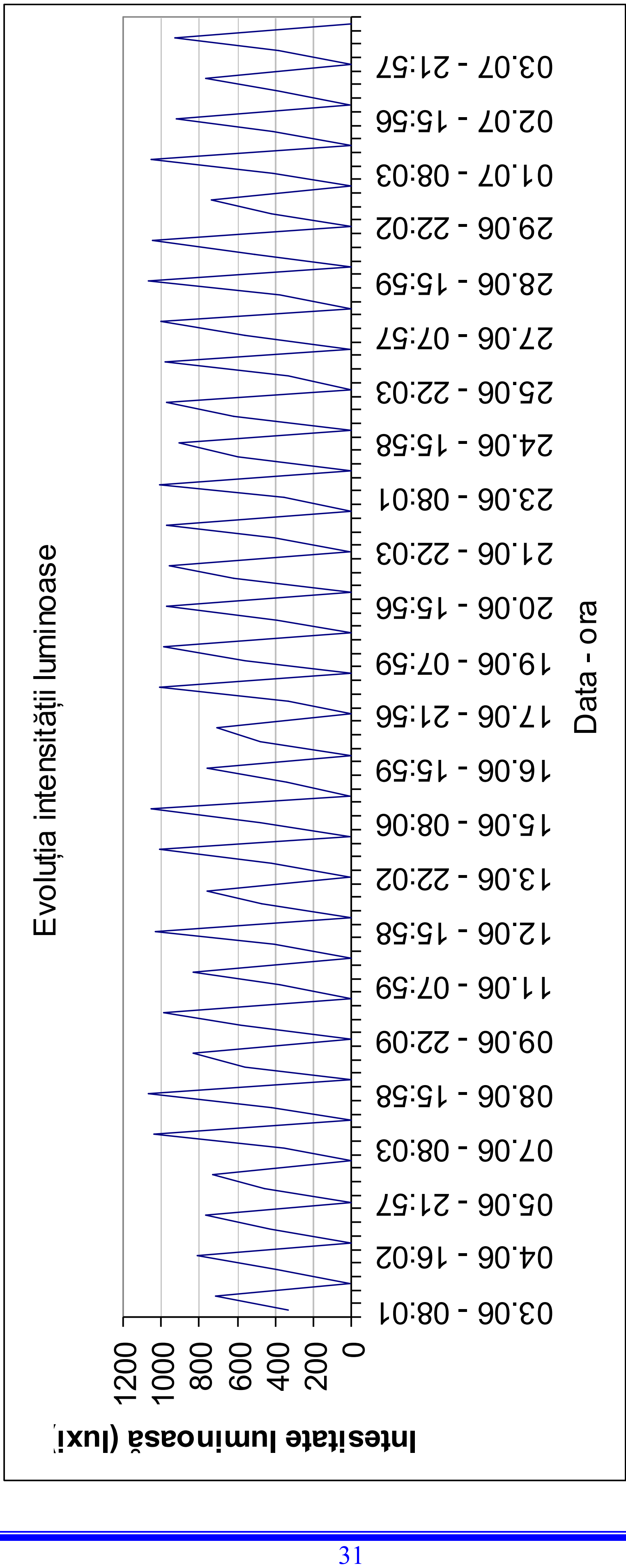

Figure 4.24. Chart development light intensity around pools culture for one month based on data collected by the automated system.

CHAPTER 5

GENERAL CONCLUSIONS, ORIGINAL CONTRIBUTIONS AND PERSPECTIVES

The main proposed objectives of this thesis were multidisciplinary nature, to know the control mechanism of water quality in recirculating systems, the main physico-chemical and biological water, their influence on quality of life aquatic organisms and design a system complete automation to monitor these parameters and to take the necessary decisions when necessary.

An automatic system brings a multitude of benefits in that it performs a continuous monitoring of parameters, instantly signaling any deviation from their normal limits as well as reducing the number of specialized personnel, personnel involving large financial costs. Immediate correction of deviations from normal water quality parameters helps to reduce stress on biological material and, therefore, increase production efficiency. An automatic system has a reaction time far better than human factor and this is confirmed by the fact that it is continuous analysis of parameters of water quality, as opposed to periodical tests carried out by operators of longer and omitted or performed incorrectly.

Costs also measured electronic parameters are much lower than those classic that require reagents and solutions titration expensive, expiring etc, and current and future development of the technique brings after itself, increasing costs low for a category growing sensor.

Research conducted to eleaborării this automated system were carried out in several stages, as follows:

-aprofundarea and literature review to identify the problems faced by recirculating aquaculture systems, the main water quality parameters that are most important, their influence on the fish population grown in culture ponds and how to maintain their (physical, chemical and biological) within limits and boundaries for optimal crop species in question;

-studies of specialized markets with automation equipment dedicated recirculating aquaculture systems and finding their shortcomings in relation to the real needs of farmers and their determination of critical points;

-setting goals that system to be designed will try to resolve them in a manner as fair as possible by implementation in a recirculating aquaculture system;

-analysis of existing microcontroller market, to choose a model that collapses as well on needs and key points of a recirculating system in relation to the possible cost of his younger and related components;

-design a software algorithm that meets the operating and are fully consistent with the hardware capabilities of the selected microcontroller;

-setting and other hardware design that meet the goal, the external memory to drive real-time clock, user interface and amplifiers signals from sensors;

-ensure a reliable and safe in operation by identifying all problems that may interfere with the proper functioning of the system and preventing them;

-realization practical function modules from designing printed circuit boards and finishing with assembling their components in boxes planted protection;

-development a menu for direct interface to help troubleshoot end user issues operating and adjusting to all necessary parameters;

-writing of necessary source code for compilation and software development for the proper functioning of microcontroller designed taking into account the algorithm;

-the calibration of measurements performed by sensors in order to make more accurate readings of water quality parameter values and other parameters vital to the system.

The research was conducted in the laboratories of the Department of Aquaculture, Environmental Science and Cadastre, from the "Dunarea de Jos" University of Galati and direct labor, the practical realization of assemblies and assembly automation system. Installation of the system was done in a recirculating aquaculture system Q07 room in the same department.

On this occasion, the experimental period, was noted the importance of monitoring and other factors, such as the electricity network of the refueling system recirculating pumps and equipment's annexes. They consisted of increases in values during the evening / night increases which contributed to the failure of equipment. In terms of water quality parameters monitored, they have not found large oscillations of their values, their being in the normal range.

Pairing rigorous measurement parameters evolution with time running in real time measurement can provide valuable information on some cyclical events that occur, as happened in the case of electric voltage the supply.

The results of this doctoral thesis is on the one hand, the result of combining basic information, existing aquaculture, electronics, automation and informatics, personal contributions are from this point of view, a harmonious combination of them in order to achieve objectives . Another aspect of personal contributions, is the study of electronic components for automation markets (microcontrollers), sensors and technical data and their characteristics from manufacturers' catalogs in order to choose the optimal variant and their compatibility. The documentation in this regard represents a critical point in the design of automated systems as the dynamics of the development of specific components experienced a high aploare lately.

Another important personal contribution in achieving the objectives of this thesis has been to design menus direct interface with the user of the system automatically. Given that a microcontroller is a computer system scale and led process it is complex overwhelming, had created a balance between them, not upload additional and unnecessary but at the same time providing resolution of variety they control problems. The user interface of the final beneficiary should be a friendly and easy bowing from the premise that it is not automatic or computer specialist.

Lastly, another personal contribution is the design and conception of the software required to operate the system. Based on the C ++ programming language that allows a wide range of facilities, the implementation of the algorithm should be considered in all situations that may arise and which may cause errors that may block the system. This is very important, given that the automatic system must be one with the safe operation of any malfunction with serious consequences to biological material in a recirculating system. For example, exceeded the scope of a variable type unsigned char (max. 255), can lead to impaired memory of neighboring areas, corresponding to other variables and then the system can be misinterpreted values.

The system has been designed so as to leave place any future developments, such as, for example, to read a wider range of parameters of the water quality by adding additional sensors, and multiplying in the sense that they can be read simultaneously the values in each culture tank, for example. A further development could be a possible, for example, automatic feeding of the fish, on the hour in fixed amounts, based on the real time clock. Also, one of the objectives in implementing the program, to let space to these developments has been achieved, meaning that all software required to operate the system at this stage, only occupies 62% of the flash memory of microcontroller ATMEGA32.

The reliability of the system was achieved another objective of this thesis. This condition is critical in the use and operation of the microcontrollers that lead to such processes as downtime can cause major damage. From this point of view, the automatic system designed here successfully passed all tests, laboratory tests operated uninterrupted for five months and installed in the system for a month and a half. During this period, there was no need to reset it nor was signaled an error or inconsistency in its operation.

The accuracy of the measured values as high as it was at the outset a research interest of this thesis and also was a goal achieved. After calibration performed in the laboratory stage, parallel tests were performed on all parameters measured in the recirculating system, random, using measuring equipment approved or metrology, which proved an accurate gauge. In this regard, there were differences of more than 3% between the measured values.

Interface with the remote system was a novelty of this research, he no longer met the author dedicated aquaculture similar systems on the market and considered a lack thereof. Making it through text messages (SMS) is actually meant to facilitate communication with beneficiaries, given that it can use any type of mobile phone, be it classic or smartphone.

Although it is relatively easy to implement remote communication via the Internet, has not done so since, at the current level of development of mobile networks in Romania, there are many areas not covered by these services. The interface enables communication via GSM chosen GPRS Internet and how to implement this method of data transmission in the following versions can be done relatively easily by changing commands to the microcontroller sends to it.

In fact, because Internet communications technology IP phones use private IPs frequently changing, it is necessary to implement a server-based Internet connection with a fixed IP, or using public DNS services. This would be radically altered costs of the system automatically by the server itself values and costs of internet subscription.

Through his using an external memory microcontroller, busy at the moment with only 24% data, the system automatically can accept a variety of further developments, such as expanding the number of people authorized expanding the number of monitored parameters (water quality in culture ponds), creating a log with a number of past alarms, a log of changes in water quality parameters monitored for a limited period of time etc.

Because of high costs, it was waived implementation of executing automatic system elements. They had intended to correct the mains voltage (voltage regulators ordered) adjusting the pH, temperature correction. However, their implementation can be done quickly by using four pins on port D of the microcontroller via a decoder can provide 24 positions, 16 additional orders for them. It would be the only goal that could not be fully achieved.

All because of high costs, no implementation could make the measurement of dissolved oxygen in water (DO). Electronic measuring method of dissolved oxygen from water involves the use of sensors, at this time, still prohibitive prices. In addition, the technology used in their construction has a big disadvantage in the use of the selectively permeable membrane in contact with water, the membranes that change their properties in time, the clogging of the fine sediments under water culture, a fact that leads to the change of their regular or unable to perform continuous measurement of this parameter. However, this parameter could be determined indirectly through others, with a probability quite good, as was pointed out in Chapter 2 of this thesis.

As stated above, automated systems based microcontrollers can be improved continuously adding new facilities, the expansion of existing or improved software algorithms that underlie their operation.

The automated system presented here allows expanding the number of authorized persons, their data being stored in Flash or EEPROM program memory but its external memory. Basically, any time, can adding more other people being able to raise their number about to 50. By changing even 256 kB memory with one of greater capacity, the upgrade can be even higher. From this point of view, PCB design and planting components, it has taken account of this and for all integrated circuits (microcontroller, EEPROM memory external real-time clock circuit).

On the same line, the system can automatically add and monitor other parameters such as levels of water in the tanks, sedimentation tanks, biological filter etc, interfacing with microcontroller may be submitted via the I2C bus. At the moment there in the marketplace a wide range of ADCs that can convert analog information, derived from the sensors into digital information that can be transmitted to the microcontroller through this type of communication.

An alternative in providing microcontroller more than eight analog information is multiplexing them through FET switches based digital technology, technology allows preserving the accuracy of information transmitted and switched within it.

Another aspect that could be further development of automated management control of processes in water quality in recirculating systems is storing data read about these parameters on an SD or MMC card. Implementing such a system of "logging" data is optimal alternative to a dedicated server. The cost of the average card capacity (16Mb) is one under 100 RON and storage at a frequency of one hour, for example, could retain values for nearly a year. Both the microcontroller and the software used in the creation of machine code for it have all the facilities for this.

At the moment, the data collected automatically by querying the system via SMS, three times a day, were stored in an Access database type. As a further development, the system may automatically add a dedicated software allowing access SD or MMC card and copying the information in these databases. This allows storing them on every lot of time and statistical analysis which can reduce production costs and optimize increases in batches future culture by associating evolution parameters of water quality with the different operations carried out synchronized based on the real time clock.

Currently, the system alerts all authorized persons from the list, which was activated this via 11 direct interface menu. A possible further development of the system would constitute a selective alerting of these authorized persons. For example, improper variations of voltage could be warned electrician system parameters related to water chemistry could be "alarmed" only chemical engineer and so on In the same vein, they can make combinations between persons who are service automatically if their working hours should be introduced in advance in system memory.

Another further development of the system could be established on the basis of commands sent remotely via text messages or DTMF tones of phones. A dictionary based on well-defined codes or commands received from the users could perform additional feeding or upgrading aeration, for example.

Such management through an automated process control water quality in aquaculture has proven to be an important tool dedicated to optimize and facilitate activities in this field.

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