TELEMETRY OF MILK PRODUCTION SYSTEM AND CONTROL OF MECHANICAL MILKING OF CATTLE BEEF, BASED ON HARDWARE PLATFORMS AND FREE SOFTWARE, IN THE EXPERIMENTAL FARM OF THE TECHNICAL UNIVERSITY OF NORTH PRAIRIE.

Pavón. Olavo Gabriel Author, O. Oña Director
Engineering in Applied Science Faculty, Technical University of the North
Ibarra, Ecuador
gabrielcime@live.com oronia@utn.edu.ec

Overview – This project has as propose the designing and construction of a telemetry system that allows to record bovine milk and an automatic milking system control to prevent over milking and mastitis. It is based on RFID technology for animal identification, and for its verification in a remote database connected through a local network. Also, will be implemented a web server to manage the database, and an FTP server to transfer cattle information. The system has to send an email to the form manager or the person in charge of the farm with bovine information.

Index of terms - Raspberry Pi, Arduino, RFID technology, LAMP server.

I. INTRODUCTION

The milking is based on the extraction of the milk from the mammary gland is made in two basic forms: natural, what is made by calf and; the artificial, that is made by man, either manually or mechanically (AVILA, p.143). Hand milking is the problem of hygienic quality of milk that is less as compared to the mechanical milking, since milk is exposed to the environment and to the hands of the computer (AVILA, p.151). Producing a number of diseases, a very common disease is mastitis, complex and costly disease of cattle from the farm.

With mechanical milking parlor or modules are used by farms, since it is an efficient way of expression, but they are still very traditional. Teatcups vacuum system, is controlled via a stopcock which must be open to the time to start to milk the animal and close at the end, the manipulation of this key is also done manually; where it has has made the extraction of cow's milk, it settles into a small container near the brete, for storage; for these reasons the process despite the fact that has a mechanical milking is very slow, which decreases the number of animals that can be milked in a day, directly affecting production (PEREZ, 2009). Furthermore if it is not controlled module can produce about milking in the animal.

The design of a system that controls the extraction of animal milk is one of the many areas in which can be controlled, dairy farming to avoid milking and common diseases such as mastitis in bovine animals of the farm, also this system must automatically record the production of milk of the bovine. Without a doubt this system will exceed the disadvantages presented, having a reliable control of production, improving their efficiency and throughput of milking, and hence the quality of life of the animal.

II. BASIC CONCEPTS

A. *Analog signal*

An analog signal is the magnitude that can take any of the infinite values of the range where it is defined at each instant of time. Examples of analog variables that occur in nature: pressure, humidity, temperature, voltage, etc. (ACHA).

Figure 1 shows an example of analog signal. You can see how the scale is relative, and various moisture continuously in a range of values over a period of time. (ACHA).

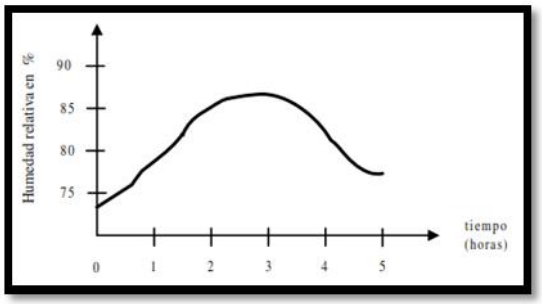

Figure 1 Analog magnitude representation

B. *Digital signal*

Digital signals are those whose magnitude, they can take a value between a finite set of discrete values, in each moment of time. There is no intermediate values so that there is a discontinuity between the step value to another. (ACHA).

The magnitude has two States: closed or open, high (High) and low (Low), high voltage (VH) or under (V), numeric value 1 or 0, level etc. To digital signals with two States they are called them binary and form the basis of digital electronics. (ACHA).

Figure 2 shows an example of binary digital signal, where the magnitude represents the State of a switch used to activate / deactivate the focus of a room depending on the time. There are no intermediate values between the open and closed state. Therefore, the digital signals are characterized by a finite number of possible values and discontinuities associated with these values. (ACHA).

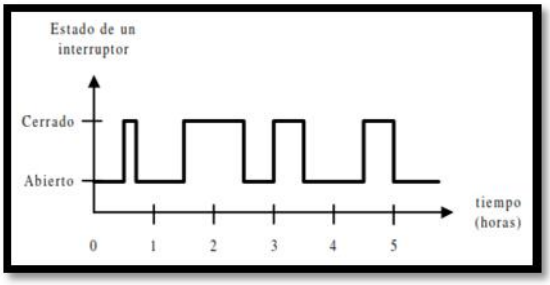

Figure 2 Representation of a digital magnitude

C. *General System*

A system is a set of elements with some feature in common. It is called to the elements of a system which have the same structure of system, subsystem. (ACHA).

The simplest system can be considered a closed structure with an entrance and an exit where the main interest is to know the relationship between these two variables. (STEREN).

Figure 3 Example of a system

A system suggests a set of interrelated, elements to perform a function well defined that none could do it if only; a microprocessor-based system is a set of components (electronic circuits) interconnected capable of making information from the process, represented in binary, arithmetic and logic, and transferring data with different devices connected to the system. (COLLAGUAZO).

D. *Input peripherals (sensors or captors)*

They are those who receive the information of physical changes in the process. Examples: pushbuttons, switches, electrical contacts, CAD, keyboard, touch panel, etc. (COLLAGUAZO).

E. *The Control Unit*

It is responsible for processing the information received on the basis of a program (logical sequence

of instructions) and delivers results to be executed. (COLLAGUAZO).

F. Output peripherals (actuators)

They are those who executed the orders based on the results of the Control Unit. Examples: relays, solenoids, contactors, display completo, led, etc. (COLLAGUAZO).

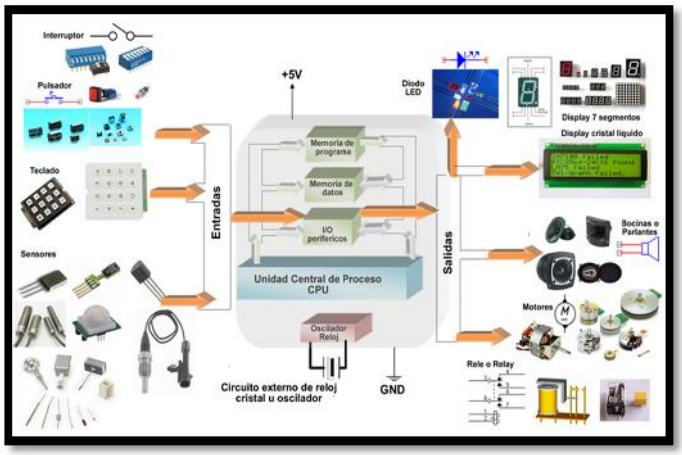

Figure 4 General System

G. Analog system

An analog system is one in which their signals are analog type. Its components often work in its linear area, in which the relationship between the input and output signals is constant, called work area. These signals can take any value within certain limits. (ACHA). An example of analog system is shown in Figure 5. It's an analog meter of the speed of a motor.

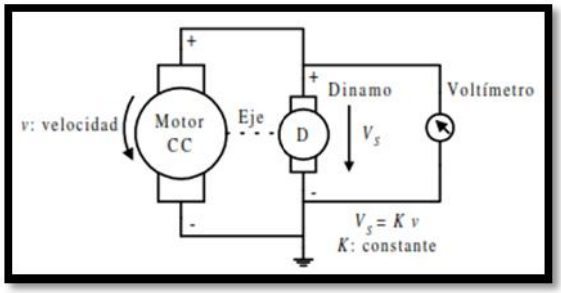

Figure 5 Example of analog system

H. Digital system

A digital system is one in which their signals are digital type. Its components work in the zones of saturation (their outputs signals do not have a linear relationship with respect to its inputs). The signals of these systems tend to be close to the potentials of food, presenting two different States, each one corresponding to a level or the magnitude of the binary value. (ACHA). A digital system is shown in Figure 6, is a digital stopwatch

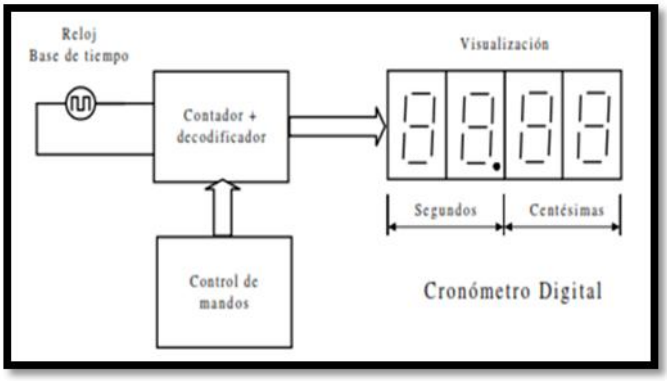

Figure 6 Example of digital system

I. Analog-digital system

An analog-digital system is the one that involves both analog signals and digital signals; i.e., it is composed of subsystems-analog and digital subsystems. (ACHA). An example of analog-digital system is shown in Figure 7, which corresponds to a compact disc player (CD). A digital-analog (d/a) converter transforms digital signals into analog, necessary to drive, once they have been amplified in the amplifier block.

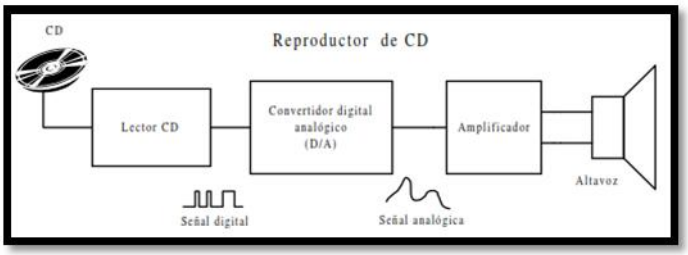

Figure 7 Example of analog-digital system

J. Wireless media types

Currently, there are three common standards of data communication in wireless media:

1) *Standard IEEE 802.11:* "the technology of wireless LAN (WLAN), commonly known as"Wi-Fi", uses a system conflict or non-deterministic with a process of multiple access

carrier detection and prevention of collisions (CSMA/CA) to access the media. (CISCO).

2) *Standard IEEE 802.15:* (WPAN) wireless personal area network standard, commonly referred to as "Bluetooth", uses a pairing of devices to communicate over distances of 1 to 100 m. (CISCO).

3) Standard IEEE 802.16: Known commonly as "world interoperability for the access for microwave " (WiMAX), uses a point-to-multipoint topology to provide access to wireless broadband services.*" (CISCO).*

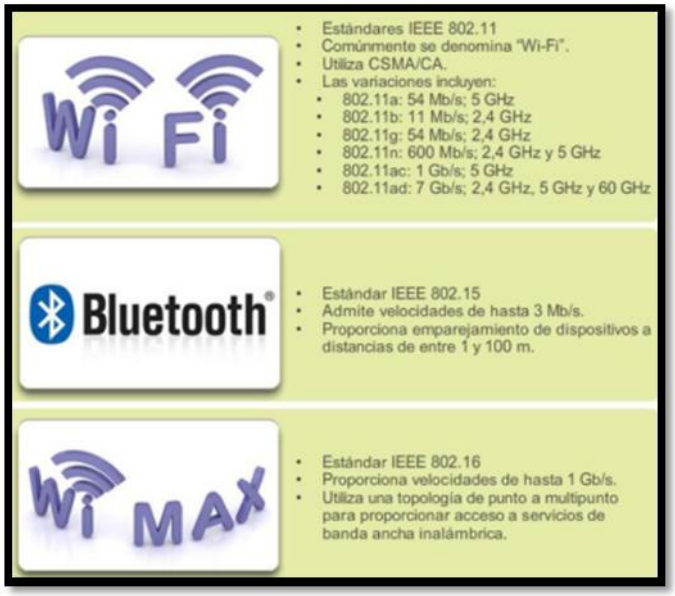

Figure 8 differences between wireless media

K. RFID technology

The radio frequency identification (RFID) is a technology of capturing and automatic identification of information in electronic tags (tags). When these labels come into the area covered by an RFID reader, this sends a signal to transmit label information stored in its memory, usually an identification code. (AETIC). RFID technology retrieves the information in the tag or label via radio frequency and does not require that there is contact between the RFID reader and the tag or label, although in most cases it requires a certain proximity of those elements. In an RFID system to identify element can be an object, person or animal.

Components of the system:

The basic components of an RFID system are:

Tags RFID or Tag.
Antennas.
RFID reader.

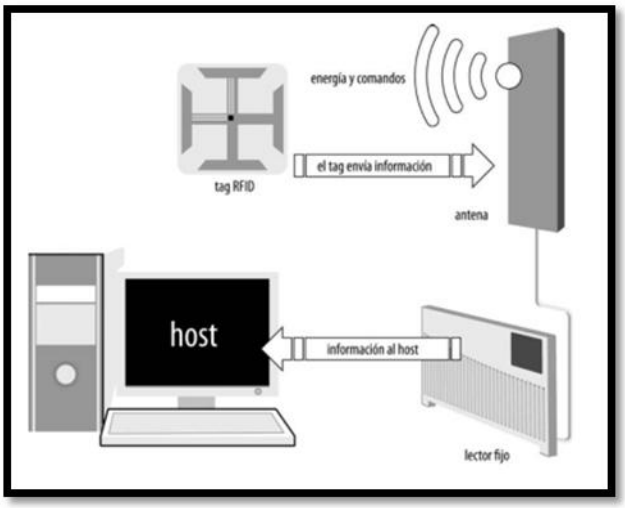

Figure 9 Basic RFID technology architecture

L. Client-server model

Layer protocols application interact with applications for end users, in this model the device requesting the information is called a client, and the device that responds to requests is called a server.

The client starts data exchange requesting data server, the server responds to the client by sending one or more streams of data. In addition to the Exchange may also require user authentication and identification of a data file that is going to transfer.

Many layer protocols exist application, below are some protocols layer application which form part of the work:

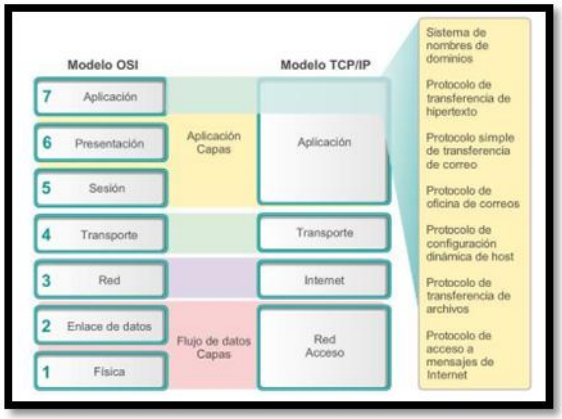

Figure 10 Layer application of the OSI and TCP/IP protocols

M. FTP server

The FTP (file transfer protocol) is another protocol that client-server works on the model application layer. (CISCO). FTP programs allow users to transfer files to a remote system, running a FTP server and from this program.

To transfer data properly, FTP requires two connections between the client and server, the first connection to the commands and responses, and other connection for file transfer. (PETERSEN, 2009)

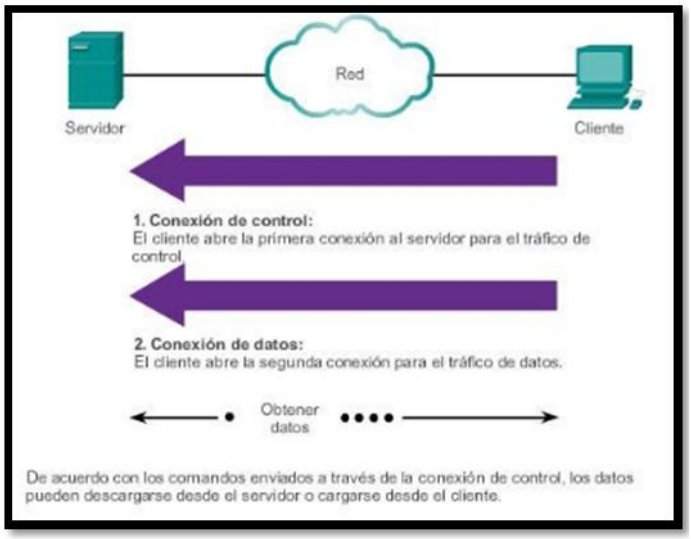

Figure 11 FTP process

N. SSH server

The Secure Shell (SSH) protocol facilitates the secure communications between two systems using a client/server architecture and which allows users to connect to a host remotely. (PETERSEN, 2009). SSH protocol provides password authentication and use encryption when it carries the session data. Thus manages to keep private the ID of the user, password, and the details of the management session. (CISCO).

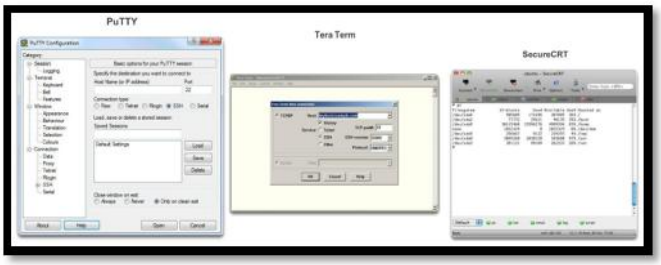

Figure 12 Terminal emulation programs

O. WEB server

When a web browser writes a web address or URL (Uniform Resource Locator), your browser establishes a connection with the Web service running on the server using the HTTP protocol. (CISCO).

Through web browsers a PC can connect to the World Wide Web and access the resources stored on a Web server. Web clients make connections to the server and request desired resources. The server responds with the resource and, upon receiving it, the browser interprets the data and presents them to the user. (CISCO).

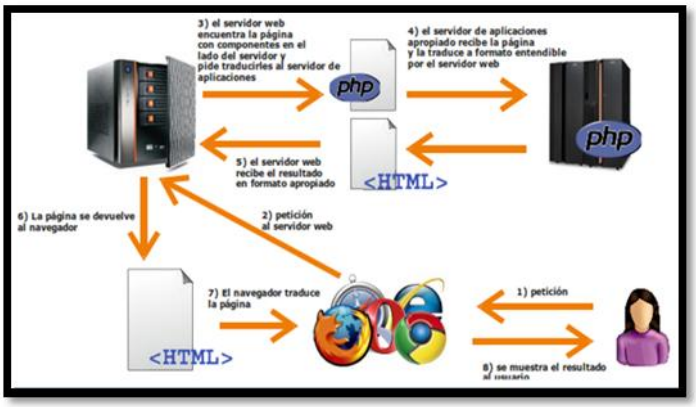

Figure 13 Performance of applications created to be performed on the server side

P. LAMP server

LAMP stands for Linux + Apache + MySQL +

PHP/Perl/Python, and is known as a platform for developing and running web applications. All the elements that are LAMP are free software.

A Web-based platform has four basic components: an operating system, a Web server, a database and a programming language. (BAQUÉ, 2011).

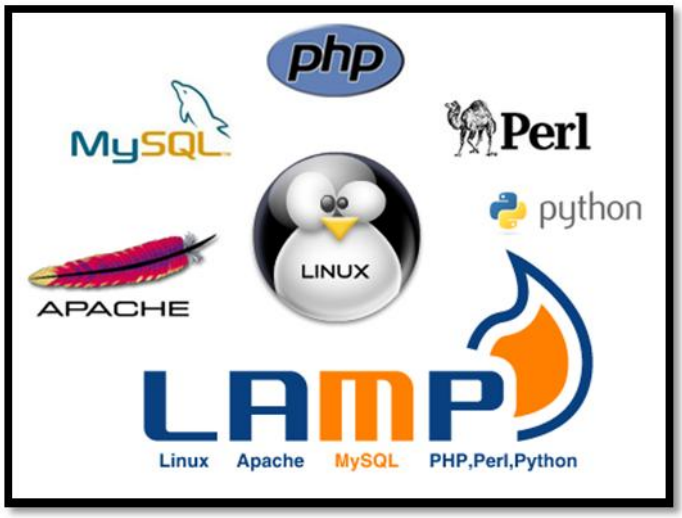

Figure 14 LAMP server

III. DESIGN

A. *The design considerations*

Taken into account fundamental aspects to make the system work properly, for which should be considered:

Wireless link-so you can access the database to the web server and so you can send emails, is necessary to the Internet resource. For it is necessary to perform a wireless link between the milking station and communications Rack, which is located in the laboratory of La Prairie Experimental Farm.

Electricity.-is an important requirement for the operation of the entire system, this electrical power subsystem must ensure energy supply necessary for the normal operation of the entire system.

Protection of electrical systems-to prevent overload to affect the operation of general purpose devices, is essential to the presence of elements of protection such as breakers, fuses.

B. *Architecture of the system*

This scheme represents the project generally develop.

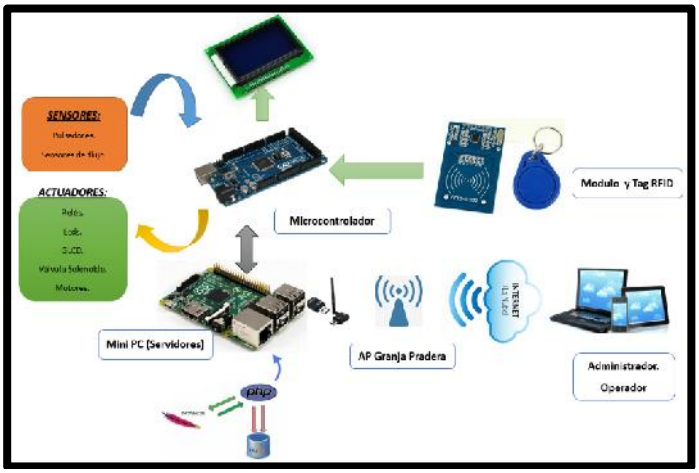

Figure 15 System architecture

C. *Block diagrams*

The following diagram shows the structure and the way in which relate the subsystems that have been taken into account to form a functional system.

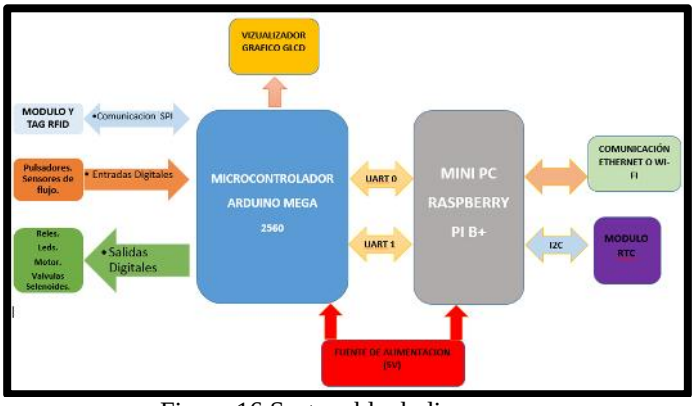

Figure 16 System block diagrams

D. *Connection diagram (schematic)*

So connection diagrams may be outlined in a didactic way, has opted for choosing software Fritzing, which allows me to documenting the prototypes to then create the printed circuit board diagrams.

The communication between devices of general-purpose (Arduino Mega and Raspberry Pi) is

performed via the UART (Universal Asynchronous Receiver/Transmitter) bus

The Arduino Mega microcontroller and RFID (RC522) module, these two devices communicate via SPI (Serial Peripheral Interface) bus.

Diagram of connection between the RTC module and the minicomputer Raspberry Pi B +, it is done through the I2C (Inter integrated communication) communication.

It is worth mentioning that you for the rotation of the electric motor control, was an H bridge based on relays, which are activated by their respective transistors. Activation of the transistors signal pins of the microcontroller, Arduino Mega 2560 made it.

And presents the connection diagram of all devices involved in the whole system.

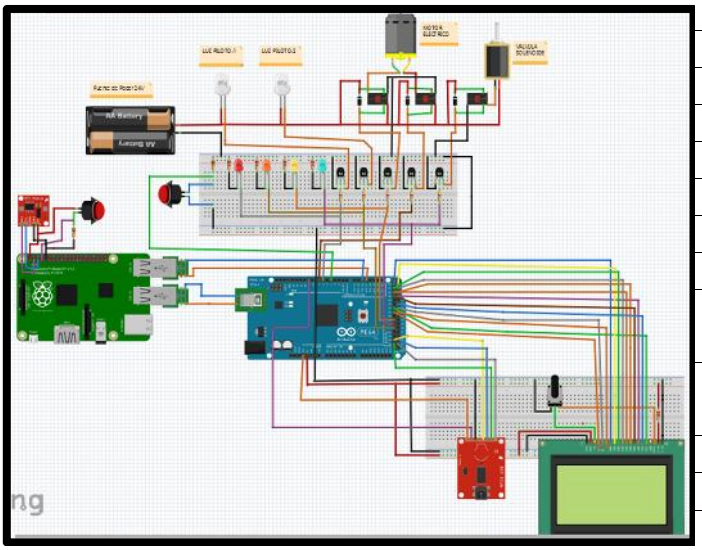

Figure 17 Connection diagram of the complete system

E. PIN on the Arduino Mega 2560 module distribution

To specify the use of module pins Arduino mega is detailed a table with pin number, if the used pin is input I notation will be used, if it is be used O notation, if the data type used is Digital or analog, is detailed function and specification that meets certain pin of the Arduino with other electronic components.

Table 1 Distribution of pin of the microcontroller, Arduino Mega 2560 with other devices

PIN ARDUINO	I/O	DATA / TYPE	SPECIFICATION/FUNCTION
22	O	Digital	DB0 GLCD
23	O	Digital	DB1 GLCD
24	O	Digital	DB2 GLCD
25	O	Digital	DB3 GLCD
26	O	Digital	DB4 GLCD
27	O	Digital	DB5 GLCD
28	O	Digital	DB6 GLCD
29	O	Digital	DB7 GLCD
33	O	Digital	CS1 GLCD
34	O	Digital	CS2 GLCD
35	O	Digital	R/W GLCD
36	O	Digital	D/I GLCD
37	O	Digital	E GLCD
50	I	Digital	MISO RFID RC-522
51	O	Digital	MOSI RFID RC-522
52	O	Digital	SCK RFID RC-522
53	O	Digital	SDA RFID RC-522
9	O	Digital	RST RFID RC-522
0	I	Digital	RX0 Raspberry Pi B+
1	O	Digital	TX0 Raspberry Pi B+
4	I	Digital	BUTTON 1
6	O	Digital	LED ON/OFF SYSTEM
2	I	Digital	FLOW SENSOR 1 (INTERRUPTIONS)
40	O	Digital	ACTUATOR VALVE SOLENOID 1
42	O	Digital	MOTOR RELAY 1
7	O	Digital	MOTOR RELAY 2
44	O	Digital	SOUND OR VISUAL SIGNAL RELAY

Source: author

Notation: I INPUT

O OUTPUT

F. Final assembly in Protoboard

As shown in Figure 18, the development of the system in the Breadboard is displayed for the respective testing.

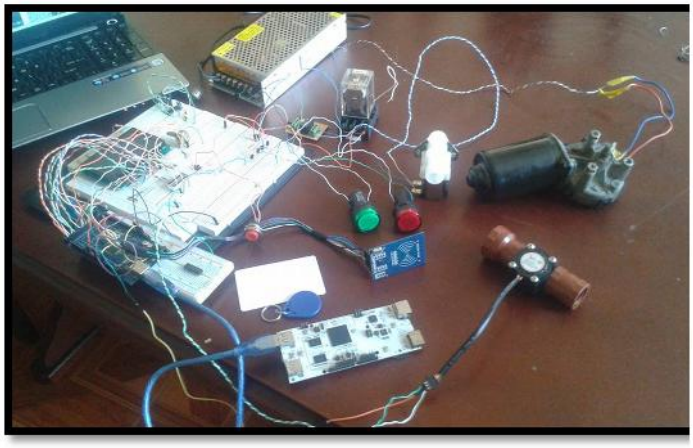

Figure 18 Previous tests of the system in electronic test Board

IV. IMPLEMENTATION OF THE SYSTEM

A. Cabinet Assembly

Electronic devices Assembly performed it on a Cabinet of 30 x 30 x 10 cm to give you a modular structure. In addition to protect and operate the circuits directly. This Board is recessed in the wall under roof to prevent rain, moisture, improper handling or any other factor that may affect the system.

The Cabinet is also composed with a protection system for the entire system as fuse and breaker, as well as relays 12V to activate the solenoid and relays 24V to control the rotation of the electric motor for the retired liners automatic.

Below are the items that are in the inside of the Cabinet.

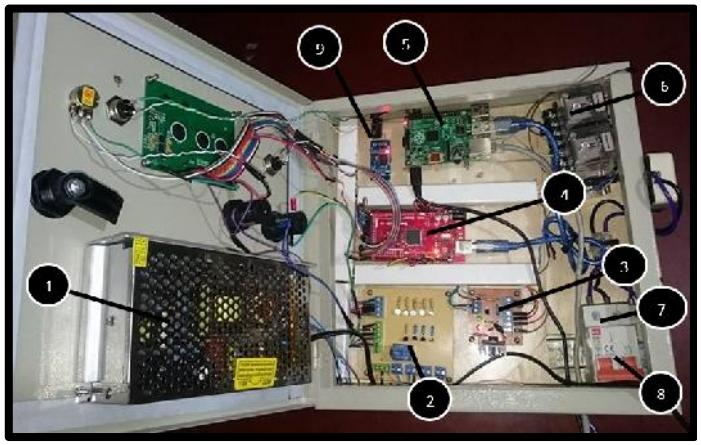

Figure 19 Inside the electrical cabinet.

1 Power supply 24V DC and 6.5A
2. Primary Board.
3. Secondary Board.
4. Microcontroller Arduino Mega 2560.
5 Minicomputer Raspberry Pi B +.
6. 24V electromechanical relays.
7. Breaker.
8. Fuse holder.
9. RTC module.

Below are the items that are on the outside of the Cabinet

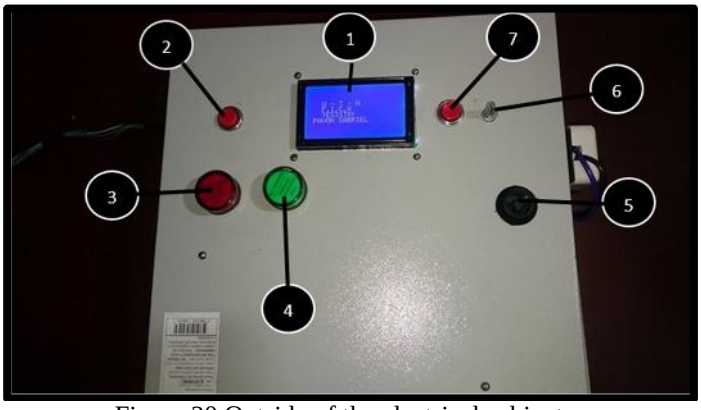

Figure 20 Outside of the electrical cabinet

1. Display GLCD 128 x 64 graphic
2. Push button activation of the system.
3. Pilot light of automatic removal of liners.
4. Pilot light on the system.
5. Access key.
6. Dimmer of the GLCD screen.
7. All system shutdown button.

B. Hardware testing.

In the graphical display message displays a welcome message when turned on system-wide.

Figure 21 Welcome message in GLCD

The operator is responsible for bringing the RFID reader to tag or label at a recommended distance of 2 cm, the tag is located in the earring from the ear of the bovine. MESSAGE the display shows a message of correct identification or incorrect identification.

Figure 22 Message of "Correct identification" of the bovine in GLCD

Subsequently the operator press the button to activate the system and the electric motor to place liners. If the button is enabled turns a white led on the main Board. And the on-screen message is displayed a certain waiting time so that the operator can place the liners in the udder of the animal.

Figure 23 Led active button display

Figure 24 Waiting time in GLCD to place liners

After you finish the waiting time, turns the pilot light (green) from the beginning of the process and the valve solenoid, with their respective led indicators located on the main Board.

Figure 25 Pilot light activated for extraction process of milk home

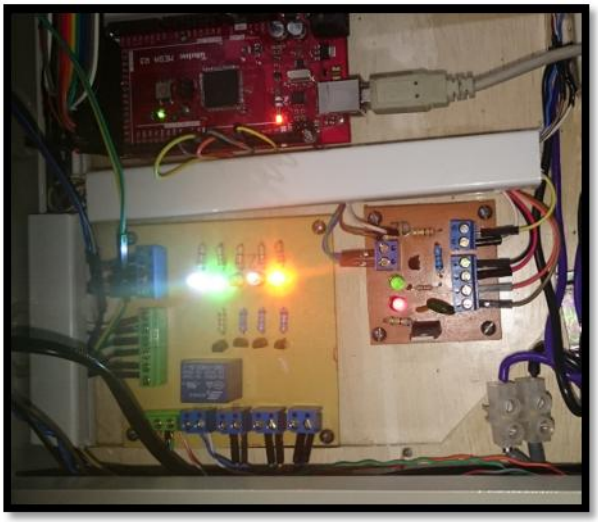

Figure 26 Start of process and valve display Leds activated solenoid

In the course of the process, is shown in the display message the amount of flow that passes by the sensor in L/min, the number of beats of the flow sensor and the elapsed time in seconds.

Figure 27 Process measuring data in operation

Once flow sensor already have nothing to measure, will terminate the process to activate the Red pilot light and activate the electric motor automatically to remove liners, with their respective led indicators. The Arduino microcontroller sends the amount of milk produced in liters by the cattle to the minicomputer.

Figure 28 On pilot light to indicate end of milk extraction process

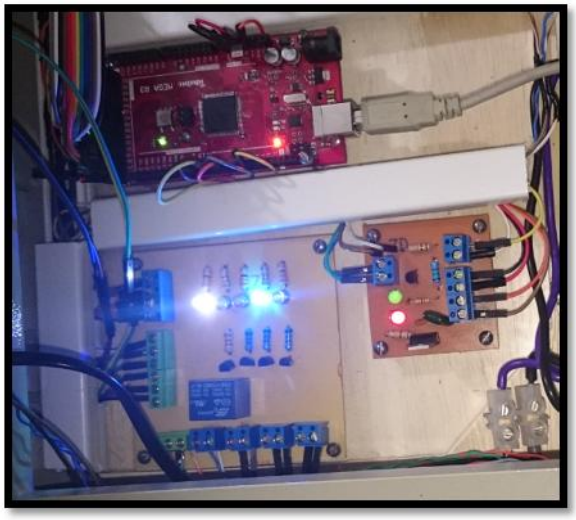

Figure 29 End of process and electric motor activated display Leds

C. Tests carried out on the minicomputer Raspberry Pi B + for database management

Tests were executed the minicomputer-accessing remotely by SSH, and obtained the following results:

Script done with the Python programming language is executed manually in the terminal emulator. But there was also the option that all scripts to run automatically when you ignite the Rapberry Pi B +. This is detailed in the Administrator's Guide.

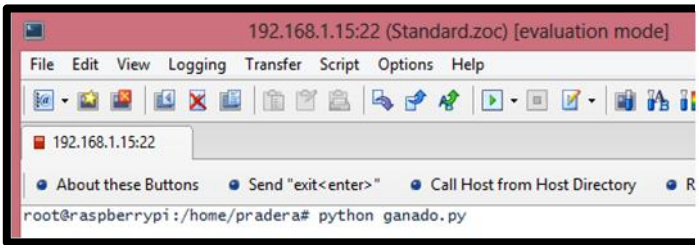

Figure 30 Manual execution of the script from the system

It prints in the terminal a message from VACA1, the name of the cattle to which data are being stored. In addition, you can see that to reveal such process is printed on screen measurement that was obtained from the microcontroller, Arduino, the date, time, number of milking and a unique way of each transaction identifier.

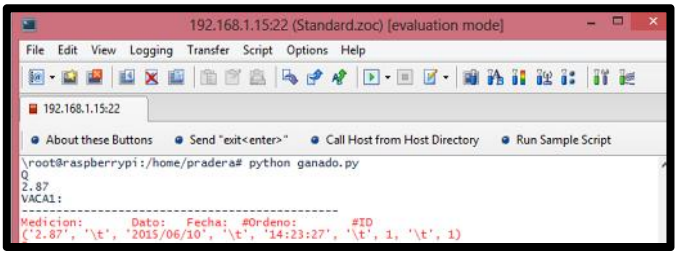

Figure 31 Printing in console data from the microcontroller

To validate that the data have been stored correctly, we use PhpMyAdmin tool, which allows us to manage the database through a Web interface. Simply enter the IP address in a Web browser, in this case is 192.168.1.15/phpmyadmin, to gain access to the database will ask you the user name and the corresponding password.

In Figure 32, seen that be accessed correctly called cattle database, to verify the results click on the name of the table that corresponds to the beef, in this case is Vaca1. You can see that the data has been stored correctly.

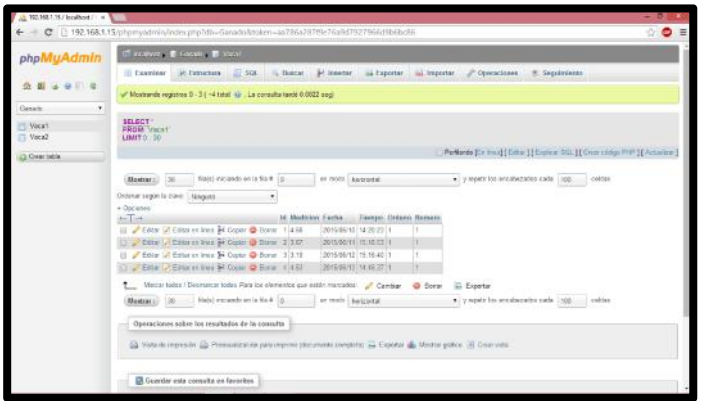

Figure 32 Data stored in the database

D. Results of storage of the data in a text file in the minicomputer

It makes use of the nano text editor, to verify that the data have been stored in a text file. It tells us that the data has been stored correctly in the text file.

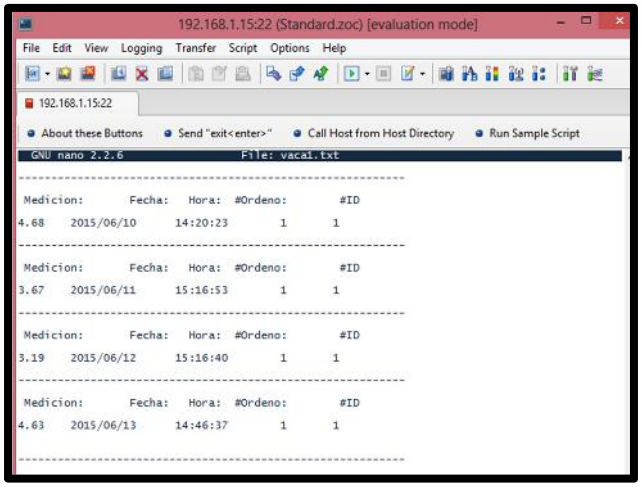

Figure 33 Verification of data stored in text file

E. Results of Access and transfer of information through an FTP server

To access the FTP server, you need a user name and corresponding password, the port number is 21. Also in the part of the server IP address or the computer name must be entered.

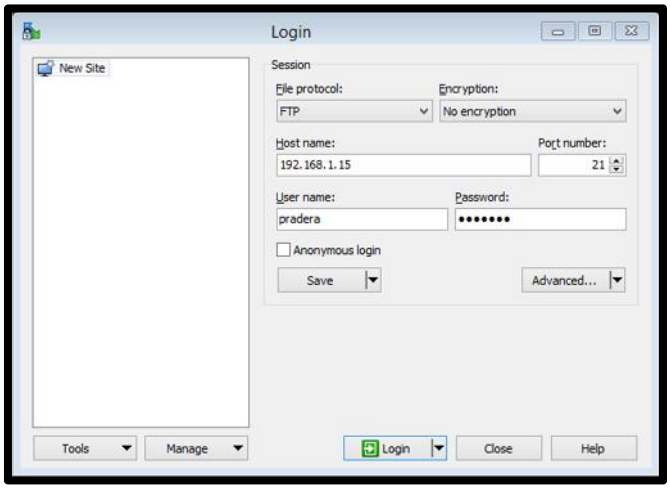

Figure 34 Connecting to the FTP serve

Once it has been properly connected to the minicomputer, you select the text file or any file which you want to transfer from the remote site, and is made simply to copy the site local, you loose the file in the folder that you want to the local site.

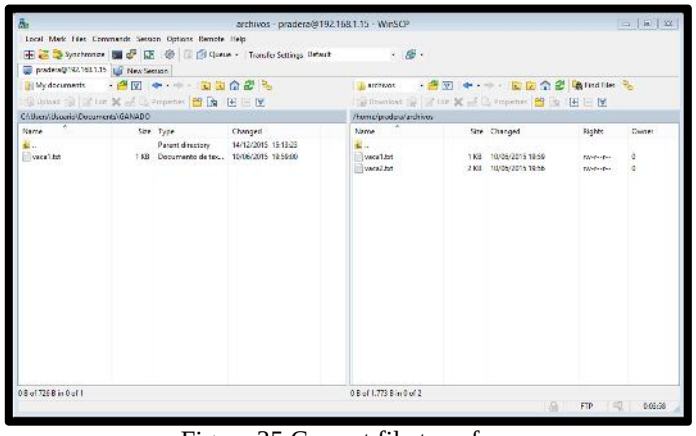

Figure 35 Correct file transfer

F. Verification of the web server to monitor and see the previous results of cattle.

In a web browser, place the address of the web page, in this case is http://192.168.1.15/pradera/index.php. You ask for a user name and corresponding password, with the aim that our web server contains privacy.

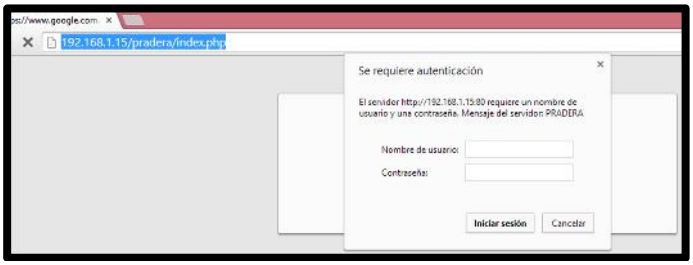

Figure 36 Authentication on the Web server

Once you have placed the user name and password correctly, will appear to us the options of the tables of the cattle that you wish to consult.

Figure 37 See results of each beef on Web server

Choose an option and click consult, appear us the respective results of selected cattle.

Figure 388 Verification of the results of the bovine one selected in a Web browser

G. Verification of the sent file with the beef information through an email.

To verify that it has been correctly sent each bovine files to email, open the Hotmail email service and check. It is worth mentioning that the email recipient can be any email account and that the sender is Google's mail service.

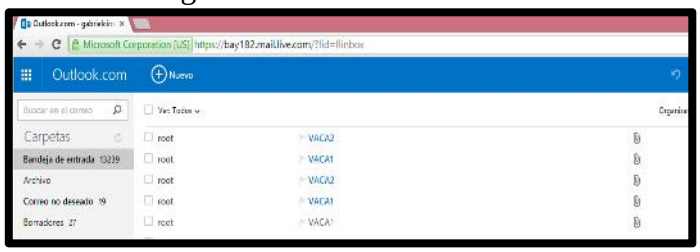

Figure 39 Verification of file sent by e-mail

V. ANALYSIS OF RESULTS

First to obtain the amount of milk produced each beef, was to perform tests, to obtain the amount of flow (flow) in one minute in an empirical way of flow sensor. This result is fundamental for results as precise as possible.

Retrieved once that amount the microcontroller is responsible for sampling the amount of flow every second, when the process is finished, the microcontroller performs an average and transforms the average obtained in litres in the elapsed time of samples.

In table 2, presents the results obtained from the flow sensor to see the amount of milk produced in litres from a cow.

Table 2 Results obtained from the flow sensor

ID	Fecha	Hora	# Ordeño	Medición del sensor (Litros)	Porcentaje de Error %
1	10/06/2015	14:20:23	1	4.68 L	4
2	10/06/2015	14:31:21	1	4.53 L	3
3	10/06/2015	14:45:02	1	4.94 L	4
4	10/06/2015	14:56:50	1	3.98 L	3

VI. CONCLUSIONS

To finish the development of the project could be observed that they met the objectives set in its entirety. In addition, improved their efficiency and throughput of milking. Since the cattle milking time performed it in about 1 hour and a half, and now with the system it it is done in about 1 hour.

System is particularity that can be adapted to any need to possess cattle stable, because both the hardware and the software of the Arduino Mega 2560 and the Raspberry Pi B + are flexible. Module Arduino up to 6 flow sensors can be connected when it (functions special interruption), 4 minicomputers (UART) and connect multiple modules Rfid (SPI). The minicomputer can be connected with 4 modules Arduinos (UART).

To avoid failures in the date and time when the Raspberry Pi B + not can connect to the NTP (Network Time Protocol) server, joined a RTC module ds3231 (Real Time Clock) which solves the problem and properly obtained such parameters on your system.

Dropped to 3-4%, the percentage of error obtained flow sensor since the microcontroller samples flow flow every second, performs a sum and finally executed an average of samples. In addition, the flow sensor is subjected to vacuum milking machine which produces a bit of foam and also affects the percentage of error.

This system enables automatic registration of milk production of cattle, with a reliable control of approximately 108 liters of milk per day. This registration was carried out manually on a sheet of paper, without any control, this action lends itself to many disadvantages.

The system to ensure the security of the data is stored in a database, a text file, sent to the e-mail address of the administrator, has enabled an FTP server to access and transfer information of cattle at any moment. And thus to have back-up information.

REFERENCES

TEXTS:

[1] ACHA, S. C., Manuel; Perez, Julio; RIOSERAS, Miguel. Digital electronic.
[2] INTRODUCTION TO DIGITAL LOGIC THEORY, PROBLEMS AND SIMULATION: ALFAOMEGA RA-MA.
[3] AETIC, o. and. RFID technology: uses and opportunities.
[4] BOLTON, w. (2006). ELECTRONIC CONTROL systems in mechanical and electrical engineering (third ED.): ALFAOMEGA.
[5] CISCO. BASIC PRINCIPLES OF ROUTING AND SWITCHING. CCNA1 V5.
[6] COLLAGUAZO, g. MICROPROCESSED systems.
[7] CREUS, a. (2011). INDUSTRIAL Instrumentation (eighth ED.): ALFAOMEGA.
[8] DAVID, P. V. H. T. D. B. J. analysis and design of digital logic CIRCUITS (first ED.): PRENTICE-HALL.
[9] ENRIQUEZ, r. (2009). ARDUINO Guide.
[10] KUMAR, S. (2010). Introduction to robotics: MC GRAW HILL.
[11] MATURANA, C. (2006). RFID: THE INTELLIGENT BARCODE LIBRARY. CHILE.
[12] PALLAS, r. sensors and signal (fourth ED.) conditioning: MARCOMBO.
[13] PETERSEN, r. (2009). LINUX (sixth ED.) reference MANUAL: MC GRAW HILL.
[14] Robotics, T. D. (2012). BOOK BASIC ARDUINO (FIRST ED.). Bogotá.
[15] SANCHEZ, j. (2012). WEB-application servers.
[16] STEREN . ABC OF MECHATRONICS.
[17] TELECTRONICA. Introduction to radio frequency identification (first.) (ED.)

THESIS:

[18] ARMENDARIZ, J. C. (2009). Comparative analysis of RFID, HID and AWID technologies to propose a system for the location and security of the books in the library of the Escuela Politécnica Nacional, Quito-Ecuador E.P.N. FIEE. Retrieved from http://bibdigital.epn.edu.ec/bitstream/15000/1085/1/CD-1923.pdf
[19] BAQUÉ, G. V., Jose (2011). INTRANET based on LAMP platform with integration of mobile devices that allow access to data from various departments of health care for the UPOCAM. Universidad Laica "Eloy Alfaro" Manta-Ecuador, Manabi.
[20] SILVA, a. B., July (2013). Activation of remote alarms via WIFI between minicomputers Raspberry PI in security applications. Superior Polytechnic School of the Litoral, Guayaquil, Ecuador.

Author

Olavo G. Pavon I.

Born in Ibarra Imbabura province on May 28, 1988. I make their secondary studies at the Treasury-missionary 'Sanchez and Cifuentes' College, obtaining the title of Bachelor of physical mathematical specialty. Currently, he is a graduate of Northern technical college in the career of engineering in electronics and communications networks.

Director

O. Ona

O. Ona, Director He is a professional in Elec-tronic Engineering and Telecommunications. He is currently Professor of the Faculty of Engineering in Applied Sciences at Technical of North University in areas such as: Electronic circuits, Physics, and others related fields. He has experience in areas such as: Preventive and corrective maintenance of data transmission equipment. Installation and maintenance of WLAN networks. Through his service, he has worked consistently and unconditionally in the development of electronics and telecommunications projects.