



Intelligent Sensing Anywhere

2009

Look4MyBody

Remote Physical Exercise Monitorization Firmware Module

Dissertation presented to the University of Coimbra to complete the
necessary requirements to obtain the Master's degree in Biomedical
Engineering



Faculdade de Ciências e
Tecnologias da
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Look4MyBody

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Universidade de Coimbra



Look4MyBody

Remote Physical Exercise Monitorization

Firmware Module

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Look4MyBody

Abstract

The project was carried out based on the new concept of gym circuit, which provides quick training for women, with hydraulic machinery.

This type of training is directed exclusively for women since the environment is similar to a group class, and it is not as intimidator as traditional gyms. The training is essentially Cardiovascular, and are used stimulate and increase the resistance of the clients. This is not suitable for men, because the carried out training does not allow increasing the muscle mass.

The Look4MyBody system is a prototype whose function is to provide a physical exercise monitorization in the gymnasiums which adopts the concept of physical exercise in a circuit program, in order to allow women that attend those places, a real-time exercise monitorization and also access to the reports that evaluate their promoting important feedback results.

The system is composed by a reed-switch, which allows the verification of the distance travelled by the client. These data is acquired in a concentrator module located near the machine.

The data is transmitted remotely to a terminal module, where it's sampled in real-time and stored in order to allow the preparation of reports.

The communication technology used and imposed by ISA was RF, since the Socket Radio 868 MHz and the Dongle Radio USB 868 MHz provided communicate via RF.

Throughout the development of this document, the project requisites will be analyzed. The system description includes all specifications and the module concentrator's firmware elaboration.

The performed testes on the end of the project, allow to obtain results which indicate that the developed system executes correctly the required functions.

Resumo

O projecto foi realizado com base no novo conceito de ginásio em circuito, que proporcionam treinos rápidos para mulheres, com máquinas hidráulicas.

Este tipo de treino é direccionado exclusivamente para mulheres na medida em que o ambiente é similar a uma aula de grupo, e não é intimidativo como os ginásios tradicionais. Os treinos são essencialmente cardiovasculares, servem para tonificar e aumentar a resistência das clientes. Não são adequados para homens, pois o treino realizado não permite o aumento de massa muscular.

O sistema Look4MyBody é um protótipo de um sistema cuja função é proporcionar uma monitorização do exercício físico, nos ginásios que adoptam o conceito da prática do exercício físico em circuito, de modo a permitir às mulheres que frequentam esses ginásios terem a monitorização do exercício realizado em tempo real e também terem acesso a relatórios para avaliar a sua performance.

O sistema é constituído por reed switches, que permitem verificar a distância que foi percorrida pela cliente, estes dados são adquiridos num módulo concentrador localizado nas imediações.

Os dados são depois transmitidos remotamente para um módulo terminal onde são amostrados em tempo real e são armazenados de forma a permitir a elaboração de relatórios.

A tecnologia de comunicação utilizada for RF pois foi a imposta pela ISA, uma vez que, o Socket Rádio 868 MHz e a Dongle Rádio USB 868 MHz providenciadas comunicam por RF.

No decurso desta tese vão ser analisados os requisitos do projecto. A descrição do sistema inclui toda a especificação e a elaboração do Firmware do módulo concentrador.

Alguns testes realizados na parte final do projecto permitiram obter resultados que indicam que o sistema desenvolvido realiza correctamente às funções exigidas.

Acknowledgments

First of all, I would like to thank the coordinators of this project, the Professors Carlos Correia and José Basílio Simões for making the elaboration of this project possible. I'm also Grateful to ISA, the entity that took me in during the elaboration of my thesis.

I also would like to express my gratitude to Engineer Soraia Rocha due to her help, orientation, coordination and presence at ISA, since it was of great value to me and a solution to many of my problems. To her I express my deep appreciation and congratulations on the work she has done.

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I also would like to express my gratitude to all the ISA employees for their support, kindness and collaboration during my curricular internship.

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Finally, I want to thank my family who, although were faraway, I always felt them close to me, by showing me support and believing in me. With no intention to devaluate any of them, I want to specially thank my father, José Manuel Sousa Carreiro, because he is my role-model and idol. I dedicate this thesis to him because he is who I owe the person I am today.

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ACRONYMS AND DEFINITIONS

Acronyms	Definitions
bps	Bit per second
CD	Compact Disc
CEI	Centro de Electrónica e Instrumentação
Cm	Centimeters
CRC	Cyclic Redundancy Check
C30	Compiler
ECG	Electrocardiogram
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMG	Electromyography
GHz	Giga Hertz
ICD	In-Circuit Debugger
ID	Identification
IDE	Integrated Development Environment
ISA	Intelligent Sensing Anywhere
LED	Light Emitting Diode
Look4MyBody	Name of the project
LSB	Least Significant Bit
MHz	Mega Hertz
MSB	Most Significant Bit
M2M	Machine to Machine
OW Reset	How Reset?
OW Search	How Search?
OEM	Original Equipment Manufacturer
PC	Personal Computer
P2P	Pear to Pear
PLL	Phase-Locked Loop
R&D	Research and Development
ROM	Read Only Memory
Rx	Receive
RS-232	Recommended Standard 232

RS-485	Recommended Standard 485
RF	Radio Frequency
SPI	Serial Peripheral Interface
Tx	Transmission
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
V	Volt

Chapter 1

1. Introduction

1.1. Motivation

Some people, especially women, see the gym as intimidating. Many of these infrastructures have only one personal trainer, incapable to attend and support the individual need of each client.

Other disadvantages are the necessity to adjust the weights of each machine to each person and the fact that they are typically manufactured for the male client.

These are the reasons that led to the creation of a new concept of a gym conceived for women. This concept is based on the use of machines with hydraulic resistances.

The user has access to complete aerobic and force strength training in only 30 minutes per session with the constant presence of a trainer. The exercises performed on these machines are considered safe. The reason for this safety is because these machines are adapted to people of all ages and physical conditions since it doesn't have any kind of impact during the exercise. Like this there is no harm caused to the articulations, making it a complete session exercise but without the risks of lesions injury and muscular pain. [1]

Based on studies carried out on women, they have relied more on this type of exercise because it's fast, lasting only 30 minutes and carried out in various circuits on 8 different machines.



FIGURE 1.1: Circuit with different machines [2]

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This is considered a full training, because in just 30 minutes it can work multiple muscles simultaneously, they are:

- Biceps and triceps;
- Quadriceps and hamstrings;
- Trapezius, deltoid and latissimus dorsi;
- Iliopsoas and gluteals;
- Abdominal and erector spinae;
- Adductor and tensor fasciae latae;
- Pectoralis major, rhomboid and latissimus dorsi;

This feature is of great importance to the women of today due to their active and demanding careers and not to mention the responsibility of a family to care for so they are generally left with little time for the gym. They consider this an easy exercise program because it offers the possibility to work all parts of the body and each person can train within their physical condition being these some of the reasons they choose this modality. [2]

Due to many women seeking this type of exercise program, our project was elaborated in order to, whoever uses this type of exercise in gyms, have control or knowledge of the calories they burn during it, the time they spend in each machine of the circuit, the distance they achieve or even the reports so that they can see and evaluate their own evolution throughout their training. Therefore, the idea for Remote Monitoring of Vital Signs in a Gymnasium came up. [2]

This new concept has a system that monitors vital signs and gives women, in general, safety, efficiency and effectiveness in a dynamic and comfortable environment. [2]

A client may follow her own progression with the certain she's not exceeding her own physical limitations. [2]

1.2. Objectives

The main goal of this project is to develop a prototype system which is a base pilot integration in a gym with eight hydraulic machines, monitoring the calories used during physical activity.

Each machine in the gym will be associated with an acquisition board (where the Socket Radio 868 MHz is) that receives the data of the physical exercise. This will send the data via radio to a Dongle Radio USB 868 MHz that is connected to a server at the gym. On this server are stored the calculated burnt calories during the exercise. This information will be shown in real time on a screen visible to all clients using a Windows application. At the end of each session, the client will have access to the data resulting from the exercise session as well as their prior previous results. They can also watch this information at home.

1.3. Scope

This project was developed in a master's degree in Biomedical Engineering taught at the University of Coimbra in the academic period 2008/2009. It's the result of a partnership between ISA - "*Intelligent Sensing Anywhere*" and CEI - "*Electronic Instrumentation Center*".

1.4. Audience

This document is mainly addressed to the supervisors and juries assigned to this project and to the academic circle around biomedical engineering, informatics, electrical and related area.

1.4. Document Structure

This document is composed by eight chapters, which enlighten all the development of the project *Look4MyBody* during the last year of Master Biomedical Engineering.

Firstly, the Abstract elucidates the reader with a brief summary explaining the content of this document.

Subsequently, are presented the acknowledgments and the thesis index.

Following the index, three tables are displayed. The first one corresponds to the figures table, the second one is the tables list and thirdly, a table with the thesis' Acronyms and definitions.

In the first chapter, as a introduction to the project is made and in which are presented the motivations and objectives that lead to the project's development, scope, audience and document structure.

The second chapter is about the project's management. There are presented the project's members, tasks division, project supervising as well as the project planning.

In third chapter – Related Works is described the sensors associated to the sport and the state of art.

Chapter four presents the project's requirements, what is necessary to measure and what is used to this purpose. Furthermore, it is presented all the used material and the reason that lead to that choice

The fifth chapter presents the system's architecture, where a brief description to the physical and logical architecture is made, as well as the local application.

Chapter 6 – System Development Tools describes the equipment used to develop the firmware, explaining the acquisition module and transmission module functioning. In addition, a brief description of the used hardware is made.

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The seventh chapter corresponds to the firmware design which is the highlight of this thesis. An introduction of the entire flowchart of the firmware is made as well as its detailed explanation.

The last chapter – 8, concludes the present document with a final appreciation, suggestions of what can be done in future work in this area and a presentation of the tests.

Chapter 2

2. Project Management

2.1. Project Members

The project team is made up of two members, students of the Intergraded Master's Degree in Biomedical Engineering of the Faculdade de Ciências e Tecnologias da Universidade de Coimbra and by the supervisors of this project.

The Remote Physical Exercise Monitoring at the gym was elaborated by the students involved in this with the help and coordination of supervisors

The members involved in this project are listed below.

Name	Role	Contact
Ana Carolina Santos	Student	Carolina.pfs@hotmail.com
Andreia Carreiro	Student	Andreia_melo_carreiro@hotmail.com
Professor Carlos Correia	Supervisor	correia@lei.fis.uc.pt
Professor José Basílio Simões	Supervisor	jbasilio@lei.fis.uc.pt
Engineer Soraia Rocha	Supervisor	srocha@isa.pt
Engineer Paulo Santos	Supervisor	psantos@isa.pt
Engineer Nuno Varelas	Supervisor	nvarelas@isa.pt
Engineer Rafael Simões	Supervisor	rsimoes@isa.pt

TABLE 2.1: Project Members.

2.2. Tasks Division

On the initial phase of the project, both students worked together.

After some of the tasks had been carried out and some goals met, there was the need to divide tasks based on the work that still needed to be done. There were proposals and ideas as to how the project was to be divided and each one chose what module they wanted to work on.

The Remote Monitoring of Calorie Calculation was divided in two modules that are listed below.

Student	Project's Module	Assigned Tasks
Ana Carolina Santos	Windows Application	Software Module
Andreia Carreiro	Data Processing and Transmission Module	Firmware Module

TABLE 2.2: Tasks Assignment.

2.3. Project Supervising

2.3.1. Supervising at ISA

One of the entities involved in the project "Remote Physical Exercise Monitoring" was the company ISA –"Intelligent Sensing Anywhere". ISA was created in 1990 and is a spin-off of the physics Department at the University of Coimbra. [3]

ISA is an award winning, global company specialized in that specializes in telemetry and machine to machine (M2M) communication. It's an enterprise in constant evolution and innovation. ISA is leader in remote monitoring solutions applied to areas such as energy, environment, security, mobility and most recently in health/medical. The products, solutions and services offered by ISA are based on their own technology and know-how in the electronics area, development of software, telemetry and control. [3]

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The ISA's R&D department provided an important support on the technical aspects of this project. [3]

The supervision at ISA was initially done by Engineer Nuno Varelas, Engineer José Luís Malaquias and Engineer Catarina Pereira.

Later on, due to a change in work posts, the supervision was carried out mostly by Engineer Soraia Rocha and Engineer Nuno Varelas which offered orientation and technical support. Many meetings were held to where the elaborated work, the tasks accomplished and proposals for new challenges were presented as well as there were clarifications to any doubts or questions that would come up throughout the elaboration of the project.

The evolution and progress of this project took place at ISA with the help of some collaborators that provided a very important technical support.

2.3.2. Supervising at CEI

CEI is a centre of investigation with its headquarters at the Physics's department of University of Coimbra. [4]

Their areas of investigation are based on Atomic and Nuclear Instrumentation, Biomedical Instrumentation, Plasma Physics Instrumentation, Microelectronics, Optical Signal Processing, telemetry and Industrial Control. [4]

CEI maintains a linear cooperation with several institutions with common ground in scientific investigation. [4]

A large part of the knowledge for in the formulation of this project was acquired at the CEI and is included in almost half of this project's content. Another big part of this project was also Professor Carlos Correia.

2.4. Project Planning

First of all was the analysis of the project context and how to achieve it. Here is presented the planning of the project:

ID	Task Name	Start	Finish	Duration	Gantt Chart											
					28-9	5-10	12-10	19-10	26-10	2-11	9-11	16-11	23-11	30-11	7-12	14-12
1	Gather bibliography of information on vital signs remote monitoring equipment	01-10-2008	07-10-2008	1w	[Bar from 01-10-2008 to 07-10-2008]											
2	Market Search about load cells and displacement sensors	03-10-2008	07-10-2008	3d	[Bar from 03-10-2008 to 07-10-2008]											
3	Perspective on the state-of-the-art monitoring equipment for gym	07-10-2008	09-10-2008	3d	[Bar from 07-10-2008 to 09-10-2008]											
4	Detail analysis of plus's sensors	09-10-2008	10-10-2008	2d	[Bar from 09-10-2008 to 10-10-2008]											
5	Study of thesis of previous work developed by Biomedical Engineers on ISA	10-10-2008	30-10-2008	3w	[Bar from 10-10-2008 to 30-10-2008]											
6	Acquiring knowledge on C programming language	13-10-2008	14-10-2008	2d	[Bar from 13-10-2008 to 14-10-2008]											
7	Study of wireless ecosystems, which communicate control between devices.	13-10-2008	24-10-2008	2w	[Bar from 13-10-2008 to 24-10-2008]											
8	Visited to the Gym with Engineers José Basilio Simões, Catarina Pereira e Paulo Santos	24-10-2008	24-10-2008	1d	[Red square at 24-10-2008]											
9	Meeting with Engineers Paulo Santos and Miguel Aragão	29-10-2008	29-10-2008	1d	[Bar from 29-10-2008 to 29-10-2008]											
10	Study the concept of fitness gym for women and its benefits	29-10-2008	31-10-2008	3d	[Bar from 29-10-2008 to 31-10-2008]											
11	Web search for wireless technologies such as GLOWPAN, ZigBee, Bluetooth, Wi-Fi, GPRS/GSM, z-wave)	31-10-2008	05-11-2008	4d	[Bar from 31-10-2008 to 05-11-2008]											
12	Dynamometers Study	05-11-2008	05-11-2008	1d	[Bar from 05-11-2008 to 05-11-2008]											
13	Research Calibration Methods	06-11-2008	06-11-2008	1d	[Bar from 06-11-2008 to 06-11-2008]											
14	Study of the muscle group worked out on each machine	06-11-2008	11-11-2008	4d	[Bar from 06-11-2008 to 11-11-2008]											
15	Meeting with Professor Carlos Correia	17-11-2008	17-11-2008	1d	[Bar from 17-11-2008 to 17-11-2008]											
16	Hardware and software equipment research that uses z-wave wireless networking.	17-11-2008	26-11-2008	1w 3d	[Bar from 17-11-2008 to 26-11-2008]											
17	Meeting with Engineer José Malaquias	27-11-2008	27-11-2008	1d	[Bar from 27-11-2008 to 27-11-2008]											
18	Implemented of the measuring system in one of the gym's machine	28-11-2008	28-11-2008	1d	[Bar from 28-11-2008 to 28-11-2008]											
19	C Tutorial	28-11-2008	25-12-2008	4w	[Bar from 28-11-2008 to 25-12-2008]											
20	Meeting with Engineer Paulo Santos	10-12-2008	10-12-2008	1d	[Bar from 10-12-2008 to 10-12-2008]											
21	PLC programming tutorials	10-12-2008	06-01-2009	4w	[Bar from 10-12-2008 to 06-01-2009]											
22	Definition of the Project	10-12-2008	10-12-2008	1d	[Bar from 10-12-2008 to 10-12-2008]											
23	Study the schematics of the Socket Radio 368 MHz Dongle Radio USB 868 and the DemoBoard	15-12-2008	26-12-2008	2w	[Bar from 15-12-2008 to 26-12-2008]											
24	Study the code of the communication via radio	17-12-2008	13-01-2009	4w	[Bar from 17-12-2008 to 13-01-2009]											

TABLE 2.3: Gant Diagram of the 1st Semester

ID	Task Name	Start	Finish	Duration	Jan 2009				Fev 2009				Mar 2009				Abr 2009							
					4-1	11-1	18-1	25-1	1-2	8-2	15-2	22-2	1-3	8-3	15-3	22-3	29-3	5-4	12-4	19-4	26-4			
1	Exams Study	07-01-2009	15-01-2009	1w 2d																				
2	Continuation of the study of the radio socket 868 mHz schematics	13-01-2009	19-01-2009	1w																				
3	Study the code of the radio communication	13-01-2009	02-02-2009	3w																				
4	PIC Programming Tutorial	19-01-2009	23-01-2009	1w																				
5	1st Interclary Presentation Poster development and revision	29-01-2009	04-02-2009	1w																				
6	Ibitons Search	05-02-2009	16-02-2009	1w 3d																				
7	Meeting with Nuno Esteves	09-02-2009	09-02-2009	1d																				
8	Chose Ibitons and accessories	16-02-2009	16-02-2009	1d																				
9	Programming the PIC 24FJ64GA004	16-02-2009	03-07-2009	20w																				
10	Meeting with Engineers Paulo Santos and Nuno Varelas	03-03-2009	03-03-2009	1d																				
11	PC installation of MPLab and Proteus 7	04-03-2009	04-03-2009	1d																				
12	Study of programming PIC in MPLab	05-03-2009	18-03-2009	2w																				
13	Study of oscilator, I/O ports, UART, Interrupt, Timer and comparators	12-03-2009	23-03-2009	1w 3d																				
14	Meeting with Engineer Joao Cardoso and Professor Carlos Correia	18-03-2009	18-03-2009	1d																				
15	Study of data sheet of Microchip related to Interrupters and timers	19-03-2009	25-03-2009	1w																				
16	"Programming 16-bit Microcontrollers in C" Reading	23-03-2009	03-04-2009	2w																				
17	Placement of the Reed switch in the Idenboard	03-04-2009	03-04-2009	1d																				
18	Placement of the 1-wire serie (DS24808) in the Idenboard	06-04-2009	06-04-2009	1d																				
19	Meeting with Engineers Rafael Simões, Nuno Varelas e Soraia Rocha	07-04-2009	07-04-2009	1d																				
20	Specification document elaboration	08-04-2009	17-04-2009	1w 3d																				
21	Transmission via radio to PC	08-04-2009	09-04-2009	2d																				
22	Study of communication protocols of the Ibiton	13-04-2009	16-04-2009	4d																				
23	Learn how to configure the UART	16-04-2009	20-04-2009	3d																				
24	Encontro Nacional de Estudantes de Engenharia Biomédica - Organization	20-04-2009	28-04-2009	1w 2d																				

TABLE 2.4.: Gant Diagram of the 2nd Trimester

ID	Task Name	Start	Finish	Duration	Gantt Diagram of the 2 nd trimester																	
					3.5	10.5	17.5	24.5	31.5	7.6	14.6	21.6	28.6	5.7	12.7	19.7	26.7	3.8	9.8	16.8	23.8	
1	Send data via radio	28-04-2009	30-04-2009	3d																		
2	Conclusion of the code for count pulses	29-05-2009	04-06-2009	1w																		
3	Study of applications notes related with 1-wire protocol	04-05-2009	15-05-2009	2w																		
4	Continuation of the study about IButton and accessories	05-05-2009	11-05-2009	1w																		
5	Reading Data sheets IButton, DS2409B,	05-05-2009	18-05-2009	2w																		
6	Study of the IButton's behavior with the Hercules Hyperterminal	06-05-2009	02-06-2009	4w																		
7	Application Note 192 and 186 related with 1-wire protocol	06-05-2009	11-05-2009	4d																		
8	Creation of a document that summarizes on how to do the IButton Firmware	11-05-2009	13-05-2009	3d																		
9	Learn C#	12-06-2009	18-06-2009	1w																		
10	C# code development	15-06-2009	19-06-2009	1w																		
11	Conclusion of the code in C# to acquire data that is transmitted by radio to the USB dongle 888.	20-05-2009	20-05-2009	1d																		
12	Conclusion of the code in C# to write and save the data acquisition on a file .TXT	20-05-2009	20-05-2009	1d																		
13	Configuration of the PLL and UART of the PIC24F64GA004	21-05-2009	21-05-2009	1d																		
14	Meeting with Sorala Rocha and Nuno Varelus	22-05-2009	22-05-2009	1d																		
15	Study of bitwise operations in C	25-05-2009	29-05-2009	1w																		
16	Decoded the ROM number	25-05-2009	29-05-2009	1w																		
17	2st Iteratively Presentation Poster development and revision	01-06-2009	01-06-2009	1d																		
18	Study communication protocols	02-06-2009	08-06-2009	1w																		
19	Change the code for counting pulses (Interruptions and timers)	08-06-2009	11-06-2009	4d																		
20	Meeting with Engineer Sorala Rocha	15-06-2009	15-06-2009	1d																		
21	Conclusion of the project	15-07-2009	04-08-2009	3w																		
22	Firmware flowchart development	01-07-2009	07-07-2009	1w																		
23	White Master Thesis	10-07-2009	03-09-2009	8w																		

TABLE 2.5.: Gant Diagram of the 2nd trimester

Chapter 3

3. Related Works

This chapter is divided in two main sections. First, it makes a brief description of the sensor related with the sports. Secondly, the state-of-the-art is presented.

3.1. Sensor Related

This project was developed from scratch; it was initiated this year, so there was not any kind of prior work. [10]

At the beginning of the projects a detailed study was started of Plux's sensors, related with health and sports, the study was based on the following sensors:

- **Respiration sensor** integrates an air pressure sensor to measure the pressure differences within a sealed chamber. With high sensitivity, it's specially designed to measure abdominal or thoracic respiratory cycles. Some of the applications of this sensor include thoracic cavity displacement measurement and respiratory cycle's observation. [11].



FIGURE 3.1: Respiration sensor [12]

- **sEMG active sensors** have low noise characteristics that allows them to be used in the most adverse condition of EMG acquisition. The amplification and signal conditioning elements placed near the acquisition area maximizes the sensor's performance and final signal quality. Some of the applications of this sensor include fatigue evaluation, muscle contraction monitoring and muscular activation instants analysis. [10].

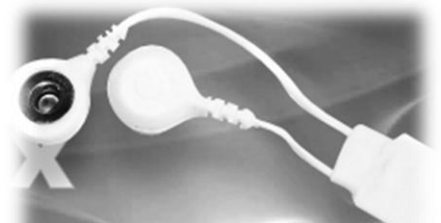


FIGURE 3.2: sEMG Active sensor [12]

- **ECG triodes** make ground for unobtrusive signal acquisition. Its state-of-the-art design maximizes the sensor performance providing high resolution signals particularly suited for fine detail analysis. Some of the applications of this sensor include heart rate and stress monitoring. [10]



FIGURE 3.3: ECG triode [12]

- **Triaxial accelerometers** are used for bodydynamics and biomechanics analysis. Depending on the application it may require an acquisition system with up to three available analog ports in order to use the full measurement functionalities. [11]



FIGURE 3.4: Triaxial accelerometers [12]

- **Force sensor** is available in multiple shapes, sizes and sensitivity. The design it is particularly suitable for integration in clothing or footwear, and its low response time provides maximum sensing performance. Some of the applications of the sensor include postural analysis, strength measurement and walking patterns evaluation. [11].

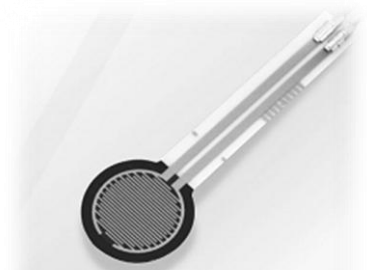


FIGURE 3.5: Force sensors [12]

3.2. State-of-the art

CurvesSmart is a device that exists in each of the eight available circuit machines. The machine contains the information of each client, and the exercise that each person individually has to perform. Thus, the CurvesSmart system is capable of providing a feedback of the performance to the client. The system also automatically adjusts the level of body resistance, like this, she stays promoting a continually challenged and to achieve her potential on every machine, during every workout. [2]



FIGURE 3.6.: CurveSmart[2]

Afterwards, the CurvesSmart system calculates automatically all the data concerning the practice to produce detailed reports that show overall muscles strength, the burned calories and how close the client is of reaching her goals. [2]

While the client works out, the CurverSmart controls the cardiac frequency rhythm, whether the client is achieving her goals at an intensive level, the number of repetitions performed and the range of motion for each repetition. [14]

And only in the end of the workout, the client receives the progress report that tells how many calories she burned and which muscles she has worked. [14]

Disadvantages:
Must be a Curves member to use
Not available at all Curves location;
Computer software program may not be accurate

TABLE 3.1.: Some disadvantages of the CurveSmart [14]

Chapter 4

4. Project Requirements

The Firmware from the project has the objective of establishing communication via radio from Socket Radio 868, where the PIC24FJ64GA004 is, to a Dongle USB 868 which contains the PIC18F66J50. An impulse counter will have to be developed as well as a program that allows the identification of iButtons/clients.

The client, wanting to initiate her training plan in circuit will have to place the button in the reader that will read and recognize the client respective iButton and proceed to sending the personal data to a PIC where data is processed and then sent to Dongle. The client is then identified after the LED turns on.

As soon as there is recognition of the presence of a person in the machine the physical exercised is initiated, the reed-switch will start counting impulses. The distance that takes place in between each impulse is approximately 2cm.

The counting of impulses can cease, this will happen when the reed-switch stops sending impulses for a certain period of time or when another person introduces a different button in the machine, it will be indentified, and as a result, initiates a new cycle.

All this data will be sent to a Dongle USB 868 that's in the PC that will process and treat the data to send later information to a screen so that it can be shown in the gym in real time.

The architecture implemented in each hydraulic machine of the gym consists of an adaptation of a measurement tape to the hydraulic resistance of the machine. This tape has four magnets and a reed-switch which communicates with the hardware board as can be seen in figure 4.1.



FIGURE 4.1.: Architecture implemented in hydraulic machine

For the developing of the project was necessary acquiring some items. Next are the introduced items and it's reason of application.

4.1. Reed Switch

A reed-switch is a very useful component that can be utilized as a sensor in many applications [2]. The reed-switch works as an electrical switch operated by an applied magnetic field. It was invented at *Bell Telephone Laboratories* in 1963 by W.B. Ellwood and it consists of a pair of contacts on reeds metal in hermetically sealed and involved in glass [15].

The reed-switches or blade switches consist of devices formed by a glass tube, within which there are flexible blades made of materials which may suffer the magnetic fields. The glass tube is filled with an inert gas in order to avoid air corrosive action on the blades, which would affect the electrical contact in short time [16].

Reed-switch type used in the project corresponds to a version composed of two blades mounted as seen in figure 4.2. The model chosen was the Meder B M8, Mk 15 series which is displayed in Table 4.1., as well as their main features.

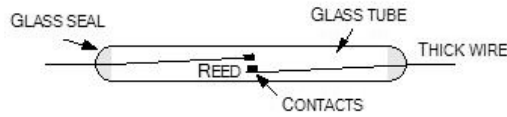


FIGURA 4.2: Reed Switch components [18]

Reed Switch Features:
Excellent for low power operations
High power switches available
Six operate sensitivities available
Tape and Reel available
No external power required for sensor operation

TABLE 4.1.: Features of the reed-switch [18]

Under normal conditions, the blades are separated and none current can circulate through the components. Approaching a permanent magnet of the device, a magnetic field occurs which causes the blades to magnetize and thus attract to one another, uniting. Under these conditions, the electrical contact is closed as can be seen in figure 4.3. A magnetic field (from an electromagnet or a permanent magnet) will cause the contacts to pull together, thus completing and an electrical circuit [17].

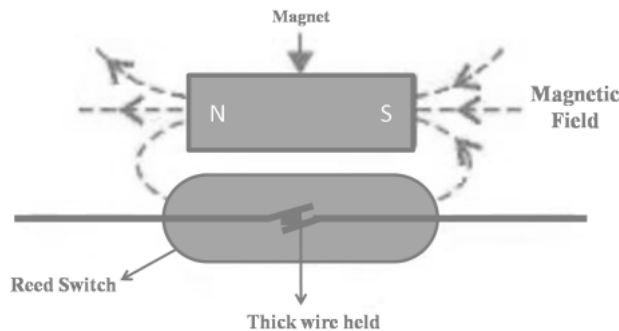


FIGURE 4.3.: Reed Switch closed. [16]

Look4MyBody

In other words, the reed-switch makes contact between the blades depending on the action of an external magnetic field.

The common reed-switches are low current devices. The usual types are specified in order to control currents which do not pass the 200 mA input.

Finally, the reed-switch is a component that has a relatively high response rate. Can be used to open and close the contacts rapidly by the passing of a magnetic field.

This allows it to be used as a rotations or movement sensor, as it's displayed in Figure 4.4.

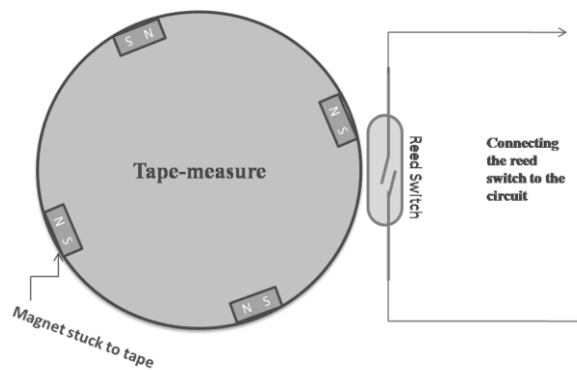


FIGURE 4.4: Tape-measure and reed switch [16]

The measurement tape within each gym device contains four magnets, which are distanced by approximately 2cm and with a reed-switch as shown in figure 4.4.

On each passage of a magnet in front of the reed-switch, this is activated. This produces a pulse that goes to a revolutions counter. It's possible to count with this kind of sensor up to 100 laps per second, however in project, this does not happen. [16]

4.2. iButton

Each client got an iButton with the main function to provide us their own identification. After several quests was chose all the items necessary to the identification of the client.

Following this it's mentioned the chose items and its main characteristics.

4.2.1. iButton DS1990A

An iButton is a rugged data carrier that serves as an electronic registration number for automatic identification, known as the DS1990A serial number iButton, transferring data serially through the 1-Wire protocol. This requires only one

single data lead as well as a ground return. [19]

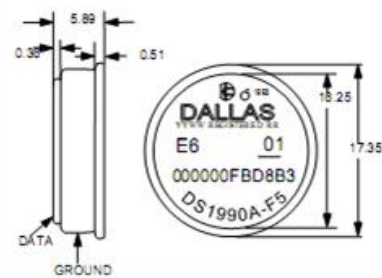


FIGURE 4.5: iButton F5 Microcan™ [19]

Allowing absolute traceability, every DS1990A is lasered at the factory with a guaranteed unique 64-bit registration number. The iButton is designed for durability with a stainless-steel package that is highly resistant to outside, environmental hazards such as moisture, shock and dirt. The DS1990A is easily used by human operators due to its coin-shaped, compact profile being self aligned with mating receptacles. The DS1990A, with the use of accessories is enabled to be mounted on almost any object including containers, bags and pallets. [19]

Operation

The internal ROM number of the DS1990A is accessed via a single data line. With the use of the 1-Wire protocol the 48-bit serial number, 8 bit family code and 8-bit CRC are retrieved (Figure 4.6.). This protocol defines bus transaction when it comes to the bus state awhile specified time slots commenced on the falling edge of sync pulses from the bus master. All data is read and written first the least significant bit. [19]

MSB		64-Bit 'Registration' ROM Number				LSB	
8-Bit CRC		48-Bit Serial Number				8-Bit Family Code	
MSB	LSB	MSB		LSB	MSB	LSB	

FIGURE 4.6.: 64-Bit Unique ROM 'Registration' Number. [20]

1-Wire System

The 1-wire bus is a system composed by a single bus master system and one or more slaves, and the DS1990A is a slave device on all instances. Commonly the bus master is a microcontroller. The three topics this particular bus system has are broken down into the following terms of discussion: hardware configuration, transaction sequence, and 1-Wire signaling (signal type and timing). [21]

Hardware Configuration

There is only a single line by definition to the 1-Wire bus and so it's important that each device on the bus be able to drive it at the appropriate time. Each one of the devices are attached to the 1-Wire bus has to have an open drain connection or a 3-state output in order to

make this easier. The DS1990A being an open drain part with an internal circuit equivalent to that shown in Figure 4.7. [21]

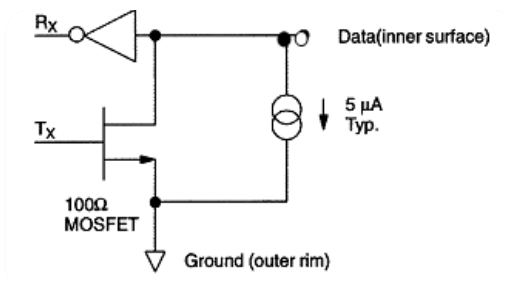


FIGURE 4.7: DS1990A equivalent circuit [22]

It's possible for the bus master to be the same equivalent circuit. It is possible to tie together separate output and input pins if a bidirectional pin is not available. At the master end of the bus, it will need a pullup resistor, with the bus master circuit equivalent to the one shown in Figure 4.8. [19].

The value of the resistor should be about 5k Ω for the short time lengths. A multidrop bus is made up of a 1-Wire bus which has several slaves attached. The maximum data rate of the 1-Wire bus is 16.3K bits per second. [22]

For the 1-Wire bus the idle state is high. The bus must be left in the idle if the transaction is to resume, should in any case or reason, a transaction need to be suspended. One or several of the devices on the bus may need to be reset if the bus is left low for more than 120ms. [22]

Accessories

Being that the iButtons are chip-based electronic tags, they attach easily to almost anything. The iButton is durable due to its protective stainless-steel case and its durability can last as long as 10 years. They have proven being easy to transport due to its portable design and pleases the user with its durable features. It's possible the user will need hardware to communicate with, mount and carry the iButton depending on the application. [22]

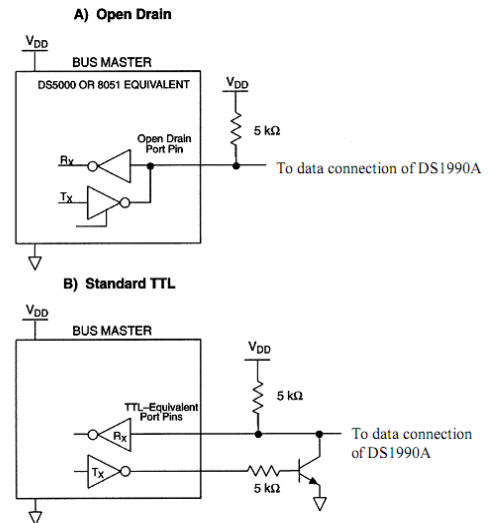


FIGURE 4.8.: Bus Master Circuit [22]

4.2.2. Reader DS9092

The DS9092 iButton Probe produces the required electrical contact to dispatch data to and from the DS19xx family of iButtons. Because of the round shape of the probe, a self angling interface that promptly matches the circular rim of the iButtons Microcan Package is provided. Metal contacts withstand wear and are easy to maintain clean. [23][25]

The model reader's center contact has no moving parts and so making it a tougher interface for harsh environments. When the iButton is brought into contact with the reader is when this probe is best suited.



FIGURE 4.9. Reader DS9092 [25]

In situations when the iButton is stationary and the movable reader is brought into contact with it, the tactile feedback probe is perfect. [23][25]

For a facilitated connection to the system microcontroller, two 15 cm 22AWG wires are provided. A 10cm handle and a one meter cable with ends with an RJ11 jack comes joined to the hand-grip mount probe. [23]

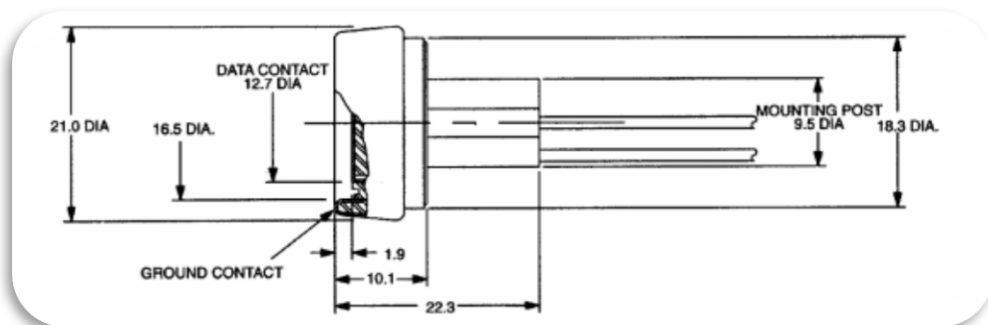


FIGURE 4.10.: Standard Probe [23]


Key Features of DS9092	
Simple, inexpensive stampings compose a read/write probe for the iButton	
iButtons entry is guided by probe	
To self clean contacts, iButton slides over the surface	
To simplify removal of debris such as mud due to an achievable superficial probe cavity	
Adaptable design supports panel-mount or hand-grip mount with elective feedback	
Millions of operations are provided by the bright discoloration-resistant metal surface	
Prewired panel-mount to facilitate installation	
For prompt installation, hand grip probe mates to RJ11 jack	

TABLE 4.3: Key Features of DS9092 [23]

4.2.3. Chip DS2480B

The DS2480B is a serial port to 1-Wire interface chip that supports regular and overdrive speeds. It connects directly to UARTs and 5V RS232 systems. The DS2480B uses a unique protocol that merges data and control information without requiring control pins. In the following table, will be referred the main features of the DS2480B. [24]

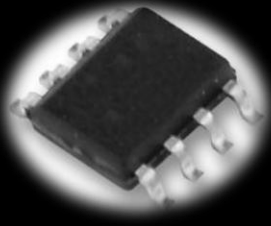
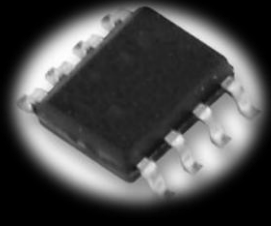
 Features of the DS2480B 	
Universal, common-ground serial port to 1-wire ® line driver for microlan applications	
Works with all ibuttons® and MICROLAN-compatible 1-wire slave devices	
Communicates at regular and overdrive 1-wire speed and serial port data rates of 9600 (default), 19200, 57600, and 115200 bps	
Supports 12V EPROM programming and stiff 5V pullup for crypto ibutton, sensors and EEPROM	
Load sensor to terminate the stiff pullup as the energy demand of the crypto ibutton drops	
Self-calibrating time base with _5% tolerance for serial and 1-wire communication	
Slew rate controlled 1-wire pulldown and active pullup to accommodate long lines and reduce radiation	
User-selectable RX/TX polarity minimizes component count when interfacing to 5V based RS232 systems or directly to UARTS	
Programmable 1-wire timing and driver characteristics accommodate a wide range of MICROLAN configurations at regular speed	
Smart protocol combines data and control information without requiring extra pins	
Low-cost 8-pin so surface-mount package	
Operates over 4.5V to 5.5V from -40°c to +85°c	

TABLE 4.4.: Features of the DS2480B [24]

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An IO pin on a microprocessor can generate the 1-Wire communication protocol, never the less, precaution should be taken so that the correct timing and proper slew rates are provided to create reliable 1-Wire network. The length of a network can be seriously limited as well as create a sporadic behavior due to uncontrolled slew rates. It is possible to rid of these problems. A serial communication UART is available utilizing a serial-to-1-Wire bridge (DS2480B). The DS2480B is a serial bridge to the one 1-Wire network protocol that permits almost any computer with a very moderate serial communication UART to produce correctly timed slew controlled 1-Wire waveforms. [21]

Escaped commands and data are received by the DS2480B and it in turn accomplishes 1-Wire operations and revert the result back to the computer. It can take up a lot of time and prove to be confusing applying this protocol and navigating the available DS2480B. [21]

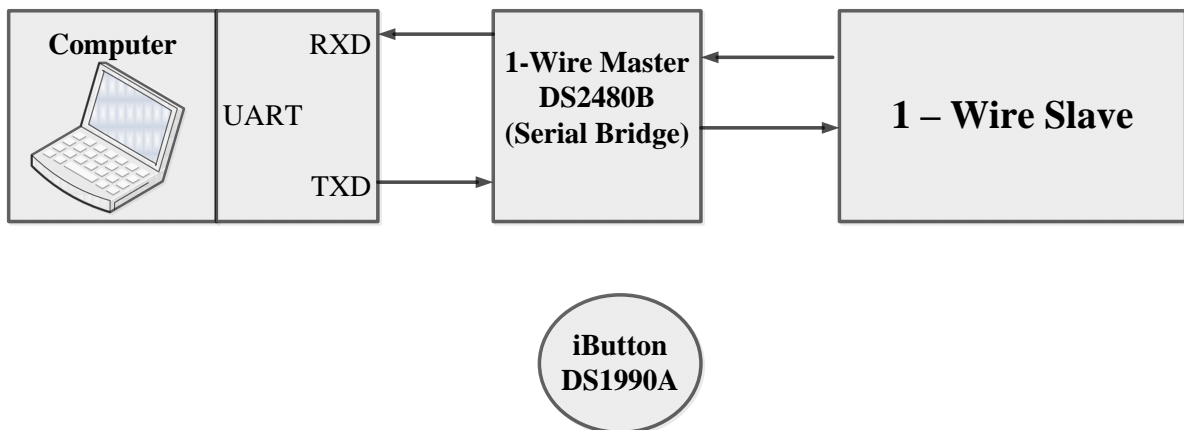


FIGURE 4.11. DS2480B usage (simplified) [21]

The 1-Wire Interface

The DS2480B's usefulness relies on the capability its commands have to be translated into a 1-Wire communication interface that applications can use and build on. For any 1-Wire operation there are a few elementary 1-Wire functions that an application must have. The 1-Wire master has to initiate all 1-Wire bit communication and so 'read' is in technical terms a 'write' of one bit with the result sampled. [21]

Hoste Configuration

The DS2480B's host must possess a UART with a capacity of at least 8-bit, non-parity, 9600 baud communication. The UART's configuration is specific and has to produce standard interface operations such as reading/writing, flushing pending reads/writes, coming to a break and selectively changing the baud rate. [26]

DS2480B Configuration

The host has to be setup and in synchronization with the DS2480B Serial 1-Wire line driver before any 1-Wire operations can be tried. This procedure of setup and synchronizing is carried out if a problem is detected between the host and the bridge. During setup the DS2480b need a 9600 baud. Before the following command is shifted in, the prior provided 1-Wire command must be able to complete. [26]

- **OWDetect**

The DS2480B has no crystal and so it has to tune it's time-base by sampling the serial communication the host sends. [26]

To initiate the setup sequence the DS2480B has to be reset and then send a predefined timing byte. This will cause all the configurations of the 1-Wire parameters to restart to their default state. It is advised that the DS2480B be used in 'flex' mode when doing standard speed communication for a good performance on small to medium length 1-Wire networks. [26]

Should a space in the stop-bit position be detected the DS2480B is reset. A serial break that is no longer the 9600 baud, 8-bit word is the easy way to generate this. In the absence of a break on the host UART it is possible to switch to slower baud rate and send a zero byte to simulate a break. [26]

Delay values in the configuration sequence are normally large to support, so that it too, can support most UART's but it is possible to reduce these values. [26]

To measure the correct functioning of the DS2480B setup, the read baud rate is register and writes 1-Wire bit at the end of the setup sequenced is used and designed for that purpose. The setup will be determined an unsuccessful should either one of these operations return invalid response. [26]

1-Wire Operations

The act of implementing each of the 1-Wire operations has in common some aspects. For the reduction of the number of exchanged packets with the DS2480B commands and data are grouped together whenever possible. A packet may start with a made changing because the current mode of the DS2480B is kept as state. [26]

- **OWReset**

The DS2480B is instructed by the OWReset operation to send a reset pulse to the 1-Wire. The main objective of this instruction is to accomplish this reset operation as well as it returns other information that is useful. It also supplies a three-bit field indicating the version of the chip. Even though the version field will be constant with all the DS2480B, it can however be utilized to detect the predecessor to the bridge, the DS2480 and so making its implementation compatible. To make the host software or firmware, whichever the case, at least partially compatible to the future bridge versions can be accomplished by masking off this field. [26]

- **OWSearch**

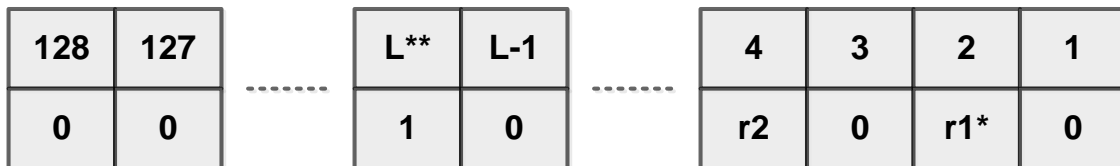
The search algorithm is known as a tree search with branches that are followed until a device's ROM number (or leaf) is found. Following searches take the other branch paths until all of the present leaves are found. [26]

This search starts with the devices on the 1-Wire being reset utilizing the rest presence pulse sequence. As a result the 1-byte search command is sent if this is a success. The search command prepares the 1-Wire devices so that the search is initiated. [26]

1-Wire search DATA Construction

It is possible to consider 16 bytes of 1-Wire search data into 128 bits of data that is grouped into 64 2 bit pairs. The first bit should be 0 and is not used. If a discrepancy is detected then the second bit is used. [26]

The DS2480B will proceed automatically with the only available path. The search direction bits must be set to ROM-ID bits from the last search up until the last discrepancy bit position when constructing the outbound data. At this stage, the search direction set to one is therefore set them all to 0. [26]



* ROM_ID bist corresponding to the id_bit_number from a previous search. See Application Note 187

** LastDiscrepancy bit position. See Application Note 187

FIGURE 4.11. Outbound Search Data [26]

Chapter 5

5. System Architecture

In this chapter, is the meticulous description of the features of the embodied components, their relationship and the environment where they are placed.

5.1. Physical Architecture

The gym monitoring system is made of hydraulic machines, each having associated an acquisition plaque, a data view screen of a real-time exercise and a server, where the program visualized will run.

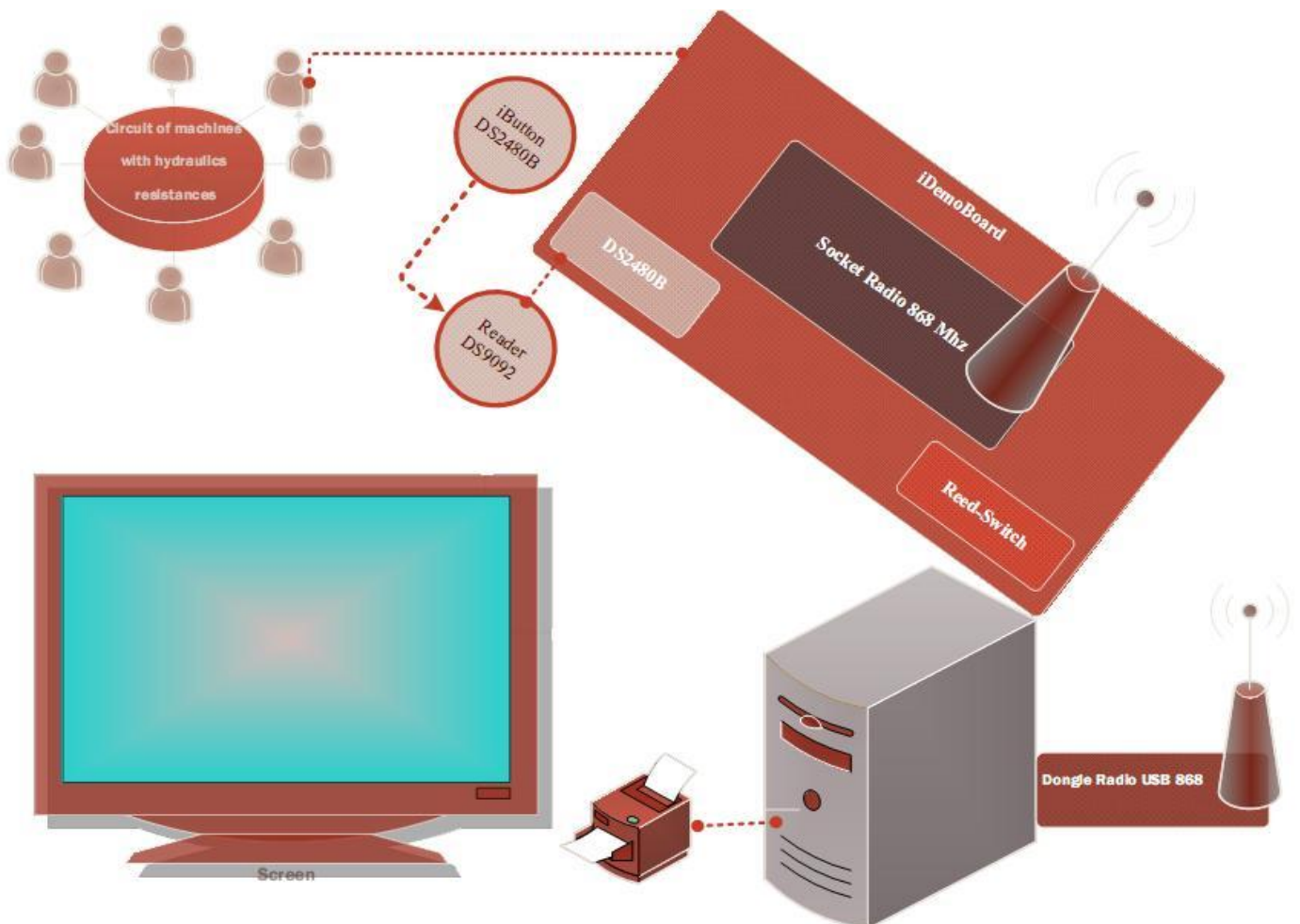


FIGURE 5.1: Physical Architecture

Look4MyBody

The acquisition module, the transmission module and the processing module are incorporated in the acquisition board.

Physically, the acquisition module is constituted by the iDemoboard and the socket radio 868 MHz, which sends through radio antennas the data coming from iButton and the Reed-switch to the Dongle Radio USB 868 MHz, which is connected via USB to a server.

The server and the screen compose the visualization module. On the server are also incorporated the report visualization modules and the database.

The reports contain information concerning the monitorization of physical exercise performed by each client, who makes his identification with the iButton assigned to him prior to the realization of the exercise.

After the client proceeds to his identification and start his training, the monitorization of his exercise appears on a screen existent in the room, as can be seen in Figure 5.2.

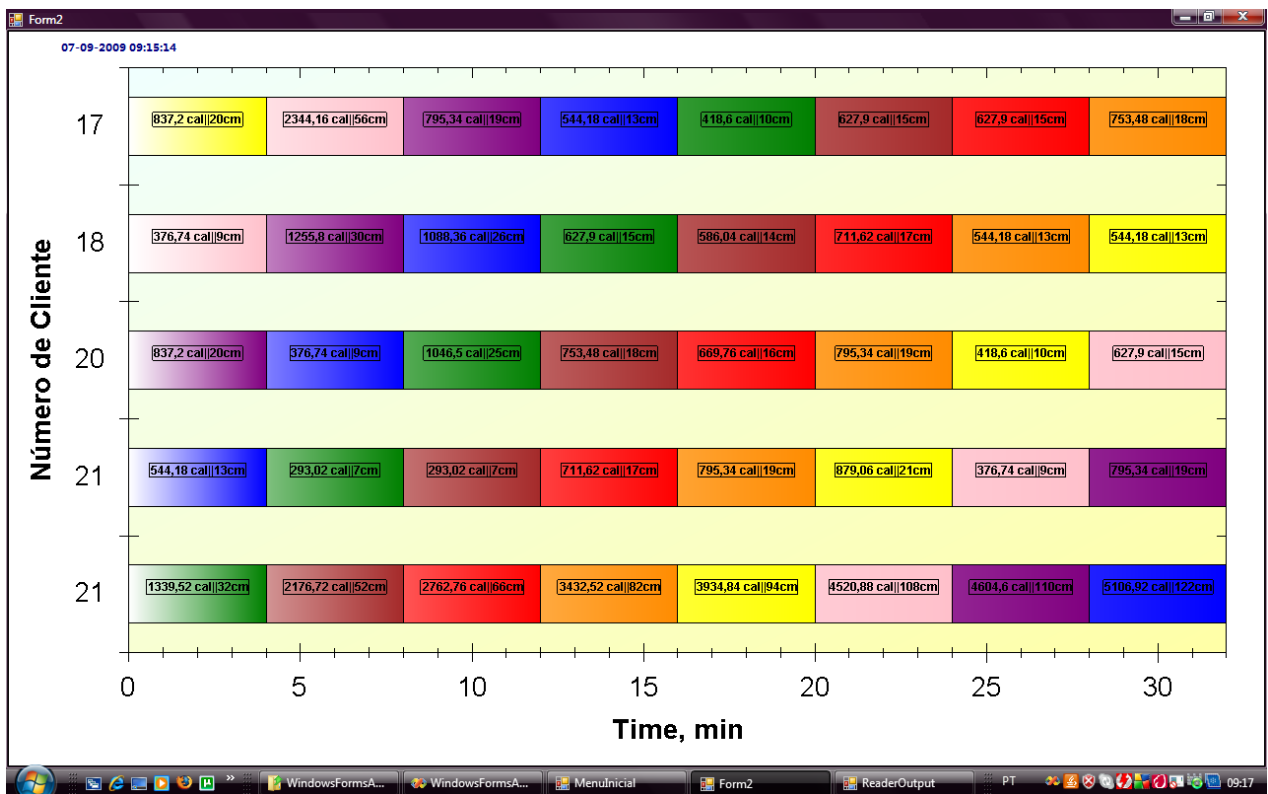


FIGURE 5.2. Presentation of the monitorization exercises

5.2. Logical Architecture

The system consists of a multi layer structure. The layer responsible of storing the data concerning the solution is the database tier. The system is enlarged with a Windows Application which is the system's interface to interact with its users.

Between the layers mentioned above is placed the logical tier which is composed of an acquisition module as well as a report module. This tier is responsible for the flux of data in the system and the coordination of data storage and measurements

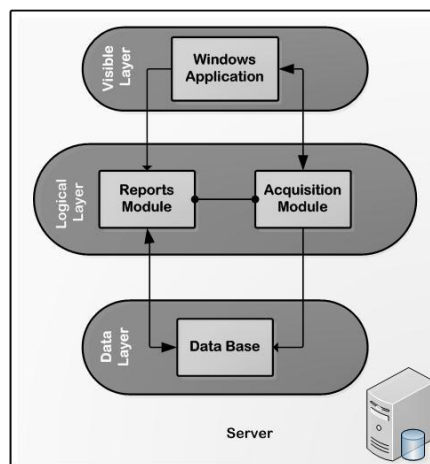


FIGURE 5.3. Logical Architecture

Local Application

The local application corresponds to the windows application. Through this application the client has access to the information referring to the exercises that are executed during the session.

Furthermore, he has real-time access to data through a screen which displays a chart with the values of spent calories as well as the distance travelled, in time.

The client can also access to his evolving history through the database that is placed in the server, where the exercise data is registered.

This information can be consulted via the report module that provides the most relevant statistics from the previous monitoring sessions.

Look4MyBody

- **Client Management:**

The people whose exercises are being monitored are the gym clients. These clients have access to the information displayed in a screen in the gym, accessing to her exercise information in real-time.

A personal will have access to the interface of the windows application on the server, being able to manage the forms of the clients as well as the report modules.

- **Real-time monitorization:**

This module allows the registration of a new client in the database, in case it is the person's first monitoring session and the monitoring session of the exercise is made in real-time.

Chapter 6

6. System Development Tools

Before code writing and development, a firmware programmer must set up and define his Development Environment.

A Development Cycle (process which is carried in an application development) is formed by a cyclical operation constituted by four main steps. These steps are Edit/Create/Design code, Compile/Assemble/Link code, device Programming and Analyze/Debug firmware (see Figure 6.1). [5]

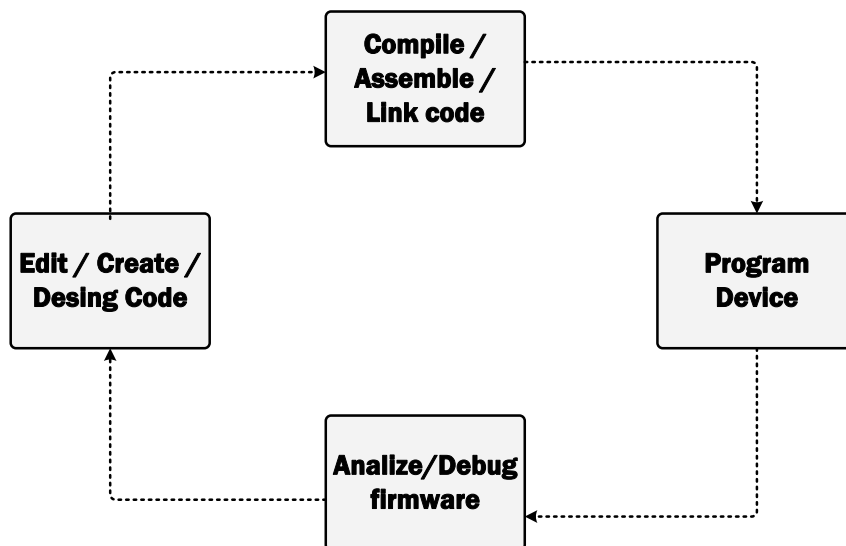


FIGURE 6.1: Development Cycle.

Once defined the Development Process, one can proceed to the identification of the Development Environment components which include the definition of a Compiler, a Programmer/Debugger and integrated Development Environment software. In the following topics it will be provided a brief overview on each component as well as the reasons that led to their choice. [5]

6.1. Compiler

During the development process the PIC24FJ64GA004 used, microcontroller architectures were approached.

Since the compiler is directly related with hardware architecture, was MPLAB C30 with 16-bit PIC microcontrollers' devices.

A compiler is a set of rules that are applied in the translation of high-level language statements into Assembly language. More recent compilers use advanced techniques to simplify programming tasks, turning them more transparent, and to optimize the assembler code. In this case, the term cross-compiler should be used instead of just compiler, since it's running on a different platform than its creation one. [5]

The main support tool to a programmer is the documentation, like books, articles, tutorials, problem solving forums and code samples, which refer to the subject of the work in progress. Thus, the amount of documentation available depends on the chosen compiler and that must be taken in consideration in its choice. A commonly used compiler like the C30 that uses PIC microcontroller C compilers has a wide variety of documentation provided either by the official manufacturer or other programmers.

Also taken in consideration was its ability to facilitate the programmers' job, in other words, the number of built-in functions and macros in the compiler that are used by the programmer to control peripherals or access microcontrollers register should be high.

The C30 compiler not only includes these low-level controlling macros and functions but also has C libraries for memory management, input/output and other libraries for general purpose that saves the developer some time and tedious work. [6]
[7]

Lastly, the easy integration with an integrated Development Environment was another important feature that contributed to the choice of the compiler, since it considerably reduces the time spent on the four developing cycle stages. MPLAB C30 compiler was planned with MPLAB IDE integration in sight. [7]

6.2. Programmer/Debugger

After being compiled, assembled and linked, the program will access the programming memory of the microcontroller. The process which allows the microcontroller to run the program as a standalone is called Programming and consists simply in transferring the final firmware into the chip.

When programming a microcontroller, if something fails, there is no output to analyze so that the problem can be fixed. To surpass this concern it is used an In-Circuit-Debugger that allows debugging the code while it is running on the PIC, providing crucial information to the developer. This debugger is a piece of hardware that is link through wires to both the computer and the system that is in test.[8]

Throughout the system's development it was used an In-Circuit Debugger and an In-Circuit Serial programmer device to maximize the developing efficiency. The chosen device for this project was the MPLAB ICD2 produced by the same company as the PIC microcontrollers, Microchip. The ICD2 not only allows the normal programming procedures but also provides real time and single-step code execution. [8]



FIGURE 6.2: ICD2 [9]

6.3. Integrated Development Environment

The most important part of the programmer's Development Environment is the IDE (Integrated Development Environment) software. This software gives the programmer, as the name implies, a single integrated environment that contains all the necessary features to code development and testing. An IDE brings programmers the necessary interfaces, supposedly user-friendly, so that they can use mouse clicking and shortcuts instead of tedious command invocations, maximizing programmers' productivity. [5]

The purpose of the IDE is to maximize programmers' productivity by providing an integrated and user-friendly single interface, in other words, programmers can

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replace tedious command invocations in several applications by button clicking or shortcuts in the same software application. [5]

The MPLAB IDE from Microchip is probably the only choice that provides total integration with the compiler and the debugger/programmer simultaneously. This makes this particular IDE one of most used among PIC programmers. [5]

In the following topics the most used MPLAB's built-in components will be overviewed.

- **Project Manager**

The project manager aids in the organization of the source files of the firmware project. This component is also responsible for the correlation between the IDE and the language tools. [5]

- **Editor**

The editor besides being a source code editor, it also represents support to the debugger module. The editor component from MPLAB is not as strong as other single-purpose text editors. However this does not constitute a problem since C language does not need a powerful tool to this purpose due to its simplicity. [5]

- **Assembler/Linker**

This component is transforms the assembly code that is returned by the compiler into object code. This operation makes possible that the programmer's code is transferred to the microcontroller. [5]

When there are several source files in the project, the linker and the assembler must be used together. The linker makes two main operations. One of them is that it links the several object code files generated by the assembler together into an executable program. The other operation consists in the positioning of the code in its proper memory areas of the microcontroller. [5]

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- ***Debugging Tools***

Although, MPLAB's debugging tools cover the most features of other debuggers, including, as mentioned above, breakpoint, single stepping and watch/modify variables, it has some limitations as well: the slow and poor synchronization between the microcontroller and the IDE software. Nevertheless, the existent method is a precious help to PIC programmers. [5]

6.4. Acquisition and Transmission Module

The iDemoBoard is a board-bearing tests and development of OEM modules of ISA.

Essentially provides the power for the various modules, interfaces and communication pin input / output. [27]

The iDemoBoard Support 3 OEM modules:

- Socket Radio 868MHz
- Socket Radio 2.4 MHz
- Socket Modem
- Socket Ethernet

The present iDemoboard provides regulated 3.3V and 5.0V. Contains interfaces RS485, RS232 and USB serial module. [27]

This iDemoBoard has a sheet of 60-pin expansion, which can be seen in attachment B and the schematics in attachment C. [27]

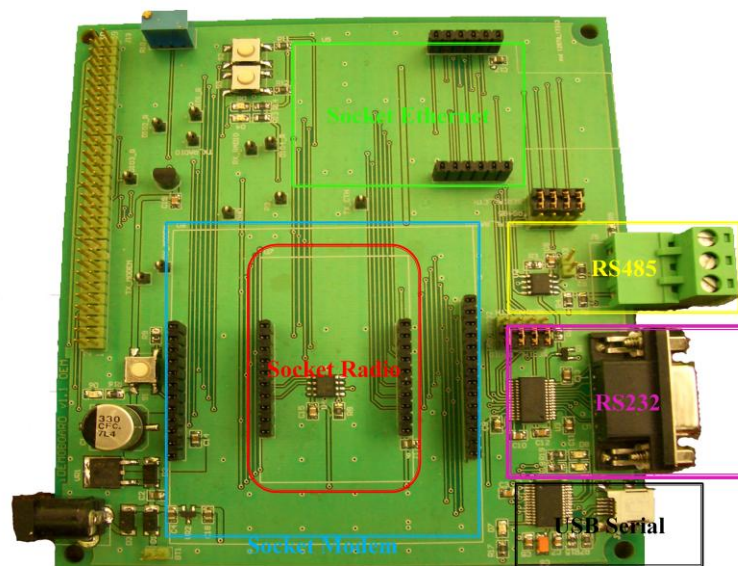


FIGURE 6.3.: General layout of the board

6.4.1. Description of the Hardware

- **Power**

The iDemoBoard can be powered with a 9-12V DC voltage. [27]



FIGURE 6.4.: Power

- **Radio Interfaces Modules**

The radio modules have their Inputs and Outputs directly linked to iDemoBoard. [27]

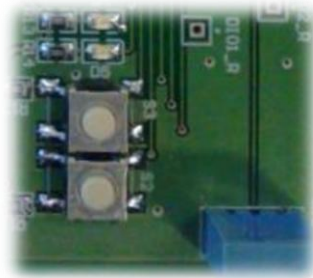


FIGURE 6.5.: Radio Interfaces Modules

- **Origin of communication series – Radio**

To select the source of the signals and serial communication cable should be selected as shown in figure 6.6. for the Radio mode socket.[27]

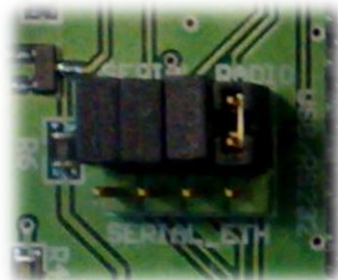


Figure 6.6.: Serial Radio

6.5. Socket Radio 868 MHz

The Socket Radio is based on the Integration Silabs SI4421 Universal ISM Band FSK Transceiver and the PIC24FJGA004. The Socket Radio is a ready-to-integrate module for operation on the unlicensed 868 MHz ISM (industrial, scientific and medical) band. [28] [29]

The Socket Radio 868 MHz is pin-compatible with the Socket Radio 2.4 GHz. Their pin compatibility enables the easy migration from one technology to the other. The schematics could be seen in attachments C. [28] [29]

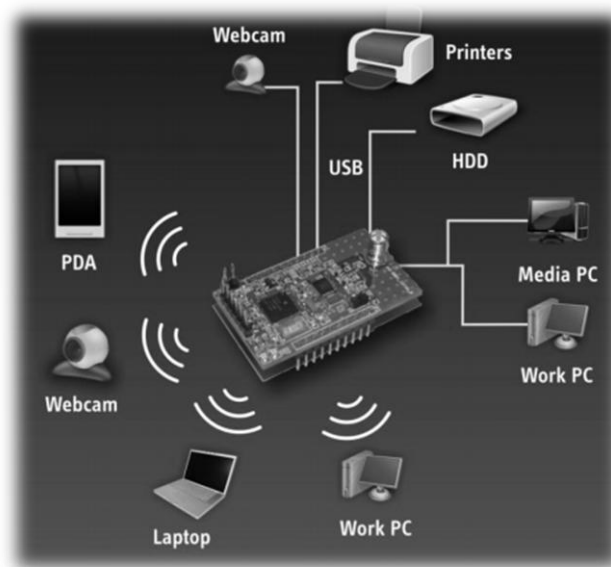


FIGURE 6.7.: Devices that communicate with the Socket Radio [28]

Applications:	
Home security and alarm	Automated meter reading
Remote control	Industrial automation
Telemetry	Wireless sensors
Process Access and Building Controls	Remote data logging
Home automation	Personal Area Network
Home appliances interconnections	PC peripherals

TABLE 6.1: Applications of the Socket Radio 868 [28] [29]

Features	
Range	300m
Radio Frequency	868MHz
Dimensions	29,5 x 50,9mm
Antenna	External SMA connector
Operating Temperature	0°C to 60°C
Power Consumption	(μC+radio) Rx: Typ. 27mA, Tx: Typ. 38mA
Operating Voltage Range	2,8 - 3,6V
RF output power	7dBm
RF sensitivity	-110dBm
I/O	2 Analog inputs, 4 Digital I/O, 1 SPI, 1 UART
RF data rate	0,6 - 115kbps
Two status indicator LEDs	
Sleep mode	
Low power consumption	
Multipath fading and interference bypass	
Allows frequency hopping	
All RF peripheral components already integrated	
UART and SPI interfaces	
No RF knowledge required	
Small footprint allows easy integration on OEM design product	
2 LED	
1 Configuration strap	
1 Reset strap	

TABLE 6.2.: Features of the Socket Radio 868 [28] [29]

6.5.1. Bridge UART 24F

This guide shows the necessary steps to be taken while programming and configure of a UART bridge between two 868 MHz radio sockets. The Socket Radio 868 MHz are based upon the chips PIC 24FJ64GA004 and on the chip SI4421. The UART bridge example code implemented on the PIC enables the transmission of data forward to another radio module with the same firmware used. Thus, the connection between UART < - > UART is transparent. [30]

In attachment 9.3.file shows a schematic of the 868 MHz showing all the connections that should be made to enable its correct function. [30]

In Figure 6.8. can be seen a description of the several socket pins. The pins marked in red should be essential since these must be linked to the bridge mode P2P (peer to peer). The socket should have a regulated input power of 3,3 V and the inputs and outputs are digital (RX_PIC e TX_PIC). [30]

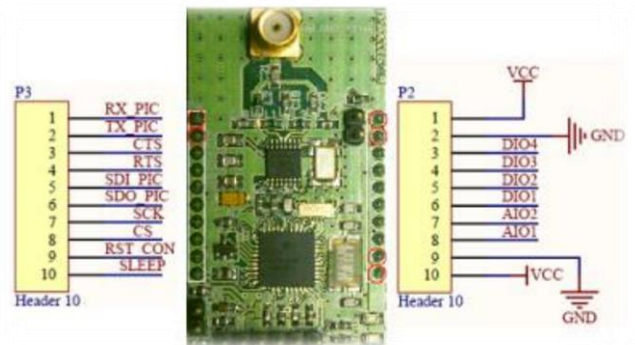


FIGURE 6.8.: Descriptions of the Socket Radio 868 MHz connections [30]

- **PIC Programming**

The PIC should be programmed with the “bridge24F.hex” firmware using an available socket connection to the ICD programmer or another compatible. The programming pins are described in figure 6.9. [30]



FIGURE 6.9: Connecting to the type of programming the ICD2 [30]

6.6. Dongle Radio USB 868 MHz

By incorporating the Silabs Integration SI4421 Universal ISM Band FSK Transceiver and the PIC18F66J50, the USB Dongle 868 MHz supports a wide range of applications operating on the unlicensed 868MHz ISM. The schematics could be seen in attachment C. [31]

The Dongle Radio USB provides an easy way of integrating proprietary protocols into personal computers, gateways or bridge devices. This solution is ideal to be used in the establishment of networks in which the dongle may be configured to act as the coordinator, router or a simple end device. [32]

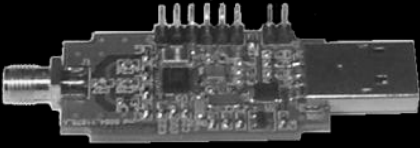


FIGURE 6.10.: Devices that connect directly whit dongle [32]

<u>Application:</u>	
Home security and alarm	Automated meter reading
Remote control	Industrial automation
Telemetry	Wireless sensors
Home automation	Remote data logging
Home appliances interconnections	Personal Area Network
PC peripherals	

TABLE 6.4.: Applications of the Dongle USB 868 [32]

Features	
Range	300m
Radio Frequency	868MHz
Dimensions	22,0 x 44,7mm
Antenna	External SMA connector
Operating Temperature	-10°C to 60°C
Power Consumption	max: 50mA (μC+radio)
RF output power	7dBm
RF sensitivity	-110dBm
RF data rate	0,6 - 115kbps



No need to develop USB drivers or RF design experience or expertise
On-Board Voltage Regulator: Dongle entirely powered from the USB Bus
Low Speed (1.5Mb/s) and Full Speed (12Mb/s) Compatible USB Serial
USB V2.0 Compliant Serial Interface Engine
Easy access to the AT command interface through an application software
High Bit Rate up to 115,2 kbps
Fast Frequency Hopping Capability
ISM (Instrumental, Scientific and Medical) 868MHz Band Operation
Small footprint allows easy integration on OEM design product
2 LED
1 Reset strap

TABLE 6.5.: Features of the Dongle USB 868 [32]

6.6.1. Bridge UART Dongle Radio USB 868 MHz

The Dongle Radio USB 868 MHz are based upon the chips PIC18f66j50 and the Si4421. The UART bridge example code implements the transmission of data regarding a virtual series gate in the Pc forwarding it to another radio module with the same code in use. Thus, the connection between UART<-> UART is transparent. [33]

- **PIC programming**

The PIC should be programmed with the “*bridgeUART_18F.hex*” firmware using an available socket connection to the ICD programmer or another compatible. The programming pins are described figure 6.11. [33]

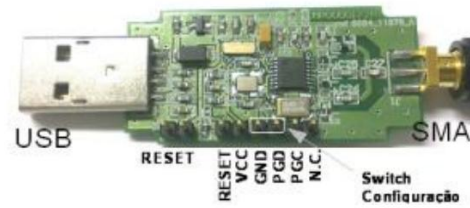


FIGURE 6.11.: Connections of Dongle USB 868 [33]

Chapter 7

7. Firmware Design

Most of the work carried out during the past academic year is experienced along this chapter. Despite being the project's main objective, firmware design was the last stage to be performed. Previous chapters can be considered as intermediate steps that aim to a common goal that's the development of the firmware transmission modules that perform all the required tasks. Throughout this chapter, several concepts approached in previous chapters, will be referenced. This way, in order to fully understand present's chapter considerations, the reader must be entirely familiarized with previous chapters.

Besides the actual firmware design sections, this chapter includes an additional section that has the purpose to explain the communication protocols defined by the programmer throughout firmware development stage.

The development of the present project's firmware required the usage of all the equipment mentioned previously.

The iDemoBoard acts as a support to the Socket Radio 868 MHz which contains the PIC24FJ64GA004. This PIC is programmed via an ICD2 that communicates with the computer via USB. The computer must have installed the MPLab to process the code. Throughout the firmware development, the iDemoboard had a reed-switch and a chip DS2480B to which a reader DS1990A was attached, as it can be visualized in scheme 7.1.

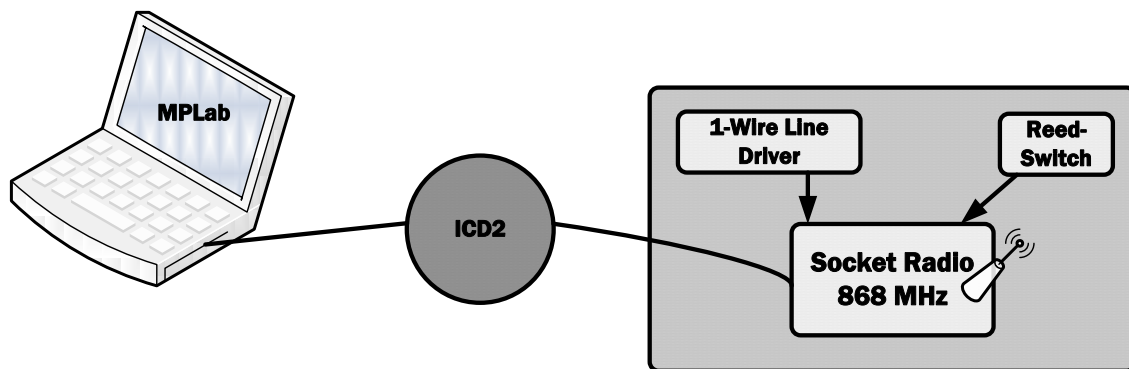


FIGURE 7.1: The most used devices during the firmware development

7.1. Firmware Description

The firmware projects aims to make the communication with the Socket Radio 868 MHz and the Dongle Radio USB 868 MHz via radio, sending the pulse counting as well as the client identification.

For each hydraulic machine there are a measure tape with four magnets and a reed switch (see figure 7.2.). Between each magnet there is a distance of approximately 2cm. For each time the magnet passes through the reed-switch a measurement takes place.

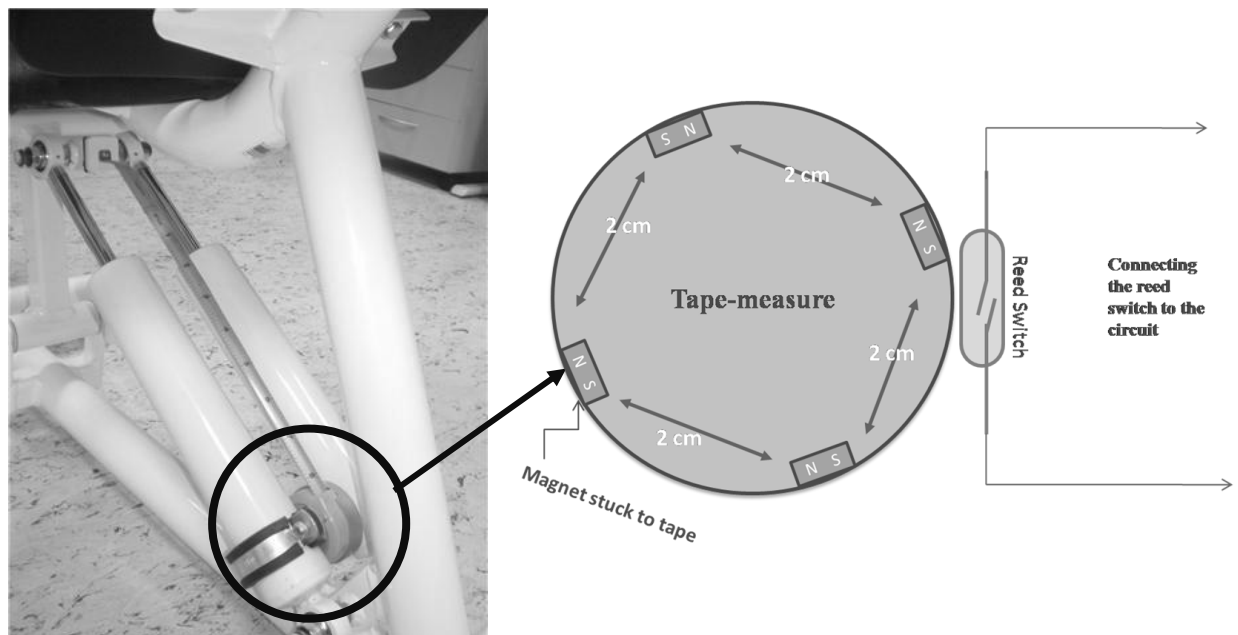


FIGURE 7.2.: Hydraulic Machine with measure tape which has four magnets and a reed switch.

The tape measure is calibrated so that the distance between each magnet is 2 cm. So, whenever there's a passage of the magnet by Reed switch the count of a pulse is made, to this pulse is added 2 cm.

Each time that a pulse is counted; this data is sent from the socket radio 868 MHz to the Dongle Radio USB 868 MHz via radio. On the computer where the Dongle Radio USB 868 MHz is entered, the data is collected in a form as presented in figure 7.3. Afterwards; these results are sampled in the chart, as in Figure 7.4.

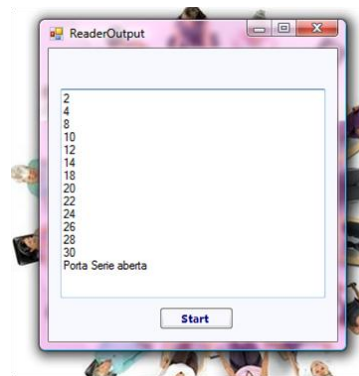


FIGURE 7.3. A form with the counting pulses

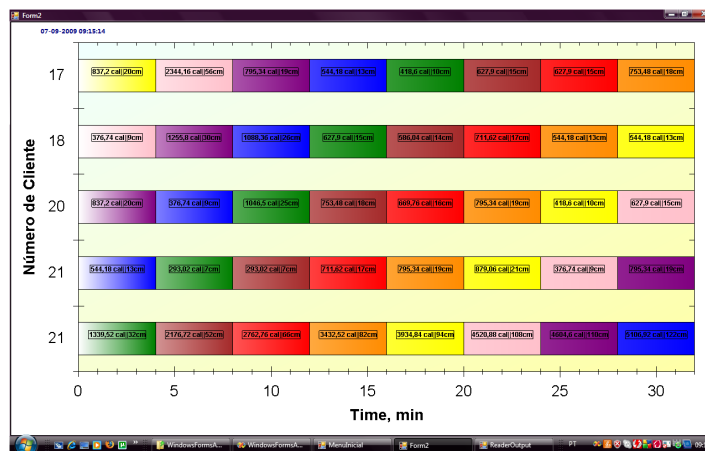


FIGURE 7.4. Chart with the monitorization of the exercise

The identification of the iButton is sent each time the client places the iButton in contact to the machine's reader that is pretended to use.

The general design of the firmware is presented in the flowchart seen in figure 7.5.

Initially, when the hardware is connected, the green LED is lighted and the red LED is turn off, indicating to the client that the equipment is available and she could

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initiate her practice. For that, she should firstly proceed to her identification, placing the iButton upon the reader.

Once the client is detected, the green LED is turned off and consequently the red LED is turned on, which indicates that the machine is now occupied. Only when the green LED is turned on, the machine is vacant again.

Posterior to the identification of the iButton/Client, the pulse count is initiated ($p=p+2$) and sent via radio. Case a new iButton/Client is identified the machine will reset the pulse count ($p=0$) and another one is initiated.

If the hardware stays more than a minute without receiving any pulse count, the hardware admits that the client stopped the practice and thereby the equipment becomes available, lighting the green LED and turning off the red LED.

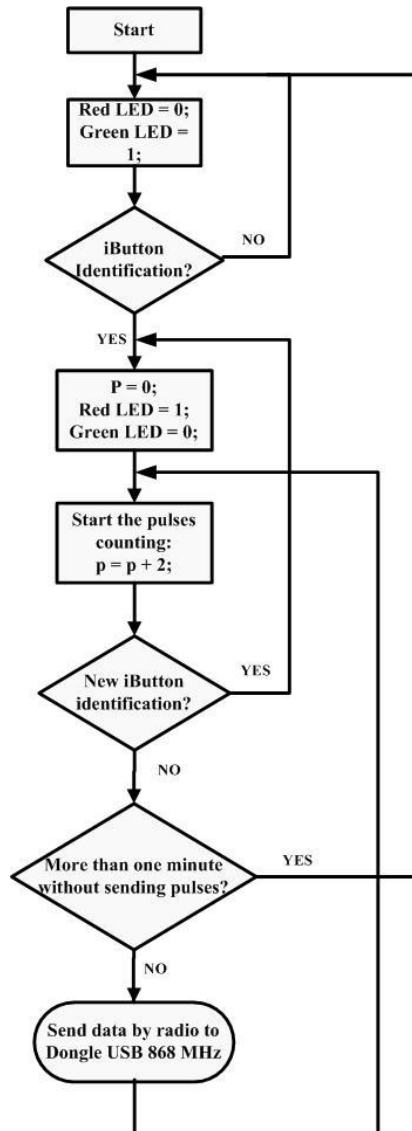


FIGURE 7.5.: General Flowchart of the Firmware

7.2. General Identification process of the iButton

This process was made with assistance of the Application Note (192), (187) and the DS1990A datasheet that can be found in annex. Subsequent to the detailed reading of these three documents, it was detected all the commands that were needed to achieve the identification of the iButton. [19][21][26]

Previously, it has occurred an iButton analysis as well as its associated components, using the RS232 communication and reading the sent/received commands through a HyperTerminal. Only when the ROM number of the iButton was obtained, the programming of the PIC 24 to the iButton identification was possible. [19][21][26]

In order to properly identify the iButton it's necessary to make three fundamental checks, as can be verified in figure 7.6. When the iButton identification process is initiated, it's necessary in first place, to detect the presence of the DS2480B, and then a reset to the DS2480B must be done. Following the reset, ROM number should be found in order to proceed with the decoding until the iButton ID is obtained. [19][21][26]

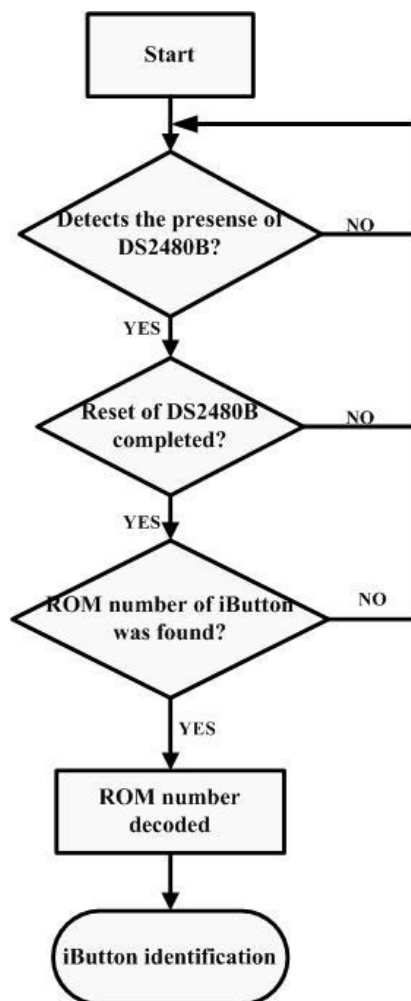


FIGURE 7.6: Identification process of iButton

7.2.1. How to detect the presence of the DS2480B

The process of detecting the presence of DS2480B chip is initiated through the sending of a C1 (hexadecimal) command and a reply may or may not be sent back. Whatever the reply is, it should be ignored. [19][21][26]

Subsequently, a command with 5 bytes (16 45 5B 0F 91) should be sent and the reply should match 5 bytes (16 44 5A 93). Case the reply obtained matches the desired reply it means that the DS2480B chip was detected; otherwise the previous steps should be repeated again until the desired reply is obtained. [19][21][26]

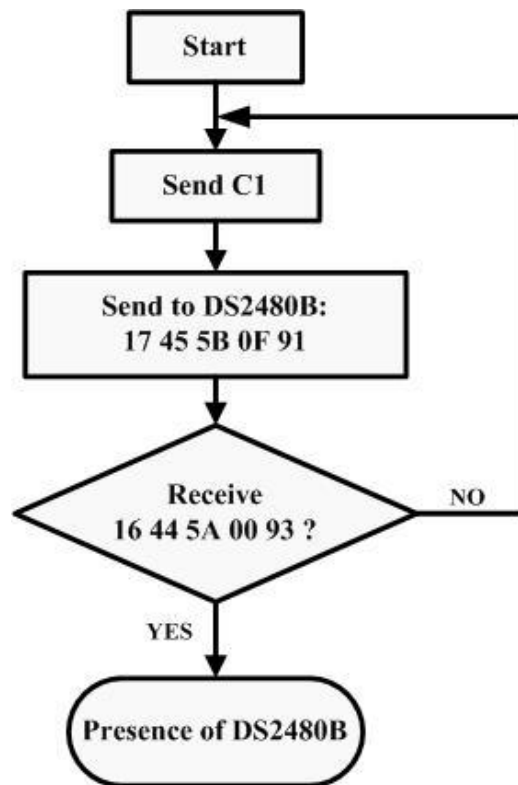


FIGURE 7.7.: Detect the presence of the DS2480B

7.2.2. How to reset the DS2480B

To reset the DS2480B, a 2 byte command (E3 C5) must be sent. There are two kinds of replies (CD and CF) that should be considered to determine that the reset was concluded and each one occur depending on the presence, or not, of an iButton in contact with the reader. [19][21][26]

When the answer is CD it means that the iButton is in contact with the reader if CF is the reply, this means that the iButton is not in contact with the reader. [19][21][26]

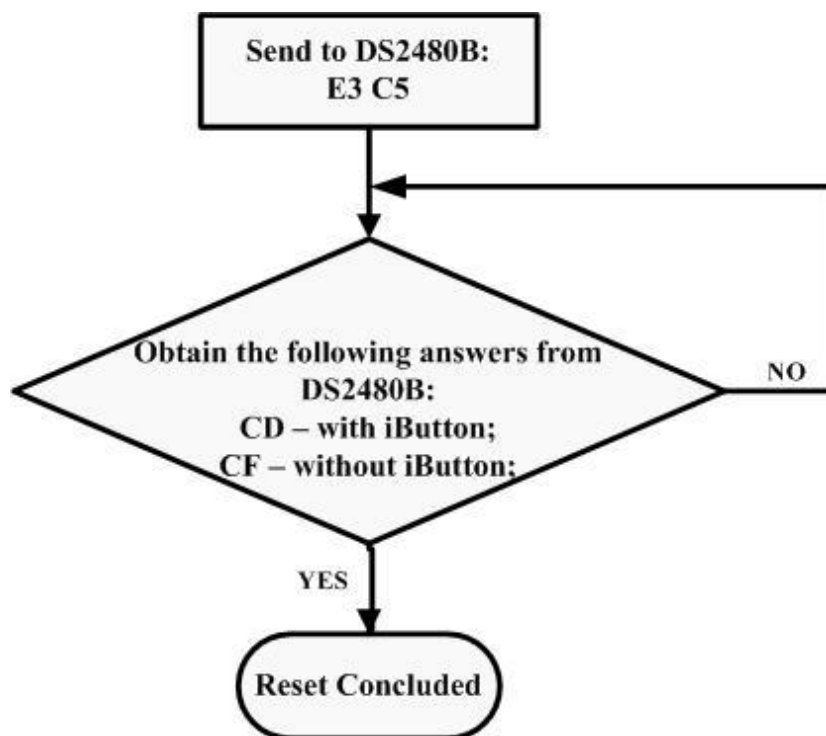


FIGURE 7.8.: Reset to the DS2480B flowchart

7.2.3. How to Search the ROM number from iButton

To obtain the CD-ROM drive number of the iButton when in contact with the reader is necessary to send a command of 22 bytes for the DS2480B, E1 F0 E3 B5 FF FF FF E1 FF FF FF FF FF FF FF FF FF FF FF FF 33 E3 A5. If the answer obtained matches 16 bytes, the number is extracted. Otherwise the previous steps must be done again. [19][21][26]

When the 16 bytes that match the ROM number are obtained, they will enter a decoding process until the iButton identifier matches 8 bytes. [19][21][26]

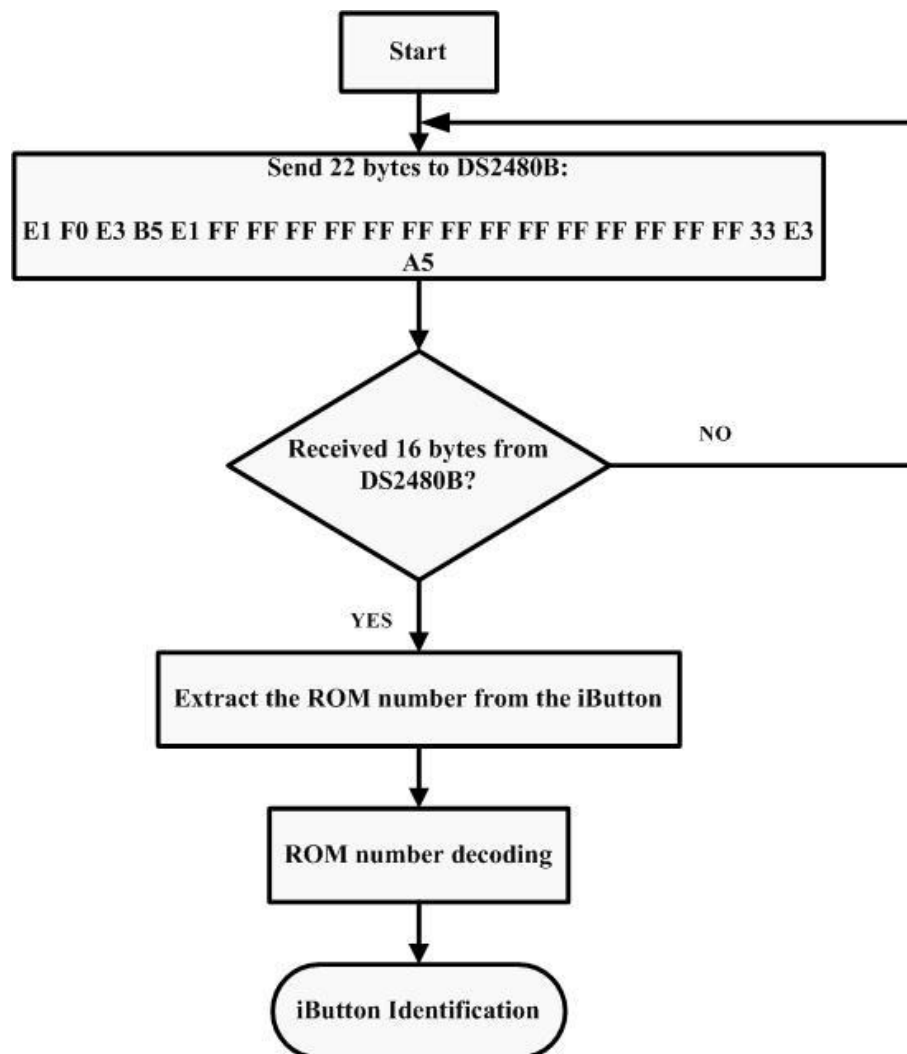


FIGURE 7.9.: Extract ROM number and iButton identification

7.2.3.1. iButton decoding

When the iButton ROM number is identified (16 bytes), it must be decoded until the iButton ID is obtained (8 bytes). First of all, all bytes must pass to bits and fill the table seen below. [19][21][26]

	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>
<i>1°</i>	A _{1,0}	A _{1,1}	A _{1,2}	A _{1,3}	A _{1,4}	A _{1,5}	A _{1,6}	A _{1,7}
<i>2°</i>	A _{2,0}	A _{2,1}	A _{2,2}	A _{2,3}	A _{2,4}	A _{2,5}	A _{2,6}	A _{2,7}
<i>3°</i>	A _{3,0}	A _{3,1}	A _{3,2}	A _{3,3}	A _{3,4}	A _{3,5}	A _{3,6}	A _{3,7}
<i>4°</i>	A _{4,0}	A _{4,1}	A _{4,2}	A _{4,3}	A _{4,4}	A _{4,5}	A _{4,6}	A _{4,7}
<i>5°</i>	A _{5,0}	A _{5,1}	A _{5,2}	A _{5,3}	A _{5,4}	A _{5,5}	A _{5,6}	A _{5,7}
<i>6°</i>	A _{6,0}	A _{6,1}	A _{6,2}	A _{6,3}	A _{6,4}	A _{6,5}	A _{6,6}	A _{6,7}
<i>7°</i>	A _{7,0}	A _{7,1}	A _{7,2}	A _{7,3}	A _{7,4}	A _{7,5}	A _{7,6}	A _{7,7}
<i>8°</i>	A _{8,0}	A _{8,1}	A _{8,2}	A _{8,3}	A _{8,4}	A _{8,5}	A _{8,6}	A _{8,7}
<i>9°</i>	A _{9,0}	A _{9,1}	A _{9,2}	A _{9,3}	A _{9,4}	A _{9,5}	A _{9,6}	A _{9,7}
<i>10°</i>	A _{10,0}	A _{10,1}	A _{10,2}	A _{10,3}	A _{10,4}	A _{10,5}	A _{10,6}	A _{10,7}
<i>11°</i>	A _{11,0}	A _{11,1}	A _{11,2}	A _{11,3}	A _{11,4}	A _{11,5}	A _{11,6}	A _{11,7}
<i>12°</i>	A _{12,0}	A _{12,1}	A _{12,2}	A _{12,3}	A _{12,4}	A _{12,5}	A _{12,6}	A _{12,7}
<i>13°</i>	A _{13,0}	A _{13,1}	A _{13,2}	A _{13,3}	A _{13,4}	A _{13,5}	A _{13,6}	A _{13,7}
<i>14°</i>	A _{14,0}	A _{14,1}	A _{14,2}	A _{14,3}	A _{14,4}	A _{14,5}	A _{14,6}	A _{14,7}
<i>15°</i>	A _{15,0}	A _{15,1}	A _{15,2}	A _{15,3}	A _{15,4}	A _{15,5}	A _{15,6}	A _{15,7}
<i>16°</i>	A _{16,0}	A _{16,1}	A _{16,2}	A _{16,3}	A _{16,4}	A _{16,5}	A _{16,6}	A _{16,7}

TABLE 7.1: 16 bytes of the ROM number converted into bits.

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Based on the table, first of all the 1st iButton ID byte will be decoded, using the 1st and 16th byte of the iButton ROM number received. Starting by withdrawing to the 1st byte the even number match bites (0 included):

$$\text{MSB} = A_{1,0}; A_{1,2}; A_{1,4}; A_{1,6}$$

$$+$$

Afterwards, withdraw to the 16th byte the even number match bites, 0 included:

$$\text{LSB} = A_{16,0}; A_{16,2}; A_{16,4}; A_{16,6}$$

$$=$$

Then add the MSB and LSB bits and obtain in hexadecimal.

$$\text{MSB} + \text{LSB} = A_{1,0}; A_{1,2}; A_{1,4}; A_{1,6}; A_{16,0}; A_{16,2}; A_{16,4}; A_{16,6} = 1^{\circ} \text{ ID}$$

✓ Identifier

Afterwards the process described above is repeated, however decoding the even pairs, starting in the 15th byte;

○ **Decoding Table**

<i>1° & 16°</i>	A _{1,0}	A _{1,2}	A _{1,4}	A _{1,6}	A _{16,0}	A _{16,2}	A _{16,4}	A _{16,6}	ID1
<i>15° & 14°</i>	A _{15,0}	A _{15,2}	A _{15,4}	A _{15,6}	A _{14,0}	A _{14,2}	A _{14,4}	A _{14,6}	ID2
<i>13° & 12°</i>	A _{13,0}	A _{13,2}	A _{13,4}	A _{13,6}	A _{12,0}	A _{12,2}	A _{12,4}	A _{12,6}	ID3
<i>11° & 10°</i>	A _{11,0}	A _{11,2}	A _{11,4}	A _{11,6}	A _{10,0}	A _{10,2}	A _{10,4}	A _{10,6}	ID4
<i>9° & 8°</i>	A _{9,0}	A _{9,2}	A _{9,4}	A _{9,6}	A _{8,0}	A _{8,2}	A _{8,4}	A _{8,6}	ID5
<i>7° & 6°</i>	A _{7,0}	A _{7,2}	A _{7,4}	A _{7,6}	A _{6,0}	A _{6,2}	A _{6,4}	A _{6,6}	ID6
<i>5° & 4°</i>	A _{5,0}	A _{5,2}	A _{5,4}	A _{5,6}	A _{4,0}	A _{4,2}	A _{4,4}	A _{4,6}	ID7
<i>3° & 2°</i>	A _{3,0}	A _{3,2}	A _{3,4}	A _{3,6}	A _{2,0}	A _{2,2}	A _{2,4}	A _{2,6}	ID8

TABELA 7.2: Decoding table

○ **Code decoded (8 – BYTES):**

ID1 ID2 ID3 ID4 ID5 ID6 ID7 ID8

The process that was mentioned above is schematized in the following flowchart, as well as the various stages of the decoding process which is briefly presented in a block diagram. [19][21][26]

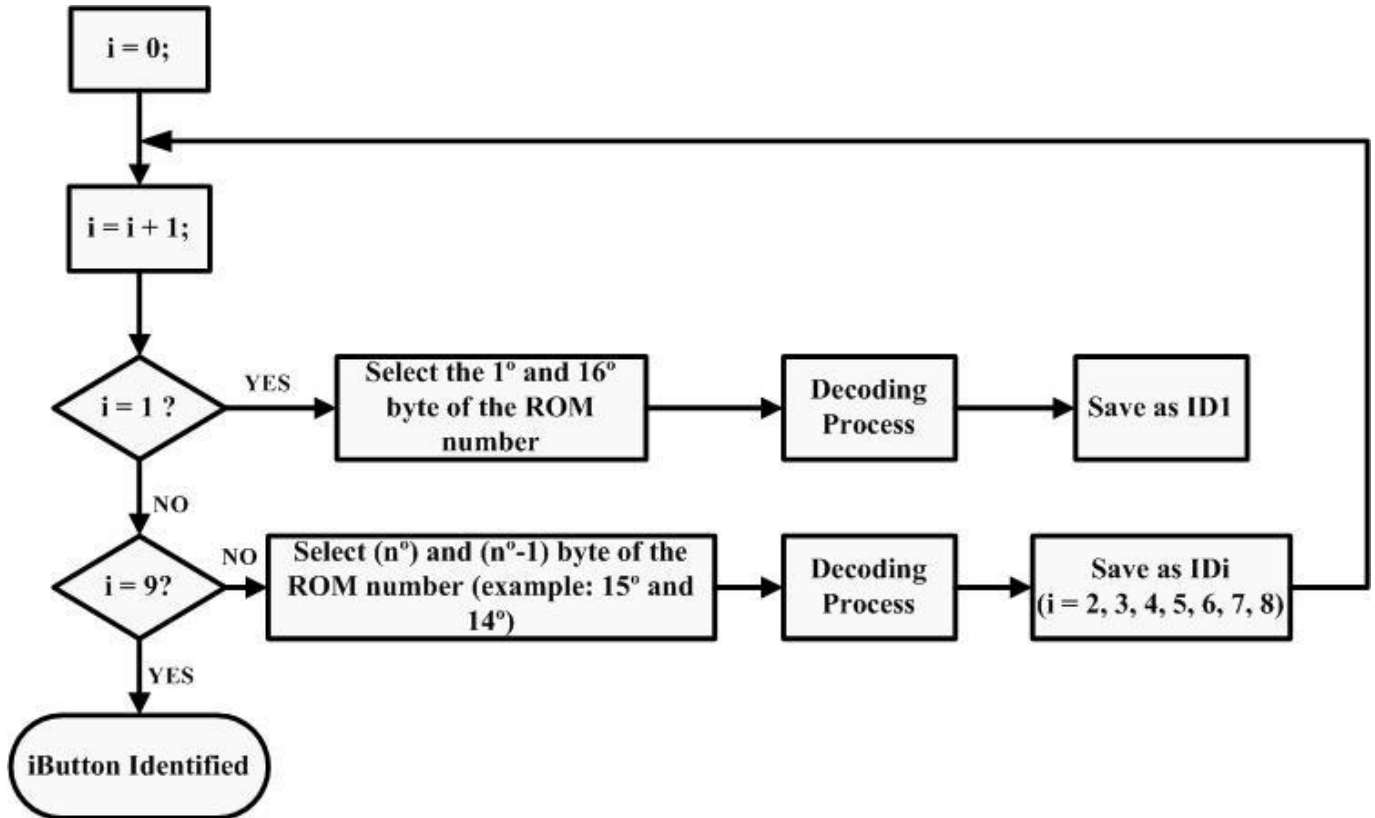


FIGURE 7.10: Flowchart of iButton decoding

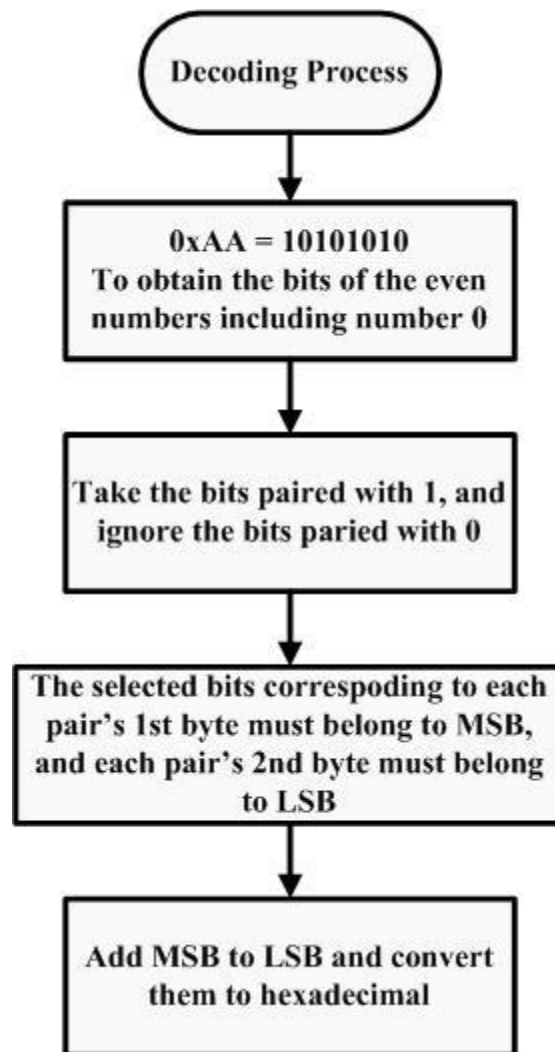


FIGURE 7.11: Block diagram of the decoding of the iButton

7.3. Communication Technologies

The need to communicate with larger amounts of data promoted the serial communication. This way, it consists on sending a sequence of data bits along the same line with a predetermined frequency. Two devices serially connected with each other can, this way, communicate unlimited amount. [35]

The purpose of short-range wireless communication technologies in the system's context is to provide monitoring of the physical exercise data transmission from the client's location into the transmission module, located nearby. [35]

The wireless personal area network (WPAN) concept seems to be the most suited to this particular application since it interconnects devices around a person's workspace wirelessly. In order to achieve optimum flexibility, security and compatibility, standards based solutions must be used. Several wireless technologies have been studied, but the technology used was RF. [34]

The following information will appear on this technology and how the chip used in the Dongle Radio USB 868 MHz permit the communication.

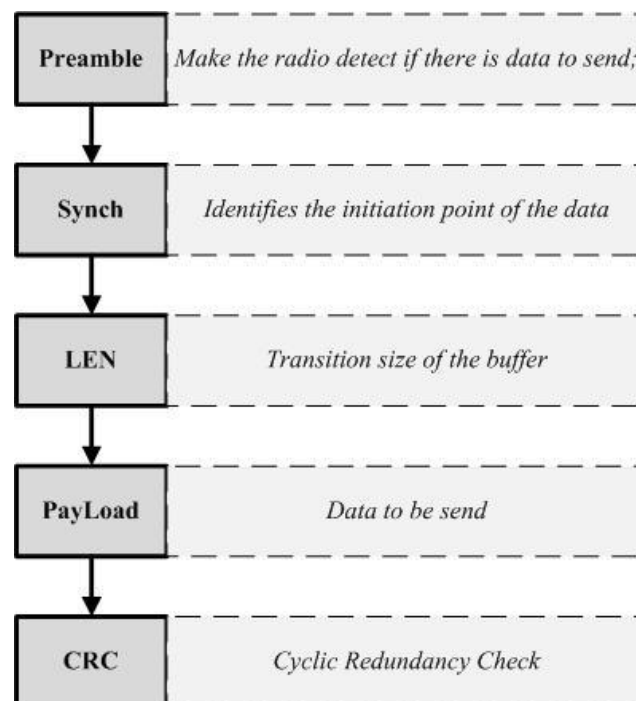


FIGURE 7.12.: Block Diagram Radio Communication

Chapter 8

8. Conclusion

The project Look4MyBody was developed in order to conclude the master degree in Biomedical Engineering. Its main feature is the remote monitoring of physical exercise in real-time. This project aims to provide for all the women that usually attend this gym concept.

The main goals proposed concerning the firmware development were achieved. Throughout the firmware development, a source code was developed with the ability to count the pulses detected by the reed-switch. These pulses translate the distance made by a client in a gym's machine.

It was also developed a system to identify the client since each one has an iButton to identify herself. A code was developed to extract a ROM number existent in the iButton. Then, this ROM number is decoded in order to obtain an ID that identifies the iButton and, consequently, the owner of the iButton.

Some suggestions for future works are presented below, as well as an overall assessment of the project. This assessment has two approaches. Firstly, the student presents the benefits that this kind of gym brings to society. Secondly, the student exposes her opinion on the project theme.

8.1. Future Works

Following, some suggestions for a future work development in this project are presented.

In a short-term effort, firstly it must be established an appropriate hardware adapter to be installed on each machine of the gym, since the hardware material used for firmware development was improvised by intern in order to achieve the goals that were proposed during the year.

It should also be explored and analyzed communication protocols, in order to choose the one to perform the function of 8 devices included in the same room to communicate with a Dongle Radio USB 868 MHz.

The firmware developed has been tested only for a single machine of the gym to communicate with the Dongle Radio USB 868 MHz, it is necessary to test it in parallel with the other hydraulic machines.

In the gym screen, when the chart with the monitoring exercise of the client appears, a video should appear simultaneously, to indicate how the exercise should be done correctly, stressing out the muscles that are being exercised in a specified exercise. This way the client feels more motivated to perform the exercise correctly in order to exercise the muscle perfectly.

In long term, it should be developed a way for the client to be identified on each machine of the circuit, and the machine should know what training the client must perform, and thus give feedback to client, indicating whether the effort/training performed is the appropriate, overstated or insufficient.

In long term should also be included some vital signs on the physical exercise remote monitoring system.

8.2. Final Appreciation

Nevertheless, this new concept presents a few gaps due to the fact that currently there is no physical exercise monitoring devices. Usually, women tend to seek the information about the time they are dispending, the distance travelled, and above all, the calories they dispend throughout the physical exercise.

From a personal point of view I believe that the project might have an immense commercial component, because, despite the circuit training being a novelty, women are adhering massively to this kind of modality since it is a quick practice, easy and complete.

As for personal benefits, the student appreciation is positive despite the initial objectives changed through the run of the project. The student feels accomplished for the work developed, for the obstacles she surpassed, for the dynamism presented, team spirit, independence and knowledge acquired.

This project prove itself very constructive in the way that it provided the opportunity for the student to learn and extend her knowledge, which was highly appreciated by the student, together with the fact that its subject is inserted in the field of electronics and firmware programming.

In addition, the enterprise environment where the student participated offered not only a valuable help in the progress of the project but it was also important for her to get perspective of the professional world and to develop and consolidate team aptitudes. The fact that this project is divided by two students also helped in the latter aspect since a good sense of team work was crucial to reach a common goal.

The wide variety of difficulties encountered throughout the project's evolution was surpassed with high dedication and external help that granted the student an increase in her problem solving competences.

8.3. Test and Final Results

The phase test is an integral part of the system development phase. It can provide confidence in the system, identify weak areas of and establish the degree of quality. The test domain has a wide range of types: unit, functionality, usability, interface, performance, security, among others.

Were performed tests to the system's hardware, and were made iDemoboard tests jointly with the Socket Radio 868 MHz a Dongle Radio USB 868 MHz. In all these equipments were performed electrical checks as well as static tests and dynamic tests, which are presented in annex.

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Attachments

A. Muscles Worked in Hydraulic Machines Circuit

- **Biceps and Triceps**

This is a double positive machine. It works biceps and triceps, the client has to pull the pads toward themselves to work the biceps and pushing the pads down and away from themselves to work the triceps. [2]

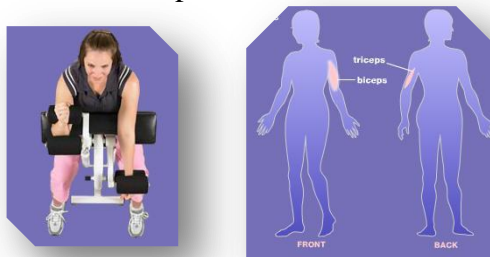


Figure A.1: Biceps and Triceps [2]

- **Leg Extension and Leg Curl**

This machine works two types of muscles simultaneously. It works the quadriceps and hamstring muscles. The client has to extend her legs and lift the pads to work her quadriceps, and then has to bring the legs and the pads in to work her hamstrings. [2]

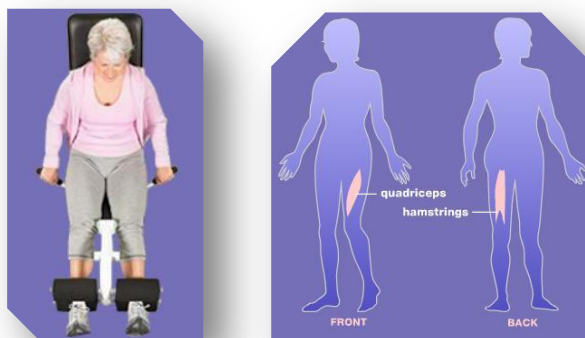


Figure A.2.: Leg extension and led curl [2]

- **Shoulder Press and Lat Pull**

This machine has the ability to work two types of muscle at the same time. It works the trapezius, deltoid and latissimus dorsi muscles on the upper body of the client. [2]

The client has to push up on the machine, working primarily the deltois muscles, and has to pull down on the machine working the trapezius and latissimus dorsi muscles. [2]

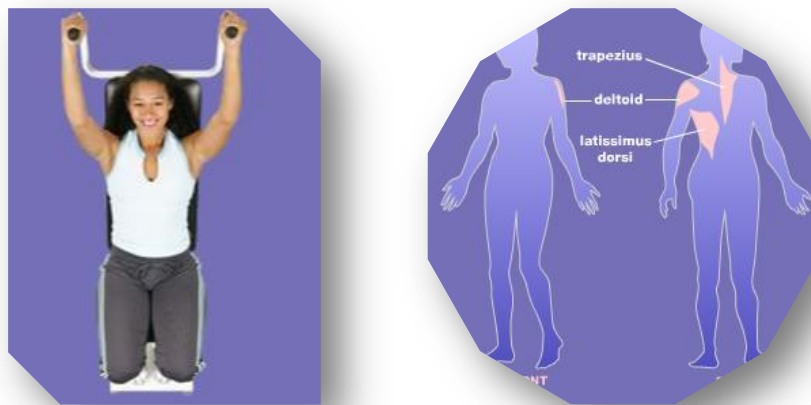


Figure A.3.: Soulder Press and Lat Pull [2]

- **Leg Press**

This is a single positive machine. It works the quadriceps, hamstrings, gluteals and ilopsoas. [2]

The client has to push the pedals away from her working well the quadriceps, hamstrings, gluteals and iliopsoas. And then the client has to allow the pedals to slowly return to the start position. [2]

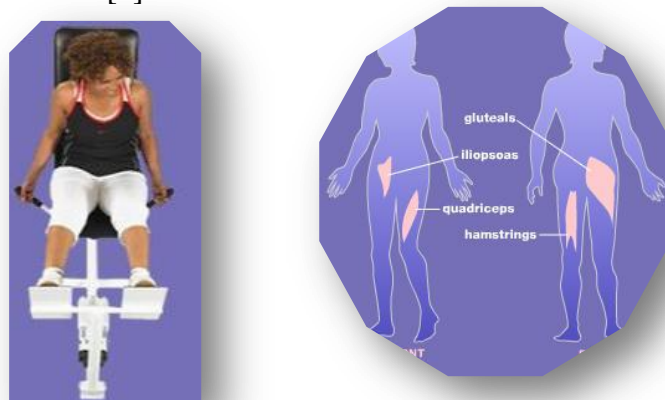


Figure A.4: Leg Press [2]

- **Abdominal and Back**

This is a double positive machine. It works the abdominal and erector spinae muscle groups. [2]

The client has to grasp the handles and then curl back to work the erector spinae muscles. Then push down on the handles using our abdominal muscles. And then curling forward and bringing the handles down works the abdominal muscles. [2]

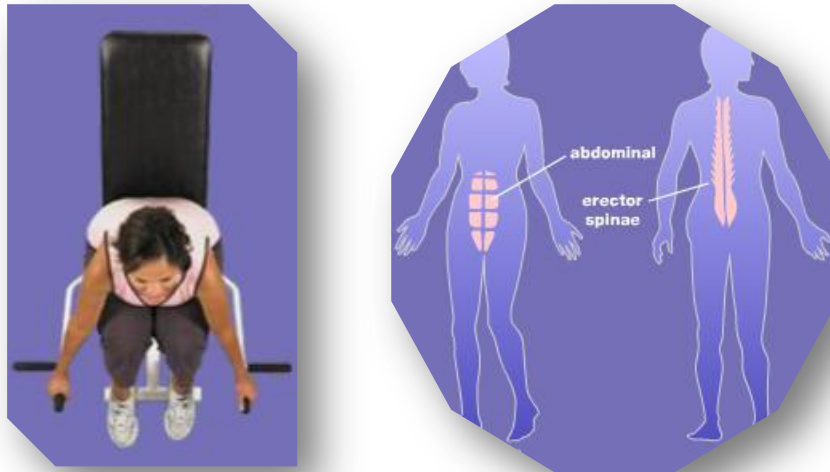


Figure A.5: Abdominal and Back [2]

- **Hip abductor and adductor**

This is a double positive machine. It works the adductor and tensor fasciae latae muscles. The client has to move the legs outward, working the tensor fasciae latae muscles and moving the legs together works the adductor muscles. [2]

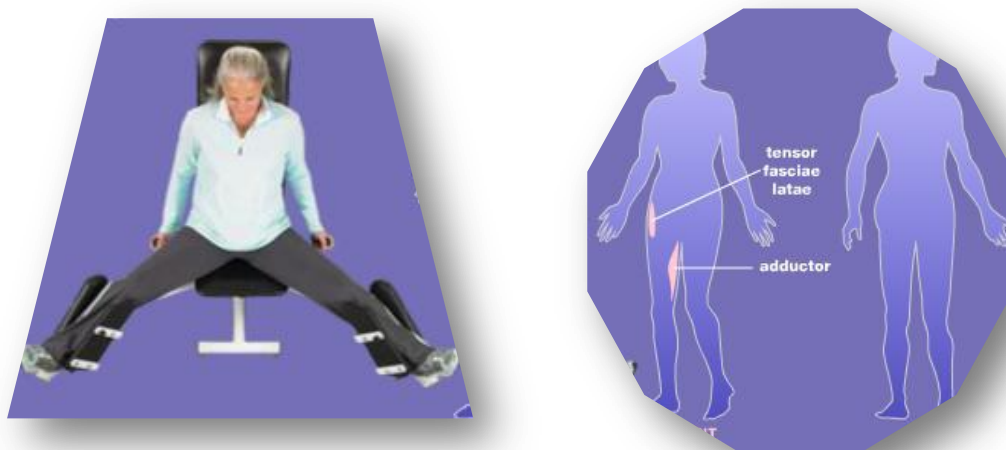


Figure A.6.: Hip abductor and adductor [2]

○ **Chest and Back**

This is a double positive machine. It works the rhomboids, latissimus dorsi, and pectoralis major muscles. [2]

The client has to push out on the handles working the pectoralis major muscles. And then pull back, working the rhomboid and latissimus dorsi muscles. [2]



Figure A.6.: Chest and Back [2]

○ **Squat**

This is a single positive machine. It works the quadriceps, hamstrings, gluteals and iliopsoas. [2]

The client has to move down slowly until her thighs are parallel with the floor works the quadriceps, hamstrings, gluteals and iliopsoas against gravity. And then pushing the pads up quickly working the quadriceps, hamstrings, gluteals and iliopsoas. [2]

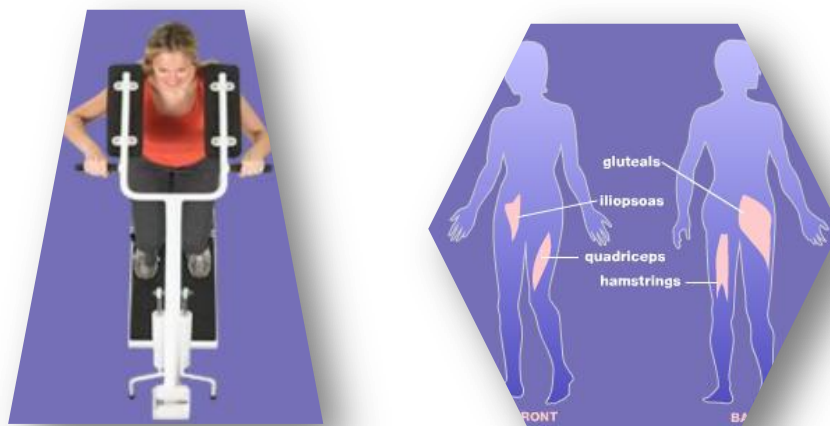


Figure A.7.: Squat [2]

B. Hardware Tests and Results

B.1. iDemoBoard and Socket Radio 868 MHz

The hardware plan test uses the support hardware iDemoBoard. The adapter does not need to have installed all the component, considering that are already installed a input power of 3.3V, sockets and support chips.



FIGURE B.9.: Board Support iDemoBoard

Bridge UART Use

To test the functioning mode of the UART bridge it is necessary two 2.4GHz socket modules both programmed with the same firmware. With the functioning mode

of the UART bridge is made a virtual connection between all the surrounding modules that can be listened. When that connection is made, it is possible to send and receive data via series with 9600 bauds,

8 bits and 1Stopbit. [29]



FIGURE B.10.: Socket Radio 868

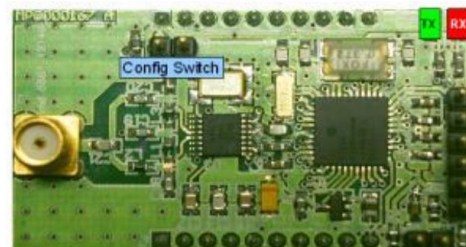


FIGURE B.11.: Socket TX and RX LED

Electrical Verification

- **Static Tests**

Parameter	Expected Value	Result	Validation
VCC (J1.11 and J1.2)	3.30 V	3.28 V	OK
SLEEP(J1.10)	3.30 V	3.25 V	OK
RESET(J1.9)	3.30 V	3.28 V	OK
CS_MEM (J1.8)	3.30 V	3.28 V	OK
J1.7:5	0.00 V	0.00 V (J1.5 = 0.125V)	OK
J1.13:16	3.30 V	2.28 V	OK
Consumption S1	(12..14)+(15..27) 27 mA ... 41 mA	30 mA Typical 36 mA Max	OK

TABLE B.1.: Static Tests on Socket Radio 868

- **Dynamic Tests**

Parameter	Result	Validation
Programming and verification of the PIC with ICD2	PIC correctly recognized, programmed and verified	OK
Connecting the RS232 to the PC after do reset, the Welcome message appears in the terminal	Received “Welcome! Firmware Test V.020”	OK
The board are with LEDs all erased, except the LED of the power	All LEDs are erased except the power LED	OK
Press S3 on the board of support	Received OK	OK
Press S2 on the board of support	Received OK	OK
Press S0 on the Socket Radio 868	Received OK	OK
All LEDs are lit	LEDs all lit in this point	OK
Potentiometer in 0V	Received OK	OK
Potentiometer in 3.3V	Received OK	OK
Potentiometer in 1.65V	Received OK	OK
All LEDs are erased	Deleted all LEDs in this point	OK

TABLE B.2.: Dynamic Tests on Socket Radio 868

B.2. Dongle USB 868 MHz

The hardware SPE.IPR040- dongle USB 868 requires a PC with a USB link and the “mchpcdc” drivers that can be found on the tests archive. To test the test point it is needed a multimeter. To ease the test, should be made a query to the design and schematic of the PCB adapter in order to detect easily the points that could be tested or verified.



FIGURE B.13.: Dongle seen from above



FIGURE B.14. : Dongle seen from bottom view

○ **Bridge P2P Use**

To test the functioning mode of the UART bridge is necessary two 868MHz USB dongle or a 868MHz socket module programmed with compatible firmware.

In a Terminal Software, is used a series gate created for the communication between modules. The series gate does not need to have a baudrate configuration or the others since it is a virtual series connection via USB. The USB dongle will accept requests from other USB dongles or the 24GHz socket modules. [32]

Electrical Verification

- **Static Tests**

Parameter	Expected Value	Result	Validation
Resistance in power terminals (G1 and P1) with the circuit off	200 K	-200 K (0.2M)	OK
Diode voltage of USB (P3)	5.00V-0.70V = 4.3V	4.21V	OK
3.3V output voltage of the regulator, after the connected module (P2)	3.30V	3.29V	OK
Consumption	(12..20)+(12..27) 24mA..47mA	Typ: 27mA Max:29mA	OK

TABLE B.3. Static Tests on Dongle USB

- **Dynamic Tests**

Parameter	Result	Validation
Programming and verification of PIC ICD2 with or similar	PIC recognized, properly programmed and verified	OK
Connecting the module to the PC, this is recognized and found the correct drivers	Module recognized and installed drivers and new COM port detected	OK
Writing data to the terminal, data is transmitted and received by another module USB	Transmission of data is correct	OK
Writing data to the terminal of another radio module, the data is received by the module in test	There is proper reception of data	OK

TABLE B.4.: Dynamic test on Dongle USB

B.3. Connector for Expansion

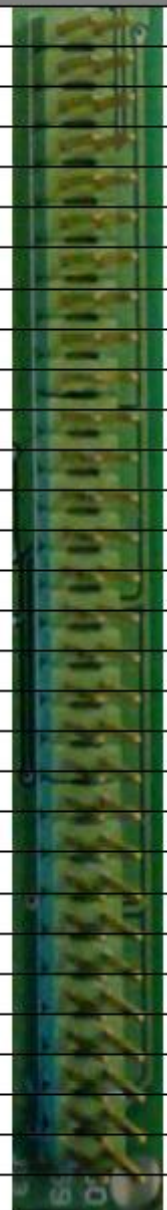
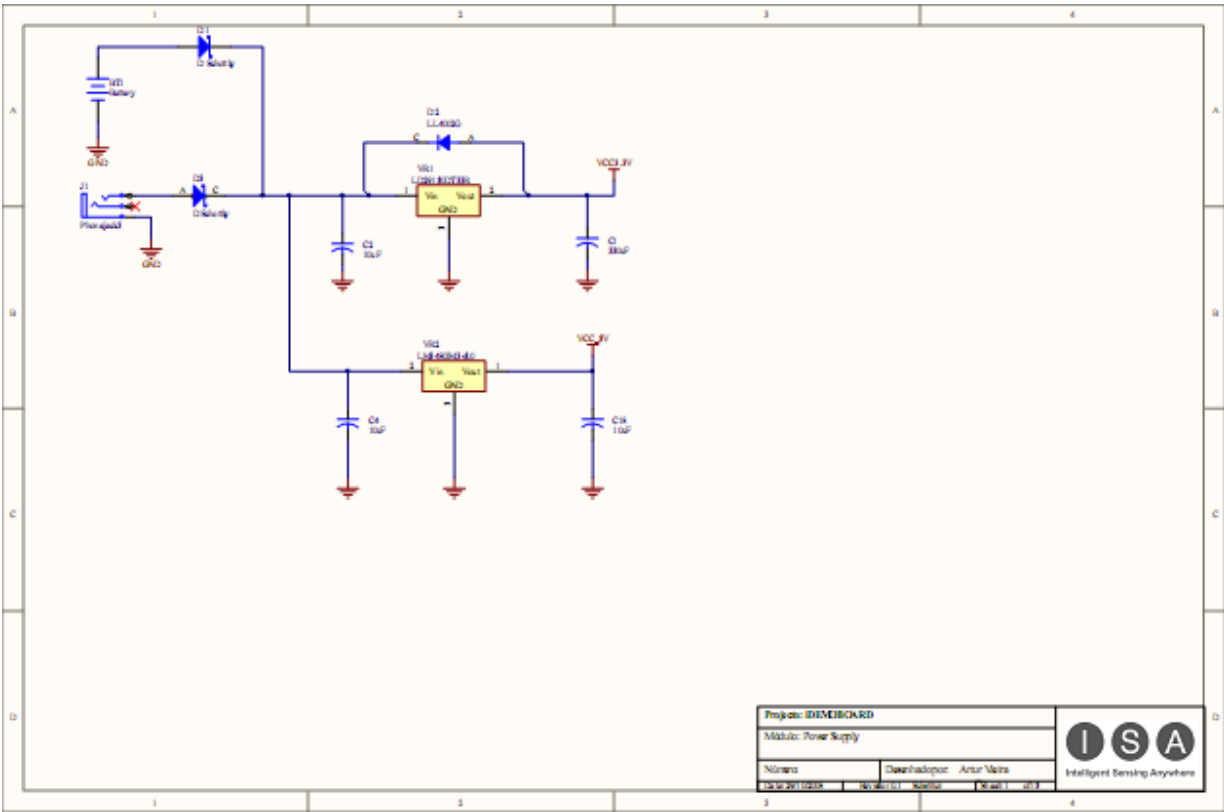
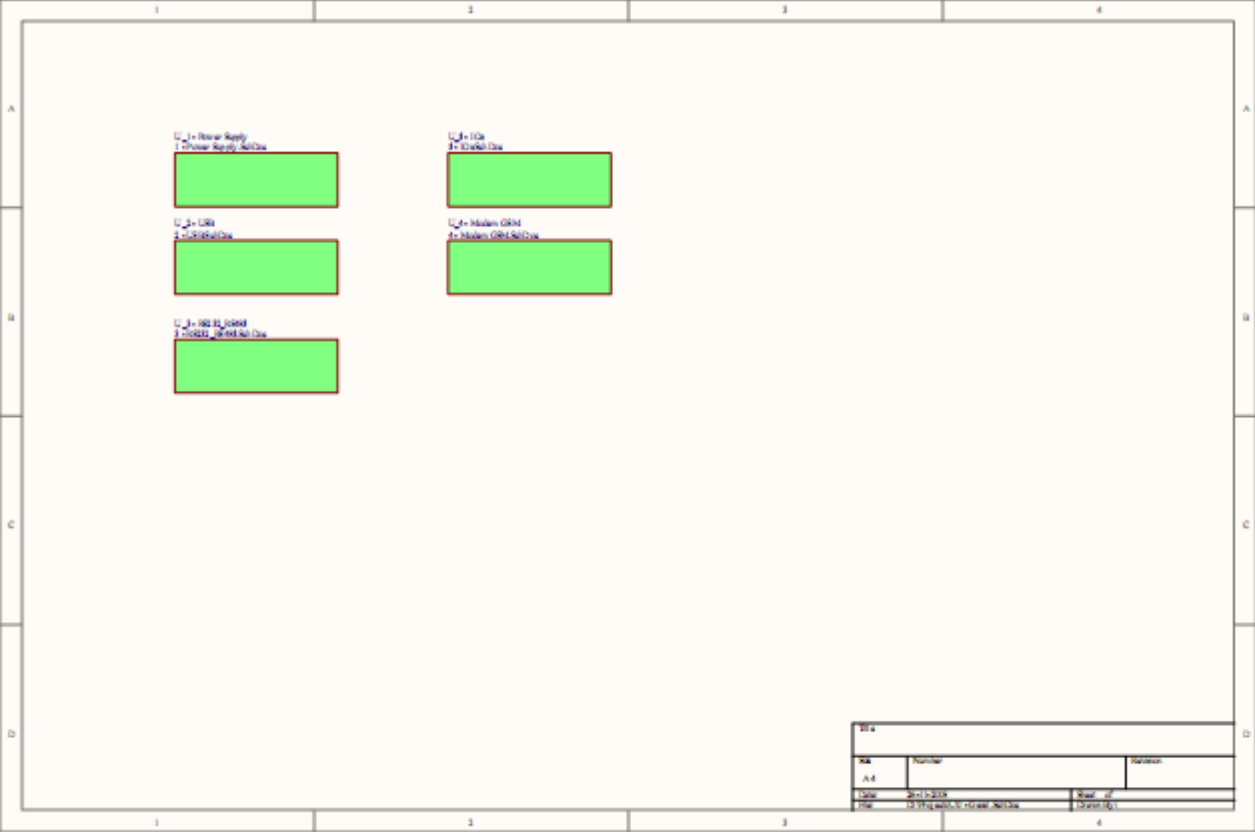
Descrição	PIN		PIN	Descrição
VCC 3.3V	1		2	VCC 3.3V
GND	3		4	GND
DSR	5		6	LED_MODEM
DCD	7		8	STATUS
DTR	9		10	RTS2
RI	11		12	CTS2
TX	13		14	RX2
RX	15		16	TX2
RTS	17		18	CTS
GND	19		20	GND
VCC 3.3V	21		22	VCC 3.3V
CTS_ETH	23		24	TX_ETH
RTS_ETH	25		26	RX_ETH
ID1_ETH	27		28	ID2_ETH
GND	29		30	GND
VCC 3.3V	31		32	VCC 3.3V
RESET_RADIO	33		34	AN2_RADIO
SLEEP_RADIO	35		36	AN1_RADIO
RX_RADIO	37		38	DIO4_RADIO
TX_RADIO	39		40	DIO3_RADIO
CTS_RADIO	41		42	DIO2_RADIO
RTS_RADIO	43		44	DIO1_RADIO
GND	45		46	GND
VCC 3.3V	47		48	VCC 3.3V
SCK_ETH	49		50	SCK_RADIO
SDI_ETH	51		52	SDO_RADIO
SDO_ETH	53		54	SDI_RADIO
CS_ETH	55		56	CS_RADIO
GND	57		58	GND
VCC 3.3V	59		60	VCC 3.3V

TABLE B.5.: Connector for Expansion [27]

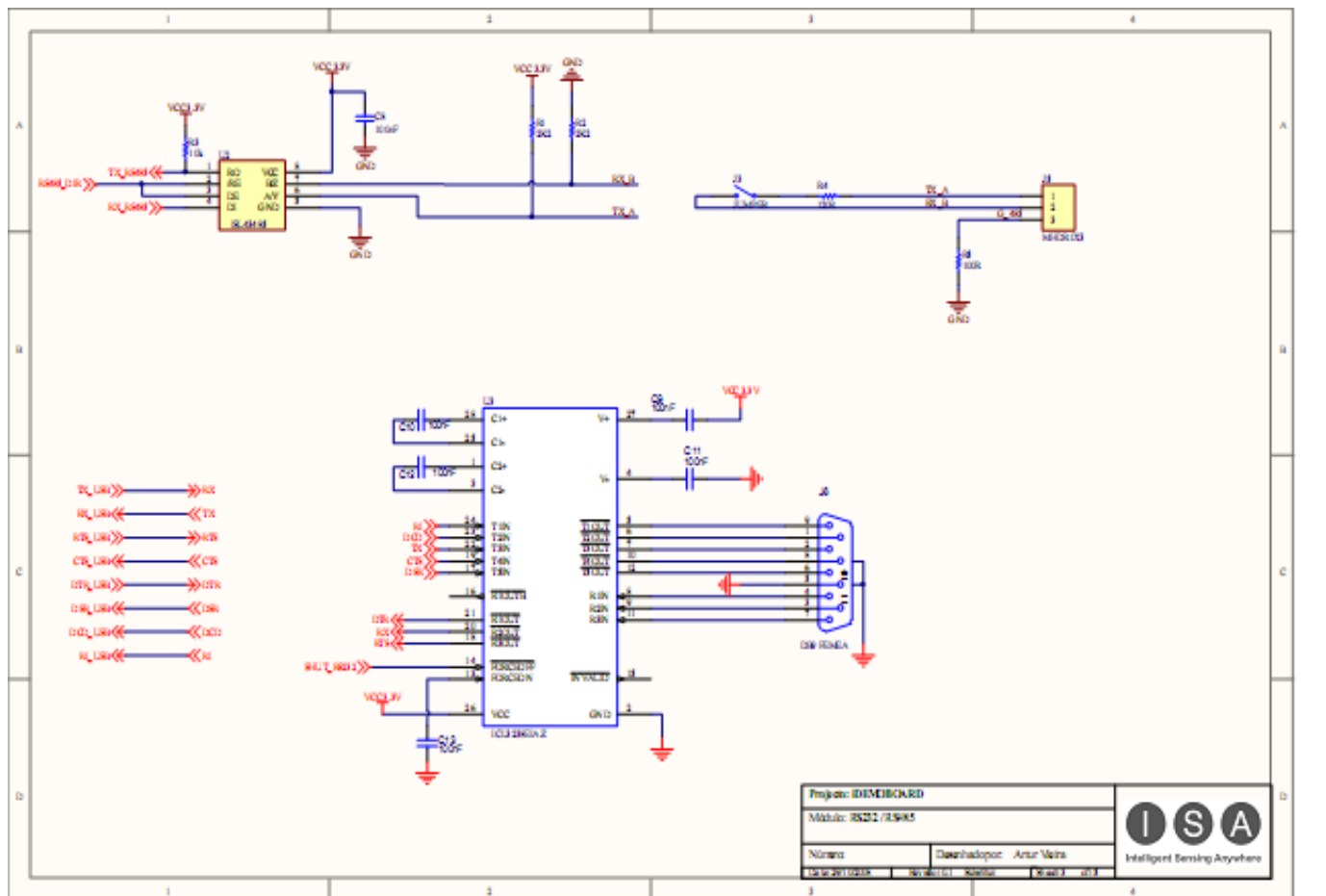
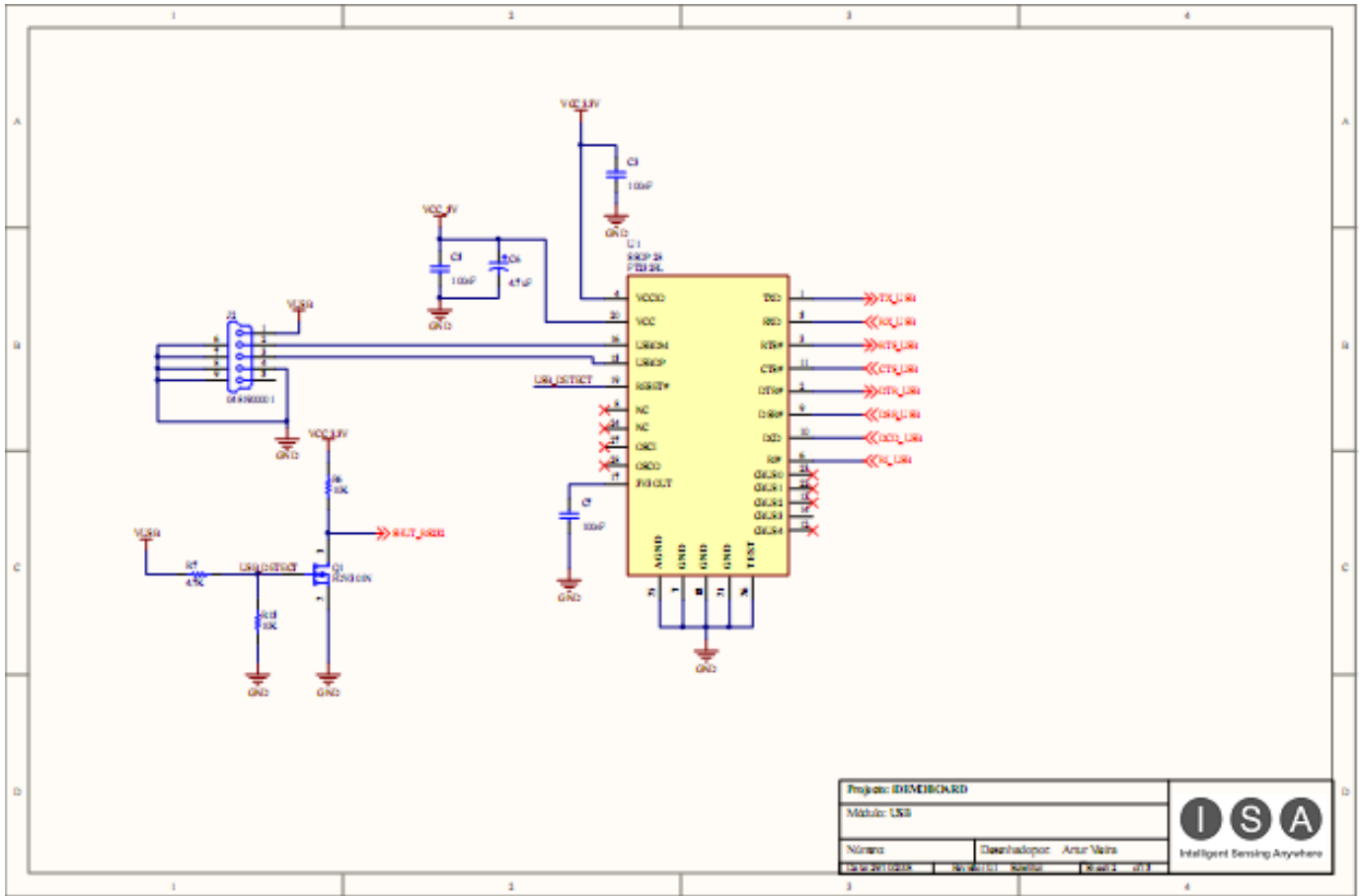
C. Hardware Schematics

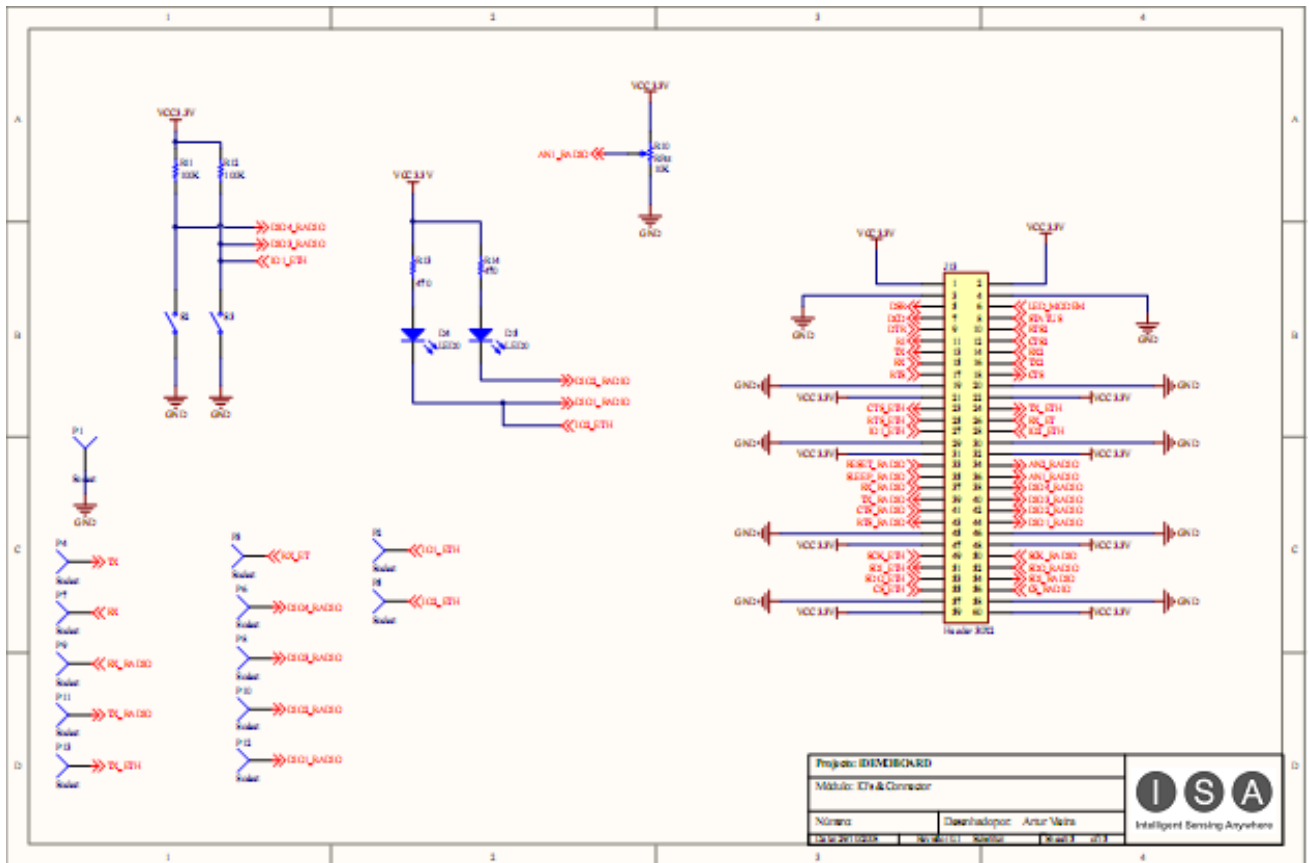
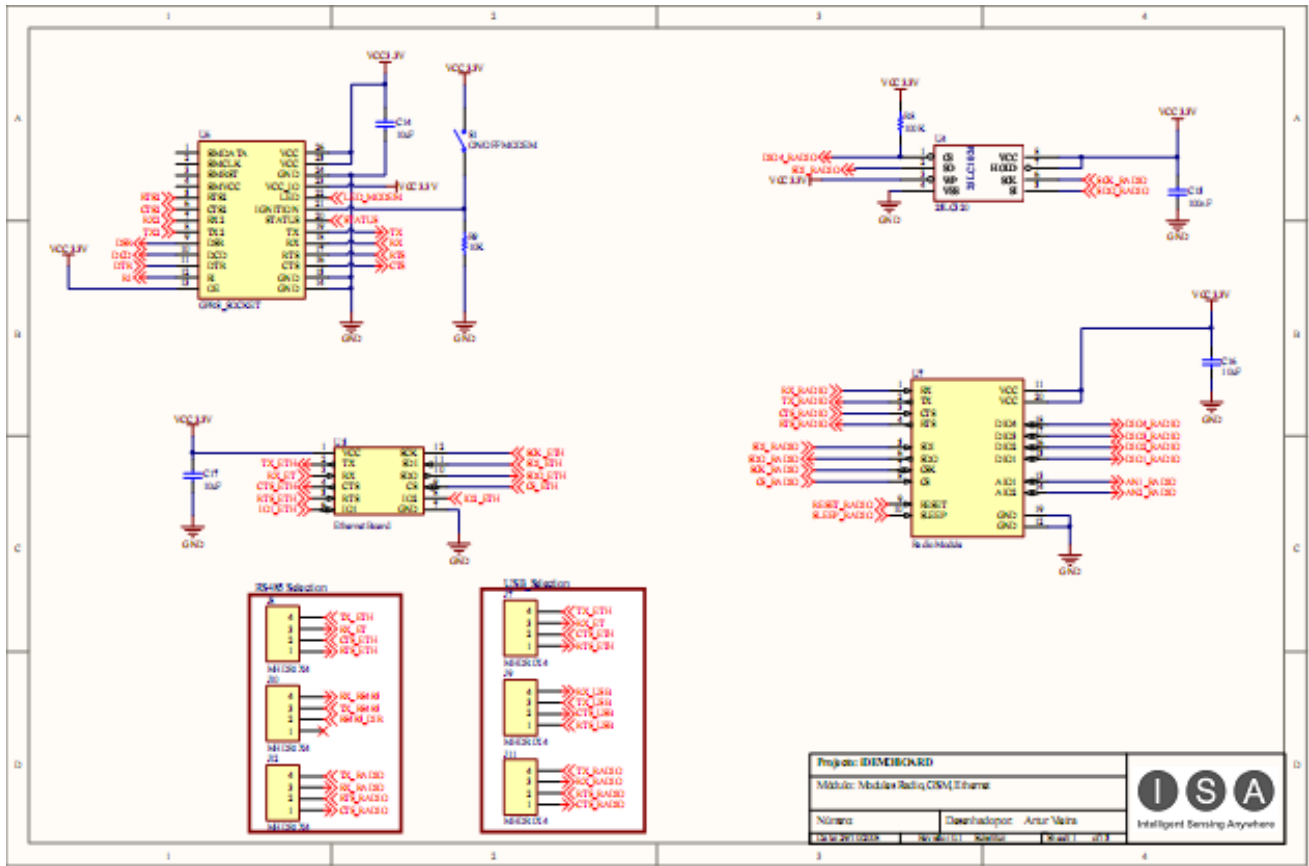
C.1. iDemoBoard

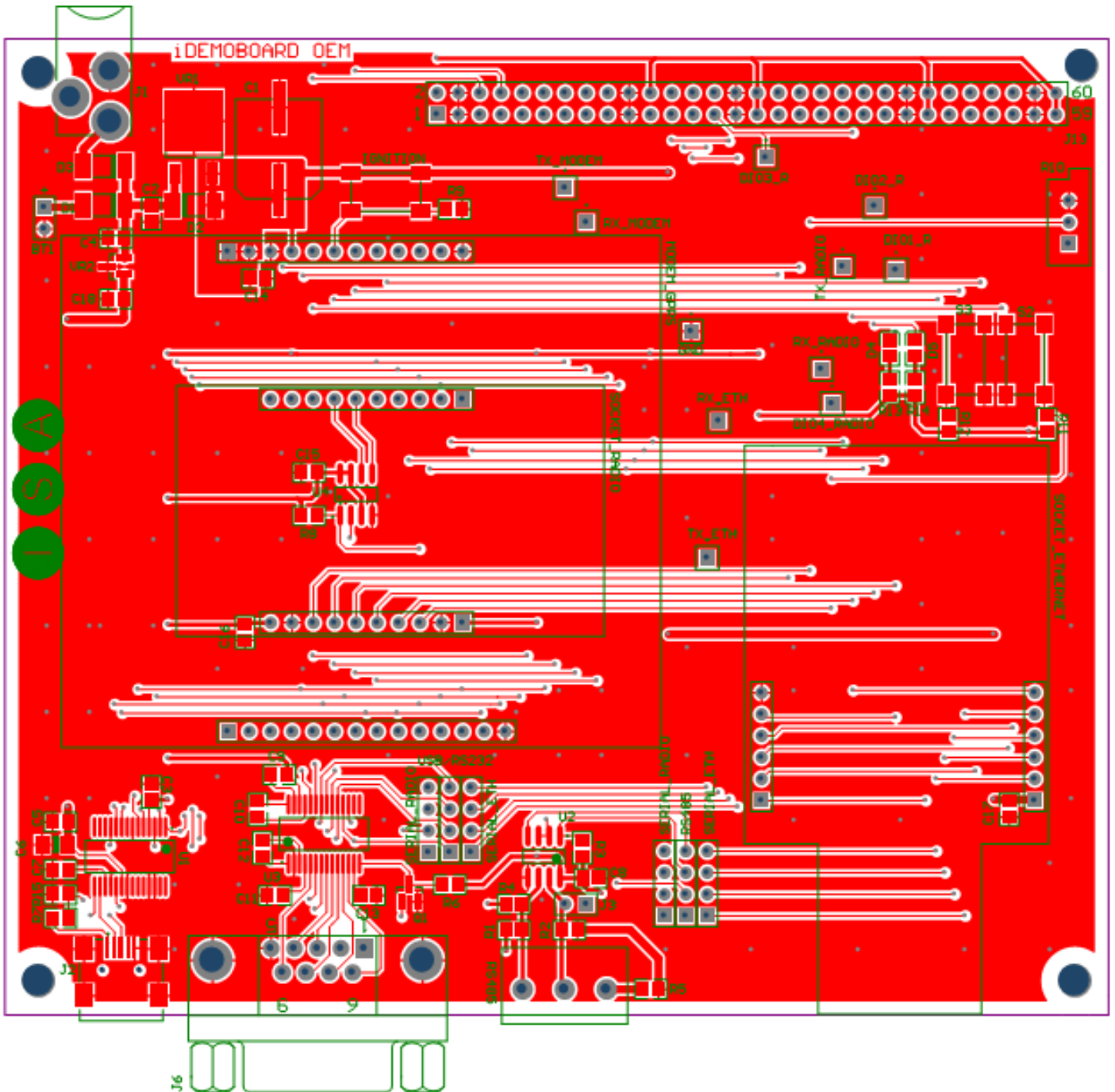


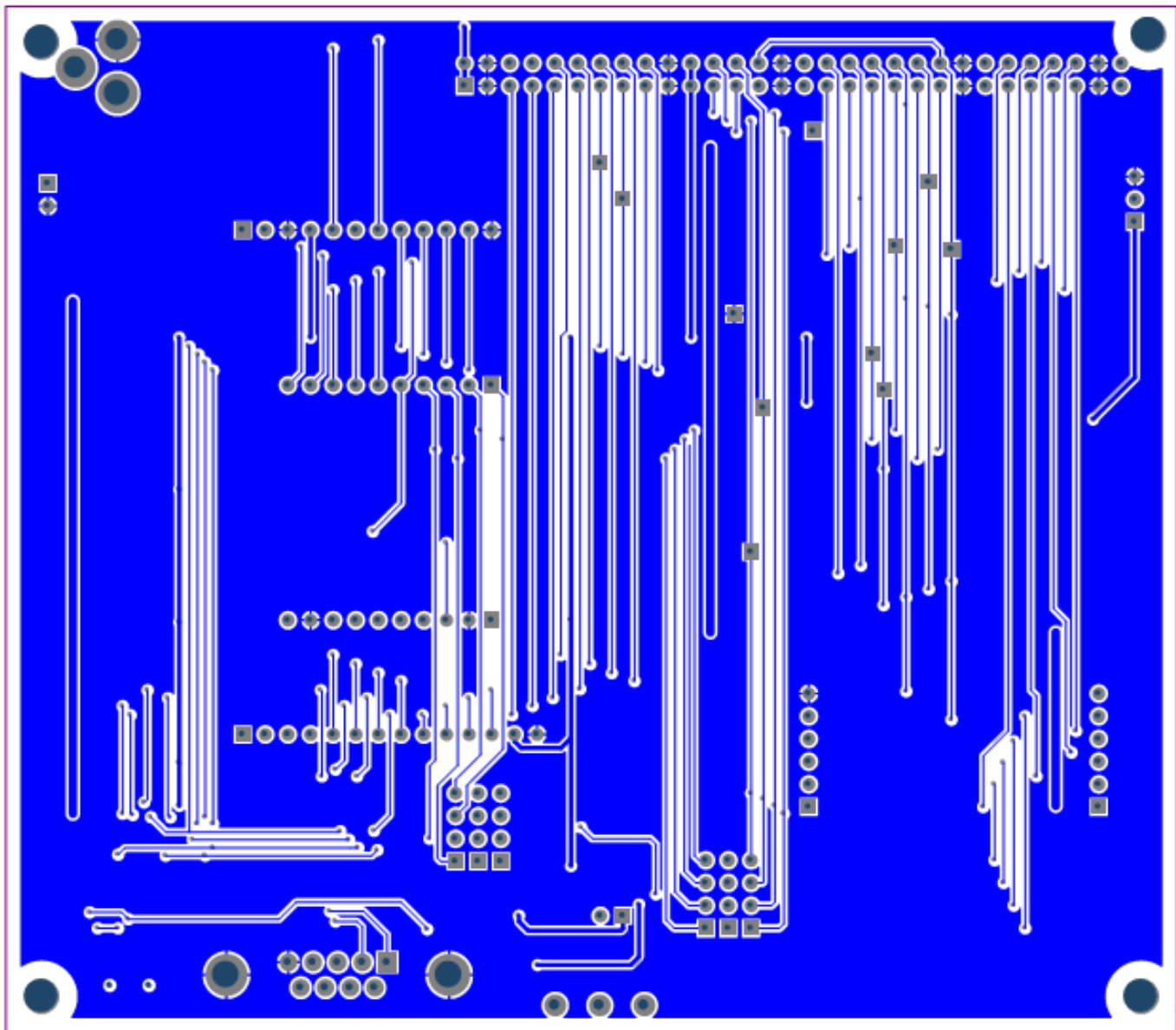
Project: iDEMOBOARD	
Module: Power Supply	
Name:	Developer: Artur Nais
Date: 2013-08-28	Version: 1.0



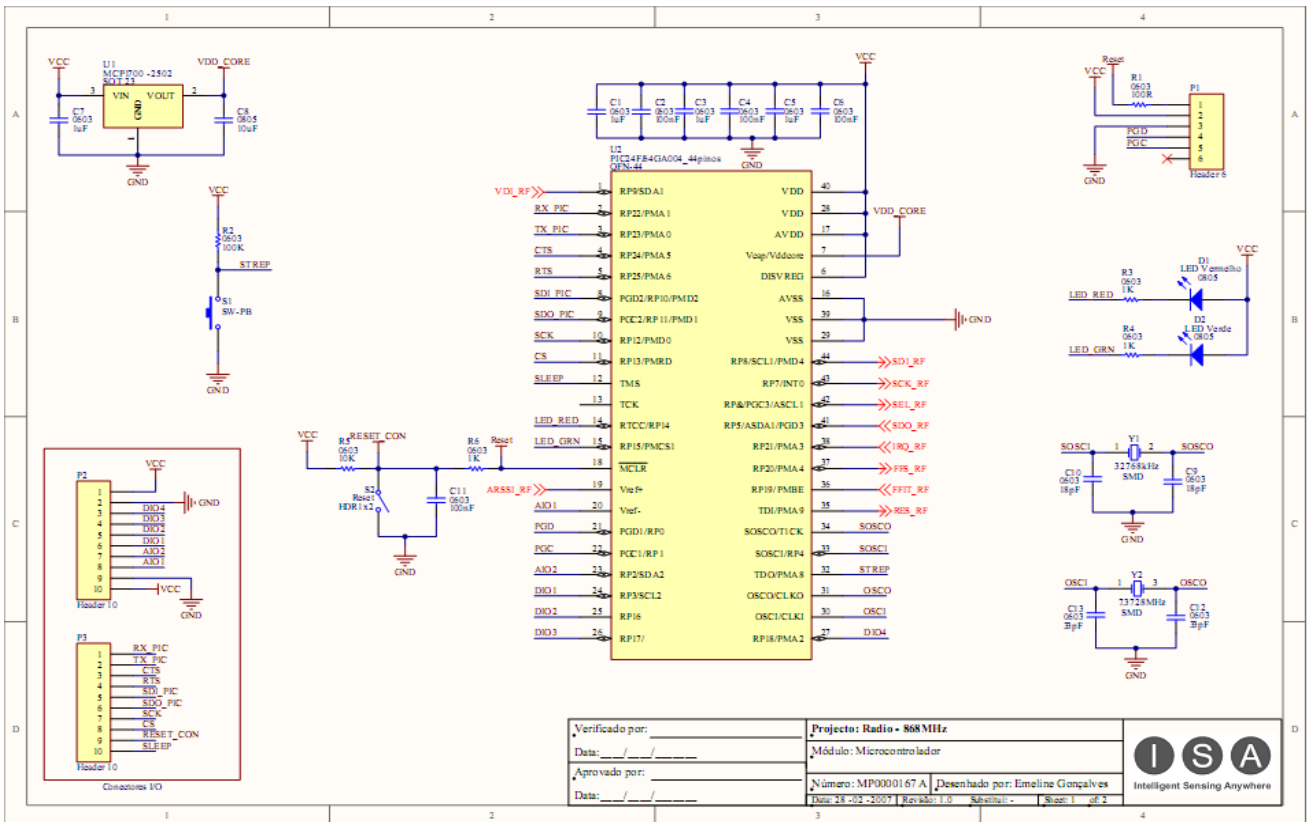
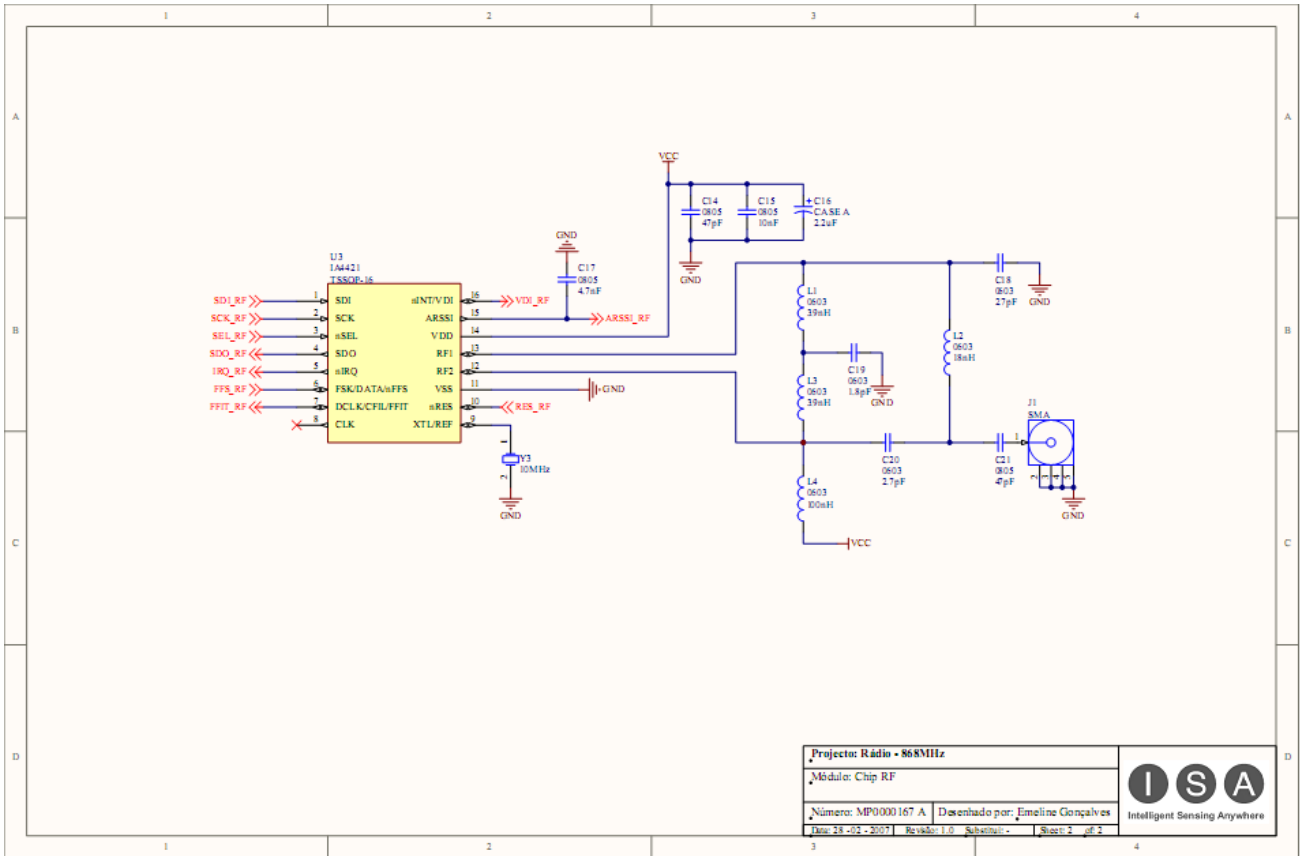


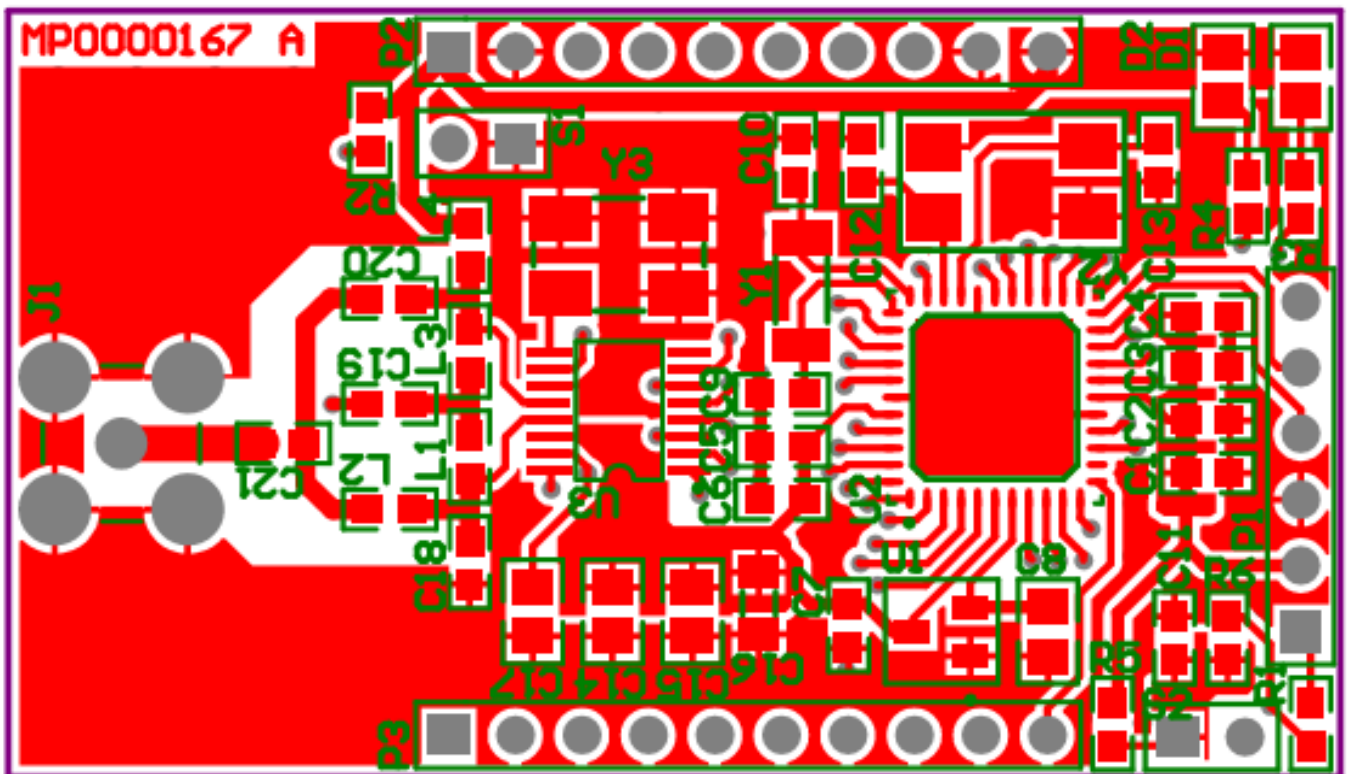
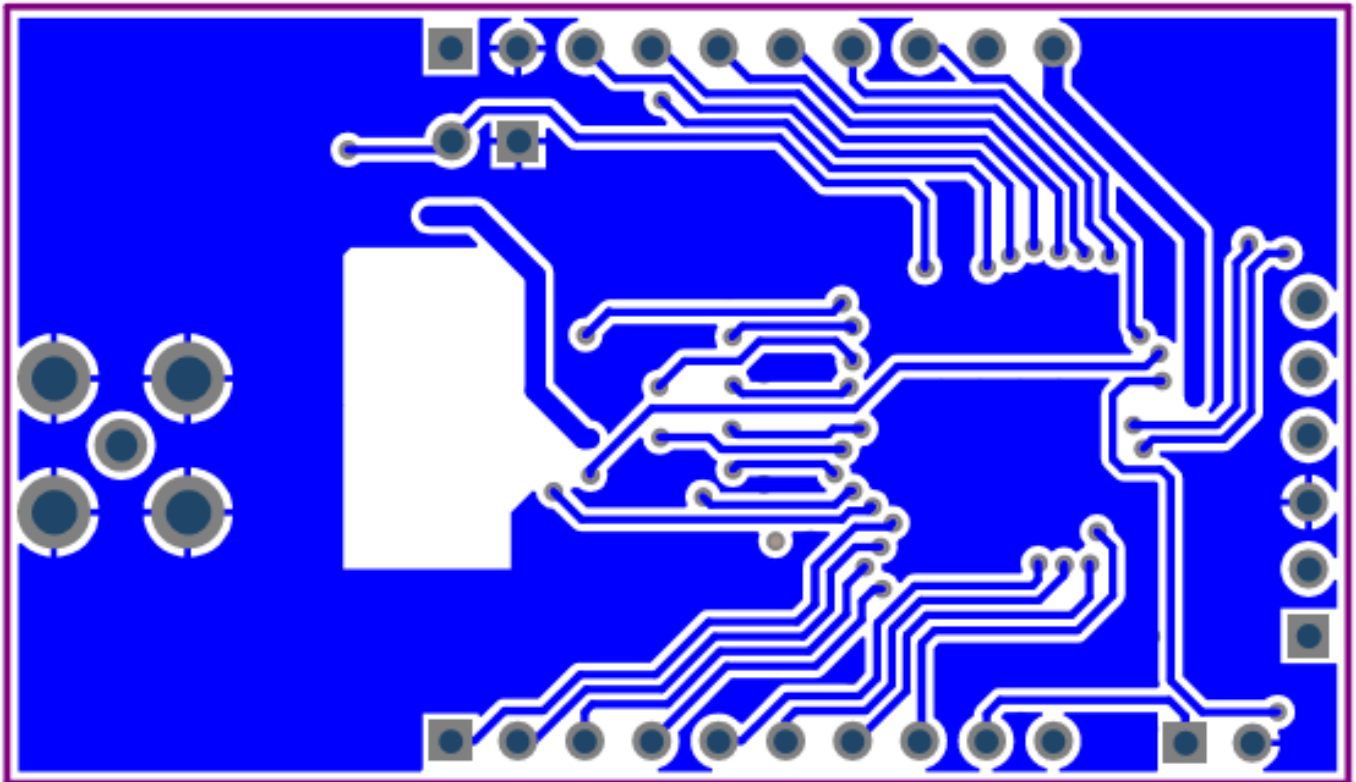






C.2. Socket Radio 868 MHz





C.3. Dongle Radio USB 868

