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Wireless Plataforms for the Monitoring of Biomedical Variables

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Abstract. The present paper aims to analyze and to compare two wireless platforms for the monitoring of biomedical variables. They must obtain the vital signals of the patients, transmit them through a radio frequency bond and centralize them for their process, storage and monitoring in real time. The implementation of this system permit us to obtain two important benefits; The patient will enjoy greater comfort during the internment, and the doctors will be able to know the state of the biomedical variables of each patient, in simultaneous form.

In order to achieve the objective of this work, two communication systems for wireless transmissions data were developed and implemented. The CC1000 transceiver was used in the first system and the Bluetooth module was used in the other system.

1. Introduction

The hospitals around the world are adopting the advantages of mobility, flexibility and speed of wireless networks LAN in medical applications. Today it isn't necessary to obtain the biomedical parameters in the patient's bed. This can be done from different joining points within the hospital,

through fixed or portable devices. In addition it is possible to know the patient's conditions in his home via Internet, and through cellular telephones. ^{[1][2]}

This technology makes that the handling of the intrahospitable medical information be exact and efficient making the hospitals most competitive. In this way, the information is available where and when it is needed.

In these atmospheres the users move freely within the hospital, without the restrictions associated with twisted networks. The personnel can move from one room to room in stead of staying in a place, hoping alarms, or checking control variables. The staff of the hospital has access to the information in real time, with all the variables required centralized in one or joining points, optimizing the task of control and supervision of patients.

The wireless implementation of platforms for the monitoring of biomedical signals, meets the necessity with indispensable equipment of medical monitoring to delayed sectors of the population, with national resources and developments; adapts technologies of general use such as personal computers to applications outposts of medical telemetry, with low costs; centralizes the tasks of control carried out bay doctors, optimizes the relationship between the patients and doctors; centralizes the storage of the released parameters.

2. Description

For the development of the work, two designed wireless platforms were chosen and implemented in the communications laboratory. Although both adapted for the monitoring of biomedical variables, they use different technologies and they work in different frequencies.

The first system has the frequency of 915 MHz. like carrier of information. However, in the second one, carrier frequency is 2400 MHz. Both frequencies operate in bands of radio frequency ISM (Industrialist - Scientific - Medical) [3], free of license and available for the developments of systems that use the wireless transmission of biomedical signals.

The topology of the radio network is in the form of star, for both systems, in which the control has a station base that is connected to a computer.

This topology uses a model of very robust network for the operation of the system, thus it is independent of the state of the remote modules.

By means of sequential interrogations to each of the remote stations, the information of the biomedical signals of each patient is obtained. [4]

In figure 1 is a scheme of a network stars.

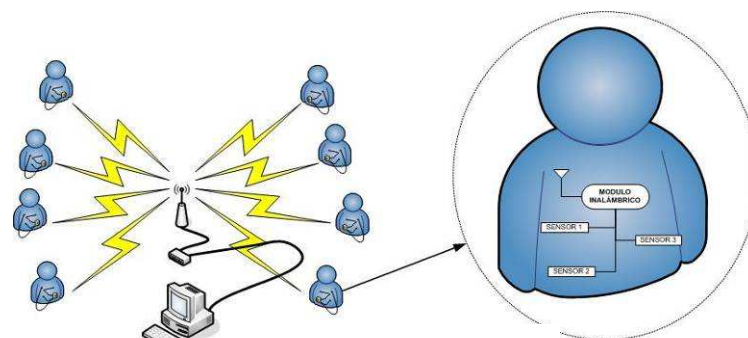


Fig. 1: Star Network

The studied and compared wireless platforms are described next:

2.1. PI-CC1000

The election of this platform and its adaptation to a system for monitoring of biomedical variables implies looking for new applications a wireless, developed and implemented module in our laboratory. The frequency used in this platform is 915 MHz.

In figure 2 a diagram in blocks describes to the system showing that it includes the modules that are located in the patient and the station base that is located in the control room.

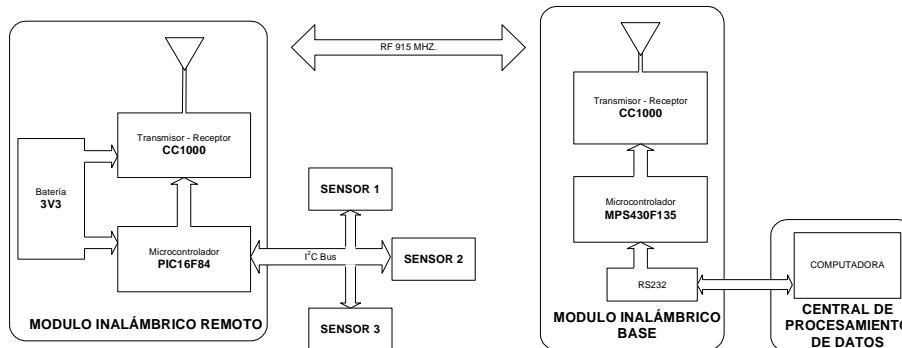


Fig. 2: System PI - CC1000

Such module PI-CC1000 is formed by an integrated circuit CC1000 (transmitting and receiving) (Chipcon, Norway), Microcontroller PIC16F84, a battery of 3v3 and a connection I²C Bus that make it possible to collect the data of the sensors of the biomedical variables, that we want to control and to register. In figure 3 module PI-CC1000 is appraised.

The station bases is constituted by a 2 CC1000 [1] [], Microcontroller MPS340F135 and a computer with a control software and registry of data developed in Visual BASIC.

Figure 4 is the transmission module and control of data located in the station bases.

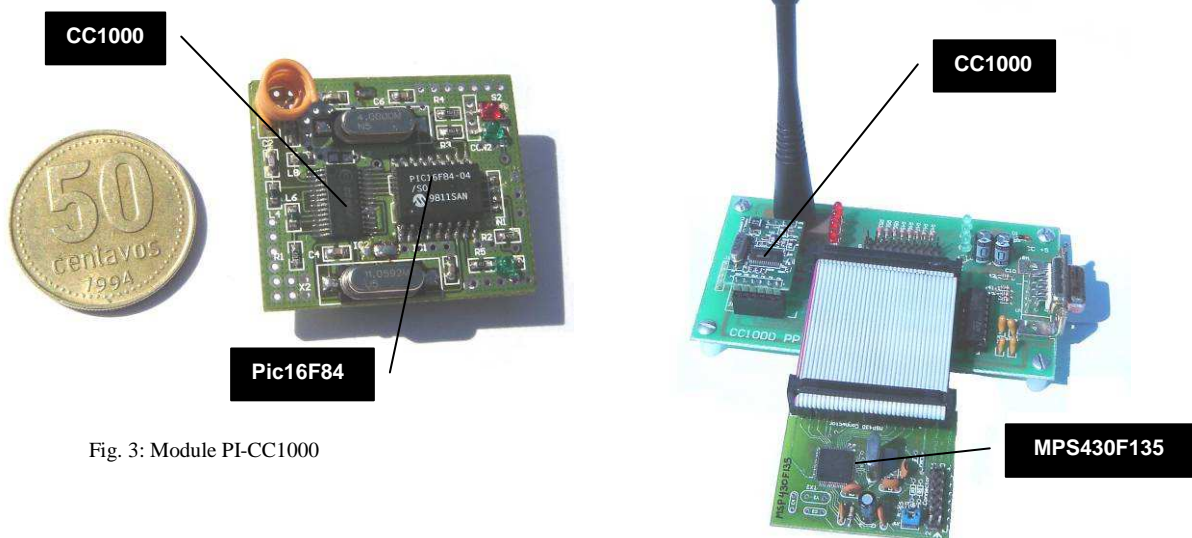


Fig. 3: Module PI-CC1000

Fig. 4: Station Base PI-CC1000

2.2. PI-Bluetooth

The second platform analyzed for the present work uses a Bluetooth module [3], denominated eb100, (A7 Engineering, the USA) and an interface for the computer were used a Pen-Drive-Bluetooth.

Besides the module eb100, the PI-Bluetooth module is constituted by a microcontroller PIC18LF4520 and the antenna. On the station it bases, a USB-Bluetooth adaptor is used, which will be

in charge of the connection of the remote modules with the computer. Firmware was developed in C for microcontroller PIC. On Figure 5 is a scheme of the system.

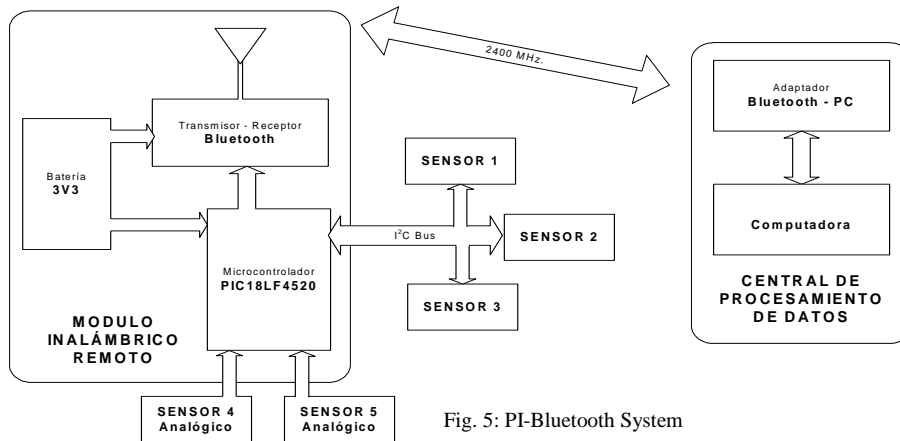


Fig. 5: PI-Bluetooth System

The microprocessor in this platform makes it possible to get the analogical signal, from the sensors, unlike the module PI-CC1000 that must receive the data in digital format from the sensors.

On Figure 6, shows the module Bluetooth transceiver and the integrated antenna.

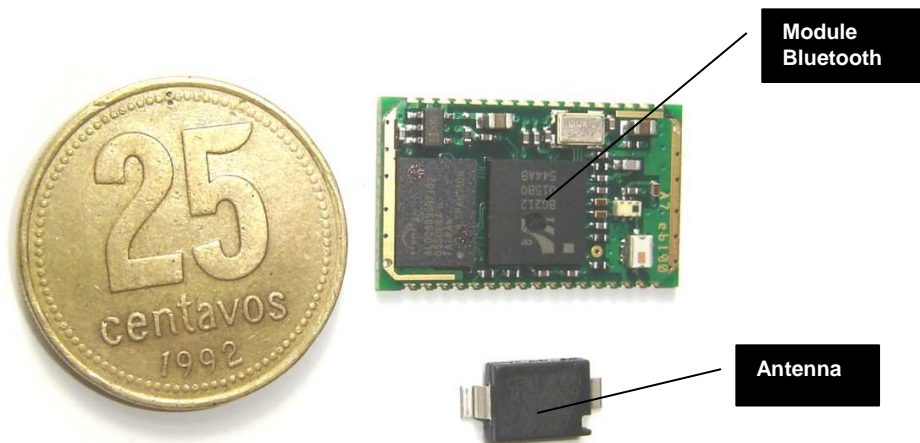


Fig. 6: Transceiver and antenna Bluetooth

2.3. The Station Base

The operation of the Station Base by the people in charge of the control and verification of the data is similar in both platforms. This is formed by a computer, a device of radio and software of management.

The functions of the station base are; to interrogate each module in sequential form, to collect the data, to visualize them, to store them and to indicate, by means of an alarm, when the obtained values are outside the normal parameters.

Software allows the visualization, the processing and the recording of the acquired parameters. Figure 7 presents one of the screens that show the biomedical variables of the monitored patients.

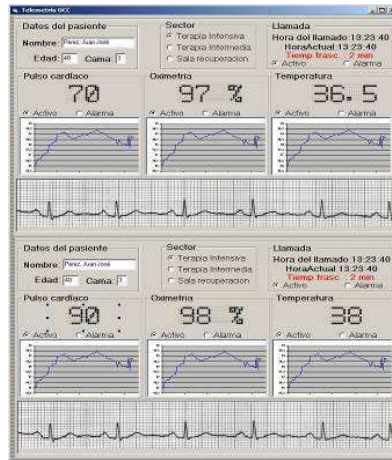


Fig. 7: Visualization screen

3. Methods and test

In order to evaluate the two wireless platforms theoretical studies and measurements were made on the following considerations:

3.1. Power of transmission, power of reception and attenuation.

The value of the power of reception in a communication system indicates the quality degree, of the signal that enters the receiver. From this parameter, the probability of the errors that can be produced in the transmission of the data is analyzed. This depends on the power transmitted.

Equation 1 indicates the relation between the transmitted power and the received power.

$$P_{RX} (dBm) = P_{TX} (dBm) - Aten(dB) \quad Ec.1$$

Equation 2 indicates as attenuation varies according to distance and frequency.

$$A(dB) = 32.4 + \log(D(km)) + \log(F(MHz)) \quad Ec.2$$

The measurements were made by means of an Spectrum Analyzer (GW-Instek GPS-827). In order to do this, a movable station and a fixed station were set. The movable station went away moving and the measurements corresponding to the power received based on the distance were obtained. This procedure was carried out for each platform.

The scheme of figure 8 shows the system implemented for the measurement.

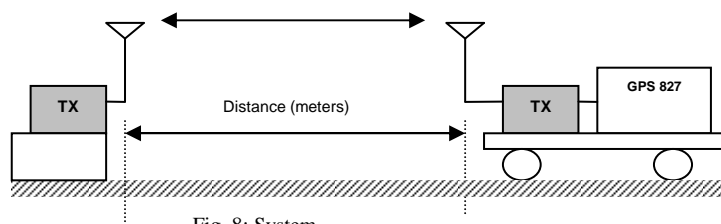


Fig. 8: System

3.2. Sensitivity

The sensitivity of each receiver makes it necessary to have the minimum value of the signal of Radio frequency so that the communication is realized without errors.

The sensitivity was verified varying the transmission power until the received signal, could not be decoded by the receiving module.

3.3. Speed of transmission

The speed trials were made transmitting data at different speeds and verifying that the data received in the receiving module were the correct ones.

3.4. Error in the transmission

For the study of the errors in the transmission a program was implemented, it is transmits constantly a data, controls the amount and verifies if it is obtained in correct form.

3.5. Compatibility with other equipment...

The study of compatibility was made verifying the compatibility of the communication protocols and test of communication with other equipment.

3.6. Size

A comparative study was carried out on the equipment and of the different antennas. It proved of great importance to verify the portability of the modules in the patients.

3.7. Stability of the system

The stability of the system is of high importance due to its application. The station bases of the system implemented with PI-CC1000 is independent of the state of the computer, warring when this one has problems and/or when the biomedical parameters of a patient are not the normal ones.

The station base of the PI-Bluetooth depends on the state of the computer, which reduces the stability of the system.

4. Results

4.1. The power transmission. The power reception. The attenuation.

The power of maximum theoretical transmission is +5dBm for PI-CC1000 and +6dBm for PI-Bluetooth. The measurement results are indicated in Table 1 and Figure 9.

TABLE 1
Power measured based on the distance

Len (m)	PI-Bluetooth	PI-CC1000
1	-37.45	-29.40
2	-44.06	-35.67
3	-48.22	-39.47
4	-51.40	-42.26
5	-54.04	-44.50
6	-56.35	-46.40
7	-58.43	-48.07
8	-60.35	-49.56
9	-62.15	-50.92
10	-63.84	-52.18
11	-65.47	-53.36
12	-67.02	-54.47
13	-68.53	-55.52
14	-69.99	-56.53
15	-71.42	-57.50
16	-72.82	-58.43
17	-74.18	-59.33
18	-75.53	-60.20
19	-76.85	-61.05
20	-78.15	-61.88

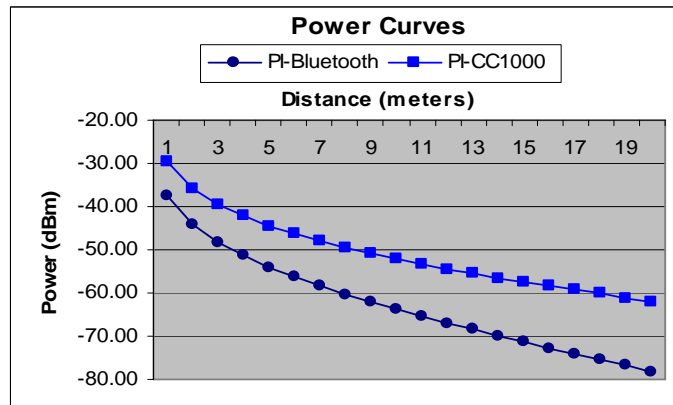


Fig. 9: Power curves

Considering these measurements it is possible to conclude attenuation depends on the distance and frequency, the first parameter affects both platforms equally, but the second does not. Equation 2 proves that the difference is 8,38 dB. Figure 10 indicates how attenuation varies according to distance.

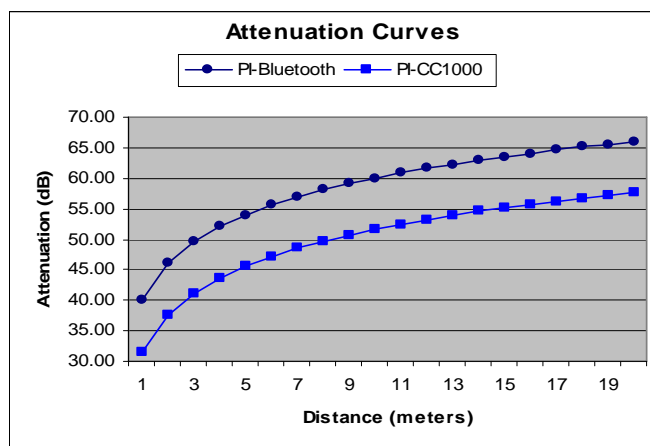


Fig. 10: Attenuation Curves

4.2. Sensitivity

The sensitivity PI-CC1000 is -80dBm, and for PI-Bluetooth: -76dBm. In the application that is used both platforms a threshold was defined security of 20 dB.

4.3. Speed of transmission

The speed of transmission for PI-CC100: bps to 56K has a speed of 600 bps and PI-Bluetooth: 9600 bps to 230.4K bps. Table 2 shows the made tests

TABLA 2: Speed Test

	Speed	Data less
PI-CC1000	600 bps	Nothing
	1200 bps	Nothing
	2400 bps	Nothing
PI-Bluetooth	9600 bps	Nothing

4.4. Error in the transmission

Several cycles of 5000 plots were carried out, obtaining 95 % efficiency.

4.5. Compatibility with other equipment.

PI-CC1000 is our development with a proprietary protocol, characteristic that makes it incompatible with other equipment.

PI-Bluetooth is compatible with any movable device that has the system of Bluetooth communication, the communication tests were realized with cellular telephones and Palm.

4.6. Size.

In table 3 it indicates the size of the modules.

TABLA 3: Modules' Size

	length	width	height
PI-CC1000	37 mm	30 mm	18 mm
PI-Bluetooth	57 mm	43 mm	12 mm

Figures 3 and 6 show the antennas used for the tests. Although they are similar size the antenna of the PI-Bluetooth has greater efficiency. In table 4 the size of different antennas for both platforms is compared.

TABLA 4: Antennas

Antenna	Substrate RF-4	PI-Bluetooth		PI-CC1000	
		length	width	length	width
Dipole Half Wave	H=1.6 mm	34.6373 mm	3.1744 mm	91.3237 mm	3.16779 mm
	H=0.8 mm	34.7856 mm	1.58334 mm	91.4132 mm	1.58446 mm
Dipole Quarter Wave	H=1.6 mm	17.3186 mm	3.17144 mm	45.6619 mm	3.16779 mm
	H=0.8 mm	17.3928 mm	1.5833 mm	45.7066 mm	1.5844 mm

4.7. Stability of the system

The result obtained from the stability study showed that the system implemented with PI-CC1000 is more stable than the one implemented with PI-Bluetooth.

5. Discussion

The first conclusion obtained from the present work is that both platforms can, generally, be applied in a system of wireless monitoring for biomedical signals.

The coverage area is greater for the platform PI-CC1000, that a reach of 19 meters while the PI-Bluetooth has 7 meters, but both manage to cover the area for monitoring.

The attenuation generated by the obstacles is smaller in the PI-CC1000, which is due to the frequency; this advantage can be very important depending on the infrastructure of the place where the system is set.

The Platform PI-Bluetooth has a greater data transfer rate.

The standard protocol of PI-Bluetooth allows integration with other movable devices (Pda, Cellular). This is not possible with the platform PI-CC1000, which has a proprietary protocol.

With respect to the size of the movable equipment, both platforms have the suitable size, but the size of the antenna is considerably smaller in the PI-Bluetooth.

The station bases corresponding to platform PI-CC1000 is independent of the Computer, and can, for example activate alarms.

In the system using the PI-Bluetooth platform, the station base depends on the state of the computer, leaving it without control when the same has some problem. As a reliable has to be set system changes in the station bases must be made.

6. Gratefulness

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