DESIGN OF A MOBILE TELECARDIOLOGY SYSTEM USING GPRS/GSM TECHNOLOGY

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Abstract- **This paper presents the design and development of a portable electrocardiograph to allow the on-line remote monitoring and real-time cardiac diseases diagnostics of patients from the specialist. This prototype has been satisfactory implemented finding a good balance between optimal signal processing and power consumption using a GPRS/GSM modem and a SMT low voltage microprocessor board.**

Keywords-**GPRS, ECG(Electrocardiogram), SMT(Surface Mount Technology), microprocessor, wireless communication**

I. INTRODUCTION

Future applications of mobile telemedicine systems are useful and potentially powerful tools to improve the quality of healthcare, particularly in remote and underserved areas [1-2]. Additionally, telemedicine services in cardiology must be offered by keeping the cost in low levels.

A preliminary system was presented as a portable electrocardiograph/holter equipment with telephony and GSM transmission [3]. If the patient feels bad or the heart rate is abnormal, he will connect to the medical center to transmit the recorded ECG. Up to date, a holter stores the acquired ECG to be transmitted later. Moreover, the problem is that a continuous transmission requires a huge amount of information and time. From the economical point of view, GSM does not represent a valid option for this kind of application. Currently, a novel service GSM-based (GPRS) and the third generation of wireless networks (3G) are being implemented [4].

In this article we will describe a portable equipment for the acquisition, preprocessing and transmission of the ECG signal and the GPRS/GSM network used to send the ECG signal to a host computer in the medical center with a database, allowing continuity of care. If the medical center cardiologist needs, he will connect to the medical center to transmit the recorded ECG without the patient realizes. Specialists can advise to the patients before alarms happen thanks to a 24-hour duty service that detects rapidly cardiac diseases in advance. GPRS modem provides a data channel and also a GSM voice channel for the wireless communication between patient and specialist. Additionally, the host computer could implement an internet site, so the information will be consulted from hospitals or other specialists.

II. TELEMEDICAL NETWORK

A block diagram of the whole system is shown in Figure 1. The system including the portable ECG acquisition consoles connected to patients; the base station (BS) receiving information; the GPRS communication protocol to transmit the continuous ECG with a minimum delay; the GSM voice channel to allow a doctor to establish a direct call and the Internet access to a database host center to monitor patient from an authorised European hospital, may become a complete cardiology network.

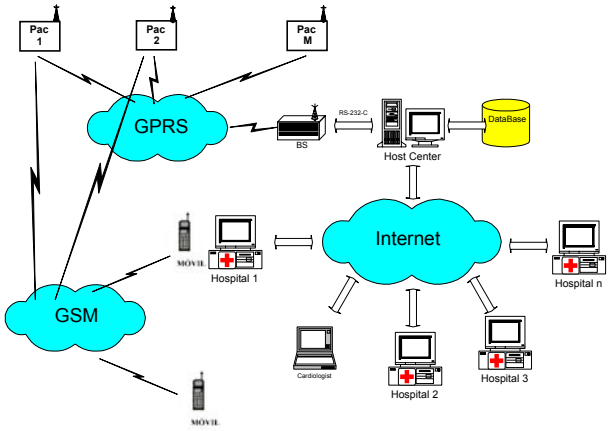

Figure 1. A block diagram of network

The database system module saves the patient records along with their ECGs and other relative information including all the fields that requires at the appropriate format such as clinical treatment, symptoms, etc. This open database architecture can be used as a telemedicine gateway to other systems located at rural or isolated areas [5].

III. PROTOTYPE AND RESULTS

In a first phase a prototype has been developed using the data channel of GSM. In the final second phase, this prototype has been migrated to GPRS, which allows the use of data packets without a connection-oriented service. According to Figure 2, it consists in the integration of three critical blocks in a device: an electrocardiograph, an efficient digital processing block and a GPRS/GSM modem. It is a pocketsize device with a low voltage electrocardiograph signals acquisition module captured with three standard leads electrodes attached to standard patches. The equipment can be directly applied on different studied positions of the patient's chest to detect some relevant pathologies without the limitation of a fixed distance among the patches.

The electric cardiac signal given by the electrodes passes to the amplifier (by a scale factor of 1000), an appropriate low-pass filtering and digital conversion stage using the 8-bit ADC of the microcontroller. The hardware is customised to the application requirements: low voltage detection watchdog failure system, parallel and serial ports

for interfacing, timers and multichannel 8-bit A/D converters. The Motorola MC68L11 is the low voltage version of the MC68HC11 microcontroller family. That implements the whole digital processing stage that includes heart rate detection, the IP protocol and link with the GPRS/GSM modem. As this GPRS/GSM modem includes a data and a voice channel for the direct communication between the patient and the cardiology specialist, a microphone and a loudspeaker has been included.

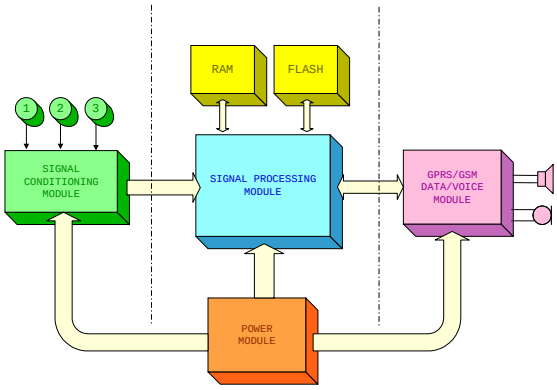

Figure 2. A block diagram of PAC

The integrated modem is a product with a SIM connector as well as a standard RF connector type MMCX (Miniature Micro Connector). From the electronic point design of view, the most critical task has been the integration of an electrocardiograph and the data modem. Special care has been taken in order to minimize the electromagnetic interference that a power RF stage can exert on an electrocardiograph that amplifies signals in the range of mV(cardiac input signal in the order of mV and 2 Watts of RF signal). This goal has been achieved designing a special shielding scheme to avoid ECG distortion.

All the integrated circuits used have the possibility of a shutdown mode, to save battery. The sampling rate is 100 Hz to reject induced noise from 50 Hz power lines. To improve the quality of the signal, a 50 Hz notch filter has been implemented. Power line interference is the main source of noise. Common mode rejection ratio of the differential amplifier, the antialiasing low pass filter and the band reject filter digitally implemented avoid the corruption of the signal. A RS-232-C serial communication link is needed to provide communication from the host to a personal computer. The next figure (Figure 3) shows an ECG signal transmitted on-line.

IV. CONCLUSIONS

A portable electrocardiograph-holter equipment including a GPRS/GSM data modem has been optimised of space and consumption, revealing that concept was technically feasible. The main innovation of our research is the recently application of a wireless technology, such us GPRS/GSM, to solve the problems of continuous monitoring of the current cardiology devices. This prototype can be used autonomously, with the modem GPRS/GSM equipment. The main target of the prototype consist of providing customers a teleassistance service with a 24 hours medical center. This system will also set up a novel collaborative environment to share data for continuity of care. The feedback information from the medical center has demonstrated that the algorithm implemented is well suited for the majority of patients.

Figure 3. A on-line electrocardiogram

The protocol layers of GPRS over IP has been implemented following the current standards. Measurement performance of the systems analysing the transmission packet sequence and failure latency has found relevant results. GPRS and Internet errors may be reported via encoded messages. Need of data privacy and an efficient transmission bandwidth is directing the study of data encryption and compression by wavelets [6].

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