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A Real time Data Acquisition and Monitoring Device for Medical Applications based on Android Platform

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Abstract

An android based real time data acquisition and monitoring device is presented here. The system finds its initial application in medical field .it serves as a remote monitor for measuring and analysing along with logging of data from patients. The system comprises of two parts. A data acquisition (DaQ) part connected to patient side and an android based display device on the receiving end. The Data Acquisition part contains sensors for picking up the vital signs from the patients, signal conditioning circuits and a Bluetooth transceiver to transmit data wirelessly to the display device. The Display Device then displays the data received from the transmitter in a readable form and also logs the data into a excel form so that it can be taken out digitally and analysed.

Keywords

Medical field, android platform, data acquisition, Bluetooth, data logging

1. Introduction

Scientists, engineers and clinicians record experimental data to evaluate physiologic responses with medical devises during acute and/or chronic testing. Assessing cardiovascular function on a systems level requires the periodic or continuous measurement and monitoring of pressures, flows, volumes and /or electrocardiogram. The outputs of the transducers used to measure these physiological waveforms are typically in microvolt or mill volt range, and, in subsequently, they require signal conditioning to provide amplification and/or offset to maximize the input range of recording devices to optimize data integrity.

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Ambulatory bio-potential monitoring is a good method for detecting heart disease and is useful in many situations, including community clinics, in homes and in hospitals. Several studies have attempted to provide continuous bio-potential monitoring for situations occurring in everyday life. A good example of ECG monitoring is the Holter system .The bioelectrical potentials generated within the human body are the result of electrochemical activity in the excitable cells of the nervous, muscular or glandular tissues. The ionic potentials are measured using biopotential electrodes which convert ionic potentials to electronic potentials. The commonly monitored biopotential signals are Electrocardiogram (ECG), Electroencephalogram (EEG) and Electromyogram (EMG). The electrodes used to monitor biopotential signals are Ag-AgCl and gold, which require skin preparation by means of scrubbing to remove the dead cells and application of electrolytic gel to reduce the skin contact resistance.. The paper presents the design and development of biopotential data acquisition and processing system to acquire biopotential signals from electrodes. The biopotential signals are processed using an instrumentation amplifier with high CMRR and high input impedance achieved by boot strapping the input terminals. The processed biopotential signals are digitized and transmitted wirelessly to a remote monitoring Android Device.

Earlier strip chart recorders were used for recording and analyzing data. Although acceptable with proper use and analysis, extrapolation of key physiological parameters using this method was tedious and time consuming. The objective of this project is to develop an integrated data acquisition system (DaQ) and documentation strategy for monitoring and recording physiological data when testing medical devices through a wireless platform based on latest android platform. The primary advantages to the digital approach are the ability to store large volumes of data, to perform waveform analysis and to analyze more data in a faster, more efficient manner by taking advantage of the processor speed. Taking this into consideration that almost every android device in the market now runs on a processor not less than a speed of 1 GHz, which more enough to get a good speed for processing the data.

2. Block Diagram

The system consists of a Data Acquisition System coupled with the electrodes to pick up vital signals from the human body. The system is equipped with an analog front end which facilitates the signal extraction and conditioning.

System also has a PIC microcontroller for converting the analog signal extracted to digital form and to send to the Bluetooth transceiver for communication. This section also equips the system with USB-HID capabilities so to interface with computer hardware if needed. The block diagram of the system is as

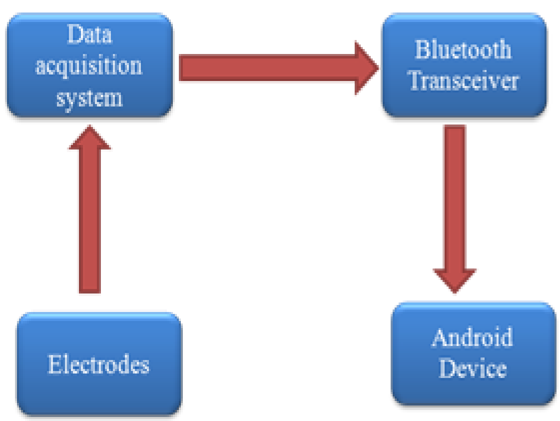

Figure 1: Block Diagram of the System

a. Data Acquisition System

Data Acquisition part is the heart of the system which is wired around a dsPIC33FJ16GS504 controller from Microchip Inc for the analog to digital conversion of the input signals on two channels. The conditioned signal from the analog front end is fed to the PIC microcontroller for conversion and the digital output is fed to the Bluetooth transceiver. DsPIC33FJXXGSXXX SMPS & Digital Power Conversion is a 16-bit Digital Signal Controller from Microchip INC. It has a 10 bit resolution ADC with up to two Successive Approximation Register (SAR) converters (up to 4 Msps). Detailed figure of the system is as in Figure 2. [1][4]

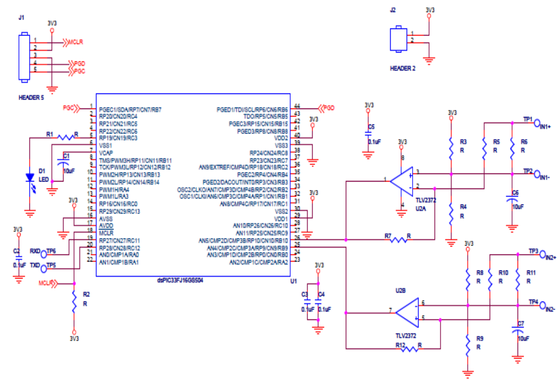

Figure 2: Data Acquisition System Schematic

i. Power Supply

The Data Acquisition part is powered from a 3.3 V power supply to keep the power requirements of the microcontroller and the transceiver used. The 3.3V ensures the current drawn from the battery to the minimum and it can be powered from a 3.3V button cell battery. The power supply system powers the Analog front end, Bluetooth Transceiver and the PIC Microcontroller.

ii. Analog front end

The analog front end contains two separate sections for each channel. The analog front end limits the input voltage to a level recognized by the controller and restrains from rising above the ADC reference level.[2][3].

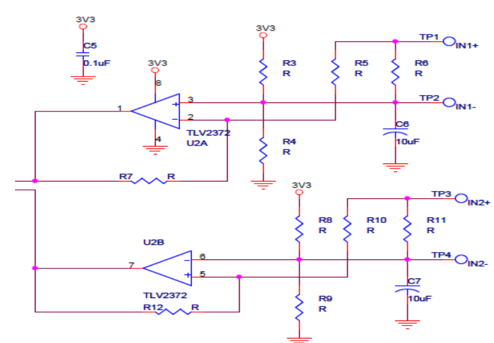

Figure 3: Analog Front End (Instrumentation Amplifier)

The front-end bio-potential acquisition chip included an ultra-low-power instrumentation amplifier (IA), filter, and gain stage. Also, noises interfere with bio-potential signals coupled to the human body. Under these circumstances, front-end circuits with a high common mode rejection ratio (C.M.R.R.), power supply rejection ratio (P.S.R.R), low-noise, and filters are required to extract signals. The proposed processing chip has low-power consumption, low noise, and high C.M.R.R. properties. These features make it a feasible bio-potential signal acquisition device. Furthermore, this proposed recording device can process and store bio-potential signal data. It is reusable, has low power consumption, and is portable. Users may record their bio-potential signals anywhere without the use of wireless receiver devices. This device can also easily be integrated with consumer electronics devices.

The analog front end (Figure 3) integrates the low-power front-end bio-potential acquisition circuit, MCU, and SD card (optional as a future add-on) for the purpose of recording the bio-signal. The proposed acquisition system can be used long-term and is more comfortable than other alternatives.

b. Bluetooth Transceiver

The Bluetooth transceiver module used for the setup is RN42 series from spark fun electronics-Bluesmirf series. The RN42 is a small form factor, low power, highly economic Bluetooth radio for OEM's adding wireless capability to their products. The RN42 supports multiple interface protocols, is simple to design in and fully certified, making it a complete embedded Bluetooth solution. The RN 42 is functionally compatible with RN 41. With its high performance on chip antenna and support for Bluetooth® Enhanced Data Rate (EDR), the RN42 delivers up to 3 Mbps data rate for distances to 20M. The RN-42 also comes in a package with no antenna (RN-42-N). Useful when the application requires an external antenna, the RN-42-N is shorter in length and has RF pads to route the antenna signal.[1][2][3]

The specifications of the established communication link is as

- Baud rate speeds: 1200bps up to 921Kbps, non-standard baud rates can be programmed.
- Class 2 radio, 60 feet (20meters) distance, 4dBm output transmitter, -80dBm typical receive sensitivity
- Frequency 2402 ~ 2480MHz,
- FHSS/GFSK modulation, 79 channels at 1MHz intervals
- Secure communications, 128 bit encryption
- Error correction for guaranteed packet delivery
- UART local and over-the-air RF configuration
- Auto-discovery/pairing requires no software configuration (instant cable replacement).
- Auto-connect master, IO pin (DTR) and character based trigger modes

Derived characteristics of the communication link

Table 1: Bluetooth hops in a pseudo-random fashion over the 79 frequencies in the ISM band to adapt to the interference. Data throughput and range vary depending on the RF interference environment.

2.7<VDD<3.0V	Min	Typ	Max	Unit
Input Logic Level Low	-0.4	-	+0.8	V
Input Logic Level High	0.7VDD	-	VDD+.4	V
Output Logic Level Low	-	--	0.2	V
Output Logic Level High	VDD-0.2	-	-	V
Default Weak Pull Down	+0.2	+1.0	+5.0	uA

Figure 4(a): Spark fun Bluetooth Module

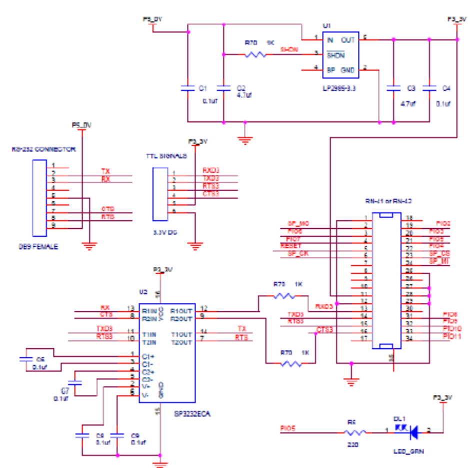

Figure 4(b): Wiring Schematics of the Module

The two design aspects of the module design are

i. Minimizing Radio interference.

When laying out the carrier board for the RN42 module the areas under the antenna and shielding connections should not have surface traces, GND planes, or exposed vias. (See diagram to right) For optimal radio performance the antenna end of RN42 module should protrude 5mm past any metal enclosure. [1]

ii. Antenna Design.

The pattern from the rf_out terminal pad should be designed with 50ohms impedance and traced with straight lines. The rf_out signal line should not run under of near the RN21 module. The GND plane should be on the side of the PCB which the module is mounted. The GND should be reinforced with through-hole connections and other means to stabilize the electric potential as in Figure 5.[1]

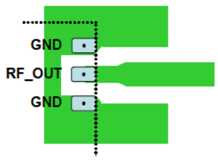

Figure 5: Ground Plane Schematics of the Antenna

The software for the android device is developed in Java platform using Windows SDK bundle for android. The display includes a canvas were the waveforms are being plotted. Figure 6(b) shows the data acquired in the screen and how it's displayed. It contains a button to connect to the Bluetooth module and to pair with it. It uses the well known UUID 00001101-0000-1000-8000-00805F9B34FB for the Bluetooth RFCOMM/SPP [4][5]

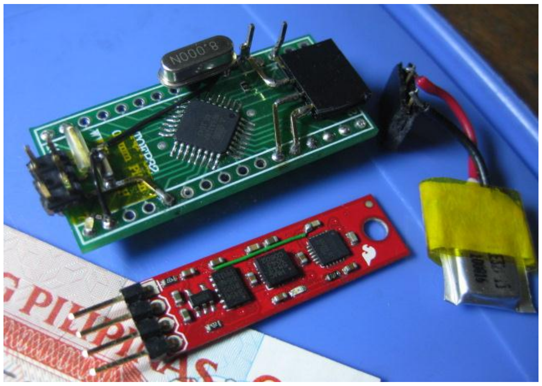

Figure 6(a): Bluetooth module and Microcontroller board

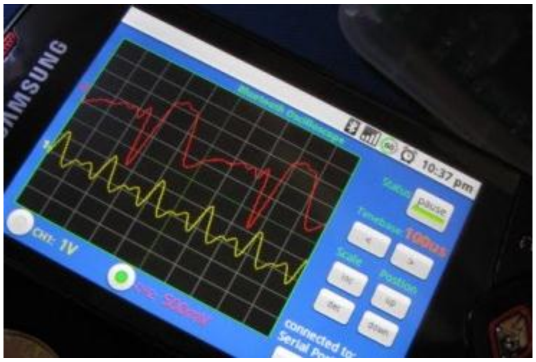

Figure 6(b): Software Running on Android Device

3. Conclusion and Future Work

The system as such is made for acquiring of bio potential data but can be extended to other domains also. The microcontroller used can be replaced with a more sophisticated system like to include analog front end processing also. Thereby a much reduction in size can be achieved for the front end side. The Bluetooth module used can be replaced with SMD modules also.

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