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LOW COST MEDICAL DATA ACQUISITION SYSTEM USING AVR-MCU AND PC

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ABSTRACT

A low cost multi-channels data acquisition system for medical signals has been designed and implemented, using personal computer (PC) and AVR-MCU ATmega16L. The system is capable of displaying bioelectric signals such as electrocardiography (ECG) signal for a patient. Temperature, blood pressure, hart rate . ..etc, can also be displayed as (text) together with the bioelectric signal on PC monitor in real time. The implemented system can be used near the patient in an emergency room or at home. The patient data can be processed and or relayed to physician via internet to monitor the patient status.

Keywords: *Acquisition, ECG monitoring, AVR.*

1. INTRODUCTION

Acquiring and displaying medical signals together with the values of some medical parameters is very important for patient monitoring, and medical diagnosis. Many acquisition systems were suggested for acquiring slow changing signals such as pH values of solutions and displaying it on an LCD using a microcontroller [1]. Luharuka et al [2] suggested an acquisition system to acquire the galvanic skin response (GSR) data using a PIC microcontroller and PC. Saraf et al [3] proposed an acquisition system to acquire the motor vibrations signal and displaying it on PC screen to detect motor faults, using microcontroller. In this paper an acquisition system is proposed to acquire and display bioelectrical signal (ECG), together with other medical parameters (temperature, systolic blood pressure, ..etc). The ECG signal can be acquired from any ECG monitor, while temperature and pressure are acquired from suitable sensors via a conditioning circuit. These signals are acquired directly to the AVR ATmega16L, and relayed to the PC for displaying the ECG signal together with the values of temperature and pressure. Further processing of the ECG signal to calculate the hart rate, for example, is also possible. Once these signals reach the PC they can be sent via local network, wireless LAN, or intranet to a distant PC to be monitored by a specialist physician.

2. AVR SPECIFICATION

The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The ATmega16 features a 10-bit successive approximation analog to digital converter. The ADC is connected to an 8-channel analog multiplexer which allows 8 single-ended voltage inputs constructed from the pins of port A.

The ADC analog input accept a voltage signal between (0 - VREF). The conversion time is between (65 - 260 μs). The sampling rate can be up to 15 KSPS at maximum resolution [4].

3. SYSTEM LAYOUT

The implemented system involves two main functions. The first is to acquire one or more ECG signals (from an ECG monitor) together with other patient medical parameters such as temperature and blood pressure. The second function is to relay these signals to a personal computer , and to display the ECG signals (as graph), together with the patient temperature and blood pressure (as text). These two functions require both hardware circuit, and the necessary software to be implemented.

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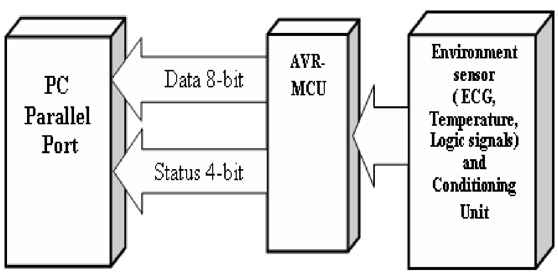
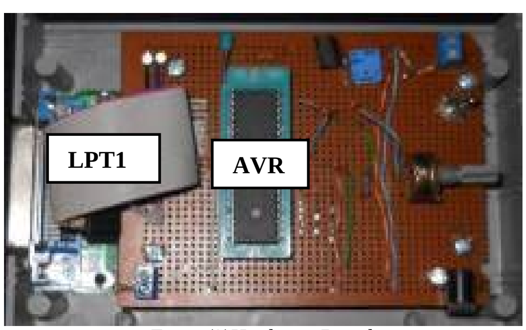
4. HARDWARE CIRCUIT

The hardware circuit (acquisition circuit) consists of environment sensor, conditioning unit, and the AVR-MCU (figure 1). The acquired data are relayed to the PC (through printer port). The clock Generator of the AVR-MCU was programmed to operate at 8 MHZ. To reduce software delays, only the least significant 8-bit of the ADC were used. The VREF of the ADC is programmed to be 2.56V. Hence the maximum input voltage for the ADC (VREF /4) is 0.64V. A thermister probe was used as temperature sensor to convert the human temperature to analogue voltage signal. This signal was applied (after conditioning) to the first channel (PA0/ADC0) of the AVR-MCU. The second channel (PA2/ADC1) in AVR-MCU was used for acquiring the ECG signal. The third channel (PA2 pin) was used to acquire logic signal (ON/OFF switch) which can be used to call the nurse. Other channels (port A lines) can be used to acquire the same signals from another patient. Figure 2 shows a picture of the implemented hardware.



Figure(1) System hardware block diagram



Figure(2)Hardware Board

Computer interface was implemented via standard parallel port LPT1 (378-380) using printer cable (1-2m in length). This interface was chosen due to its simplicity and fast data transfer. The 8-bit data bus, ground pin, and The 4-bit status pins of the parallel port were used as shown in table (1). The 4-bit status signals were used to define the acquired channel see table (2).

Table (1) parallel port pins function

Pin	I/O	Bus	Function
2-9	In put	Data	ECG, Temp., logic signal
10,12 13,15	In put	Status	Channel selection

Table (2) Status Bus Function

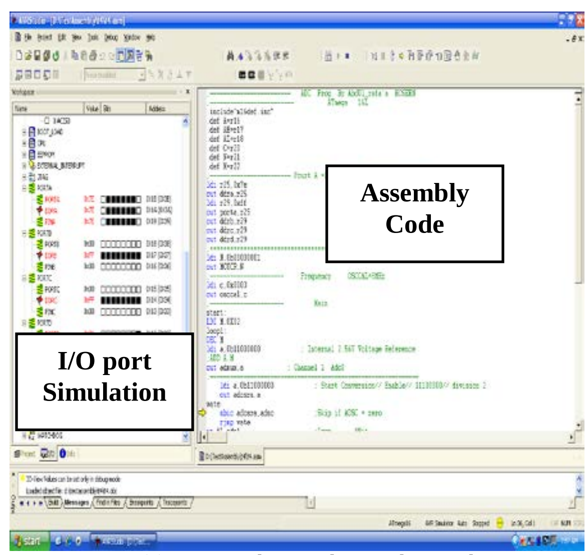
S6	S5	S4	S3	Data Bus	The selected AVR channel
0	0	0	0	Temperature signal	PA0/ADC0
0	0	0	1	ECG signal	PA1/ADC1
0	0	1	0	Logic signal	PA2
X	X	X	X	----	----

5. SOFTWARE DESIGN

The software involves two parts. The first part is programming the AVR in assembly language to acquire the ECG, temperature, and logic signals. These acquired signals are then relayed to the PC. The second part of the software is to receive the data of these signals, and to display them using visual basic language.

5.1 AVR SOFTWARE

The AVR software was written in assembly language using AVR-Studio package. This package is a simulator and compiler for the AVR-MCU. Figure 3 shows one screen from this software package where the code and the simulation output data are shown.



Figure(3) AVR-Studio Simulator and Compiler

The Written software (figure 4) includes an initialization and a loop. The loop includes staring conversion, getting the ADC digital outputs, sending these data to the AVR port (B), and the

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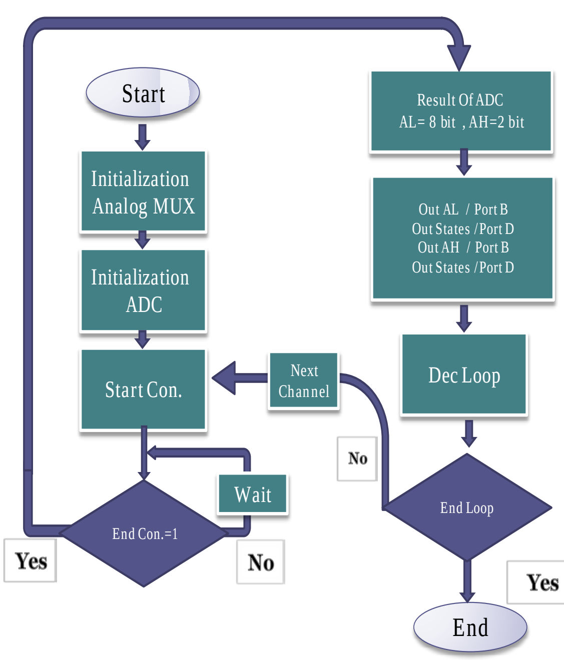
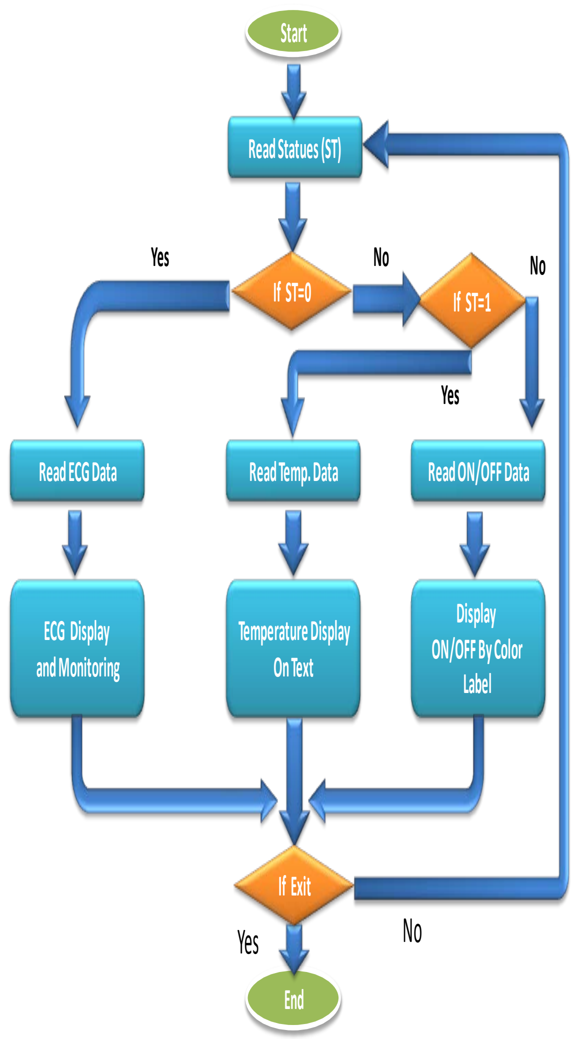
status signals to AVR port (D) for the three channels in sequence. By monitoring the status signals between the AVR and the parallel port, a sampling rate of 10KSPS was reached with the AVR program running. The samples from the three channels were time division multiplexed. In order to have a clear display of the ECG signal on the PC screen, each 255 samples taken from ADC1(ECG signal), a one sample is taken from ADC0 (temperature), and one sample from ADC2 (Logic signal).

5.2 GUI DESIGN

A graphical user interface (GUI) has been designed using Visual Basic programming language. The GUI displayed screen includes the ECG signal display, the temperature (as text), and finally displaying the logic signals from ON-OFF switch as coloured labels (CALL ON, CALL OFF) to indicate a nurse call. A flowchart of the V.B. program is shown in (figure 5). It includes the Discrimination between the data for the three channels (ECG, Temperature, and logic signals) and displaying them on the screen. To display the ECG signal a point to point graph is constructed using V.B. command (P1.PSet (n, z), &HFFFF&). The GUI has four buttons: Start, Exit, Pause and Continue (figure 5). The Start button is to start display all data on PC screen. The Exit button is to exit the program. The Pause button is to pause displaying the ECG signal. The Continue button is to start displaying the ECG signal again.



Figure(4) Flow Chart AVR-MCU



Figure(5) Graphic user interface using Visual Basic

6. RESULT AND CONCLUSION

In this paper, a low-cost portable ECG monitor has been designed and implemented. It can be used in a clinical emergency room near the patients or at home, so that the ECG, temperature and other signals can be send to the physician via cable or wireless LAN.

The ECG signal was taken from an ECG monitor recorder (ECG-901B) through its output port. The output of this monitor is conditioned to be in the range of (0 – 640) mV and applied to the AVR channel (ADC1). The sensed patient temperature is conditioned and applied to AVR channel (ADC0). Using a look-up table the temperature is also displayed on the GUI screen as text (figure 6).

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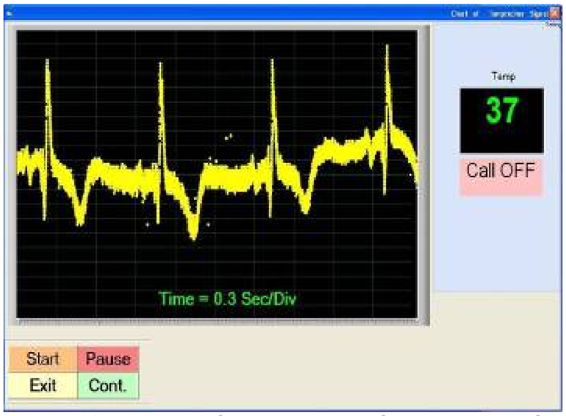

Figure(6) GUI screen showing ECG signal, temperature, and Nurse call OFF for patient

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