Implementation Of ARM7 Based Handheld ECG Unit Prototype For Remote Areas As Premedical Checkup At Home

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Abstract

The concept behind this paper involves handheld ECG unit for remote areas for individual use which facilities to have premedical check-up at home . For this the design circuit is implemented which should be miniature model of ECG sensor. Rather than making circuitry complicated and bulky, direct high precision ICs are used which is interfaced with efficient controller like ARM7 TDMIS serving many facilities and provide easy interfacing with required modules. The soul part of this implementation is programming, which should be efficient during switching information. This ECG unit don't use leads as that of conventional ones. Thus, there is no purpose of using leads or electrodes using gels, multiple leads etc. Though multiple leads contribute to efficient waveform, this ECG unit is near to comparison with the conventional ECG machine. Moreover, this data can be send to doctors in urban areas for diagnosis. And this can be implemented by AT commands of GSM unit which is in future scope because of extra circuitry. Also, there can be feedback facility from doctors in this overall unit which helps in premedical check-up at home.

Keywords: ECG signal, sensor, ARM7, FIR filtering, Proteus,Visual studio, Keil,GLCD GSM,GPS-GIS.

1. INTRODUCTION

The Electrocardiograph (ECG) signal is an electrical signal generated by the heart's activity, which can be used as a diagnostic tool for examining some of the functions of the heart. It has a principal measurement range of 0.5 to 4 mV and signal frequency range of 0.01 to 250 Hz. Each time the heart beats, it produces three distinct ECG waves: P wave, QRS complex and T wave. ECGs provide useful data and can help detect various problems related to heart function. Diagnosis of certain medical problems is also possible. For example, in patients with high blood pressure, the amplitude of the QRS complex is significantly increased. Damage in the heart can also be observed by a deformation in the Q wave. The typical ECG signal showing PORST wave in Fig.1

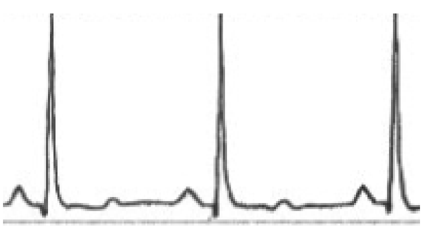

Fig. 1 Typical ECG Signal

2. BASIC SCHEMATIC OF IMPLEMENTATION

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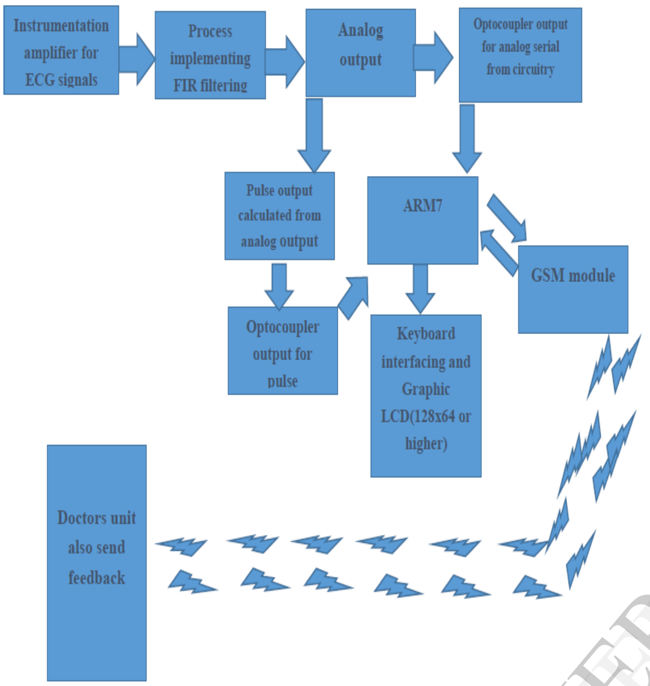


Fig.2. Block schematic

The Fig.2. involves instrumentation amplifier with high CMRR to remove the noise induced from body and amplify the difference between right and left body parts. Here thumb pads are used as transducer input interface. The analog amplified ECG voltage is then made to pass through digital FIR filters. High pass and low pass filters are implemented to get ECG signal of proper range. Various processors are available for implementing Digital FIR filtering. This converts these signals to analog output in serial format and pulse output. The serial data is 1 byte every 5 milli-second. Each byte can be from 0-255 indicating an analog value of the signal. The pulse output is outputted through optocoupler. The serial output is given to ARM7 which processes the value. This is interfaced with keyboard and GLCD which shows desired output. This then can be send to doctors at far places by cheap GSM technology. Sensor unit uses two optocouplers to isolate the circuit from external voltages since any little noise from external source can be amplified as noise.

3. ECG MAIN UNIT OVERVIEW

3.1 Instrumentation amplifier 0846:

IC technology uses Op Amps to design an ECG amplifier. This amplifier allows differential input, have enough gain to amplify a small ECG signal (<4mv) and reject DC, 50-Hz and high frequency noises.

Requirements:

1. Differential input
2. Adjustable gain: 200 – 2,000
3. Band pass filter:
4. Minimize 50 Hz noise

There are many factors that should be taken into consideration in the design of an ECG amplifier, such as the frequency distortion, saturation distortion, interference from electric devices and other sources. The most important kind of noise in an ECG amplifier is the 50 Hz noises, since using a band-pass filter can easily reject both the DC and high frequency noise. A major source of noise when one is recording or monitoring the ECG is the electric power system. And this is possible in implemented instrumentation amplifier.

3.2 FIR Filtering

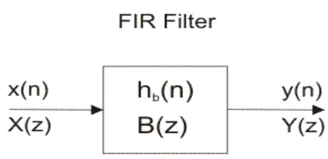


Fig.3.2 FIR filter

FIR filters are digital filters with finite impulse response. Fig.3.2 is also known as non-recursive digital filter**.** In practical

ECG measurements, the primary signal is often contaminated by relatively strong disturbances, which should be removed before signal further proceed. Even EMG signals causes disturbances. The varying ECG contact potentials and breathing artefacts (below 0.5 Hz) causes unwanted baseline drift. Especially in stress ECG recordings, this drift may sometimes make the recording impossible. Another problem is the mains frequency (50 Hz) noise which occurs within the clinically important frequency range. Up to now, the harmful baseline drift is usually removed from the measurements using analog high-pass filters. Because of their highly nonlinear phase response, the pass band cutoff frequency is usually selected to be only one-tenth of the heart rate. With these filters it is not possible to effectively remove low-frequency noise without distorting the ECG signal shape. In the case of linear-phase filters, like linear-phase finite impulse-response (FIR) filters, it is possible to increase the cutoff frequency up to the fundamental heart rate without causing any distortion to the ECG signal. The linear-phase performance of FIR filters enables us to make the stop band deeper and wider compared with nonlinear-phase filters. Thus, linear-phase FIR filters give us a potential tool of effectively eliminating low-frequency noise components (<0.5 Hz).

3.3 Optocoupler PC817

PC817 is a 4 pin 1-channel type optocoupler having high isolation voltage. Optocouler transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 10 kV/μs. The main function of an optocoupler is to block such high voltages and voltage transients, so that a sudden surge in one part of the system will not disrupt or destroy the other parts.

3.4 ARM-TDMIS

The LPC2148 microcontroller in Fig.3.4 is based on a 32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32kB to 512kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. Due to their tiny size and low power consumption(3.3V), LPC2148 is taken for applications where miniaturization and handheld is sine qua non. Serial communications interfaces ranging from a USB 2.0 Full-speed device, 2 UARTs, SPI, SSP to I2C-bus and on-chip SRAM, make these devices very well suited for communication. The ARM controller is used to take the output from sensor unit. This then outputted on GLCD by keyboard pressed keys. Moreover, the pulse output from sensors is taken into counter to calculate the heart beats in the form BPM (Beats/minutes) which is processed and outputted on LCD. The fast processing speed enables this facility. Also, the data can be send other place by interfacing GSM module to ARM7.

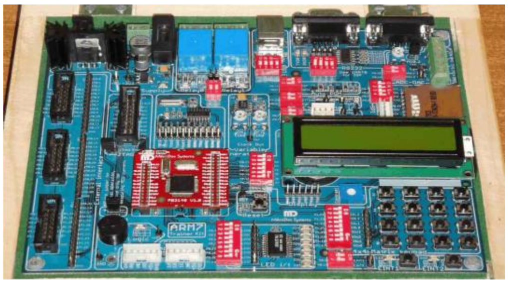


Fig. 3.4 MikroDes MD2148 Trainer Kit

4. TESTING AND SIMULATION

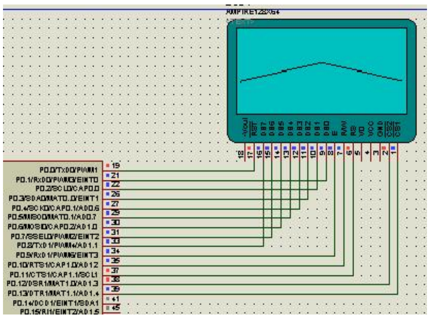


Fig.4.1 Proteus simulation of predefined ECG

Proteus simulation shows incremented value of variable, say ecg as shown in Fig.4.1 having initial value ecg = 100 in first half of GLCD RAM and decremented in other half to get a running waveform.

```
//Pixel plotting
Ecg=100;
pixon = U0RBR/4;
plin = pixon/8;
ploc = pixon%8;
pon = 1<<ploc;
wrcmd(0xb8|plin);
wrdat(pon);
ploc++;
delayms(5);
```

Further Fig.4.2 display the ECG waveform information like heartbeat in BPM (Beats/min) and status as low, normal or high BPM derived from the waveform we obtained in first stage of GLCD i.e. ECG waveform plot to give more information.

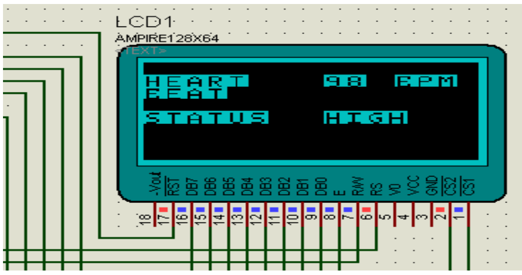
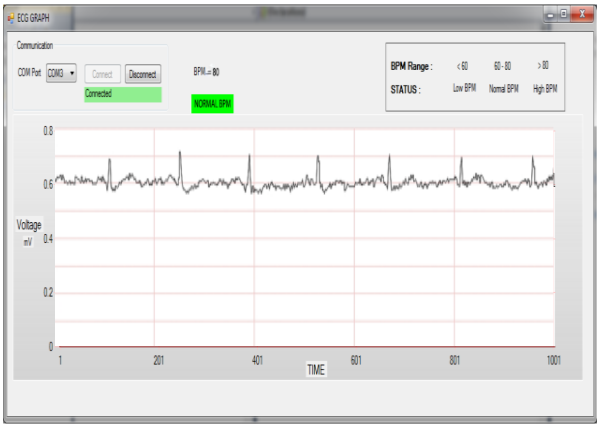


Fig.4.2 Proteus simulation of calculated ECG status

GUI implementation on PC using visual studio is shown in Fig.4.3.It involves running waveform, information showing BPM and status of patient.

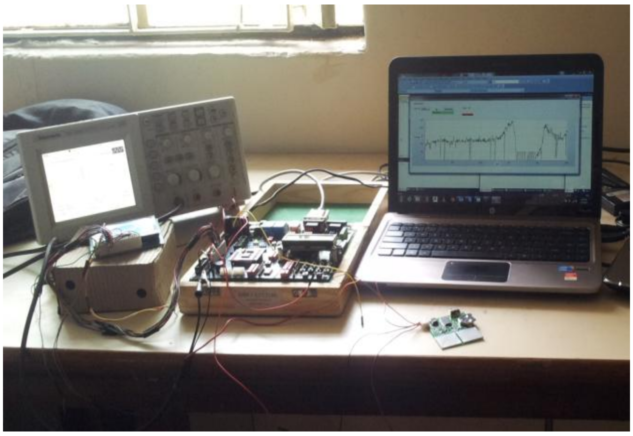
Fig.4.3 GUI simulation on PC



5. HARDWARE IMPLEMENTATION AND RESULTS

Fig.5.1 Experimental Setup

Experimental setup as shown in Fig.5.1 gives



idea about the components required for implementing the possible model.

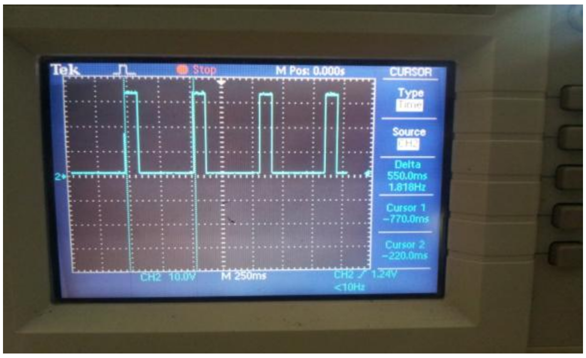


Fig.5.2 Pulse frequency is around 1Hz, which is for a normal person heartbeat

This pulse outputted from optocoupler as shown in Fig.5.2 given to ARM7 which calculates BPM by averaging the samples.

Fig.5.3 GLCD (128X64) output

The GLCD output from detected ECG signal is shown in Fig.5.3 which is not so clear because of resolution of GLCD. High resolution GLCD can be interfaced which gives accepted results. Also, some noise is involved due to deterioration of thumb pads after long use. The change of screen information can be achieved by key pressed functions which can also be used for giving attention to GSM module.

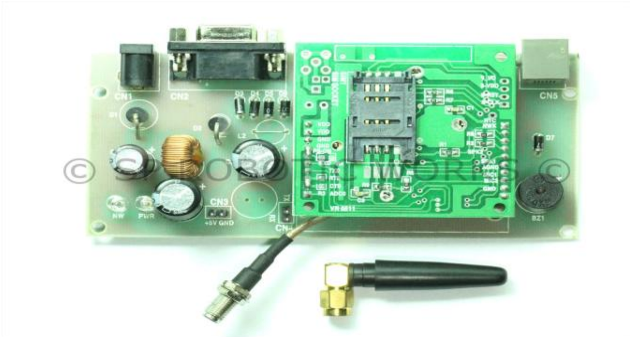


Fig.5.4 SIM 300

The above Fig.5.4 is SIM300 which is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800MHz and PCS1900MHz. Best thing about SIM300 is that it have SIM card slot as that of mobile phone device for sending and receiving message and also provides GPRS multi-slot class 10 capability and support the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. With a tiny configuration of 40mm x 33mm x 2.85 mm, SIM300 can fit almost all the space requirement in any application like smart phone, PDA and other mobile device. Moreover SIM300 is designed with power saving technique, the current consumption to as low as 2.5mA in SLEEP mode.

6. FUTURE SCOPE

The major value of this system is in the detection of cardiac disorder of the patients who are located in the remote areas or in travel and are not in a position to report to the doctor for immediate treatment .An alert SMS can be transmitted using the GSM technology to the doctors and advises can be sought for saving the life of the patient which can contain medicines prescription or food proscription. As a future enhancement, system can be interfaced with GPS & GIS facility for effective rescue of patient from any location detected at doctor's place by ambulance in any case of cardiac emergency. Moreover, newer cellular access technologies, such as Third generation (3G/3.5G) or Fourth generation (4G) provide much higher data transmission speed than basic second generation (2G) GSM cellular system offering future telemedicine solutions endless choices for high-end designs. These relatively new wireless technologies are now been deployed in most of the regions.

7. CONCLUSION

The implemention of ECG unit using Graphics User Interface on PC is successful. However, it is difficult to implement sensitive run-time ECG signal on 128X64 GLCD using ARM7 and also joining pixels of large difference values requires different algorithm. Higher resolution display should be used for clear display with accurate scaling. Input to ECG sensor must be stable in order to avoid unexpected high pulse in signal. Output on PC through GUI using VB.NET is more explanatory as compared to output on GLCD.

8. REFERENCES

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