Prototype of a Patient Monitoring Device based on an embedded RISC/DSP system

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Abstract

Existing patient monitoring devices usually record long-term activity as raw data from the patient to some type of storage. This requires offline analysis on a physician's desktop for the recorded period. Clearly, longer monitoring periods on the same storage are feasible, when doing analysis in real-time and storing only characteristic or critical results. This can then be used to even tell the wearer its health state or sound a public alarm on life threatening situations. In order to proof this concept and make the best from nowadays microelectronics developments we chose to develop a battery operated, low power, high performance device utilizing Hyperstone's RISC/DSP developer board. This enables fast execution of state of the art algorithms on the DSP-side with speed advantage and multitasking of the RISC architecture. The prototypical device acquires 8 channel analog data with a maximum of 10 kHz sampling rate/channel running real-time ECG analysis. It will communicate with a central monitoring station with the help of a Bluetooth channel.

Keywords:- Patient Monitoring, RISC/DSP Board

1 Introduction

1.1 Portable Patient Monitoring

The increasing costs of Hospital stay and the shifting trend of medical procedures from curative towards preventative, has led to a demand for increased mobility from doctors and patients. Thus, research in portable monitoring applications is developed to more modern stages. Rapid progression of technology in analog to digital conversion, digital signal processing, and ICs has provided the potential of multiple measurements from sensory devices to be analysed concurrently.

1.2 Holter

Holters are portable, battery operated, devices for monitoring of physiological signals [1][2][3]. ECG or EEG 24-hour activity is recorded currently on tape or more recently on solid-state memory. Recorded signals are then analyzed off-line using dedicated diagnostic systems. With the current state of processor technology, standard processing of biomedical signals (such as filtering, spectral and statistical analysis) does not require significant processing power. Monitoring of the electrocardiogram during normal activity using Holter devices has become standard procedure for detection of cardiac arrhythmias, transient ischemic episodes and silent myocardial ischemia [1][2][4]. This paper presents development of a portable system for real-time analysis of ECG/EMG signals, proposed to be used as an intelligent and advanced warning holter device.

2 Medical Applications

The new generation of holter devices is capable of analyzing and interpreting electrocardiographic signals in real time [5]. As the world's healthcare systems becomes more custom-made, Artificial Intelligence and medical decision theory provides an ideal platform for personalized diagnosis. As home-use monitors become commonplace, the accurate real-time analysis of vital-sign waveforms could result in an AI-derived prediagnosis that automatically triggers a telephoned or email request for a physician visit. [6]

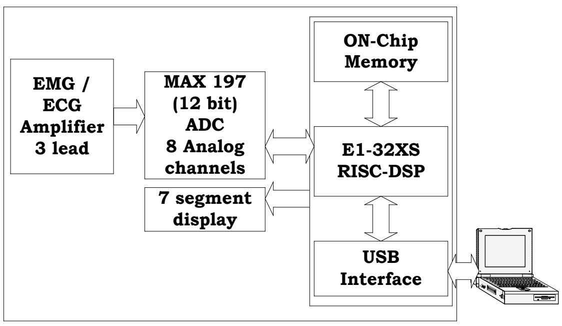

Fig. 1 Block diagram showing the RISC-DSP board, amplifier and the ADC.

3 Description of the Prototype

3.1 Processor Board

The Block diagram of the prototype is shown in **Fig 1.** The prototype utilizes a Hyperstone 32-bit E1-32XS development board (with 200 MIPS processor) The Hyperstone core has been specifically designed to combine both RISC and DSP functions – but as an single integrated core and instruction set, rather than a combination of a 2 different cores on single piece of silicon. A major factor in achieving the high power-efficiency delivered by this design is the parallel operation of three functional blocks of the integrated core: the RISC ALU, the DSP Unit and the Load/Store Unit. The integrated architecture allows instructions to be streamed through all 3 units simultaneously to deliver a peak performance of upto 500 MOPS at 140 Mhz. A multitasking real-time operating system optimized for loading, debugging and running programs is available with the board for applications where a fast and deterministic real-time response is required replacing dedicated hardware peripherals like timers.

3.2 Amplifier

The three channel ECG/EMG holter amplifier is dedicated for low power consumption. The circuit works on a single supply with 3.3V. The signal is filtered by a 8^{th} order low-pass filter (fc = 340 Hz). [7]

3.3 ADC

Analog to Digital conversion is done using Dallas Semiconductor's MAX197, a 12 Bit (8+4) ADC with 8 bit data bus and 8 analog input channels that are independently software programmable for a variety of ranges. The data is sampled at 300Hz to 1kHz depending on the desired analysis. The interfacing of the ADC chip with the board is shown in **Fig. 2.**

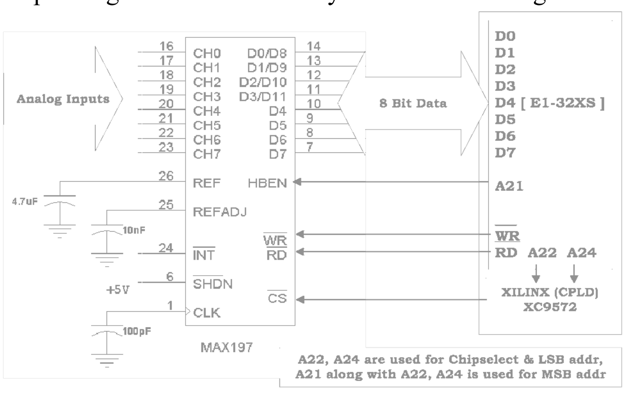

Fig. 2 Interfacing of MAX 197 with the Board

3.4 Analysis

Algorithms for base-line detection, R-R interval, Heart rate turbulence analysis, ischemia pattern recognition are implemented in MATLAB first and will be optimized in the C language. Warning conditions will be coded in numbers and displayed using a seven-segment display and also stored on the on-chip memory. Ongoing development to the board will include increasing the on-chip memory and introducing USB plug and play feature to retrieve the analysis results on a PC. Eventhough the power consumption is low (200mW at 2.5V), the power consumption for Long time monitoring is still to be evaluated.

4 Results

Real-time muscle signal were sampled at 1kHz. Filtering and FFT analysis is done. The results and analysis will be shown in the poster

5 Conclusion

The RISC-DSP combination of the processor is well suited for our complex tasks. With the parallel work of Bluetooth for WBAN [7], there will be a possibility to connect the system to a central monitoring station. The technology due to its implications should only be used to assist human decision-making.

6 Literature

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