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The Design of A DSP Based Portable Physiological Signal Monitor

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ABTRACT: A portable, high performance, and multifunction physiological signal monitor is presented. We use digital signal processor(DSP) instead of general microcontroller to make all data processing including filtering and compression real-time computing. By well-designed analog amplifier circuit and make the signal digital processing, this system is suitable for almost frequently used EKG, EEG, and EMG.

I. INTRODUCTION

It is of considerable important to develop a portable real-time display and high-performance physiological data monitoring and recording systems for ambulatory patients. There are many different systems that have been designed to monitor various signals obtained from ambulatory patients and even to be used as a means of early diagnosis of some diseases.

There are some different, precise, and multifunctional systems which have been designed to monitor physiological signal in the hospital. These systems couldn't monitor the sick in their own environment because these systems are heavy, large, and expensive. Several single and multichannel portable biological signals recording systems have been developed to record physiological signals, such as blood pressure, oesophageal pressure, EEG, EKG, EMG, and other variables[1-4]. These monitors use magnetic tape, DRAM, or SRAM as their storage device. In recent years, the growth of the engineering and technology has greatly improved the development of the small-size, large capacity, shocked-protected and low-power consumption disk device[5], but it is still not convenient for long-term multichannel storage. For example, the 4-channel EMG ambulatory recording has 1000 Hz sampling rate, 12 bits A/D resolution. The requirement for 1 hour recording of an EMG requires 21.6 Mbytes. It is necessary for a long-term portable physiological monitor to storage the data which has been compressed. The DSP-based physiological monitor can filter and compress the real-time physiological signal by the software, so it can storage much more data in the same media.

The system to described employs these approaches in conjunction with contemporary integrated circuit technologies to provide a small, flexible and low-cost data-acquisition system whose performance substantially exceeds that of the large and expensive commercial systems currently available. The system features low noise, high common-mode rejection, patient isolation, high gain, sample and hold circuitry on all channels, and appropriate bandwidth (~1000Hz) and sampling rate (up to 2kHz per channel). Most adjustable functions are software-controlled, and means for automatic calibration are built-in.

The major purpose of our study is to design and develop a long-term physiological signal monitoring and recording systems, based on the DSP-chip, for ambulatory patient's use in a natural environment. The design concept and development as well as signal recording are described in the paper.

II. METHODS

A. Implementation of Hardware

The hardware is divided into a well-designed amplifier unit, a main system part and some peripheral devices. The amplifier unit includes low-noise instrumental amplifiers and OPs used to amplify signals.

The main system part includes signal processing circuits, a 12-bit resolution A/D converter and an 32-bit floating TMS320C31 digital signal processor (DSP). The DSP has superior compuing power(50 MFLOPS) so that we can built in many digital processing algorithms. Besides, we use complex PLD(CPLD) to simply our system.

The peripheral devices used to communicate with the users include liquid crystal display(LCD), keypads, and a UART interface. The LCD displays waveform to the users. The keypads receives commands from users. The UART interface can transfer saved data to PCs directly or via duplex telephone line by modem to doctors in hospitals. The whole system is powered by a single 9 V battery. The block diagram is shown in Fig.1.

B. Implementation of Software

The programming structure is divided into two parts. The first one is the digital processing software incorporating the digital signal filtering algorithms and data compression program. The filtering program contains a 60Hz notch filter to eliminate power-line interfence and filters used to reduce the noise from unwanted physiological signal like respiration or muscle contraction. In order to require the minimum number of parameters to represent a given signal, we use a transfrom-based compression technique, Karhunen-Loeve transform(KLT). Here we use DSP's advanced structure make real-ime compress data and get high compression ratio possible. The other one is the interface program. It includes waveform display, command processing, and transferring data. The block diagram is shown in Fig.2.

III. RESULT

The physiological signal monitor characteristics are:

1. Portable, battery powered.
2. Use DSP and CPLD to simply system design and reduce the physical size.
3. All filters including LP filter, 60Hz notch filter, and high pass filter are implemented digitally in the software.
4. Use DSP to real-time implement high CR algorithms.
5. LCD diplay and keypad included.
6. UART for data transmission.

New features:

1. All analog filters are digitalized. It not only reduce the PCB space to make system smaller but also the need to tune the component values of the analog filter. This enhances the stability of the system.
2. Because all functions implement digitally, we can change the parameters for different physiological signals.
3. A real-time high CR algorithm is implemented by DSP, thus we can enlarge the capability for data storage. This reduce the cost in data storage and transmission.

IV. CONCLUSION

The features of this physiological signal monitor include reduce the need for analog 60Hz notch filter, artifitial signals filtering, high CR, and get all data real-time. What is most important is that because we implement almost signal processing algorithm in the DSP' software, we can easily change parameters or even the whole algorithms when considering different signals. This eliminates the need to develop different systems.

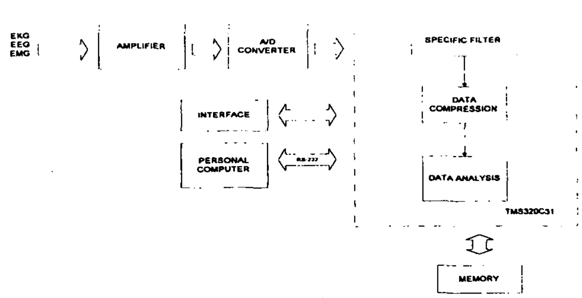

Fig.1 Hardware Block Diagram

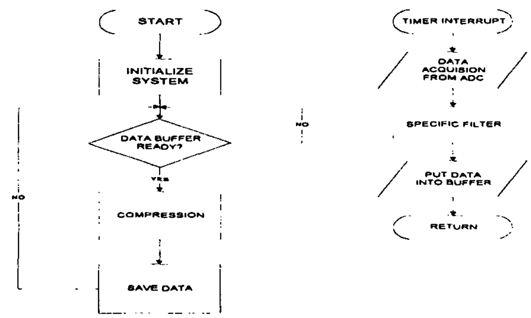

Fig.2 Software Block Diagram

V. REFERENCE

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