PLANT'S BIOPOTENTIAL ACQUISITION

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Abstract - The paper describes PC based Data Acquisition System for acquisition and processing biopotential signals taken from plants. The DAS hardware performs sinchronous sampling with acquisition time of 10μsec per channel. The input amplifier gain can be software selected from the range of 1 to 100.000. The acquisition speed and the number of active channels are also software selectable. The software has an option for automatic gain adjustment in order to minimize the error. The input signals are displayed on PC screen in real-time, processed or not.

1. Introduction

Last decade a major breakthrough has been made in signal measurement from life organisms and in development of medical instrumentation. But when it matters to particular experiments and research this instrumentation is not accesible because of it's high costs and so sometimes is necessary to modify or develop special measyring system that will suit the experimentator's needs.

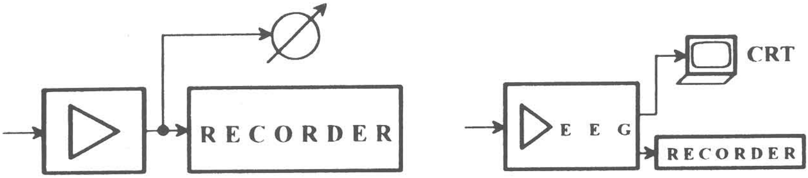
As a part of the project for investigation of the plant's electrical activities and their reactions to different external stimulus (light, heat, humidity, etc.) that is covered by the Forestry Faculty in Skopje, it was necessary to develop appropriate cheap but reliable measuring system. This article describes the developed system for this purpose, which can be also used in variety of data acquisition applications.

2. Preliminary Experiments

First of all two preliminary experiments were taken in order to determine the biopotential attributes. The basics schematcs are presented on the figure 1a and 1b.

In the first experiment we used Bruel&Kjaer Precision Sound Level Meter type 2203 as input amplifier and Bruel&Kjaer Level Recorder type 2305. The voltmeter was used as a control instrument. The amplifier was set on Linear Amplification mode with gain of 90dB. The recorder had the following settings:

- input attenuation of 40dB;
- peak rectifier response;
- writing speed of 160mm/sec;
- paper speed of 0.3mm/sec;
- drive shaft speed of 0.36rpm.



a) b)

Figure 1. - Schematics of a) the first and b) the second experiment.

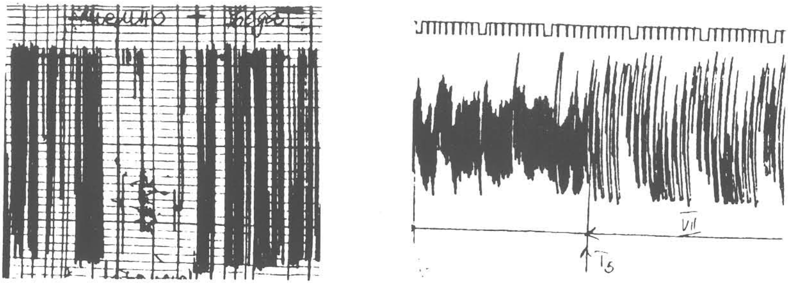
The operating frequency range for both instruments was from 50Hz to 20kHz.

The second experiment was performed using EEG aparatus type EEG-4400 model 18CH. It has 12 multiplexed channels and the analog to digital conversion is 12-bit with accuracy of 1% and linearity of 0.5%. The frequency operating range is between 0.1Hz and 10KHz with noise level lower than 1μVrms (0.25Hz-50Hz).

The biopotentials were recorder using the following settings:

- sensivity of 7μV/mm;
- paper speed of 30mm/sec;
- the 50Hz filter was set on in order to eleminate the power line influence.

The samples of the recorded biopotentials from a plant are presented on figures 2a and 2b. It is obviously that processing the signals taken in the described way is very slow, tedious and inaccurate. Also the vast of very expensive recording paper can not be neglected. Anyway, the performed experiments helped us to design the equipment that is much more useful not only for this purpose.



a) b)

Figure 2. - Recorded charts from the initial experiments.

2. The Data Acquisition Equipment

This kind of measurements are very suitable for implementation of data acquisition equipment. Since the recording of data is strongly desired we decided to build the equipment using personal computer. The hardware design objectives were the following:

- sixteen multiplexed channels;
- sinchronous sampling with multiplexed A/D conversion;
- the acquisition time per channel to be lower than 10μsec;
- software programmable input gain with channel independance;
- low cost.

At this moment of reality, the last objective was the most important, so the decision was made to use a low cost 8-bit bus Flytech ADDA-12 V2.0 board. It was build using 12-bit AD7521 DA converter and had analog multiplexer. Unfortunatelly it had not any sample-and hold circuit, so it was applicable only for acquisition of very slow signals, with a rate in order of seconds.

To increase the performance of this card we decided to add a second card with all the necessary circuitry for sampling all the channels simultaneously and to control the input amplifiers gain independantly for every channel. The basic configuration of this

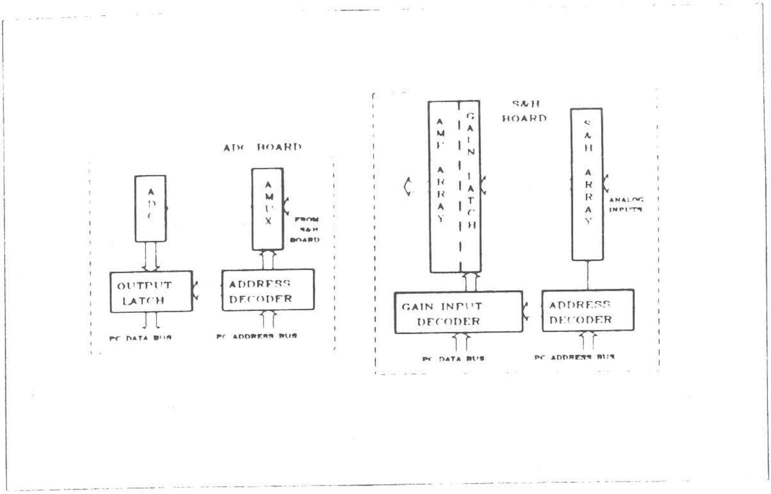


Figure 3. - Basic configuration of the ADC and S&H boards.

solution is given in the figure3. Analog signals instead to be led in the ADC board they are led into the S&H board. Every channel has it's own S&H circuit, but all of them are controlled for simultaneous operation/sampling. The variable gain amplifiers are following the S&H outputs. This is made in order to lower the costs for amplifier design. Instead the S&H circuits are designed using the LF398 monolitic S&H amplifier. The value for the capacitor is chosen so it could allow the desired acquisition rate of 10μsec. The outputs of the amplifiers are led to the ADC board which is independently controlled from the computer.

The Gain Input Decoder is designed so it has predefined gains of 1, 2, 5, 10, 100, 1000, 10.000, and 100.000. The later two gains are realised using two amplifier stages.

The type A/D conversion, unipolar or bipolar can be set via jumper on the ADC board. Also, the input voltage range, 0.9V or 9V, of the ADC can be set via jumper on the board. This two options are the major drawback of this solution and they are determined by the ADC board.

The software that drives the equipment is mainly consisted of two main parts. The first one is the communication routine, and the second one is GUI module. The first module performs the communication between the computer and the two boards and the second one preforms the communication between the user and the computer.

The Communication Routine allows the speed of acquisition lower than 2μsec per channel which is far beyond the hardware limitations. To avoid the occurrence of faster communication with the ADC board than the limit of 2μsec, and to cause measurement error increase, the communication routine is limited not to address ADC board faster than the hardvare limitations. This limitation is independent from the processor type and operating frequency. The communication routine investigates the computer speed and adjustes itself to match the hardware limitations.

The software also has an option of automatic gain adjustment independently for every channel. This option slightly slows down the acquisition speed, but always keeps the signal in the upper dynamic range of the A/D converter. This results is achievment of desired high accuracy of the A/D conversion process.

The acquired data can be displayed in real-time, and saved for future processing. It can be saved in different formats, ASCII, IEEE-854, etc., so they can be accessed by other software packages such as spreadsheets and data bases or different user's programs.

4. Conclusion

With this construction we have achieved very fast data acquisition without any degradation of the overall accuracy (0.025%) and with minimal investment we achieved performance that can be found in boards that cost several times more.

We have found that the automatic gain adjusment option is very useful, but it needs further development in the direction of implementing a larger set of predefined gains.

Although this equipment was designed for acquisition of plant's biopotentials it can be used for any other data acquisition purposes.

LITERATURE

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