PORTABLE COMPUTERIZED MULTICHANNEL ELECTROMYOGRAPHIC AND ELECTROCARDIOGRAPHIC PROCESSOR / RECORDER

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ABSTRACT – This paper concerns a processing and recording system for electrophysiological signals . A device allowing signal recording of 7 EMG plus 1 ECG/EMG has been constructed . Recording can be done on a subject at exercise situation, because it is accurate in measuring, light, easy and versatile to use and programming, according to the different user's needs : sport and work physicians, ergonomists, physical therapists etc ... It is fully computerized with the MOTOROLA MC68000 microprocessor. All internal parameters are managed by program . The equipment setup consists of a portable processing/recording box with its sensors, a configuration module, a large capacity memory card and a remote control . Its originality and performances come from the integration of many electronic and software functions on a portable set . Its conversational aspect, makes transparent all technical questions and allows the user to concentrate on the physiological problem, by giving him all necessary informations; at the same time it proposes a large panoply of functions . The system calculating power, allows the combination of raw signal recording and real time processing of IEMG, RMS value and cardiac frequency, and it will allow processing of other parameters .

INTRODUCTION

Systematic use of computers power in electromyography these last 15 years, gave a new application perspective of such technique in different fields . The goal of our new generation apparatus is to combine in a simple, practical and reliable device, many of today's investigator's technical resources . Then, this new equipment, called MYODATA, presented at this paper, has been constructed . It proposes an extended range of signal manipulation from its acquisition to its conditioning, processing and digital storage .

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FUNCTIONS

MYODATA has eight EMG recording channels proceeding from human body surface muscles; one of these channels can be dedicated to record the ECG . It must work at real exercise situation with a minimal discomfort; then, it is light, portable and autonomous powered . It helps the user during electrodes and sensors placing stage, giving indications about operation quality and, in this manner, limiting wrong manipulation risk . Signal acquisition is done by an electronic sensor that integrates the electrodes in order to diminish artefacts and to increase measuring quality . Recording and primary processing are made on-site (human subject at exercise), by means of interchangeable self powered cards containing 512 Kb CMOS RAM memory . After, data on the card are transferred to a PC-AT compatible computer, where high developed visualizations, temporal and frequential calculations are made .

Recording characteristics

During configuration stage, one can choice :

- ..... signal frequency bandwidth (100 to 1000 Hz) .

For each channel :

- ..... raw signal only;
- ..... primary processing : IEMG or RMS value;
- ..... raw signal plus primary processing.

In this last case, the operator can program the sequences duration of raw signal he wants to record, for further digital processing and, by remote control, he can start recording for each sequence . Recording duration available, can go from 10 s in the worst case (1000 Hz raw signal on 8 channels) to few hours in combined tasks .

Sensor placing help

Our on-site recording, does not allow real time signal monitoring, i.e. the operator has no on line controlling possibility of good functioning . It is then, important, to give him all possible aids, when control and sensor placing phases occur, and to free him, as most as possible, from non physiological problems . Then, the following protocol has been implemented :

Phase 1) sensor placing -- different internal functions are activated to give informations, and keep certain parameters . At this point the operator has at his disposition :

- ..... analog signal of the channel tested;

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- ..... signal level sound indication;
- ..... display in μ Vpp of maximum signal level;
- ..... display of 50 Hz (*), noise estimation level . (*) (European line frequency).

Phase 2) Signal and calculus variables calibration – It has to best adapt, the signal to available dynamic of the analog chain and the processing calculus variables . The machine searches the maximum signal value and the maximum value of processing calculus results . Here, we emphasize that the professional user must have a certain EMG measuring experience and a previous idea of protocol movements to be made .

PHYSICAL DESCRIPTION

The system is composed of different modules (figure 1) that intervenes subsequently on the utilization steps . The portable carrying parts are the recorder/processor box and its sensors . The conversational module is attached at the recorder during the first configuration step . It can be left fixed for static recording or removed, to alleviate the system, for dynamic situations .

A FM wireless remote control allows to take action on recording . Among its functions, it permits to drive control signals from equipments (attached to it) or manually .

The memory card is connected before the recording and when it is finished, the data transfer to the PC AT may be effected by serial connection with the recorder, or directly, by connecting the memory card on an interface card living on a AT slot, also implemented .

All hardware and software functions are built around the MOTOROLA MC68HC000 microprocessor . Its power allows to ensure necessary calculus, access all memories, hold the 24000 (3 * 8 channels * 1 KHz) acquisition sequences per second and to execute the necessary primary processing in less than 37 μs, time enough for one channel processing cycle . In effect, one supplementary cycle is necessary to allow the microprocessor to hold the channel task distribution and to take account of remote control orders (1/(8+1)/3000 = 37 μs) .

Important number of electronic functions imposes the use of SMD (Surface Mounted Devices) in CMOS technology .

Processor/recorder parts are (figure 2) :

Microprocessor card – it includes the circuits that manages all programmable functions (memories, analog functions, real time clock etc) and assures the establishment of

external communication (conversational module and remote control reception) .

Power supply card including commands reception module – A switched power supply provides the following outputs :

- + /- 5 Volts (analog), 100 mA;
- 5 Volts (stand-by), 40 mA;
- 5 Volts (digital), 150 mA.

Remote control receiver accepts logical signals to mark temporal events or to order raw signal acquisition besides primary processing . In addition, it transmits orders to commute between stand-by and functioning state (sequence halt/continuation) .

Analog card (figure 4) – it allows signals conditioning in accordance with recording characteristics . It has eight identical channels, the only difference is on ECG/EMG switching channel that has its own F2 and F3 cut-off frequency command .

Its functions are :

- ..... F1 high pass filter for sensor residual DC voltage elimination;
- ..... input disconnection to measure DC offset of complete chain;
- ..... programmable amplifier with 8 steps from 1 to 128 gain;
- ..... F2 programmable antialiasing switching capacitor BUTTERWOTH 4th order low-pass filter;
- ..... F3 low-pass filter to eliminate F2 transitions;
- ..... 8 channel MUX;
- ..... 10 µs conversion time 12 bits ADC converter with integrated sample and hold.

Communication module (figure 3) : a LCD (2*24) display, 5 keys keyboard to access all menu functions, a RS232 electrically isolated interface and a sound indicator constitute all input-output devices .

INTERNAL SOFTWARE

It allows management of all recorder functions :

- ..... monitor program;
- ..... input/output drivers;
- ..... communication and configuration "pop-down" MENU ;
- ..... signal acquisition, raw and processed.

Real time recording

Time available for recording, with or without primary processing, in each channel is

37 μs . Then, strategic measures need to be taken to minimize the processing execution time . Maximum optimization assembler code and minimum instructions execution time had been assured with a resident software called "autoprogrammer", also implemented . It writes machine code before each processing and recording task, depending on configuration parameters inputs .

It utilization consists of :

- ..... analysis of configuration inputs;
- ..... software modules recopy from EPROM to RAM;
- ..... missing code generation;
- ..... locating, calculating and writing all necessary parameters;
- ..... holding software jumps .

GENERAL CHARACTERISTICS, RESULTS AND PERFORMANCES

Number of channel (EMG + 1 ECG) 8
Maximum frequency bandwith 1000 Hz
Portable set typical maximum consumption - functioning 160 mA
- Stand-by 10 mA
All portable set weight 1.1 Kg
Processor/recorder box dimensions 16x10x5 cm
Interchangeable memory RAM cassette capacity 512 Kb
Minimum raw signal recording duration available 10 sec
Maximum processed recording duration available with raw signal 8 hours
Input signal resolution with gain of 1 4.8 μV
Input signal resolution with gain of 128 38 nV
Complete analog chain conversion accuracy (gain 1 to 128) > 11 bits
Complete analog chain linearity (gain 1 to 128) +/- 1/2 LSB
Line frequency (50 Hz) noise indicator software filter bandwith 3.8 Hz
Maximum EMG channel processing cycle execution time (10 MHz 68000) 20 μs
Maximum ECG channel processing cycle execution time (10 MHz 68000) 26 μs

CONCLUSION

Electromyography is not a today's technique, but the EMG occupies a place more and more important at neuromuscular function and disease investigation . Increasing of computer using and performances, plus development of portable electronics combination, put in advantage the use of this technique . Different users other than fundamentalists could, then, use such a machine that will spread electromyographic technique application . These users should be specialists on their own applications, concerning neuromuscular analysis (sport and work physicians, physical therapists, ergonomists, biomecanic physicians, etc ...), then, they should

technique, and on physiological situation at study . At these conditions, the existence of a powerful equipment, integrating processing and recording in a portable autonomous set, with easy programmation, will be very helpful to these professionals that should not worry about non physiological tasks . MYODATA do this, by reassembling in a "walkman" like box, the power of a MOTOROLA 68000 processor and amount of interchangeable self powered memory, with pop-down MENU programming, letting the users, only sensor placing and recording mode definition tasks . Easy utilization and good precision released measure by MYODATA ensures reliability of powerful data processed on PC AT computer . Real time processing optimization opens the addition possibility of new processing parameters others than IEMG and RMS value . We preview to include zero crossing and threshold crossing rates, and the permission of all these processes combination .

ACKNOWLEDGMENT

To MAZET ELECTRONIQUE firm (43520 LE MAZET ST VOY - FR), for its help and participation .

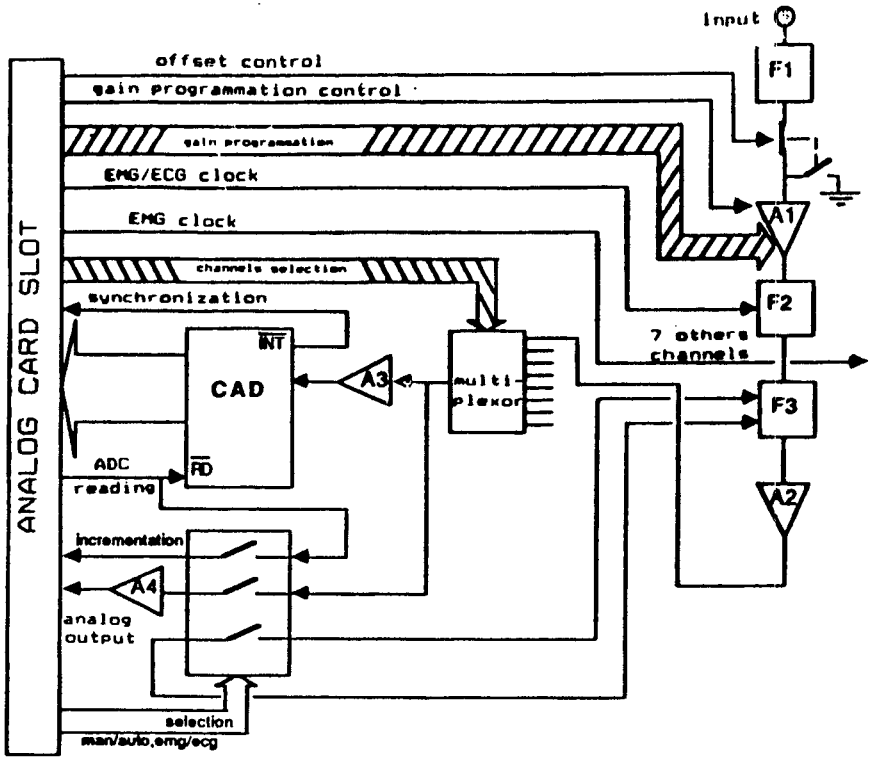

Fig. 4: Analog card diagram.

REFERENCE

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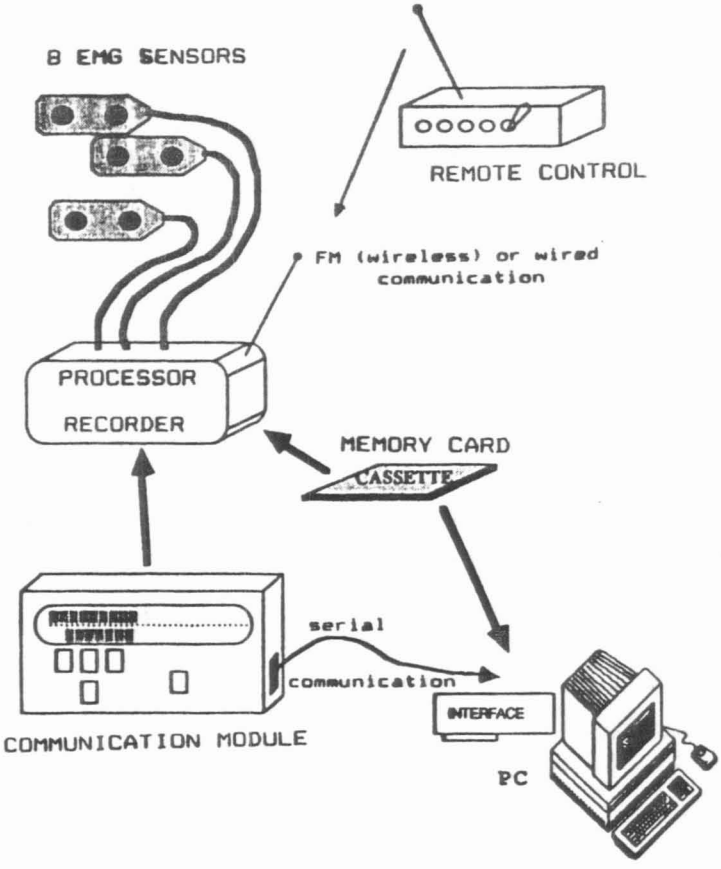

Fig. 1: General setup diagram.

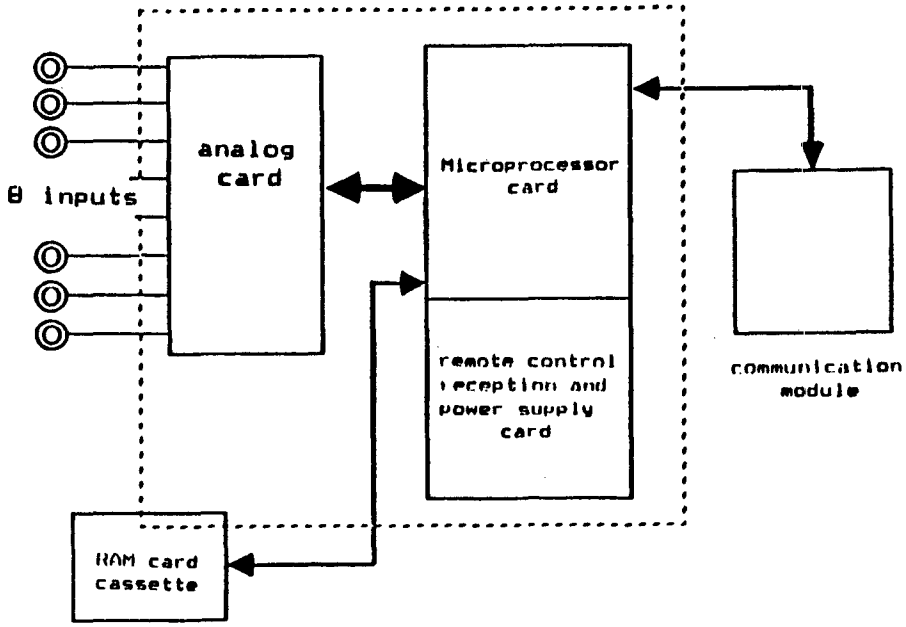

Fig. 2: Recorder Processor hadware parts .

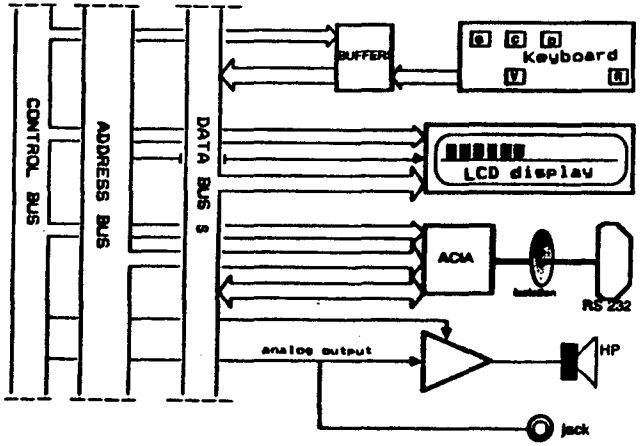

Fig 3: Communication Module Diagram.