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THE MICROPROCESSOR SEISMIC EQUIPMENT

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ABSTRACT. The described measuring equipment is intended for recording the near seismic events. It is constructed as a unit-built system with a data and control bus. It contains a fully automatic equipment with optional parameters and logical conditions for triggering the records. The record of three seismic channels is completed by absolute time and calendar data.

KEY WORDS: seismic observations, equipment, A/D converter, triggered apparatuses, microcomputer.

1. INTRODUCTION

The seismic observations, which in the past served especially for tracing strong natural earthquakes, have recently acquired a significance in tracing seismic events of small intensities ($M_L = 2$–3), arising from both natural and man-made sources.

Artificially induced events are generated, e.g. by underground or surface mining of coal and minerals, but also by industrial sources as power generators, heavy processing machines, and especially blasting in quarries.

The size of seismic events to be measured has decreased due to the requirements of determining the seismic hazard to large engineering constructions (dams, bridges, underground reservoirs, nuclear power plants, and precision optical and electronic manufacturing). A considerably frequent occurrence of small seismic events calls for establishing regional and local seismic networks in each locality of interest.

A background for judging the magnitudes and the distribution of events in time is the continuous monitoring by seismographs linked into a network. Theoretically, such monitoring should be performed by a continuous recording of the ground motion components Z, EW, NS, at least at four stations. These requirements represent a prerequisite for locating the foci of recorded seismic events.

2. THE INSTRUMENTATION OF SEISMIC NETWORKS

The equipments of local seismic networks cannot operate with the continuous analog recorders used for teleseismic signals. The near seismic events include frequencies of up to tens of Hz. To record the time history of these events, very high record speed of 10–100 mm/s, would be necessary.

At this speed the consumption of registration media is unjustifiable from the economical point of view and also the requirements on the equipment operation are considerable. Those were the reasons why these measurements were carried out by the systems of automatically triggered apparatuses with either analog or digital recording [Brož and Buben 1982].

The most important parts of these automatic seismographs are circuits securing initiation of recording devices in a required pre–event time. These circuits contain internal delay lines in which the seismic signals are stored.The capacity of this memory influences the number of channels, sampling frequency and a the duration time of recorded events.

The principal modification of automatically triggered apparatuses utilizes the criterion of comparing the value of current amplitude with the level of the long time mean value of seismic noise at the station. For the function of the time delay, the analog or digital delay lines can be used. In modern apparatuses based on PC certain parts of RAM are reserved for this function.

Examples of solution of such apparatuses are the systems TELEDYNE, RACAL, EARSS DATA, LENNARTZ, etc. Their prices represent values many times exceeding the levels of common computers and they are capable of functioning as triggered digital seismographs being supplemented with some peripheral circuits. For special purposes described in this paper, a simple PC based apparatus was designed meeting also the requirements of compatibility with expensive seismic apparatuses [Lennartz 1990].

3. The microcomputer based seismograph

In order to determine the local seismic velocities, the seismic records of underground explosion are to be performed. The focal time of explosion and times of seismic wave onsets are to be recorded with high precision and resolution. For recording in the epicentrum of explosions it is advantageous to use a special focal apparatus with accurately known response characteristics.

The fundamental requirement for an focal apparatus is an easy simple mobile set, which makes possible to be operated by every technician performing the blasts.

Our construction of the seismic apparatus is based on exploration of a single board microcomputer, mark DIDAKTIK–GAMA produced in Czechoslovakia, which is compatible with the SINCLAIR computers.

The central processing unit (CPU) of the computer is based on the Z80 microprocessor; the computer has an extended internal memory to 80 kByte and the possibility of connecting the shaded MOS memory up to 8 kByte. The basic set of the computer comprises the keyboard and two types of input/output ports, which are provided by the bus connector and communication ports of the 8255 circuit (Didaktik, 1989).

The task set for this construction followed from the requirement of a simple digital recorder which would make possible:

a) to record seismic events with the dynamics of at least 70 dB under the field conditions,

b) synchronous record of absolute time information,
c) operating on the internal battery source.

The block scheme of the set is shown in Fig.1.

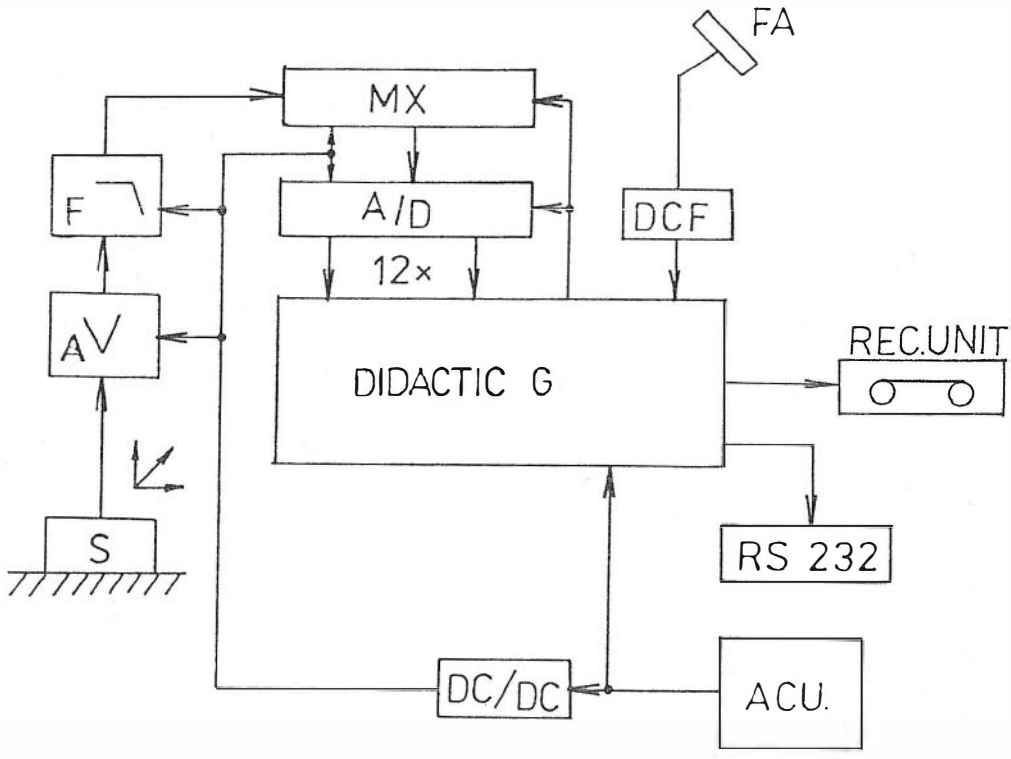

FIG.1. The block scheme of the apparatus

Several types of seismometers can be used:

a) geophone sensing the ground motion velocity (e.g. DGA 101 made in Germany, SM3 made in USSR),
b) ground motion acceleration pick up (e.g. BaK 8306 made in Denmark).

The velocity sensor is connected to the input amplifier "A", which is the precision hybrid integrated circuit type TESLA WSH 526 with adjustable gain of 0–70 dB. The acceleration sensor can be used without a pre-amplifier. However, in both cases it is necessary to use input antialasting filter "F" adjusted according to the demanded frequency band.

This band is determined by the value of sampling frequency, which is adjustable to 125 or 250 Hz. Output analog signal from the pre-amplifier and filter is entered to the block of analog-to-digital converter. It is formed by input multiplexor "MX" and a hybrid 12-bit approximation converter "A/D" operating in the range of input voltage ±2,5 V.

The second input signal is the time information. The absolute time is acquired by receiving the time code of a long-wave broadcast transmitter DCF 77 (Germany).The time marks are transmitted in the interval of 1 pulse per second. The calendar/time information is encoded by the pulse width code modulation of time marks.

The receiver DCF of time marks is formed by an active ferrite aerial "FA" with narrow-band filter and amplifier, adjusting the signal to the logic level 2,5 V which is connected with input gate of communication circuit 8255 (BLOCK DIDACTIC). The time signal shows the character of binary data and indication of second marks is provided on the keyboard panel.

Data output is programmed so that the data listing is automatically carried out after the termination of each measurement. Copying is performed in the same manner. If the apparatus will be operated in the field regime on batteries without output peripherals, the measured data remain stored in the computer memory for a time period given by the accumulator power source capacity (min 1 hour).

4. Software

Utilization of the apparatus is assumed not only for recording of blasts in near-focus distances but also on points of seismic profiles while determining the hodographs of seismic waves.

The measured data are stored in the internal memory of the computer. After completing the measurement, the data are copied and stored on the tape or on floppy disks. In case of making use of a PC, it is possible to transport the data by the serial channel RS 232. It is also possible to connect the printer or plotter and to make a hard copy of the recorded time histories.

The original microcomputer makes possible to load the program from the tape only. However, this loading was unsuitable for the field seismographs, and therefore the program was stored in the internal EPROM memory in the machine code. One of other possibilities is also utilization of a shaded memory EPROM in the communication interface with the circuit 8255. Measurements are initiated by connection of the computer to the power supply, and before the first measurement also by pressing the command "start" on the keyboard. If the recorded data are not treated, the apparatus must not be disconnected from the power supply, because their loss would occur.

The software of the apparatus makes possible to acquire the record of three seismic channels with the sampling frequency 125 Hz and with dynamics of 70 dB. Setting of the the value of least significant bit (LSB) is adjusted by amplification of the input amplifier. The triggering occurs after the "THRESHOLD" value is exceeded, which is set by the program as a multiple of a unit of the LSB value.

The priority task of the program is the determination of the time which is carried out by automatic decoding of the time signal DCF 77. The decoding program "DECOD TIME" operates according to the following algorithm:

1. Search for the identification mark of the start of the program "DECOD TIME", which is the missing 59th second mark. This free interval between 58 and

00 second marks determines the beginning of each minute.

2. Count of the first twenty second marks, which do not bear the demanded time information.

3. Decoding the width of the time marks beginning with the 21th up to 58th according to the code used by DCF 77.

4. Repetition of the procedure of time decoding for the following minute.

5. Comparison of time data according to the following condition:

- Data on year, month, day in a month, and day in a week have to be identical
- Data on hours, minutes may differ by one only, e.g. 3 may be changed to 4, 19 to 20, and also 24 to 0, and 59 to 0.

6. In case of meeting these criteria, the time information is frozen in the memory and the program is in the state of expectation the initiation of the seismic signal record, which is given by the time of exceeding the "THRESHOLD" value.

7. Starting the point of freezing of the time data, the variable of frequency of 125 Hz is incremented and seismic data are recorded from the AD converter into RAM memory, in which 657 values are stored corresponding to 5.2 seconds of record. The record is continuously renewed, and in essential, it corresponds to the time of sampling of the seismic signal prior to initiation of explosion record. (PET – in front of time).

8. After exceeding the threshold values of the start, freezing of the variable occurs, which was incremented during waiting period for the initiation, and the instruction for sampling is performed with recording of the seismic signals in real time.

9. On filling up the full RAM memory capacity in microcomputer, the sampling of input signals is terminated and the instruction for data listing is generated. In case of connected output peripherals the measured values are automatically recorded together with the data of time (minute, hour, day, month, year) and the value of pre-event-time.

The actual time of recorded event is determined by addition of the value of pre-event-time to the recorded time data. The precision of time determination is given by the stability of internal computer clock and it is sufficient for the given purposes.

The program of time decoding is stored in the machine code starting from the address 60 000. It is initiated from keyboard by the command RAN DO (MIZE USER 60 000). It contains about 250 instructions and occupies 0.6 kByte of memory. The sampling program is written as a partial subprogram. The principle diagram of the apparatus operation is shown in Fig.2.

5. Peripheral circuits of the computer

The connected analog-to-digital converter is assigned to multiplexed input analog computer units. The multiplexer "MX" is connected to the filters in a unipolar way. Its operation consists in coding the input voltage by gradual approximation of twelve graded weights. The conversion is initiated by the decreasing edge of the initiating impulse. During conversion, which is notified by a high level of state

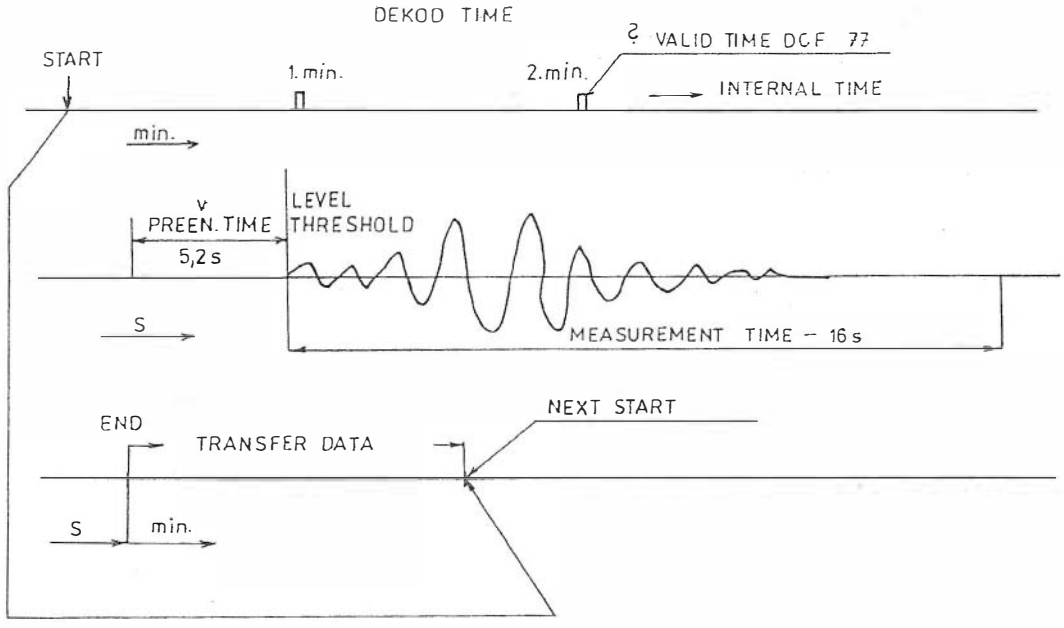

FIG.2. The scheme of time and seismic data recording

output, the converter emits 13 clock impulses and synchronously also twelve bits of serial output.

The parallel output is valid only after the termination of conversion, which is confirmed by the return of the state output to a low level. Data bits of the parallel output are kept valid until the initiation of following conversion.

Analog input of multiplexer "MX" is used with maximum value +2.5 V with input resistance 2.5 kΩ or 100 MΩ. The selection of input impedance is adjustable by the interconnections and can be changed independently at the function of converter. Other parameters are given in the company literature (VUMS 1989).

The connection of "A/D" converter is carried out via analog multiplexer "MX" and other auxiliary circuits "IT,CO" according to the block diagram in Fig.3.

The power of +15 V is supplied from the DC/DC converter, which is supplied from the 6 V power supply of the apparatus.

This voltage supports also the supply of the input amplifier, filter, and DCF 77 receiver. Microswitches are specified for the tests and manual handling, making possible testing the apparatus prior to starting of the measurement.

6. CONCLUSION

The described seismic apparatus based on the use of an microcomputer is an example of solution of a single purpose digital system. Although its utilization

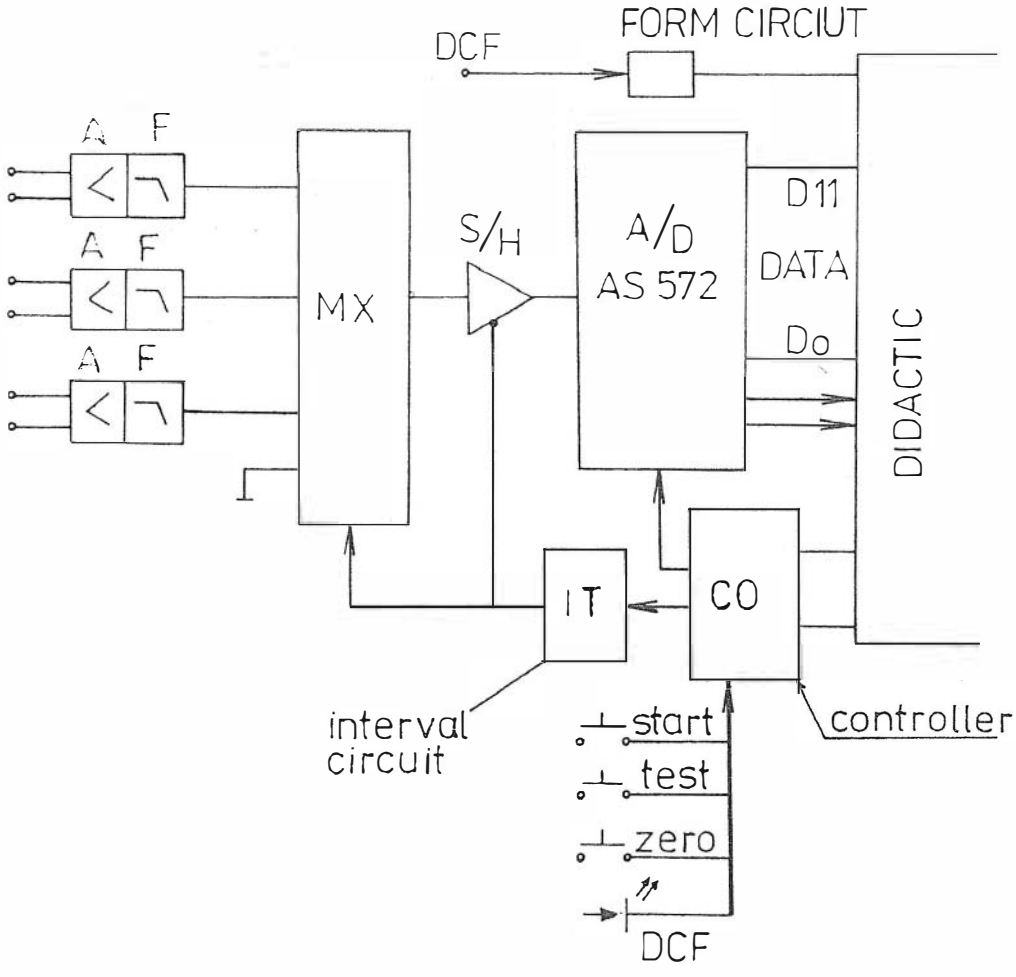

FIG.3. The block scheme of the connection A/D converter

is limited by the technical parameters of the microcomputer, its indisputable advantage is simple construction and low price. The experience obtained during its design and test operation will be further used for the design of the apparatus of advanced properties. However, this will already utilize one chip microprocessors and peripheral circuits in the form of tailor-made hybrid chips.

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Mikroprocesorová seismická aparatura

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Sestava této aparatury je určena pro registraci seismických jevů vzniklých při průmyslových trhacích pracích. Registrace seismické události obsahuje informaci o průběhu vlnového obrazu rychlosti kmitání a času vzniku. Základem seismické aparatury je komerční 8 bitový počítač DIDAKTIK (ekvivalent SINCLAIR), který je doplněn 12-ti bitovým A/D převodníkem, přijímačem časové informace z dlouhovlnné stanice DCF 77,5 kHz (Německo) a obslužnou logikou.

Zařízení je koncipováno jako automatický seismograf s programovým vybavením umožňujícím záznam seismického jevu včetně jeho nas
5,2 sec který je vytvořen nekonečnou časovou smyčkou. Okamžik startu záznamu je určen amplitudovým kritériem jehož nastavení se provádí před startem vyčkávacího režimu aparatury. Nastavení vzorkovacího kmitočtu 125/250 Hz udává max. hodnotu frekvenčního obsahu zaznamenávaných signálů 40/80 Hz.