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# APPLICATION OF ANALOG-DIGITAL CONVERTER FOR SEISMIC DATA

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**Abstract**

An analog-digital converter is applied for analysis of seismic data. This apparatus is generally designed for digitizing the analog data recorded on magnetic tape. The maximum sampling speed is 3,000 per sec. Some results for the aftershocks of the Niigata Earthquake are shown.

## Introduction

It is the purpose of this paper to describe one particular solution to the problem of high speed analog-digital conversion of seismic data. For this problem, two processes are generally used. One system is as follows: seismic data are recorded on analog magnetic tape and then converted to digital form on digital magnetic tape or punched tape by AD (analog-digital) converter. The other is the process that the data are directly converted to digital form without recording on analog tape. The latter process is desirable, especially on routine observation. Long waves of earthquakes are detected and analyzed by sampling with comparatively long intervals, for example, at the California Institute of Technology, with the interval of 0.1 sec. In the case of examining the short period character of earthquakes, however, we must sample the data with short interval, and thus the direct digitizing system demands a great deal of magnetic tape. For economic and practical reasons, the high speed driving of magnetic recorder and the high speed digitizing may not be feasible. Then the former process is frequently applied for seismic data, mainly of near-distance, medium distance, volcanic and sometimes explosion earthquakes. Moreover we devise one system of endless tape recorder with the time delay of about 3 min. By its use, we can fully record the seismic signals without consumption of analog tape. The recording system will be described in another paper. In this paper, the instrumentation of AD converter (DATAC-1030) and some results of analysis by its use are shown.

## Instrumentation

The block diagram of the system of DATAC-1030 is represented in Fig. 1. Continuous input signal in analog form (usually recorded on magnetic tape) is put in the input of apparatus and then is converted to digitized output. The AD converter widely used is classified into three or four types. Among them the method of the

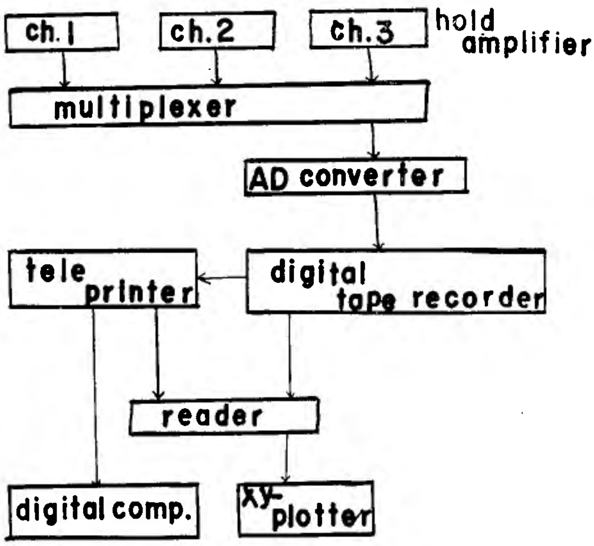



Fig. 1. Block diagram of AD converter.

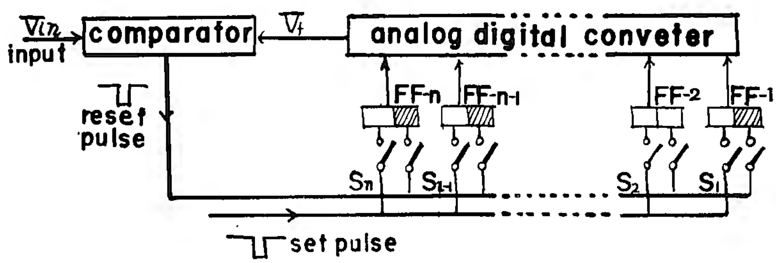



Fig. 2. Block diagram of successive comparison method.

successive comparison is generally adopted in such a case of seismic signals that they contain comparatively high frequency components and must be analyzed with high degree of accuracy. Fig. 2 represents the working process of the successive comparison method. In the figure, FF represents Flip-Flop circuit and if the right relay is open, it represents zero, and conversely if shunt, 1. If FF-n is 1, the output becomes $2^{n-1}$. If $V_f > V_{in}$, the output pulse starts from the comparator, and FF-n is again reset. $V_{in}$ is successively compared with each $V_f$ and each FF-n becomes "on" or "off". Then their combination represents the digital form of $V_{in}$.

The AD converter used by us is DATAC-1030(manufactured by Iwasaki Communication Apparatus Co.), of which the main ability is as follows: the range of input voltage is from +9.99 to −9.99V; the input impedance is over 100 k$\Omega$; the conversion accuracy is ±5mV+1/2LSD; the conversion time is 8 $\mu$sec.; the number of channels is three; the maximum sampling speed is 3,000/sec., when only one channel is used; if an arbitrary oscillator is applied for generating the clock pulse, any sampling speed not beyond 3,000/sec. is available.

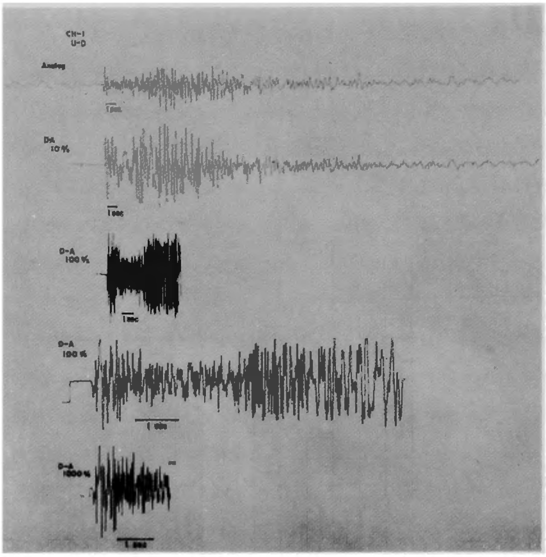
Digital-analog conversion can also be worked, and this process is used for combining any pair of three components to form wave orbital motions. The wave orbits are written on section paper by XY-plotter. In the case, the seismic signals converted in digital form are punched on paper tape by tele-printer and then any pair desired is converted again in analog form. The tele-printer has the maximum speed of 110 characters/sec. If the sampling speed is smaller than that of tele-printer, the signals are directly punched on the paper tape without recording on magetic tape.

**Results of analysis**

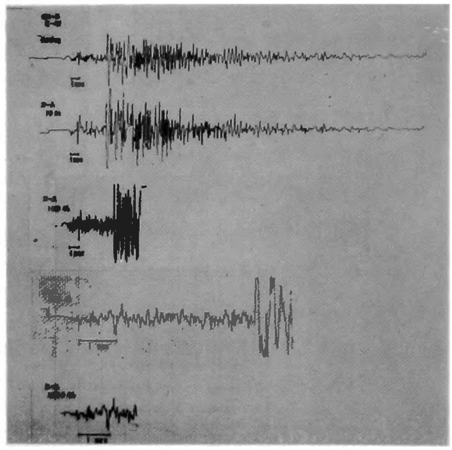
Some after-shocks of the Niigata Earthquake in June 1964 were treated with DATAC-1030. The seismometer used has the period of 1 sec. and is electro-magnetic moving-coil type. The seismic signals are recorded on analog magnetic tape with the tape speed of 9.5 cm/sec through transistor amplifier. In Figs. 3a, 3b and 3c, the examples of signals directly reproduced without any conversion and signals converted in AD and again DA are represented. The latter is sampled in 10, 100 and 1,000/sec., respectively. Comparing them with the referred direct records, we can see the reproduction of seismic signals in digital form without distortion. Figs. 4a and 4b, represent the wave orbital motion in horizontal plane and Fig. 4a represents the portion of *p*-phase and Fig. 4b the portion of *s*-phase. It is very useful for the determination of epicenter and identifying the phases that the orbital motion is easily obtained by use of DATAC-1030.

Fig. 5 represents the three components of the portion of *p s*, which are converted in digital form with sampling of 100/sec., and of which the *p*- and *s*-portions are corresponding to Figs. 4a and 4b, respectively.

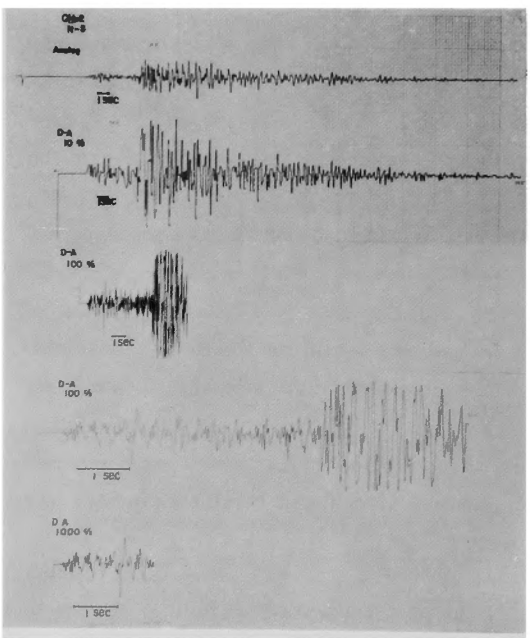
On the other hand, the most important application of AD converter is making the input into digital computer and an example of the application is shown in Figs. 6a and 6b, in which the Fourier spectrum of the *p*-portion is represented. In the computation, we used KDC-I. The perfect treatment will be described in another paper and here we concern the use of AD converter.



(a)



(c)



(b)

Fig. 3. Examples of seismic signals of after-shock of the Niigata Earthquake. Analog means the direct analog record, and D-A means DA conversion of the data converted one from analog to digital. 10, 100 and 1 000 c/s mean sampling speeds.

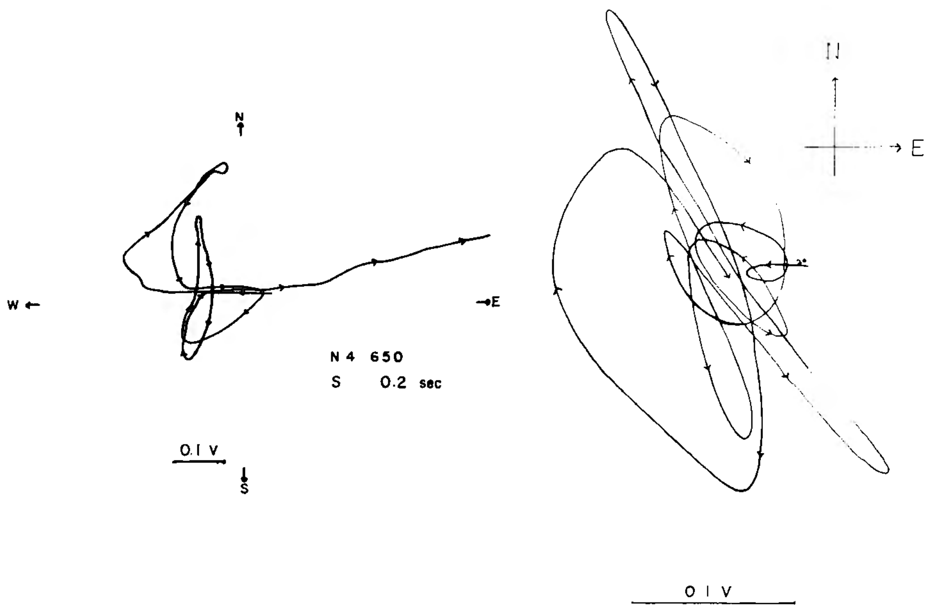



Fig. 4. Examples of wave orbital motions written on XY-plotter from the data sampled with the speed of 1,000 c/s. 4(a) indicates the $p$-portion and 4(b) the $s$-portion.

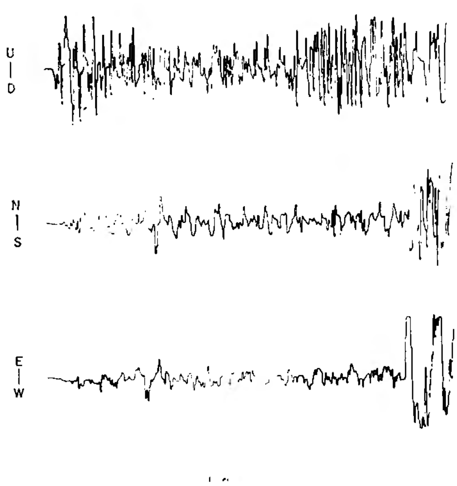



Fig. 5. Examples of three components of the shocks corresponding to Fig. 4. The sampling is carried out with the speed of 100 c/s.

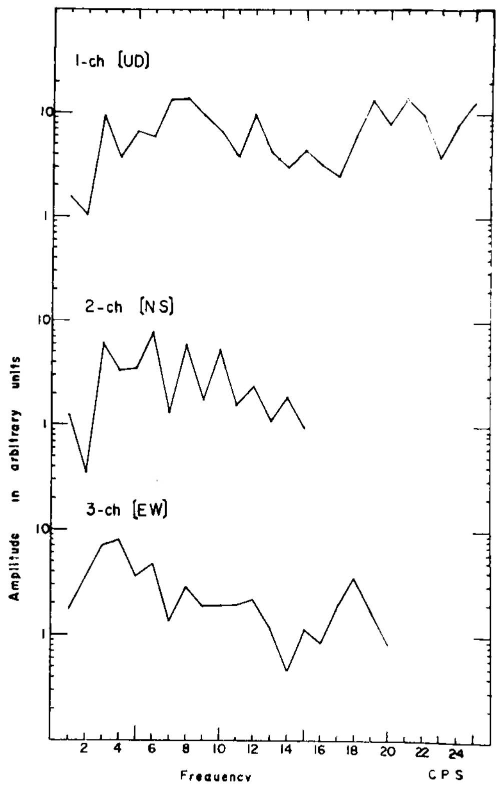



Fig. 6. Examples of Fourier spectrum of $p$-portion.

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