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ANALOGUE TAPE-RECORDING SYSTEM FOR SEISMOLOGICAL USE

by

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Abstract

An analogue frequency-modulated tape-recording system has been developed for seismological recordings. Three channels from 0.01 to 80 Hz and one channel for time information are recorded on one track of the 1/4 inch magnetic tape by a frequency-multiplex-modulation technique. As the bandwidth of the system is 3000 Hz, ordinary telephone lines can be used for data transmission. Compensation for variations in tape speed are provided by a stable compensation oscillator. With input filters of 30 Hz the subtractive compensation increases the dynamic range to 60 dB. This system was developed in 1969.

1. *Description of the system*

Data recording

The output voltages of the transducers are amplified and filtered by low-noise active RC low-pass amplifiers (Figs. 1 and 2). Above a fixed frequency the low-pass filters have a roll-off of 24 dB per octave, and can be changed by replacing the filter card.

The voltage gain is adjustable from 24 dB to 120 dB (16 to 10^6) in the steps of 12 dB with three attenuation switches (12 dB, 24 dB, 48 dB). A voltage-controlled-oscillator (VCO) (Fig. 3) converts the amplified voltage to frequency (Fig. 4). All carrier waves are then filtered and led to a mixer, from where the frequency-modulated information is recorded on one track of 1/4 inch magnetic tape.

The frequencies of the carrier waves are as follows: 300 Hz for time information, 800 Hz for channel 1, 1200 Hz for channel 2, 1800 Hz for channel 3 and 2700 Hz

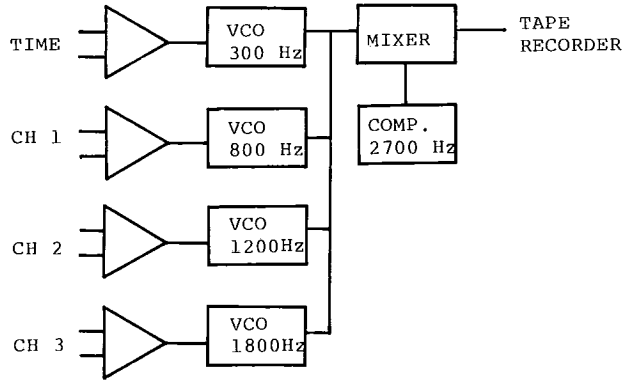

Fig. 1. Block diagram of recording section.

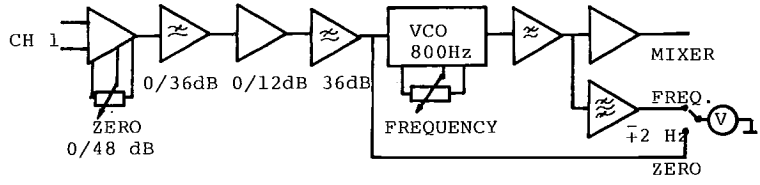

Fig. 2. Block diagram of channel 1 of recording section.

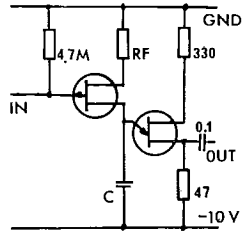

Fig. 3. Voltage-controlled oscillator (VCO).

for the compensation of the variations in tape speed. The maximum deviation is 10 % and every channel has a frequency meter to check the carrier frequency. This meter is accurate to ±2 Hz.

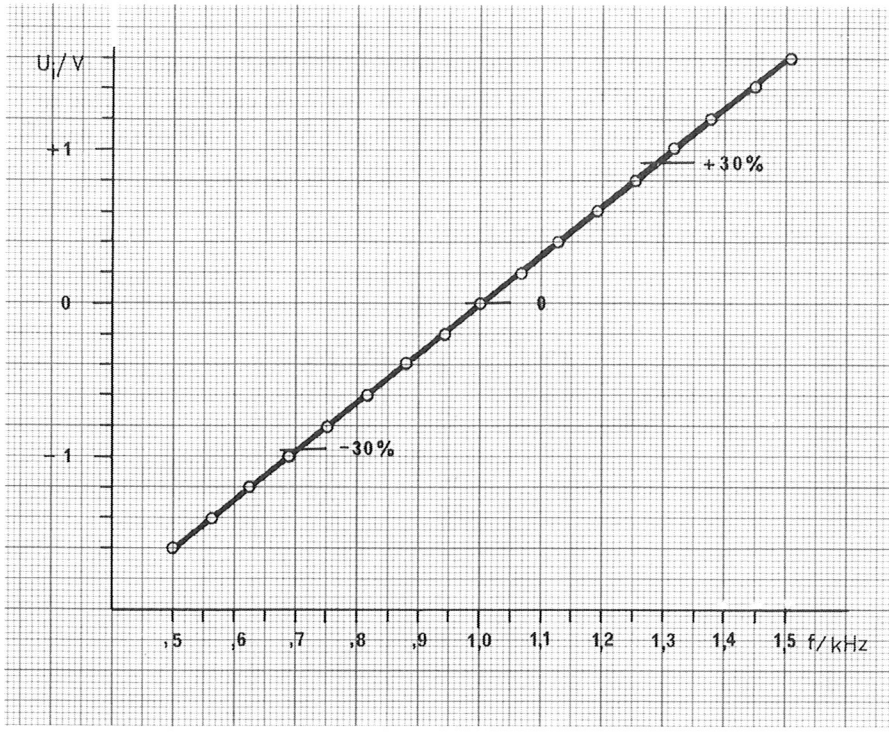

Fig. 4. Linearity of the voltage-controlled oscillator.

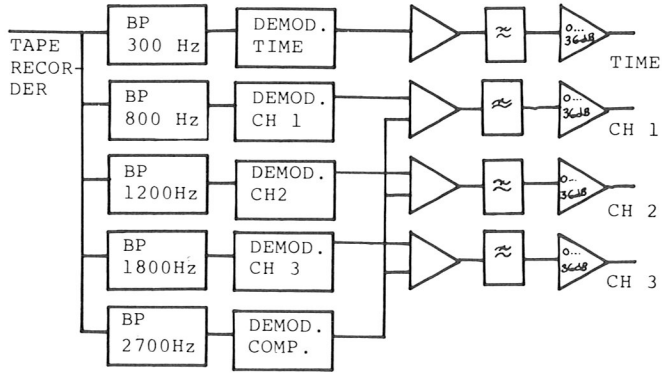

Fig. 5. Block diagram of the reproducing section.

Data reproduction

The data from the tape recorder are amplified and filtered by band-pass filters (Fig. 5), each consisting of two pairs of active RC networks carefully adjusted to fixed frequencies. For example, the 800 Hz band-pass filter is made of two narrow-range double band-pass filters, 745 Hz and 855 Hz (Fig. 6).

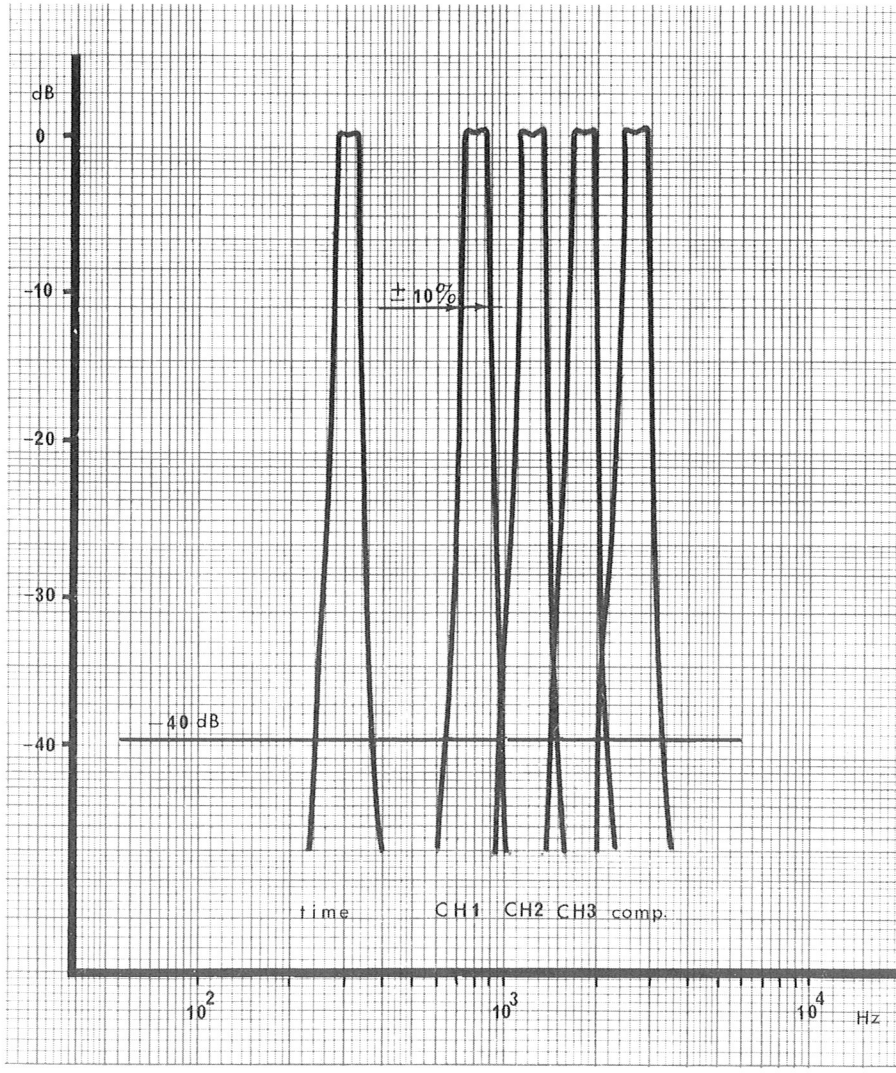

Fig. 6. Band-pass filters of the reproducing unit.

The separate carrier waves are then demodulated by a cycle-counting detector, and the demodulated information is low-pass filtered and amplified to the desired level by steps of 6 dB.

Operation instructions

The seismometers and tape recorder are connected to the recording unit, and the power is switched on. The attenuation level can be set to every channel by three attenuation switches, and the amplifiers are adjusted with a zero potentiometer until the control meter reads zero. Next, the carrier waves are checked with the same control meter. When the carrier frequency has been adjusted, the correct frequency is seen as a deep dip on the control meter. Now the recording unit is in operation and the tape recorder is switched on. During the recording the control meter shows the input level.

2. *Discussion*

The recording time with a 7-inch reel at a tape speed of 2.4 cm/s is about 10 hours. The operation temperature ranges from 0 to +40°C. Outside this range small internal adjustments have to be made.

The right input level is seen on the control meters, but for rapid events it is better to listen to the carrier frequency, as the control meter is rather slow. When the observer is listening to the carrier wave, the input level is convenient as any

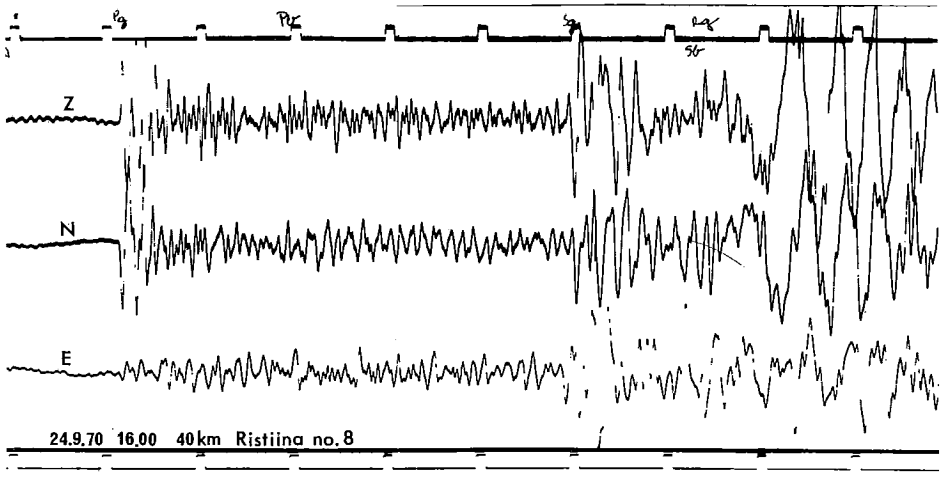

Fig. 7. An example of a seismic recording.

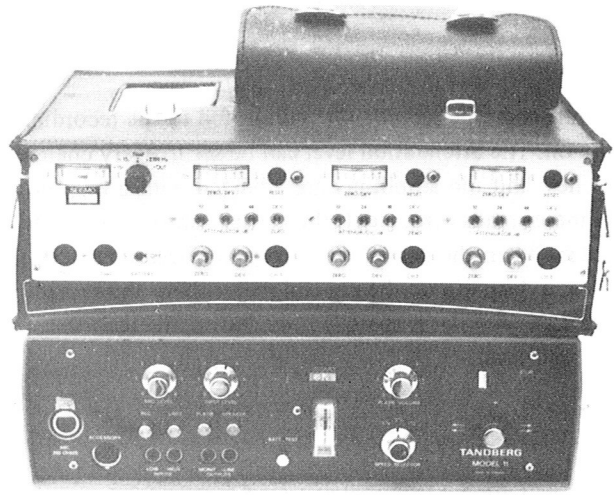

Fig. 8. The tape-recording unit.

small frequency shift is heard. The deviation is then about 1 – 3 % (maximum deviation 10 %).

The instrumental noise is 1 μV_{p-p} with a 40 kΩ input impedance and the microseismic level to instrumental noise is about 40 dB. For lower seismometer impedances the S/N ratio is worse and high magnification is not recommended for impedances of less than 500 Ω.

During several field measurements we have used Willmore and Hall Seas transducers. Figure 7 shows an example of these recordings.

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