MATHEMATICAL ANALYSIS OF ELECTROENCEPHALOGRAMS BY THE MN-7 ANALOG COMPUTER

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The use of the MN-7 analog computer for integrating bioelectrical activity and recording periods of the original waves of the electroencephalograms is described.

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Mathematical analysis of electroencephalograms is increasing in importance at the present time [2, 3, 4]. Despite some progess in the application of methods of mathematical analysis to electroencephalography [1, 5-8], difficulties still remain.

We accordingly suggest the use for mathematical analysis of the EEG the MN-7 bench analog computer, which is cheap and in large-scale production. It has 16 operation amplifiers, the inputs and outputs of which are brought out onto a commutation field, and various accessories are also available. By commuting the amplifiers in a certain way, the MN-7 computer can be used for mathematical analysis of the EEG.

In this paper we describe the use of the computer for integration, differentiation, and recording the periods of the original waves of the rabbit EEG.

For the operation of integration by level, three operation amplifiers are used. The circuit of commutation between amplifiers is illustrated in Fig. 1. The design of the output cascade of the encephalograph channel (developed by the "Biofizpribor" Technical Design Bureau) is such that an upright and inverted signal can be obtained. These signals enter through diodes on the summating inputs of amplifier 1 for integration. Amplifiers 2 and 3 simulate a relay with controllable levels of operation. As soon as the signal at the output of amplifier 1 exceeds the operation level, a discharge takes place in the 0 of the integrating amplifier and the integration marker is given to the encephalograph. Altogether four processes can be integrated at the same time.

To analyze a larger number of processes the method of integration by time can be used. Compared with the circuit just described, in this case there is no need for a relay consisting of the amplifiers 2 and 3 in the circuit. Discharge of the integrating amplifier at zero in time is brought about by closing the contacts of the relay shunting the feedback capacitor C_1. The relay can be controlled by time marker signals from the encephalograph at a frequency of 1/sec or from the computer at frequencies of 1, 2, 5, and 10/sec. During integration by time, as many as 16 processes can be analyzed simultaneously.

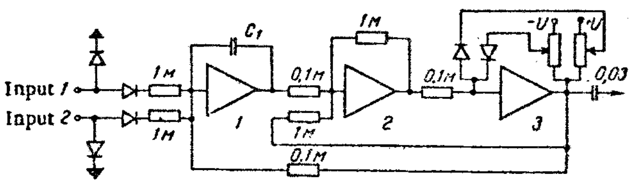

Fig. 1. Circuit of commutation between units of the computer for the operation of integration by levels. 1) Integrator; 2) amplifier-inverter; 3) unit with two steady stages. M = MΩ.

The operation amplifiers can be used to form EEG waves for subsequent analysis on the PF-20 computer. For this purpose, the signal from the encephalograph is fed into the input of the operation amplifier through a 0.01 μF capacitor. Every 10th halfwave, counted by means of the PS-20 instrument, is marked on the encephalograph tape.

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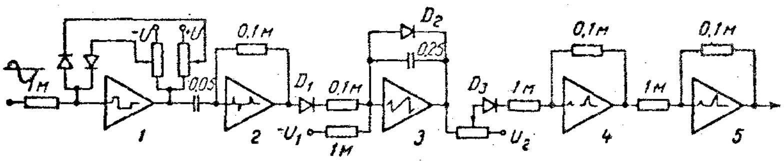

Fig. 2. Scheme of commutation between units of computer for automatic measurement of small changes in frequency of the EEG. 1) Unit forming square pulses; 2) differentiating unit; 3) sawtooth voltage generator; 4) amplitude selector; 5) amplifier. M = MΩ.

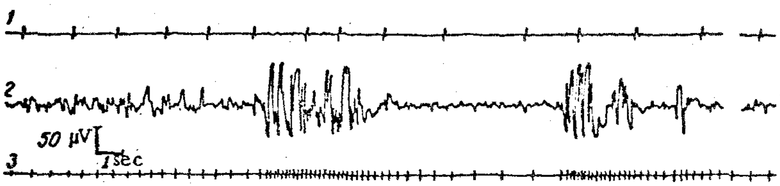

Fig. 3. Analysis of rabbit encephalogram by the MN-7 computer. 1) Mark counting every 10th wave of EEG; 2) EEG of rabbit's somatosensory cortex; 3) record of results of integration by levels.

The MN-7 computer can be used for automatic measurement and detection of small changes in frequency of the EEG. The commutation circuit of the operation amplifers of the computer when used for this purpose is shown in Fig. 2. The signal from the encephalograph enters the input of the unit forming square pulses (1). The differentiating unit (2) converts the square signals into a series of short pulses precisely marking the times when the original signal intersects the zero line. A constant voltage V_1 is applied to one input of the integrating amplifier (3). As a result of integration, a voltage increasing linearly in time is present at the output of the amplifier. Positive signals from amplifer (2) enter the other input of the amplifier (3) and return amplifier (3) to its original state. The zero level at the output of amplifier (3) is fixed by diode D_2. At the end of the positive pulse a linearly increasing voltage again appears at the output of amplifier (3). As a result, the amplitude of each tooth of the sawtooth voltage is dependent on the duration of the corresponding period of the input signal. The waves obtained are fed into the amplitude selector (4), which passes only the apices of the "saw" at the output, and these pass through the amplifier (5) and are recorded. Small changes in frequency of three channels of the electroencephalogram can be detected at the same time.

All the circuits have been built and tested and have acquitted themselves well in operation. As an illustration we give a record of the biopotentials of a rabbit's somatosensory cortex with simultaneous integration by levels and counting of every 10th EEG halfwave (Fig. 3).

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