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An amplitude modulated earthquake telemetering system

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ABSTRACT. A telemetering system using amplitude modulation for transmission of earthquake signals is described. The working of the circuit designed for the purpose is explained. The results so far obtained are given as examples with suggestions for further improvement.

1. Introduction

The transmission of earthquake signals using conventional methods poses a problem because the Very Low Frequency (V. L. F.) signals near to d.c. cannot be normally amplified by a.c. amplifiers. Chopper modulated amplifiers have been used in the past for amplifying V.L.F. signals. Mechanical choppers having frequencies ranging from 50 c/s to 300 c/s were used frequently in various applications. A chopper can, however, handle very narrow band of frequencies. The driving coil is also prone to pick up hum and complete isolation of input and output stages are essential. Finally the efficiency of mechanical choppers is very low and they are unsatisfactory for the signal level down to microvolt region.

In the present case a balanced bridge modulating system employing diodes was used in a grounded emitter circuit for high sensitivity.

2. Principle

The block diagram of transmitting and receiving system is shown in Fig. 1. The frequency of transmission was selected 22 mc/s because a commercial receiver can be used for receiving the signals.

A short period (1·6 sec) horizontal component (E.W.) electromagnetic seismometer was used to pick up seismic signals. The seismometer was fabricated in our department. The output impedance of the seismometer was 400 Ohms. The output signal of the seismometer modulated a reference oscillator of 1·2 kc/s using balanced bridge type modulator. The resulting signal was amplified by a four-stage audio amplifier and a power amplifier.

This signal modulated a class-C, r.f. amplifier and was fed to a centre fed dipole antenna.

A commercial receiver was used for receiving signals which were filtered and detected. The output signal was amplified by a d.c. amplifier and fed to a galvanometer type ink and pen recorder.

3. Balanced bridge modulating circuit |

Fig. 2 shows the circuit of diode modulator. This circuit modulates the input signal from the seismometer and also provides required amount of damping. Four OA79 diodes were connected in a balanced bridge configuration in the base to emitter circuit of a OC75 transistor. The other ends of the bridge were connected to a 1·2 kc/s driving oscillator. In the positive half cycle of driving oscillator all four diodes conduct, lowering the base to emitter voltage level and no signal passes to collector side. In the negative half cycle all four diodes stop conducting and the signal is passed to the collector of OC75 transistor. The resulting output singal has the same frequency as that of driving oscillator and amplitude that of input signal. The signal was amplified to 1 volt level by a two-stage transistorised amplifier.

The modulating frequency of 1·2 kc/s was selected for the convenience of monitoring the signal. The two potentiometers avoid overloading of the bridge circuit and can be adjusted for optimum operation. The sensitivity of the circuit is also determined by the settings of these potentio meters. The output impedance of final amplifier was kept high to match the input impedance of the tube modulator.

4. Demodulator and d. c. Amplifier

The circuit diagram of demodulator circuit and d.c. amplifier is shown in Fig. 3. The output from the voltage amplifier of the receiver was

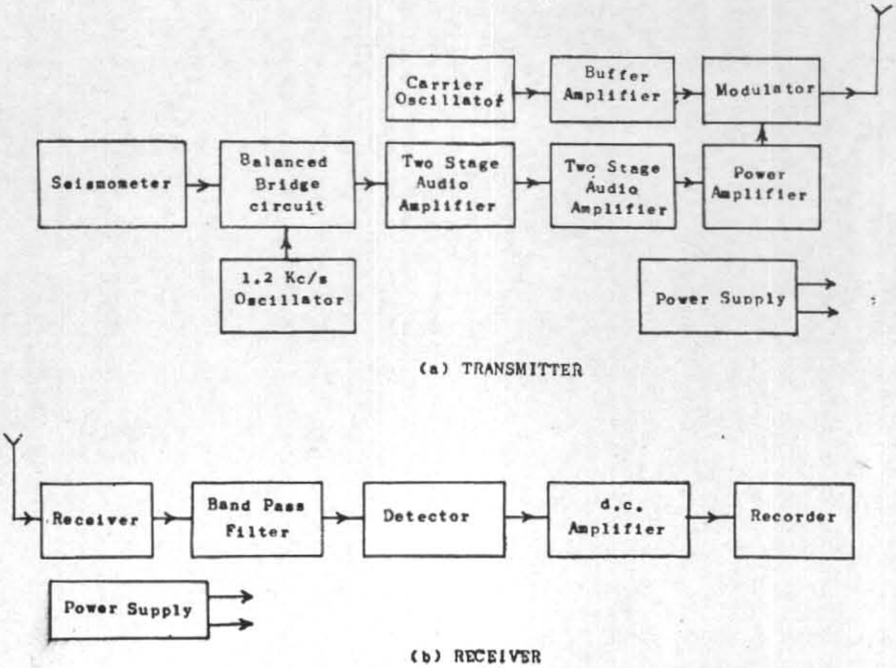

Fig. 1. Circuit block diagram : (a) Transmitter & (b) Receiver

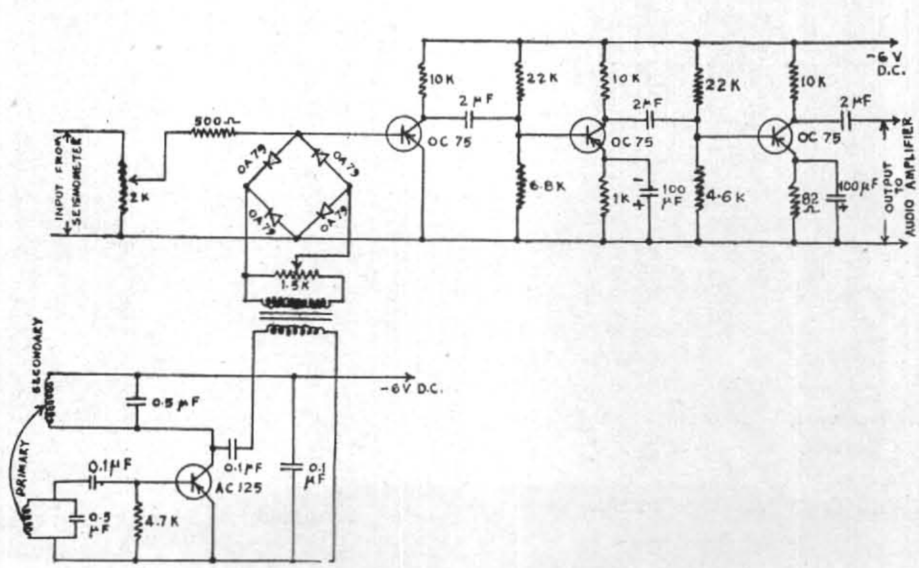

Fig. 2. Balance bridge diode modulator circuit

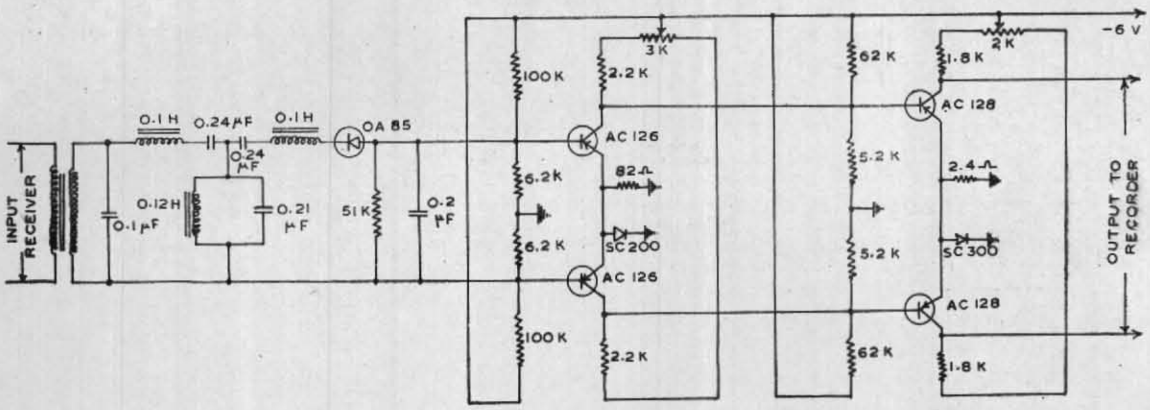

Fig. 3. Detector Circuit

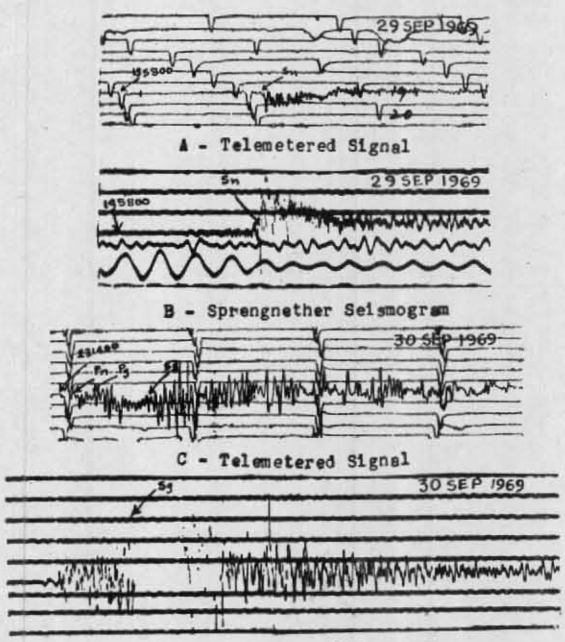

Fig. 4. Earthquake records of 29 September 1969 (A and B) and 30 September 1969 (C and D)

A and C — Telemetered signals

B and D — Sprengnether Seismograms

fed to a band pass filter, having pass band from 500 to 2000 c/s. The modulated output was detected by a OA85 detection diode. The detected signal was fed to a two-stage push-pull d.c. amplifier. The amplifier was designed for low drift and the temperature compensation was made by heat sinks and varistor diodes. The output of d.c. amplifier was connected through a 20 db attenuator to the pen recording galvanometer.

5. Results

Unlike the mechanical chopper the balanced bridge modulating circuit was very efficient down to microvolt signal level. The sensitivity of the circuit was high. Higher sensitivity of the overall system can be achieved by increasing the gain of the audio amplifier stages. Number of stages in the d.c. amplifier can also be increased. A sensitive receiver and galvanometer type recorder will further increase the efficiency of the system.

The modulation efficiency was good upto 95 to 100 per cent modulation. The wave shape distortion was kept low by using class-A operation.

The phase inversion may occur in the telemetered signal because of class-A operation. This was taken into account after calibrating the system. The first stage of the d.c. amplifier may also be connected as phase inverter, with slight modifications.

The system can be used in remote places where unattended performance is desirable. The recorder portion may be kept in a central place. The system can also be used in a seismic array. The magnetic tape recording of the earthquake signals may also be done by utilising the system.

By using a short period seismometer and recording galvanometer the system can be used for receiving short period signals. Long period seismic signals can also be received conveniently by using long period seismometer and a suitable galvanometer.

Fig. 4 shows some typical seismograms recorded by the earthquake telemetering system. (A) shows the near shock of 29 September 1969. The *P*-time and *S*-time were compared with the standard seismograms (U.S.C.G.S.) and showed good agreement. The epicentre was 2·5° away from Shillong. (B) shows the same shock recorded by the Sprengnether seismometer with 3·6 k magnification. The near shock of 30 September 1969 is shown in (C). The value of $\triangle$ was 2·1° and agreed well with the value determined from the standard seismograms. (D) is the same shock recorded by Sprengnether seismograph system.

A sensitive galvanometer type pen recorder is being designed for use with the system which will improve the performance. The system will also be designed to operate at 72 mc/s with a suitable transistorised receiver and improved d.c. amplifier.

Acknowledgement

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