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A New Model of Telluric Amplifier for Magnetotelluric Soundings

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A b s t r a c t

In 2005, a new series of two-channel telluric amplifiers has been designed and constructed at Belsk Observatory. This model named TWG-0501 is designed mainly for magnetotelluric field measurements. These amplifiers basing on microprocessors provide a number of new functions, e.g., automatic compensation for the constant part of input voltage and remote setting of working parameters by means of a RS-232 interface and a local computer network. The range of input voltage is ±100 mV and that of output voltage ±10 V for this device. More details are presented in this article.

A two-channel telluric amplifier has been constructed for investigation of telluric currents. Such currents are induced in the upper layers of the Earth's crust by natural geomagnetic field variations. Table 1 shows basic parameters of this amplifier and Fig. 1 its photo. A telluric amplifier serves for amplification of weak incoming signals from the sensors (electrodes) buried in the soil. The device contains two independent differential amplifiers placed in a common casing. This enables a synchronous recording of the electric field of two pairs of electrodes that are usually directed perpendicularly, N-S and E-W. We can see an example of such a registration in Fig. 2.

The amplifier can be used with any electrodes, if their contact resistance to the soil is lower than 10 kΩ and their polarization voltage lower than ~250 mV. In practice, the length of the telluric lines can take values from several meters to few hundred meters. Figure 3 shows such an electrode.

Table 1

Basic parameters of Telluric Amplifier model TWG-0501

Nr	Parameter	Unit	Value	Remark
1	Gain per channel	V/V	100 ± 0.2%	for DC
2	Average noise (G = 1)	μV	< 1	
3	Damping of in-phase signals	dB	95	for f < 0.02
4	Input resistance	MΩ	> 100	for DC
5	Output resistance	Ω	70	for DC
6	Maximum input signal	mV	± 250	
7	Maximum output signal	V	± 10	
8	Thermal coefficient	mV/°K	< 1	
9	Signal transfer band	Hz	0 – 0.25	
10	Output voltage of thermograph	V	0 ± 0.5%	for 0°C
11	Thermograph scale value	°K/V	10 ± 0.5%	
12	Current consumption	A	0.15	for 13.0 V

Fig. 1. Telluric amplifier model TWG-0501.

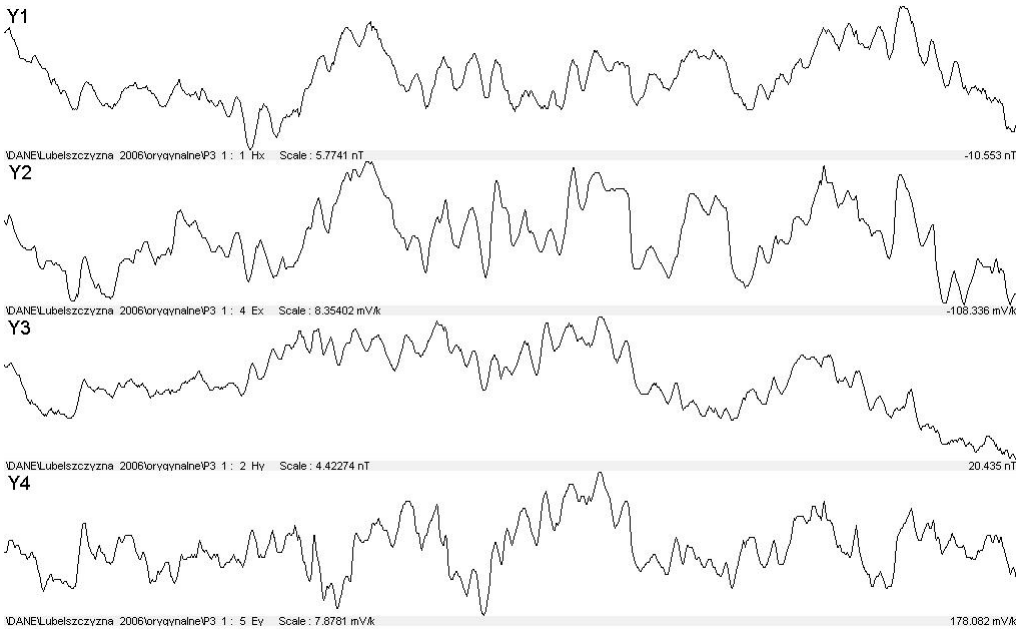

Fig. 2. Example of registration. X axis – 1000 sec. Y1 axis – Hx 5.77 nT; Y2 axis – Ex 1.67 mV/km. Y3 axis – Hy 4.42 nT; Y4 axis – Ey 1.71 mV/km.

Fig. 3. Electrode.

The amplifier has been designed for usage together with transduced magnetometers LEMI-003P, which are produced in Lviv (Ukraine). This set of devices is applied to magnetotelluric field measurements. The DC low-pass filters in both devices are practically the same, which allows to avoid the necessity of introducing the instrument's characteristics for the person who is processing the collected data.

For magnetotelluric field soundings there is usually applied a telluric length of about 100 m. With regard to thermal coefficients, the electrodes are buried to a depth of minimum 70 cm. Since the electrodes work well only in moist ground, it is necessary to place ca. 10 kg of a mixture of technical bentonite with water in every electrode hole. Bentonite is very hygroscopic (it absorbs water from its surrounding), so it preserves the moisture of the electrodes and improves stability of their potential. When installing the electrodes, one has to pay special attention to the state of the insulation of telluric cables too. Every (even the smallest) damage causes a contact between the conductor and the soil (even through plants) and therefore worsens the quality of telluric registrations.

The resistance of the conductor's insulation to the ground should be at least 100 times as big as the transition resistance between electrode and ground, i.e. not less than 0.5-1 MΩ.

The amplifier is equipped with a controlling system for telluric lines. In case of an interrupted line, there appears a signaling "OFF LINE". Furthermore, it is possible to measure the resistance of the line in the range of 0.1-50 kΩ. This measurement is carried out by means of AC of 20 Hz. Thereby a polarization of the electrodes is avoided.

The input circuits of the amplifier are protected against over-voltages, which can be inducted between electrodes and telluric lines during atmospheric discharges. The protecting system consists of diodes and varistors and is able to hedge the amplifier against short-term over-voltages of amplitudes up to 1000 V. Figure 4 shows a block diagram of the telluric amplifier.

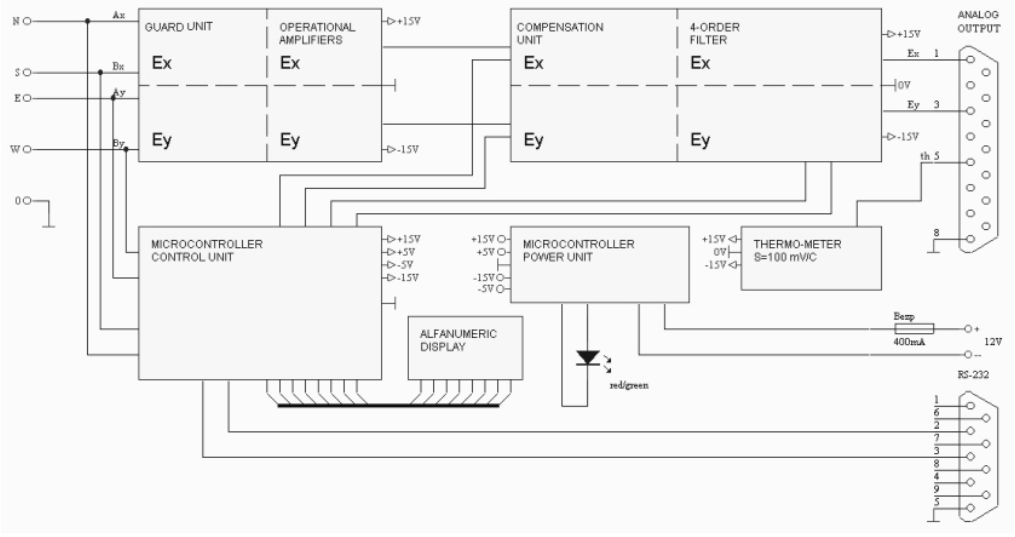

Fig. 4. Block diagram of telluric amplifier TWG-0501.

The filters are of 4-th order of Sallen Key with a cut-off frequency of 4 s. The filters of both channels possess very similar parameters. We show their characteristics in Figs. 5 and 6.

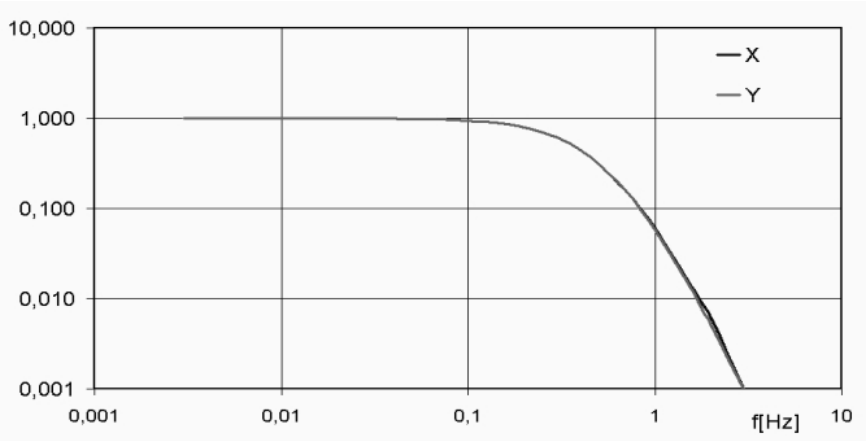

Fig. 5. Amplitude characteristic of the amplifier.

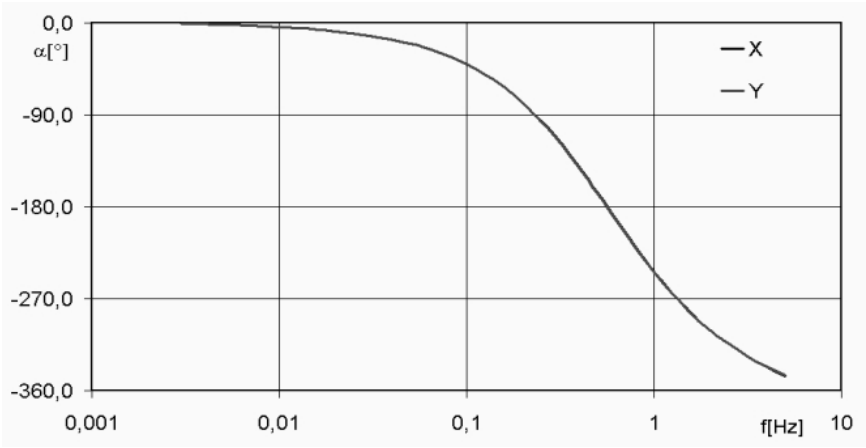

Fig. 6. Phase characteristic of the amplifier.

The amplifier possesses a detailed setup, where all working parameters can be adjusted. An additional digital calibration based on given memorized voltage and resistance patterns provides a fast correction of parameters even under field conditions by means of a simple calibrator. A remote control is enabled by means of a RS-232 port and standard terminal programs.

Due to this, no special software is necessary for a remote control of the amplifier. The software “Hyper terminal” for Windows, “Minicom” for Linux or “Mirror” for DOS is sufficient. A control of the amplifier by means of a local network “LAN” is also possible. See Fig. 7 for an example of control of such a kind.

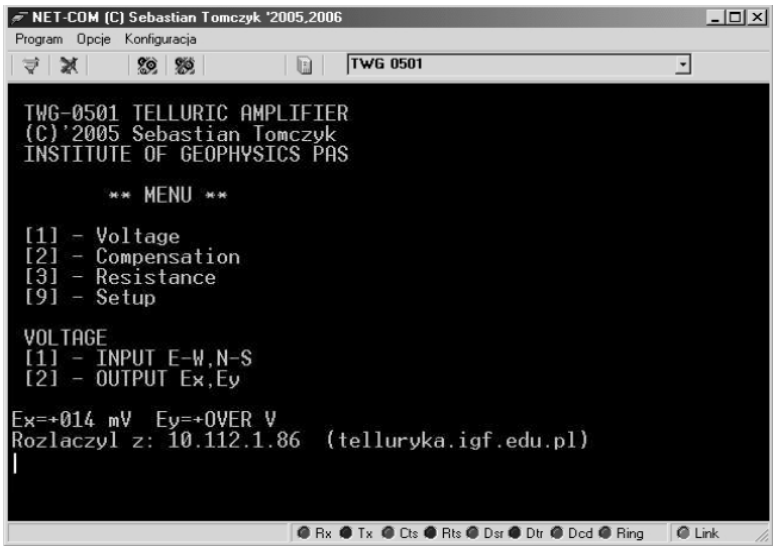

Fig. 7. Operation of the amplifier.

Conclusions

The presented telluric amplifier proved to be the best one in practical applications, especially for field measurements. The automatic compensation for the constant value improves the data quality, and the remote control enables to check the telluric lines in case of difficult access to the place of measurement.

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