APPLICATION OF THERMISTORS FOR STABILIZING
LOW UHF POWERS

V. I. Krzhimovskii, I. A. Sergeev, and N. N. Sergeev

At present there exists a requirement for reducing the instability of the output power level of UHF sources to variations of the order of 0.1% or less.

A wide application of UHF power stabilization is impeded by the lack of mass-produced electrically controlled power regulators suitable for precision devices.

A common element, a transistor, is being used as a regulator of low UHF powers at the VNIIM (All-Union Scientific-Research Institute of Metrology). The UHF power is controlled by changing the attenuation of the regulator with the variation of the current which flows through the thermistor.

A TK-2-50 thermistor without its glass bulb was bridged across a break in the central conductor of a coaxial channel, thus forming an attenuator for study purposes (Fig. 1). In places where thermistor 1 was connected, the diameters of the coaxial conductors were reduced. The diameter of the external conductor is equal to 1.2 mm. The characteristic impedance is then equal to 100 Ω. Chokes 2 and the feed-through capacitors 3 are used for connecting the thermistor to a dc circuit. Such a very simple matching circuit serves to obtain at the input and output of the thermistor attenuator a VSWR not worse than 2 in the range of 150-10,000 MHz without any adjustment operations.

The VSWR at the input and output of thermistor attenuator 3 in the circuit of Fig. 2 is a secondary parameter, since the reflection factor of an equivalent generator does not depend on the VSWR of the thermistor attenuator and is fully determined by the characteristics of directional coupler 4 and the amplification factor of the automatic control system. The loss of the thermistor attenuator decreased nonlinearly with a rising direct current through the thermistor and assumes values from 8 to 1 dB for current changes from 2 to 20 mA (Fig. 3a).

For describing the properties of a thermistor attenuator as an electrically controlled UHF power regulator it is convenient to use the concept of a regulator sensitivity under which we understand the controlled power relative variations in decibels produced by a change of 1 mA in the dc current flowing through the regulator. The sensitivity of the regulator increases (Fig. 3b) with a rising thermistor effective resistance, which it is advisable to set in the range of 50 to 200 Ω, with the maximum power in the load then being in the range of 20 to 3 mW (Fig. 3c). In this range of the thermistor effective resistances the regulator sensitivity assumes the values of 0.1 to 0.6 dB/mA.

The reflection factor from the input and output of the attenuator changes with variations in the thermistor resistance. Variations of the reflection factor produce additional changes in the power at the output of the thermistor attenuator and, in case of unfavorable phase relationships, reduce the sensitivity of the regulator. The relationship of the voltage standing wave ratio to the thermistor resistance is shown in Fig. 3d. In order to reduce the effect of the thermistor attenuator's reflection factor variations on the attenuator sensitivity it is advisable to insert between the generator and the attenuator a precisely matched ferrite gate 2 (see Fig. 2).

The control circuit (Fig. 4) consists of bolometric head 1 which serves as a UHF power detector, a bridge cir-
Fig. 3. Characteristics of an attenuator with cartridgeless thermistors TK-2-50 measured at 5 GHz.

The circuit with automatic balancing, and a dc amplifier. The bolometric head is connected to an arm of bridge $R_9$, $R_4$, and $R_5$. The unbalance signal controls through the photogalvanometric amplifier FGU-1 the resistance of transistor $T_1$ in such a manner that variations of the current through the bolometer reduce the voltage across the bridge diagonal.

The bridge circuit includes a heater of thermopile $T_P$ whose thermal emf is proportional to the dc power in the bolometer.

When switches $S_1$ and $S_2$ are closed the UHF power is disconnected. The thermal emf corresponding to the dc power in the bolometer is compensated (stored) by means of the galvanometer and a storage element consisting of battery $B_1$ and potentiometer $P_1$. When the UHF power is connected, the thermal emf at the output of thermopile $T_P$ is proportional to the residual dc power in the bolometer (switch $S_1$ is open). The voltage at the output of the thermopile and the storage element, which are connected in opposition, is proportional to the UHF power. This voltage is compared to the voltage tapped off potentiometer $P_2$ which carries a dc current set by means of a standard cell. The potentiometer is calibrated in UHF power units.

When switch $S_2$ is opened, a signal proportional to the difference between the effective value of the UHF power and the value set on the dial of potentiometer $P_2$ (error signal) is used for regulating through photogalvanometric amplifier FGU-2 the resistance of transistor $T_2$ in such a manner that variations of the direct current flowing through thermistor attenuator 2 produce changes in the UHF power tending to reduce the error signal.