*Henryk Pykacz, Józef Mróz**

A Pyroelectric Detector for i.r. Radiation

The design of an i.r. radiation detector, based on pyroelectric effect is presented. Its basic performance, including its frequence characteristics, has been analysed.

In pyroelectric detectors, like in thermal ones, the radiation absorption is associated with the increase in the temperature of pyroelectric material. This process, in turn, is accompanied with the changes in the state of polarization, manifested by the polarization charges which appear on the surface perpendicular to the pyroelectric axis. In contra distinction to thermal detectors the voltage signal in pyroelectric detectors is proportional to the temperature derivative with respect to the time. The main principles of the operation of pyroelectric detector have been given in papers [1—4].

The following advantages of pyroelectronic detectors may be mentioned:

a) no cooling needed,

b) flat spectral-response within a wide range of wavelengths,

c) a remarkably higher (than in thermal detectors) detectivity within frequencies (kHz and higher),

d) flat frequency characteristic of sensitivity, when combined with an equalizing amplifier. For these reasons pyroelectric detectors may be employed to reproduce laser pulses [2–5].

The design and properties of pyroelectric detectors made of triglycine sulphate (TGS) working at room temperature are described below.

Square (2.1×2.1 mm) plates, 0.1×0.2 mm thick were obtained by cleaving the crystal, so that its pyroelectric axis be perpendicular to the surface. Thereupon the plates were polished to the thicknes of about 0.07 mm and cemented with substrate by means of a silver paste.

The substrate was constituted by a polyester film 0.03 mm thick, stretched over a plexiglass ring, with square (1.5×1.5 mm) gold electrode, and a conducting track. The gold electrode, its reflectivity being equal to unity, was the rear electrode of pyroelectric capacitor.

The front electrode of the same area, obtained by evaporating the nichrome on the crystal plate was semitransparent for i.r. radiation. Its transmittance equal to 70% corresponds to the resistance 400Ω/square. A gold wire, 0.1 mm in diameter, was glued with front electrode by means of silver paste.

The whole assembly was installed in a transistor housing of TO-5 type with a window of 3 mm aperture diameter, made of KRS-5 (70% transmission within the wavelength range 2–40 μm). The view field of the detector amounted to 60°, while its d.c. resistance was higher than 10^{11} ohm.

Bearing in mind a high resistance of the detector and a relatively low input resistance of the measuring amplifier the electrical matching of both devices has been realized by means of an electric circuit, (Figs. 1a nad b). An electric circuit with MOSFET BSWP-30 unipolar transistor is presented in Fig. 1a. This circuit is characterized by a very high (10^{13} ohm) input resistance, and a low (1kΩ) output resistance, its voltage amplification factor being 0.8.

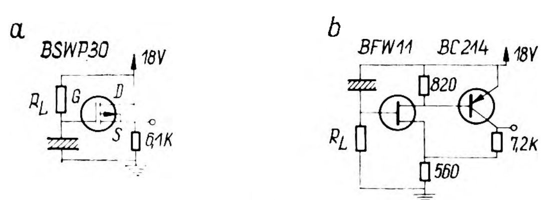

Fig. 1

At the same time this system ensures an automatic polarization of the crystal. The load resistance value R_L fitted according to actual task cf the detecting system, influences the transmitted frequency-band, as well as the responsivity at low frequencies. The results presented in the sequel are given for $R_L = 10^{10}$. In the electric circuit (shown in Fig. 1b)

* Institute of Technical Physics, Technical University of Wrocław, Poland.

with BFW 11 field-effect transistor and BC 214 bipolar transistor the respective (considering their order) values of the input resistance and voltage amplification are by 10^2 lower and 10^1 higher than in the circuit presented in Fig. 1a.

Results obtained from the measurements of a relative spectral responsivity are presented in Fig. 2. As the reference detector a V-Th-1 vacuum thermoelement with a KRS-5 window has been applied. Spectral characteristic is flat in principle, like in thermal detectors. The deviations from the linearity (i.e. from horizontal straight line) are due to the coefficient of absorption, which within the range below 3.5 μm is smaller. The linearity may be improved, if needed by blackening the surface.

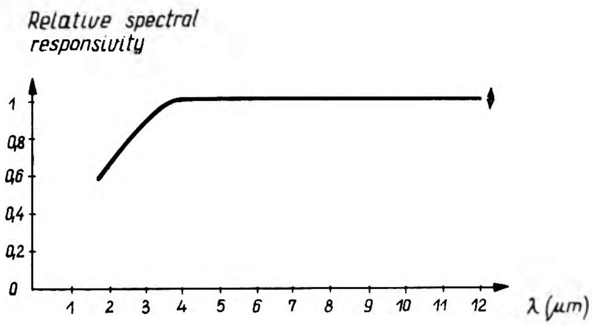

Fig. 2

Fig. 3 presents the results obtained from the measurements of responsivity, rms of noise voltage, and NEP values, taken for the pyroelectric detector applied to the input electric circuit shown in Fig. 1b.

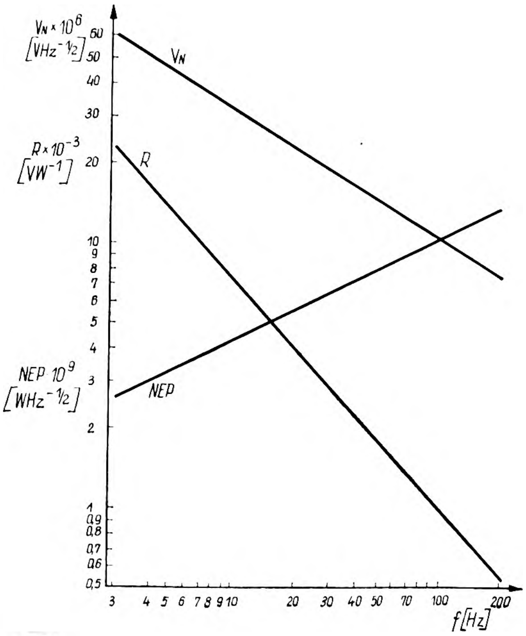

Fig. 3

A model of a black body heated to 500 K has been used as the source of radiation. Within the measuring range (3-200 Hz) the voltage signal from the detector was inversely proportional to the frequency. This result is consistent with the cut-off frequency $1/2\pi R_L(C+C_a) = 0.6$, estimated theoretically, (where $C = 8$ pF is pyroelectr.c detector capacitance, and $C_a = 20$ pF is preamplifier input capacitance) being smaller than the lowest measuring frequency. The rms noise voltage and the NEP values are proportional to $f^{-1/2}$ and $f^{1/2}$, respectively. The main detector noise may be due to thermal or to Johnson noise; the latter is associated with the a.c. loss in pyroelectric material, the equivalent resistance of pyroelectric capacitor being $1/\omega C \tan\delta$. The main sources of the preamplifier noise are: the Johnson noise coming from the load resistance as well as the current and voltage noise of the preamplifier.

From the analysis of the noise spectrum it may be stated that the main source of the noise in the investigated measuring system is the Johnson noise associated with a.c. dielectric loss.

Since NEP depends, among others, on the dielectric loss $\tan\delta$ it is clear that the lowering of oss value would improve the detector performance.

Détecteur pyroélectrique du rayonnement infrarouge

On a présenté la construction d'un détector du rayonnement infrarouge fait en sulfate de triglycine (TGS). On a donné ses paramètres de base et son diagramme de réponse en fréquence.

Пироэлектрический детектор инфракрасного излучения

Представлена конструкция детектора инфракрасного излучения, изготовленного из сульфата триглицина (TGS) Приведены его основные параметры и частотные харак. теристики.

References

[1] Ludlow J. H., Mitchell W. H., Putley E. H., Show N., J. Sci. Instrum. **42**, 694 (1967).

[2] Glass A. M., J. Appl. Phys. **40**, 4699 (1969).

[3] Putley E. H., Semiconductors and Semimetals 5, 259, R. K. Willardson i A. C. Beer, New York, Academic Press 1970.

[4] Beerman H. P., IEEE Trans. Electron Devices **ED-16**, 554 (1969).

[5] Dudley W. W., J. Sci. Instr. **44**, 629 (1967).

Received, February 23, 1974,