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# METHOD FOR DETERMINATION OF THE FREQUENCY-CONTRAST CHARACTERISTICS OF ELECTRONIC-OPTIC SYSTEMS

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***Abstract***

*The frequency-contrast characteristics is an important criterion to judge the quality of electronic-optic systems, which boast an increasing application in space research, astronomy, martial art etc. The paper provides a brief description of the methods for determining the frequency-contrast characteristics of optic systems, developed at the Space Research Institute of the Bulgarian Academy of Sciences. The suggested methods have been used to develop a couple of electronic-optic systems participated in the designed ground-based and aerospace scientific-research equipment. Based on the obtained practical results, the conclusion was made that the methods provide to obtain sufficiently precise data, which coincide well with the results, obtained when using other methods.*

Electronic-optic systems boast an increasing application in space research, astronomy, physics etc. [1, 2, 3]. They are used not only as amplifiers and converters of UV and IR emissions, for registration of continuous signals, but also as autonomous image receivers, inclusive for the purpose of determining the coordinates of remote subjects.
An important evaluation criterion for the quality of electronic-optic systems is the measured value of the frequency-contrast characteristics (FCC) [4, 5]. The well-known and most widely used methods to determine the FCC are based on using the Mira tables with sine contrast change and mechanical scanning of the generated image [6].

The paper provides a description of suggested methods for determination of the FCC of electronic-optic systems that has been developed at the Space Research Institute of the Bulgarian Academy of

Sciences in relation with the ongoing work on the developed electronic-optic systems for ground-based aerospace research apparata.

The image from the stroke Mira is projected by the object-glass onto the photocathode of the electronic-optic converter (EOC). Then, from the screen of the EOC, the image is scanned perpendicularly to the strokes and, through a photo-electronic multiplier (PEM), in photon-counting mode; the illumination brightness of the EOC's screen at some particular point (coinciding with the screen radius) of the Mira table image along the scanning axis is recorded.

Using a set of Mira touch tables of various spatial frequency $\upsilon$, the contrast $K(\upsilon)$ may be calculated:

(1)
$$K(\upsilon)=\frac{L_{max}-L_{min}}{L_{max}+L_{min}} ,$$

where $L_{max}$ and $L_{min}$ are accordingly the maximal and minimal brightness of the Mira touch image.

The FCC is determined by the expression [7, 8]:

(2)
$$F(\upsilon)=\frac{4}{\pi}[K(\upsilon)-K(3\upsilon)+K(5\upsilon)] .$$

Formula (2) makes it possible to determine theoretically the FCC.

In the present contribution, using Universal Night Vision Device Verification .Equipment (UNVDVE) [6], scanning the image from a single slit of width 2t, the amplitude corresponding to N touches from the Mira table has been recorded.

The FCC of an image representing a set of N touches of a slit of width 2 will be:

(3)
$$F(\upsilon)=\frac{\sin 2\pi\upsilon tN}{2\pi\upsilon tN} .$$

The analysis of (3) reveals that, when the number of touches in the Mira table is increased, the expression tends to zero; therefore, it is expedient to operate with a single slit. Moreover, at:

(4) $$\upsilon \to \frac{1}{2t} F(\upsilon) \to 0 \ .$$

Consequently, to expand the measured area of $\upsilon$, 2t should be reduced.
Using the a.m. equipment [6] and the suggested formulae, the FCC of electronic-optic systems with a micro-channel plate (MCP) has been measured. When the size of the used Mira is commensurable with the diameter d of the MCP plate, the contrast of its image depends on the position with respect to the center of the MCP channel, whereas at coincidence with insensitive boundary between channels it is minimal, and at coincidence with the center it is maximal.

The determination of the FCC is reduced to measurement of the FCC of the overall system

(5) $$F(\upsilon) = F_1(\upsilon).F_2(\upsilon).F_3(\upsilon) \ ,$$

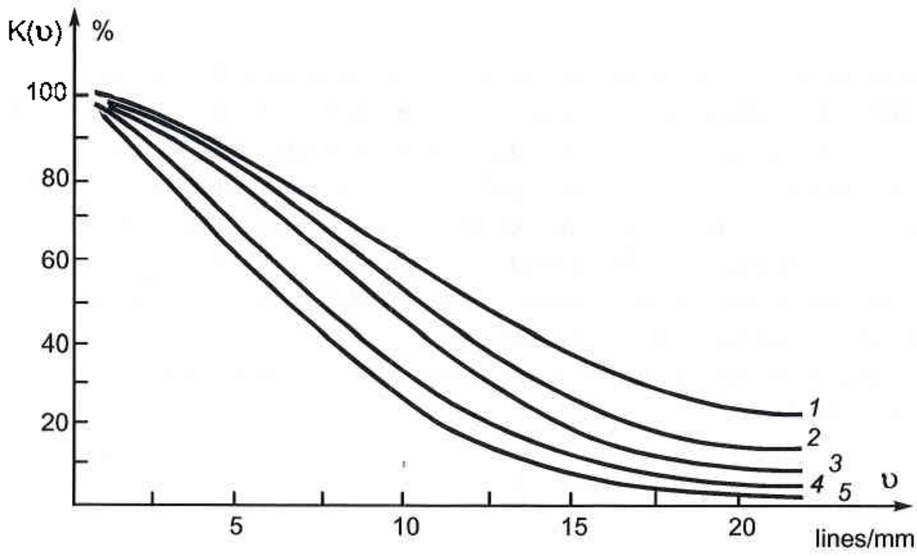
where: $F_1(\upsilon)$ – the FCC of the object glass;
$F_2(\upsilon)$ – the FCC of the EOC with MCP;
$F_3(\upsilon)$ – the FCC of the eye-lens of the electronic-optic system.

The most essential and precise moment here is to determine the $F_2(\upsilon)$, accounting that $F_1(\upsilon)$ and $F_3(\upsilon)$ feature higher resolution, i.e. higher FCC. The measurement time of the FCC of the EOC with MCP with spatial frequency of 2 to 22 double lines per mm is 5 min.
The results from the measurement of the FCC are shown in Fig. 1, Fig. 2 and Fig. 3.

A major factor determining the FCC is the system's focusing property. As a result of the insignificant dissipation by direction and energy of the outgoing electrons from the MCP channels, a point at the MCP's input is pictured on the EOC's screen as a circle.

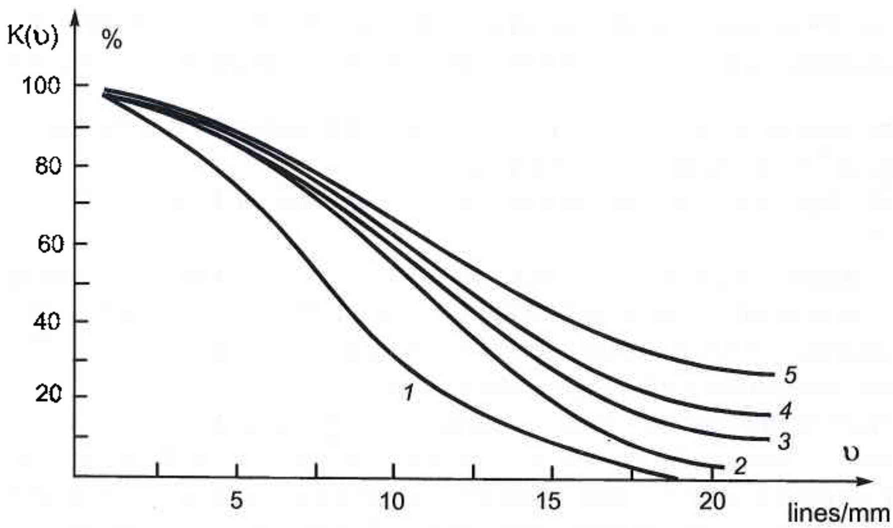
Apart from this, the FCC is influenced by system noises, mostly spatial ones. Temporary noises are caused by the fluctuations of the recorded emission and by the channels' amplification factor. They are manifested when weak signals are recorded and they deteriorate the resolution of the electronic-optic system.

Spatial noises are caused mostly by dissipation depending on the diameter of the MCPs and accordingly, the amplification factor K, depending on the ratio between the channel length l and diameter d.



K(υ)
%
100
80
60
40
20
5
10
15
20
lines/mm
υ
1
2
3
4
5


**Fig. 1**



K(υ)
%
100
80
60
40
20
5
10
15
20
lines/mm
υ
1
2
3
4
5


**Fig. 2**

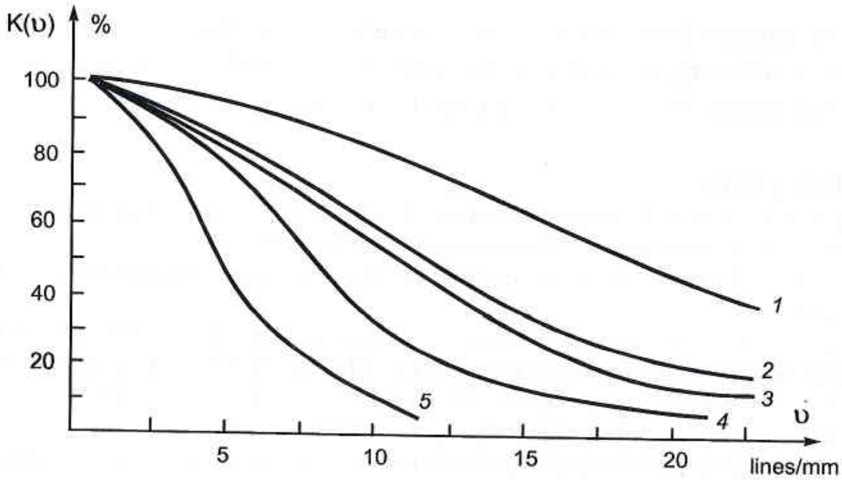



**Fig. 3**

The dependence of the FCC of an electronic-optic system with MCP on the voltage of the MCP is shown in Fig.1. It can be seen from the shown curves that when increasing the electric voltage u, the system's FCC gradually deteriorates. This can be attributed to the increase of the dissipation by direction and energy of the outgoing electrons from the MCP channels.

The dependence of the FCC on the potential difference applied between the MCP and the cathode-luminescence screen is shown in Fig.2. Increasing the voltage up to a certain value enhancing the focusing properties of the electrostatic lens and contributes to a more contrast image of the Mira table touches on the cathode-luminescence screen, whereas the FCCC increases as well.

In Fig. 3, the FCC of an EOC with MCP depending on the diameter d of the MCP channel is shown. The measurements were performed by an EOC with MCP with channel diameter d of 8 μm, 10 μm, 12 μm, 20 μm and 40 μm. Because there is no EOC with MCP with d = 6,4 μm, no such study was performed. Comparing curves 2, 3, 4 and 5, it may be seen that, when the MCP channel diameter is increased, the FCC deteriorates as a result of lowering the FCC of the individual channel [9].

Finally, based on the obtained results it may be concluded that the suggested method provides to obtain data with sufficient reproducibility and precision, coinciding well enough with the results obtained by using other methods.

The authors believe that it is expedient to use the FCC as a unified parameter in selecting electronic-optic systems for construction of scientific-research equipment, inclusive for aerospace application.

## References


1. М а р д и р о с я н, Г. Аерокосмически методи в екологията и изучаването на околната среда. Акад. издат. "Марин Дринов", 2003, 208 стр.
2. Г е ц о в, П. Космос, екология, сигурност. Нов български университет, София, 2002, 211 с.
3. Ф и л и п о в, Л. Проект "Шипка" – експерименти по космическа физика. Сб. доклади "10 години космически проект "Шипка", ИКИ – БАН, София, 1999, с. 29–32. Wilcock, W., D. Emberson, B. Weekly. Trans. Inst. Radio. Engvs., N 5–7, 126, 2000. Mandel, L., J. Brit. Appl. Phys., N 10, 1990, p. 233.
4. Универсална контролна апаратура за проверка на прибори за нощно виждане УКНП. Военно издателство, София, 1995.
5. F o w l e, F. Appl. J., 42, 2000, p. 233.
6. M e i n e l, A. Appl. J., 13, 1999, p. 241.
7. D r a n g a r d, R. JOSA, 1994, vol. 54, N 7, pp. 907–916.


# МЕТОДИКА ЗА ОПРЕДЕЛЯНЕ НА ЧЕСТОТНО-КОНТРАСТНАТА ХАРАКТЕРИСТИКА НА ЕЛЕКТРОННО-ОПТИЧНИ СИСТЕМИ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### Резюме


Честотно-контрастната характеристика е важен критерий за качеството на електронно оптичните системи, които намират все по-голямо приложение и в космическите изследвания, астрономията, военното дело и т.н. В статията е описана накратко разработената в Институт за космически изследвания при Българска академия на науките една методика за определяне на честотно-контрастната характеристика на оптичните системи. Предложената методика е използвана при създаването на няколко електронно-оптични системи в състава на разработените наземни и аерокосмически научно-изследователски апаратури. На базата на получените резултати от реалната практика резултати е направен изводът, че методиката позволява получаване на достатъчно точни данни, които добре съвпадат с резултатите, получени при използването на други методи.