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ANODE SYSTEM QUALITY FACTORS OF CROSSED–FIELD DEVICES

Possible quality factors of anode systems of crossed field devices were discussed. These quality factors used to estimate these devices operation quality. A scale to measure the values of these factors were offered

Keywords: *quality factor, crossed–field device, anode system, oscillations separation.*

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ПОКАЗАТЕЛИ КАЧЕСТВА АНОДНОЙ СИСТЕМЫ ПРИБОРОВ СО СКРЕЩЕННЫМИ ПОЛЯМИ

Рассмотрены возможные показатели качества анодной системы приборов со скрещенными полями, которые применяются для оценки качества работы этих приборов. Предложены шкалы измерений значений этих показателей.

Ключевые слова: *показатель качества, прибор со скрещенными полями, анодная система, разделение колебаний.*

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ПОКАЗНИКИ ЯКОСТІ АНОДНОЇ СИСТЕМИ ПРИЛАДІВ ЗІ СХРЕЩЕНИМИ ПОЛЯМИ

Розглянуто можливі показники якості анодної системи приладів зі схрещеними полями, що застосовуються для оцінювання якості роботи цих приладів. Запропоновано шкали вимірювання значень цих показників.

Ключові слова: *показник якості, прилад зі схрещеними полями, анодна система, розділ коливань.*

Introduction. The quality factors influencing on modes of crossed fields electron devices' oscillations of crossed–field devices were identified in earlier work [1]. These devices are widely used in industry, communications, medicine and everyday life.

Such devices usually consist of the following main units: power supply, anode system, cathode system, magnetic system. Manufacturing technology influences to magnetron's work also.

To determine the quality factors of crossed fields devices it were considered each block and processes.

As a result [1], it was identified 29 quality factors for such devices. All mentioned above factors can be considered as separate indicators of the magnetron quality. Here we consider the impact of anode system's quality factors to output magnetron spectrum.

There are such quality factors of anode system:

– anode system material;
– anode resonators;
– straps;
– mode separation;
– tolerance.

We shall consider these factors separately.

Anode system material. As base devices we used widely known magnetron M–105 shown in fig.1.

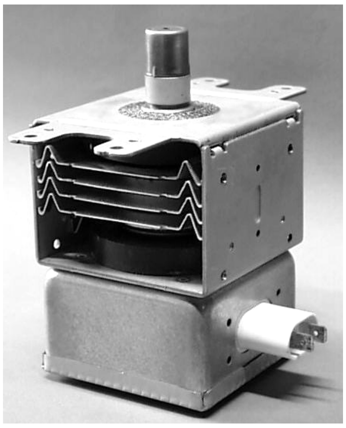

Fig.1. General view of magnetron

Anode system of vacuum devices including crossed–field devices was manufactured from copper or aluminium. In natural conditions these materials were absorbed gases' molecules both air (nitrogen, oxygen) and technological (argon, hydrogen, helium).

When such devices were operated above mentioned gases' molecules presented in interaction space. Gases' molecules interacting with electron beam were ionized. Positive charged ions made oscillated ion cloud. These oscillations are low frequency oscillations and excite due to the relaxation mechanism. Such mechanism is responsible for periodic relaxation of the ions and potential decrease. These oscillations are ion–relaxation oscillations.

To calculate the frequencies the ion–relaxation oscillations we used a result of investigation that were carrier out in [2] and obtained the following expression

$$f_r = 16{,}85 * 10^{-18}\left(\frac{b}{x^2}\right)\frac{x}{w}\frac{\omega_H p}{kT} s r_c\left(1-\frac{1}{s^2}\right)\ln\frac{w}{x},$$

where b – constant defined by kind of gas; x – gas ionization energy; w – electron energy; ω_H – cyclotron frequency; p – residual gases pressure; k – Boltzmann constant; T – gas temperature; $s=\frac{r}{r_c}$; r – radius; r_c – cathode radius.

As results of theoretical investigation it is get the ion–relaxation oscillations exist when pressure of residual gases in crossed–field device is less or equal dozens microtorrs and frequency band stretches from some Hetrz to dozens kilohetrzes. Such oscillations made parasitic oscillations in super long wave band and widen spectral lines of fundamental and other oscillations. Typical ion–relaxation spectrum was shown in fig. 2.

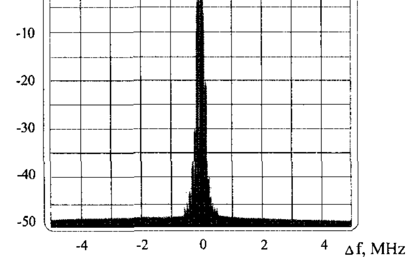

Fig. 2. Output spectrum with ion–relaxation oscillations

Thus one of quality factors is widen spectral lines. This factor can measure by Hertz or percent and characterized pressure of residual gases in crossed–field device is less or equal dozens microtorrs.

Second oscillations mechanism is ion-plasma and ion-hybrid ones. It is well known the frequency of plasma oscillations was defined as

$$f_p = \frac{1}{2\pi}\sqrt{\frac{n_0 e^2}{m_i \varepsilon_0}},$$

where n_0 – electron density; e – electron charge; m_i – electron mass; ε_0 – dielectric constant.

The ion-hybrid oscillations had excited due to presence of crossed electric and magnetic fields. The frequency of such oscillations defined as

$$f_p = \frac{1}{2\pi}\sqrt{\frac{pe^2}{m_i \varepsilon_0 kT} + \frac{e^2}{m_i^2}B},$$

where B – magnetic density.

As results of theoretical investigation it is get the ion–plasma and ion-hybrid oscillations exist when pressure of residual gases in crossed–field device is less or equal dozens millitorrs and frequency band stretches from some hundred kilohetrzes to hundred megahetrzes. Such oscillations made parasitic oscillations in radio and TV wave band and appear new spectral lines near fundamental and other oscillations. Typical ion–plasma spectrum was shown in fig. 3, and typical ion-hybrid was shown in fig.4.

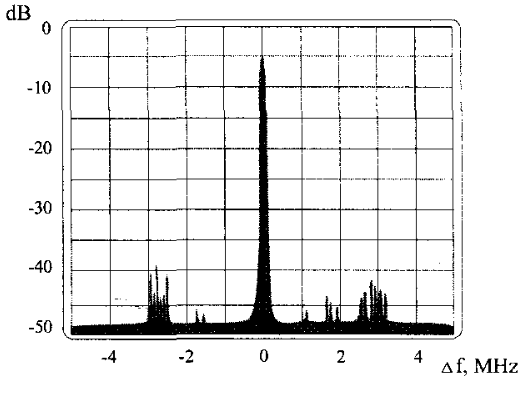

Fig. 3. Output spectrum with ion–plasma oscillations

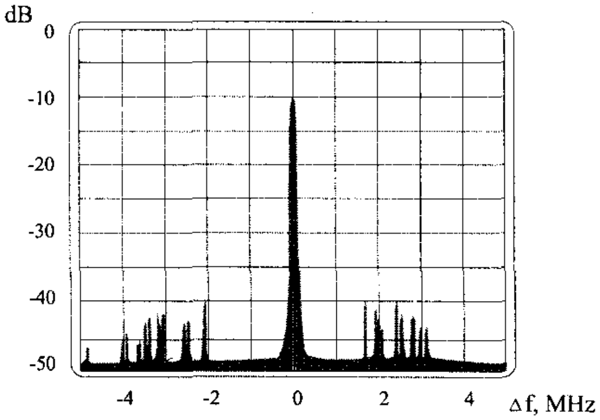

Fig. 4. Output spectrum with ion-hybrid oscillations

Thus one of quality factors is, a new spectral lines. This factor can measure by megahetrzes or percent and characterized pressure of residual gases in crossed–field device is less or equal dozens millitorrs.

Anode resonator. Slow-wave structure, which using in electron devices, is intended to create conditions when propagating electromagnetic wave can the most intensive to interact with moving electron beam.

It is found experimentally that the best conditions of electron interaction with field define in those causes when electron velocity and phase wave velocity close one to other.

The principal part of slow-wave structure is to accumulate the high-frequency energy and fixation of oscillation frequency.

The slow–wave structure may become like filter with narrow bandpass that from all frequencies connecting with electron beam discriminate definite one [3].

The slow–wave structure consists of different cavity such as

- plane comb type;
- stairs type;
- interdigital type;
- "slot-aperture" type;
- "sector-aperture" type;
- wane type;
- wane type with straps.

Typical slow–wave structure shown in fig. 5.

Every cavity form has self resonance frequencies thus one of quality factors is resonance frequencies of cavity. This factor can measured by gigahetrzes.

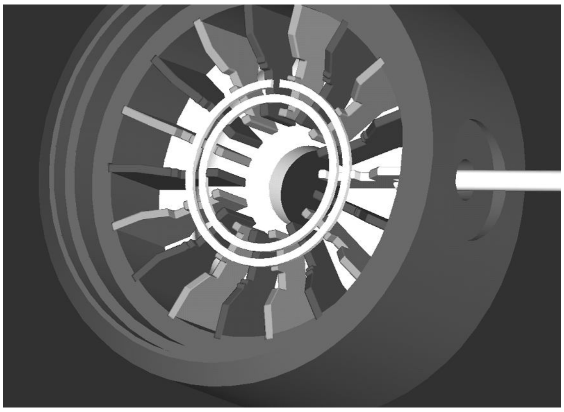

Fig. 5. Typical slow–wave structure

Straps. To separate modes of slow–wave structure often used straps (yellow rings in fig. 5). The mode separation define as

$$sep = \frac{|f_n - f_{n-1}|}{f_n} = \frac{|\lambda_n - \lambda_{n-1}|}{\lambda_n},$$

where f_n – n mode frequency; f_{n-1} – $n–1$ mode frequency; λ_n – n mode wavelength; λ_{n-1} – $n–1$ mode wavelength.

These frequencies or wavelengths defined from dispersion characteristics of slow–wave structures. The resonance equation to investigate dispersion characteristic described as

$$Y_n + Y_r + Y_p = 0,$$

where Y_n – interaction space impedance; Y_r – resonator's impedance; Y_p – strap impedance.

$$Y_n = j\sqrt{\frac{\varepsilon_0}{\mu_0}}\frac{Nh}{2\pi r_a}\sum_{m=-\infty}^{\infty}\left(\frac{\sin\gamma\theta}{\gamma\theta}\right)^2\frac{Z_\gamma(kr_a)}{Z'_\gamma(kr_a)},$$

$$Y_r = j\sqrt{\frac{\varepsilon_0}{\mu_0}}\frac{h}{\psi a}\frac{J_0(ka)N_1(kb) - J_1(kb)N_0(ka)}{J_1(ka)N_1(kb) - J_1(kb)N_1(ka)},$$

$$Y_p = -2Y_0\frac{\cos\frac{2\pi n}{N} + \cos\frac{2\pi k r_p}{N}}{\sin\frac{2\pi k r_p}{N}}.$$

Calculated dispersion characteristic for some bandpasses was shown in fig. 6.

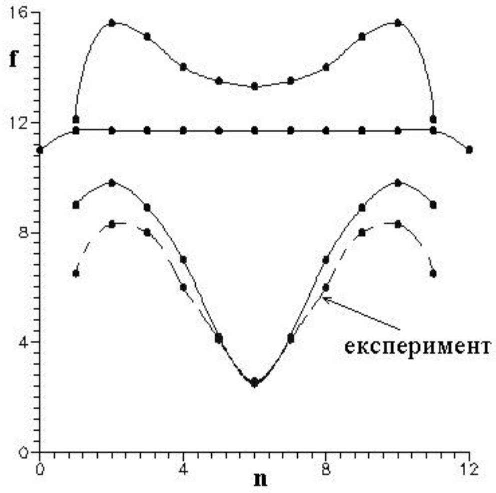

Fig. 6. Dispersion characteristic of slow–wave structure from fig. 5

Thus one of quality factors is mode separation. This factor can measured by percents or rate.

Tolerance. When crossed–field devices were manufactured inevitably tolerance was presented. To take into account the influence of tolerance during manufacturing these devices we must calculated dispersion characteristic for whole tolerance fields. The influence of tolerance was calculated as a deviation from a sample.

Thus one of quality factors is influence of tolerance. This factor can measured by percents or rate.

Conclusions. Here we discussed quality factors of anode systems of vacuum crossed–field devices. To analyze such components of anode structure as anode system material, anode resonators, straps, mode separation and tolerance we come to the conclusion the quality factors of anode systems can be

- widen spectral lines;
- new spectral lines;
- resonance frequencies of cavity;
- mode separation;
- tolerance.

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