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ON USEING PERIODIC REFERENCE SIGNAL IN HOMODYNE ACOUSTO-OPTIC SPECTRUM ANALYZER

Abstract

Introduction. *In order to ensure the proper functioning of a homodyne acousto-optic spectrum analyzer, it is necessary to establish a reference optical channel. The signal in this channel should provide uniform reference illumination across the spatial frequency range. In the general case, the spectrum analyser function can be evaluated by means of a continuous photosensor coupled with a charge accumulation photosensor. With reference to the latter, the signal in the reference channel is proposed as a wide-band periodic pulse sequence.*

Objective. *To analyze the functioning of a spectrum analyzer using a periodic reference signal.*

Materials and methods. *We derive the mathematical expression to describe the influence of a reference signal structure on the analyzer's output signal for the cases of continuous photosensor and photosensor with charge accumulation.*

Results. *It is shown that in the case of a continuous photosensor, the reference signal periodicity does not lead to a degradation of the operating characteristics. However, in the case of multiple frequency resolution points this is impractical, since each photodetector signal is parallel and filtering, amplification and digitisation processing is required. In the case of using of the charge accumulation sensor, a discrete frequency grid appears, which means signals omissions in frequency. This can be avoided by choosing an accumulation time equal to the minimum among the values of the acousto-optic modulator time aperture and the reference signal period, which is hard to implement, or still leads to the signal omissions in frequency or time.*

Conclusion. *To perform a real-time mode in the homodyne acousto-optic spectrum analyser, the reference signal must be either non-periodic, which raises the question of its synthesis, or a continuous photodiode array should be used.*

Key words: homodyne acousto-optic spectrum analyzer, interferometric acousto-optic spectrum analyzer, reference signal, Young's interferometer, discrete frequency scale.

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О ВОЗМОЖНОСТИ ИСПОЛЬЗОВАНИЯ ПЕРИОДИЧЕСКОГО ОПОРНОГО СИГНАЛА В ГОМОДИННОМ АКУСТООПТИЧЕСКОМ СПЕКТРОАНАЛИЗАТОРЕ

Аннотация.
Введение. *Для работы гомодинного акустооптического спектроанализатора необходимо организовать опорный оптический канал. Сигнал в этом канале должен обеспечивать равномерную засветку по всей области пространственных частот. В общем случае можно рассматривать работу спектроанализатора с фотоприемником мгновенного действия и фотоприемником с накоплением. В последнем случае сигнал в опорном канале предлагается формировать в виде периодической последовательности широкополосных импульсов.*
Цель работы. *Анализ работы спектроанализатора с периодическим опорным сигналом.*
Материалы и методы. *Анализ основан на выводе математического выражения, описывающего влияние структуры опорного сигнала на выходной сигнал спектроанализатора для случаев применения фотоприемника мгновенного действия и фотоприемника с накоплением.*
Результаты. *Показано, что для спектроанализатора с фотоприемником мгновенного действия периодичность опорного сигнала не приводит к ухудшению характеристик. Однако такой вариант при большом количестве точек разрешения в частотной области нецелесообразен с практической точки зрения, так как требует параллельной обработки сигнала каждого фотоприемника трактом с фильтрацией, усилением и оцифровкой. При использовании фотоприемника с накоплением процесс накопления заряда приводит к формированию дискретной сетки частот, что означает наличие пропусков сигналов по частоте. Установлено, что избежать этого можно, выбирая время накопления, равное минимальному среди значений временной апертуры акустооптического модулятора и периода сигнала. Реализация такого варианта на практике либо невозможна на современных фотоприемниках с накоплением, либо приводит к наличию пропусков по частоте или времени.*
Заключение. *Для обеспечения режима реального времени в гомодинном акустооптическом спектроанализаторе опорный сигнал должен быть либо непериодическим, что ставит вопрос о синтезе подходящего сигнала, либо необходимо использовать фотоприемник мгновенного действия в виде линейки фотодиодов.*

Ключевые слова: гомодинный акустооптический спектроанализатор, интерференционный акустооптический спектроанализатор, опорный сигнал, интерферометр Юнга, дискретная сетка частот

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Introduction. Spectral analyzis devices based on acousto-optic interaction and spatial Fourier-transformation phenomena are characterised by their high analyzis bandwidth [1]–[4], which is of interest for solving problems of radio monitoring, as well as in radio-electronic warfare signal detection devices. Of greatest interest in this connection are acousto-optical spectrum analyzers having spatial integration (AOSSI) based on interference schemes [5]–[7], in which optical heterodyning is carried out, allowing the dynamic range of the device to be significantly increased (by 2 times when measured in decibels) in comparison with simple AOSSIs used to record the energy spectrum [2], [6]. Before the research papers [5]–[7] were published, optical heterodyning was performed to some nonzero frequency that assumed the use of a photodiode array as a photosensing device followed by filtration, amplification and detecting paths. The schemes proposed in these papers assumed a shift to zero-frequency by introducing the desired light beam modulation in the reference optical channel.

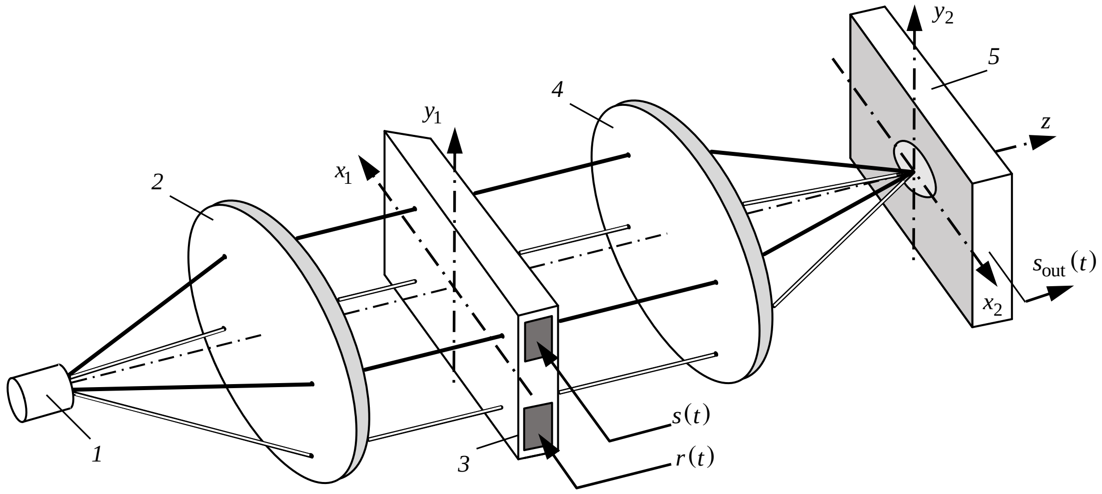

Fig. 1. The scheme of the homodyne acousto-optic spectrum analyzer based on Young interferometer

With the advent of storage photosensors having a high dynamic range, researchers [8] proposed the implementation of a heterodyne circuit with a CCD array photosensor, which, in addition to greatly simplifying the device design, also allowed for a higher frequency resolution. In the same paper it was proposed to refer to such a spectrum analyzer as a homodyne acousto-optic spectrum analyzer with spatial integration (HAOSA)

The optical scheme for realizing optical heterodyning could be made in form of an interferometer, for example of the Mach–Zehnder or Young type. Although the choice of interferometer type is arbitrary, let us consider a scheme based on a Young interferometer (Fig. 1). Here, the HAOSA consists of: *1* –monochrome light source; *2* – collimating lens; *3* –dual-channel acousto-optic modulator (AOM); *4* –spherical lens; *5* – matrix photosensor (MPS) or photodiode array.

It is appropriate to use a semiconductor or gas laser as a light source *1*. A generated diverging radiation with wavelength λ_1 is transformed into plane wave by collimating lens *2*. Next, a light beam illuminates an aperture of the dual-channel AOM. The analyzing signal $s(t)$ is applied to one channel of this AOM 3, while the reference signal $r(t)$ is applied to the other channel. After passing through the AOM, the light beam is focused by spherical lens *4* in the plane of the photosensor (PS) aperture *5*.

Aim of the research. The choice of the reference signal is one of the key tasks in spectrum analyzis due to its influence on such analyzer characteristics as operation frequency range and amplitude-frequency characteristics. At the same time, it is important to retain undistorted information about the analysed signal spectrum. The authors of the research papers [5]–[8] considered a periodical sequence of chirped pulses or pseudo-random signals within the spectrum, providing a uniform reference across the wide-band frequency range. The results of operational analysis of a HAOSA having a charge accumulation photosensor and reference signals in a form of a single chirp-pulse and a radio-pulse based on the pseudo-random sequence are presented in [9], [10]. It is shown that, despite the non-stationarity of the instant spectrum of the reference signal, the result of charge accumulation during a time period equal to that of a single pulse propagated through the AOM aperture allows information to be obtained concerning the amplitude spectrum of the investigated signal. However, the realization of such a short accumulation time and PS output is limited by its operation speed. Therefore, the question arises concerning the capability of a HAOSA with reference signal providing long accumulation time.

HAOSA with quasi-periodical reference signal. Let us consider a numerical HAOSA model. The source of radiation *1* and collimator *2* form the light wave having intensity spatial distribution $\dot{E}_0(x, y)$. This propagates through the AOM, to which ports the analyzed signal $s(t)$ and reference signal $r(t)$ are applied. Thus a spatial and temporal change of the refractive index of the modulator crystal is created according to the laws

$$n_s(x_1, t) = n_0 + \Delta n\, s\left(t - \frac{x_1 + L}{v_{ac}}\right);$$

$$n_r(x_1, t) = n_0 + \Delta n\, r\left(t - \frac{x_1 + L}{v_{ac}}\right),$$

where n_0 is the undisturbed refractive index; Δn is the amplitude of variation in the refractive index of the medium; L is the half of the AOM aperture in the direction of the acoustic wave propagation; v_{ac} is the velocity of the acoustic wave in the AOM crystal. The length of the acoustic wave in the vertical plane is not considered since a sound field along this coordinate is assumed to be uniform.

As a result of the diffraction, a light field is obtained in the plane behind the AOM. The complex signals of the light field intensity corresponding to diffraction results can be written as follows

$$\dot{E}_s(x_1, y_1, t) = \dot{E}_0(x_1, y_1) \times \\ \times \mathrm{rect}\left(\frac{x_1}{2L}, \frac{y_1 - D/2}{H_0}\right) e^{j\omega_{\text{light}} t} e^{-jms\left[t - (x_1 + L)/v_{\text{ac}}\right]}; \quad (1)$$

$$\dot{E}_r(x_1, y_1, t) = \dot{E}_0(x_1, y_1) \times \\ \times \mathrm{rect}\left(\frac{x_1}{2L}, \frac{y_1 + D/2}{H_0}\right) e^{j\omega_{\text{light}} t} e^{-jmr\left[t - (x_1 + L)/v_{\text{ac}}\right]}, \quad (2)$$

where

$$\mathrm{rect}(x_1, y_1) = \begin{cases} 1, \ x_1 \in [-0.5;\ 0.5], \ y_1 \in [-0.5;\ 0.5]; \\ 0 \ \text{else} \end{cases}$$

is the two-dimensional dimensionless rectangular function of unit length and height; D is the distance between centres of the acoustic beams; ω_{light} is the circular frequency of the light wave; m is the index of the light wave phase modulation.

There are two regimes of light diffraction on the acoustic wave [11], [12]. A symmetrical diffraction pattern having many diffraction orders is formed according to the Raman-Nath diffraction regime. However, the single-diffraction-order Bragg diffraction regime is more is more interesting from a practical point of view. According to the latter regime, expressions (1) and (2) could be written in form of the sum of non-diffracted light and +1st order*. The following expressions can be obtained using in (1) and (2) the complex envelopes of the optic field signals and well-known mathematical transformations [8], retaining only the terms of interest in the considered problem:

$$\dot{E}_{ms}^{+1}(x_1, y_1, t) = j\dot{E}_0(x_1, y_1) \times \\ \times \mathrm{rect}\left(\frac{x_1}{2L}, \frac{y_1 - D/2}{H_0}\right) \sqrt{h}\, \dot{s}\left(t - \frac{x_1 + L}{v_{\text{ac}}}\right) e^{-j\Omega_s t}; \quad (3)$$

$$\dot{E}_{mr}^{+1}(x_1, y_1, t) = j\dot{E}_0(x_1, y_1) \times \\ \times \mathrm{rect}\left(\frac{x_1}{2L}, \frac{y_1 + D/2}{H_0}\right) \sqrt{h}\, \dot{r}\left(t - \frac{x_1 + L}{v_{\text{ac}}}\right) e^{-j\Omega_r t}, \quad (4)$$

where $h = \sin^2(m/2)$ is the diffraction efficiency of light; $\dot{s}(t)$ and $\dot{r}(t)$ are the complex envelopes of analysed and reference signals, respectively; Ω_s, Ω_r are the circular frequencies of analyzed and reference signals, respectively. The exponential multiplier in expressions (3) and (4) represents the fact of the Doppler frequency shift on the sound wave during the diffraction. For further investigation, the only interesting case is the equality of the carrier frequencies of analyzed and reference signals: $\Omega_s = \Omega_r = \Omega$.

The transformation of light carried out by the lens *4* and space segment, which length is equal to the lens focal length F is the spatial Fourier transformation [11], [13]. Therefore, the complex envelope of the light field intensity of the diffraction orders in the lens focal plane can be described by the expression:

$$\dot{E}_{ms_{\text{f.p}}}(p, q, t) = \\ = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \dot{E}_{ms,r}^{+1}(x_1, y_1, t) e^{jpx_1} e^{jqy_1} dy_1\, dx_1, \quad (5)$$

where

$$\dot{E}_{ms,r}^{+1}(x_1, y_1, t) = \dot{E}_{ms}^{+1}(x_1, y_1, t) + \dot{E}_{mr}^{+1}(x_1, y_1, t);$$

$p = kx_2/F$, $q = ky_2/F$ are the spatial frequencies in the $x_2 0 y_2$ plane and k is the wave number of the light wave. The expression (5) describes the distribution of the light field in the photosensor plane as placed in the focal plane of the lens *4*.

Let us assume that the AOM is illuminated by the uniform plane wave as described by $\dot{E}_0(x_1, y_1) = \text{const}$. Under these conditions, integration over the y_1-coordinate in (5) is performed independently of x_1. Since the field distribution along the vertical coordinate does not carry any information about the signals x_1 we will further consider only y_1 without loss of generality. Let us analyze the field distribution in the photosensor plane by placing (3) and (4) into (5):

$$\dot{E}_{ms_{\text{f.p}}}(p, t) = j\sqrt{h} e^{-j\Omega t} H_0 \times \\ \times \int_{-L}^{L} \left[\dot{s}\left(t - \frac{x_1 + L}{v_{\text{ac}}}\right) + \dot{r}\left(t - \frac{x_1 + L}{v_{\text{ac}}}\right)\right] e^{jpx_1} dx_1.$$

* Consideration of diffraction to -1st order is also correct.

The change of the variable is introduced

$$\tau = \left[t - (x_1 - L)/v_{ac}\right].$$

Introducing the term $T_a = 2L/v_{ac}$, which is the time aperture of the AOM, as the signal $\dot{g}(t) = \dot{s}(t) + \dot{r}(t)$, which is the sum of the complex envelopes of analyzed and reference signals, we will obtain:

$$\dot{E}_{ms_{f.p}}(x_2, t) = \dot{A}e^{-j\Omega t} e^{jkx_2(v_{ac}-L)/F} \times \times \int_{t-T_a}^{t} \dot{g}(\tau) e^{-jv_{ac}kx_2\tau/F} d\tau, \quad (6)$$

where $\dot{A}$ combines the constants and it is taken into account that $p = kx_2/F$. The integral transformation in (6) gives the sum $\dot{G}_{T_a}$ of instantaneous spectra $\dot{S}_{T_a}$ and $\dot{R}_{T_a}$ of analysed and reference signals, respectively, in the time interval T_a. Let us introduce the variable $\omega = v_{ac}kx_2/F$ and represent $\dot{G}_{T_a}$ as follows

$$\dot{G}_{T_a}(\omega, t) = \int_{t-T_a}^{t} g(\tau) e^{-j\omega\tau} d\tau = = \int_{-\infty}^{\infty} g(\tau) \operatorname{rect}\left(\frac{\tau - t + T_a/2}{T_a}\right) e^{-j\omega\tau} d\tau = = \frac{1}{2\pi} \dot{G}(\omega) \otimes \dot{W}_{rect}(\omega, t), \quad (7)$$

where $\dot{G}(\omega)$ is the spectral function of $\dot{g}(t)$, i.e. the sum of reference and analyzed signal spectra; "$\otimes$" is the symbol of the convolution over ω variable;

$$\dot{W}_{rect}(\omega, t) = -T_a \operatorname{sinc}(\omega T_a/2) e^{-j\omega(t-T_a/2)}$$

is the spectral function of the window sliding along the timeline, which describes the signal propagation along the AOM aperture.

Strictly speaking, $\dot{G}_{T_a}(\omega, t)$ in (7) depends not on ω, but on ω', which is used in convolution. With that in mind, expression (7) could be transformed further

$$\dot{G}_{T_a}(\omega', Et) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \dot{G}(\omega) \dot{W}_{rect}(\omega' - \omega, t) d\omega = = -T_a \frac{e^{-j\omega'(t-T_a/2)}}{2\pi} \times \times \int_{-\infty}^{\infty} \dot{G}(\omega) \operatorname{sinc}\left[(\omega' - \omega)T_a/2\right] e^{-j\omega(t-T_a/2)} d\omega.$$

The distribution of the radiation intensity in the focal plane of the lens *4* could be obtained as a square of the absolute value of (6), that gives:

$$I_f(\omega', t) = |\dot{A}|^2 \left|\dot{G}_{T_a}(\omega', t)\right|^2 = = |\dot{A}|^2 \left|\dot{S}_{T_a}(\omega', t)\right|^2 + |\dot{A}|^2 \left|\dot{R}_{T_a}(\omega', t)\right|^2 + + 2|\dot{A}|^2 \operatorname{Re}\left\{\dot{S}_{T_a}(\omega', t) \dot{R}^*_{T_a}(\omega', t)\right\} = = W_{s, T_a}(\omega', t) + W_{r, T_a}(\omega', t) + + \left|\dot{S}_{T_a}(\omega', t)\right| \left|\dot{R}^*_{T_a}(\omega', t)\right| \times \times \cos\left[\varphi_{s, T_a}(\omega', t) - \varphi_{r, T_a}(\omega', t)\right], \quad (8)$$

where W_{s, T_a}, W_{r, T_a} are the instantaneous power spectrum densities of analyzed and reference signals correspondingly; φ_{s, T_a}, φ_{r, T_a} are the instantaneous phase spectra of analysed and reference signals correspondingly; "*" is the symbol of complex conjugation. Since it is only the last component of this expression that allows the amplitude spectrum of the analyzed signal to be obtained, the others can be discarded. At the same time, $\dot{R}_{T_a}$ must provide the uniform reference in the frequency band. The expression for $\dot{R}_{T_a}$ is:

$$\dot{R}_{T_a}(\omega', t) = -T_a \frac{e^{-j\omega'(t-T_a/2)}}{2\pi} \times \times \int_{-\infty}^{\infty} \dot{R}(\omega) \operatorname{sinc}\left[(\omega' - \omega)T_a/2\right] e^{-j\omega(t-T_a/2)} d\omega. \quad (9)$$

Let us analyse $\dot{R}_{T_a}$ for two cases of radiation detection: using the continuous photosensor and using the photosensor with accumulation.

HAOSA with continuous photosensor. In this case, the output signal of the photosensor is proportional to the radiation intensity. Let us assume that the signal to be analyzed has $\dot{S}_{T_a} = \text{const}$, while the reference signal $r(t)$ is the periodical sequence of the wide-band pulses having period T_r. Then the spectrum $\dot{R}(\omega)$ is discrete and can be represented by the single pulse spectrum $\dot{R}_{s.p}(\omega)$ as

$$\dot{R}(\omega) = \frac{1}{T_r} \sum_{i=-\infty}^{\infty} \dot{R}_{s.p}(i\omega_r) \delta(\omega - i\omega_r),$$

where ω_r is the pulse repetition frequency. Then (9) can be written as

$$\dot{R}_{T_a}(\omega', t) = -\frac{T_a}{T_r}\frac{e^{-j\omega'(t-T_a/2)}}{2\pi}\times$$
$$\times\sum_{i=-\infty}^{\infty}\dot{R}_{s.p}(i\omega_r)\,\mathrm{sinc}\left[(\omega'-i\omega_r)T_a/2\right]e^{-ji\omega_r(t-T_a/2)}.$$

It can be easily seen that the sum in the obtained expression is reduced to the Kotelnikov series if the pulse period T_r is equal to the time aperture T_a. For this reason, a continuity and a uniformity of the single pulse amplitude spectrum $\dot{R}_{s.p}(\omega)$ could be interpreted as a continuity and a uniformity of the instantaneous spectrum of the pulse sequence in the time window T_a. This means that the amplitude spectrum of the analyzed signal in (8) is multiplied by the continuous function, which form is defined by the amplitude spectrum of the single pulse of the sequence. This approach was presented in [2], [5]–[7], where, however, the necessity of organizing the quadrature channel is not taken into account due to the presence of the spatial carrier in the last component of (8).

HAOSA with photosensor with accumulation. Let us now consider the case of the photosensor with accumulation. Denoting the accumulation time as T_q, we investigate the influence of $\dot{R}_{T_a}$ considered as the multiplier by accumulating charge. We still assume that $\dot{S}_{T_a} = \mathrm{const}$. Let us rewrite (9) as

$$\dot{R}_{T_a}(\omega', t) =$$
$$= -\frac{T_a}{2\pi}\int_{-\infty}^{\infty}\dot{R}(\omega'-\omega)\,\mathrm{sinc}(\omega T_a/2)e^{-j\omega(t-T_a/2)}d\omega.$$

The accumulation in PS is equivalent to the time integration that gives the charge distribution:

$$Q(\omega') = A_2\int_0^{T_q}\dot{R}_{T_a}(\omega', t)dt =$$
$$= A_2\int_0^{T_q}\int_{-\infty}^{\infty}\dot{R}(\omega'-\omega)\,\mathrm{sinc}(\omega T_a/2)e^{-j\omega(t-T_a/2)}d\omega\,dt,$$

where A_2 combines variables that are nonsignificant for the problem under consideration. Let us transform obtained expression and change the order of integration over the time and the frequency during this transformation

$$Q(\omega') = A_2\times$$
$$\times\int_{-\infty}^{\infty}\int_0^{T_q}\dot{R}(\omega'-\omega)\,\mathrm{sinc}\left(\omega\frac{T_a}{2}\right)e^{-j\omega\left(t-\frac{T_a}{2}\right)}dt\,d\omega =$$
$$= A_2\int_{-\infty}^{\infty}\dot{R}(\omega'-\omega)\,\mathrm{sinc}\left(\omega\frac{T_a}{2}\right)\int_0^{T_q}e^{-j\omega\left(t-\frac{T_a}{2}\right)}dt\,d\omega =$$
$$= A_3\int_{-\infty}^{\infty}\left[\dot{R}(\omega'-\omega)\,\mathrm{sinc}\left(\frac{\omega T_a}{2}\right)\mathrm{sinc}\left(\frac{\omega T_q}{2}\right)\times\right.$$
$$\left.\times e^{-j\omega\left(\frac{T_q-T_a}{2}\right)}\right]d\omega = A_3\dot{R}(\omega)\otimes\dot{F}(\omega), \qquad (10)$$

where A_3 is the new constant;

$$\dot{F}(\omega) = \mathrm{sinc}\left(\frac{\omega T_a}{2}\right)\mathrm{sinc}\left(\frac{\omega T_q}{2}\right)e^{-j\omega\left(\frac{T_q-T_a}{2}\right)}. \qquad (11)$$

Thus, the reference formed during the charge accumulation is the convolution of the reference spectrum $\dot{R}(\omega)$ and the function $\dot{F}(\omega)$. If the accumulation time T_q is much greater than the AOM time aperture T_a, that is usual in practice, and $T_r = T_a$, then the second width of the central peak, narrower sinc-function defines $\dot{F}(\omega)$. The greater accumulation time the narrower this peak. The function $\dot{R}(\omega)$ is discrete in the case of the periodical reference signal, and the δ-function discretes are replaced by $\dot{F}(\omega)$ after the convolution with $\dot{F}(\omega)$. This means that in the case of the photosensor with accumulation the reference signal in form of the wide-band pulse sequence provides the quasi-discrete reference in the spectrum range (Fig. 2) and the signal omissions are possible.

Let us perform the numerical investigation using obtained expressions. For this purpose, we will assume that AOM time aperture $T_a = 1$ μs [11], [12], [14]. The accumulation time T_q is assumed to be equal to the time of signal output from PS. The pixel quantity in PS string is equal to 1000 [15], [16], while the minimum required quantity of strings for reading is 3 [17] or 4 [18]. The charge read time and the accumulation time is 75...100 μs if the output speed is equal to 40 MHz. The calculation using (10) in the case of $T_r = T_a$ gives the quasi-discrete frequency grid with discrete width measured in zeros no more than 27 kHz and the distance between the discrete maximums being equal to 1 MHz.

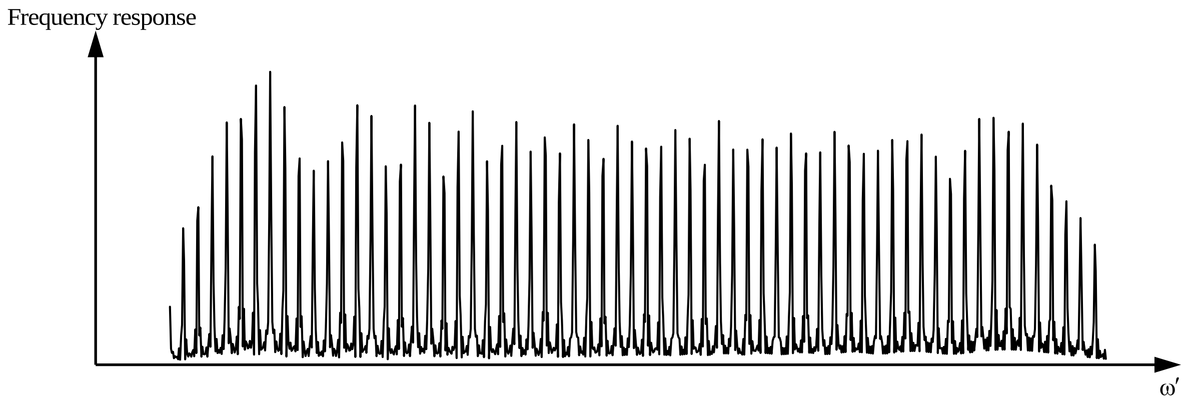

Fig. 2. Homodyne acousto-optic spectrum analyzer frequency-response characteristic for case of quasiperiodic reference signal

It is also necessary to consider the discrete structure of the MPS, whose photosensitive area does not occupy the whole pixel surface. This leads to an additional discretization of the charge distribution; consequently, the distortions of the analyzed signal amplitude spectrum are sufficient. Analyzing (11), it can be shown that the effect of the quasi-discrete frequency grid disappears in the following cases. In the case of an increase of the pulse period up to the values T_q, a single period of the reference signal is equal to the accumulation cycle and the discrete structure does not appear. Additionally, in the case of a decrease of the accumulation time T_q down to the AOM time aperture T_a, the function $\dot{F}(\omega)$ becomes relatively wide such that the convolution result in (10) will be a continuous function of frequency. The pulse width of the reference signal must be equal to T_a. Meanwhile, if the time of signal output from PS exceeds the accumulation time then the spectrum analyzer will omit signals in time.

Conclusion. Thus, the periodic sequence of the wide-band pulses can be used as a reference signal if detection of the optical radiation in HAOSA is performed by a continuous photodiode array. A modern AOM could provide [14] up to 2000 resolution elements in the frequency domain and three photodiodes are required for each element [1]. In this case, the photodiode array consisting of 6000 photodiodes is required. From a practical point of view, it is not feasible to individually amplify, filter, detect and digitalise output signal of each photodiode. Moreover, the fact that modern linear PS have no more than 100…300 elements [19] results in the impossibility of realising the otherwise potentially achievable spectrometer frequency resolution. Conversely, HAOSA schemes with PS Photosensors are of interest due to having an accumulation and serial output with up to 16 thousand elements in the string [20].

The analysis represented in this paper shows that it is necessary to set the accumulation time to be equal to the lowest value of the AOM aperture time and the pulse period in the case of utilisation of HAOSA with photosensor with accumulation. In the first case, the time required for output of 6000 values of the charge could be significantly greater than the accumulation time, with the result possibility that the spectrum analyzer will operate in the omitting regime. In the second case, an equality of the pulse period and the accumulation time of the signal omissions is possible if the pulses are sufficiently narrow; additionally, omissions in frequency could emerge if the pulse width and period are equal. Therefore, the reference signal of HAOSA cannot be periodic if frequency or time omissions are unacceptable. This poses the problem of wideband nonperiodic signal synthesis, which would be capable of providing the operation of HAOSA without omissions.

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