INFLUENCE OF DISTRIBUTION OF ACOUSTIC FIELD IN ACOUSTO-OPTIC CELL TO THE TRANSMISSION FUNCTION

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ABSTRACT

The problem of transmission function side lobes suppression is discussed. The influence of acoustical field distribution on the apparatus function of AOTF is investigated. The optimal acoustic amplitudes for the case of piezotransducer divided into equal parts is calculated. The maximum side lobe level at different number of sections Is investigated. The role of spacing between the piezotransducer's parts is estimated. The parallel scheme of section connections is presented. The first AO cell with voltage divider provides to optimal distribution of acoustic amplitude is manufactured.

KEYWORDS

Acousto-optical cell, transmission function, side lobe, suppression, piezotransducer.

1. INTRODUCTION

One of the major applications of acousto-optic (AO) devices is their operation as filters of optical frequencies and radio signal spectrum analyzers. The most important characteristic of these devices is the AO cell transmission function (TF) describing the dependence of diffracted light intensity on its wavelength at a given frequency of acoustic signal, or the dependence of the diffraction efficiency on the driving signal frequency at a given optical wavelength.

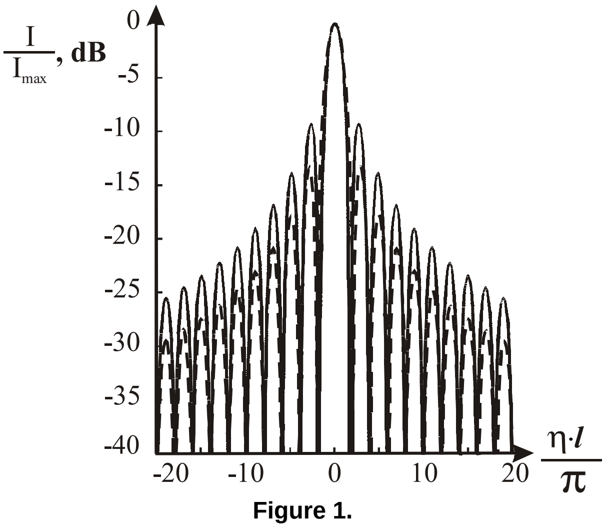

Figure 1.
Typical AO cell transmission function.

The AO filter and spectrum analyzer dynamic range is defined by its transmission function form. Usually the TF, besides the main maximum, contains side lobes (fig. 1). The level of a maximum side lobe reaches -9.3 dB at 100% diffraction efficiency. The presence of side lobes restrains the dynamic band of spectrum analyzer and increases the noise level and spurious signal of AOTF.

2. THEORY INVESTIGATION

The distribution modification of acoustic field amplitude in crystal influences the AO cell TF shape - Ref. 2.

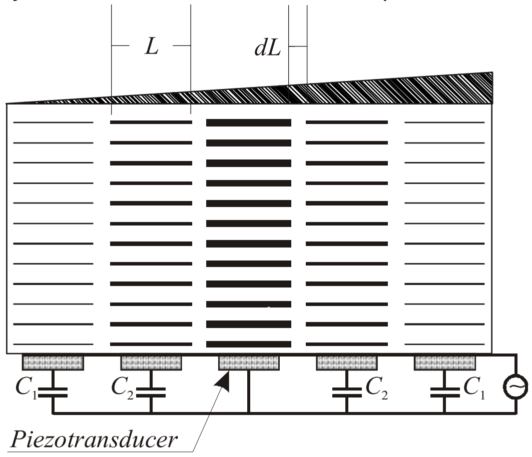

Figure 2.
The scheme for piezotransducer divided into sections and the modes of its connection.

This report is demonstrated a possibility of AO cell TF side lobes suppression by the method of cutting piezotransducer into some equal parts and symmetrical distribution of an acoustic field in crystal.

To create an optimal non-uniformity distribution of acoustic field amplitude in crystal the scheme of the AO cell with divided piezotransducer was chosen (fig. 2). Piezotransducer sections connected to generator by systems of capacities with different magnitude on each part.

Optimal distributions of acoustic amplitude were found that provides the minimal side lobe intensity and the output noise level for different number piezotransducer parts *N*.

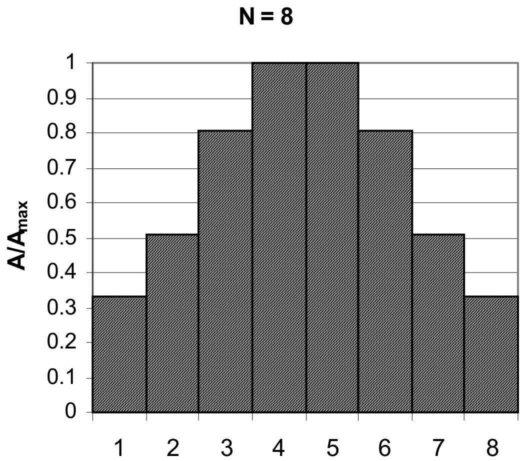

Figure 3.

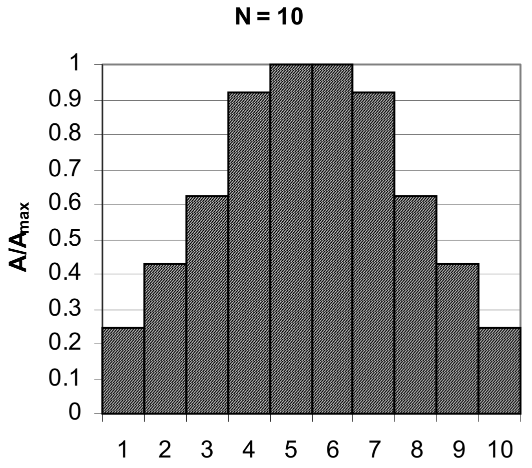

Figure 4.

On fig. 3 and 4 the optimal distribution schemes for 8 and 10 piezotransducer sections are shown. For each distribution the amplitude maximum is in the middle of the piezotransducer and the amplitude volume decreases in direction of the crystal ends. Table 1 shows the real values of optimal amplitude along the piezotransducer.

Table 1

N = 8	0.333	0.508	0.808	1	
N = 10	0.246	0.426	0.623	0.918	1

For example, the maximal side lobe of TF for AO cell with piezotransducer divided into 10 parts and optimal amplitude distribution decreases by -14.6 dB compared with undivided piezotransducer (fig. 5). The suppression of side lobes is accompanied by an insignificant broadening of the AOTF's main maximum. At 3 dB level this broadening does not exceed 33%.

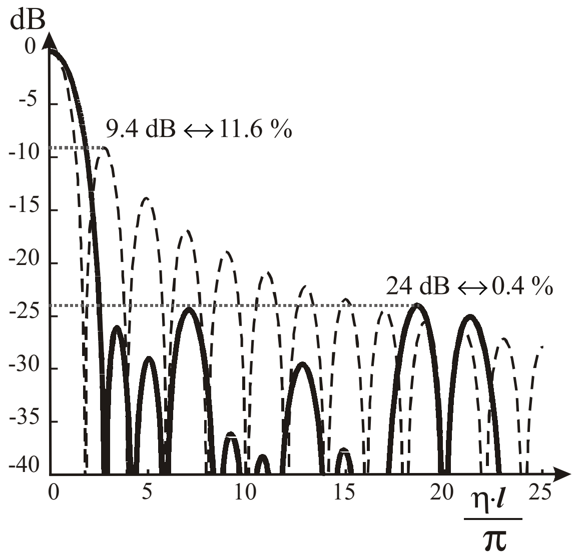

Figure 5.
The transmission function of the AO cell with divided piezotransducer (solid curve) and undivided piezotransducer (dashed curve).

The maximal side lobe level at optimal distribution of acoustic amplitudes in crystal for apodized piezotransducer at different number of parts is shown in Table 2.

Table 2.

Number of sections *N*	1	3	4	5
Maximum value of a side lobe without clearance, [dB]	-9.3	-14.5	-17.0	-18.3
Number of sections *N*	6	8	9	10
Maximum value of a side lobe without clearance, [dB]	-20.0	-21.5	-23.3	-24.2

The division of the piezotransducer into sections results in the appearance of the clearance between sections. The width of this clearance affect considerably the side lobes level. The influence of spacing between piezotransducer parts on maximal side lobes level is investigated at optimal acoustic distribution in crystal (fig. 6), here *N* = 1, 3, 6, 10. The results of calculation are presented in Table 3.

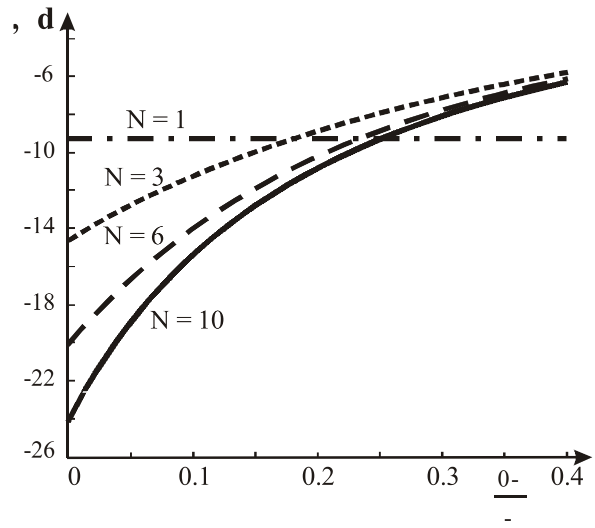

Figure 6.
Dependence of a maximum side lobe level on a clearance width.

Table 3.

Number of sections	3	6	10
Maximum value of a side lobe without clearance.	-14.5	-20.0	-24.2
Maximum value of a side lobe, at clearance width 5% from length of one acoustic column, [dB]	-12.8	-16.6	-18.9
Maximum value of a side lobe, at clearance width 10% from length of one acoustic column, [dB]	-11.3	-13.9	-15.3

It turned out that the increase of spacing between two acoustic column leads to a growth of side lobes. Moreover, this growth accelerates with the number *N*. It sets limits on admitted ratio of the spacing from the piezotransducer part length.

The important role is played by a ratio of a light energy diffracted in a main maximum *S* to a light energy diffracted in side lobes N_0 for the spectrum analysis. In this case incident on AO cell optical beam with a wide spectrum, thus on the output of AO cell a receiver with wide spectral sensitivity is situated. This parameter determines the noise level.

Table 4.

Number of sections	1	6	10
S/N_0, without spacing between acoustic columns	3.3	16.6	41.4
S/N_0, at spacing 5 % from length of one acoustic column	-	6	7.7
S/N_0, at spacing 10 % from length of one acoustic column	-	3.6	4.2

Fig. 7 presents the dependence of the parameter S/N_0 on the clearance width, here N = 1, 6, 10. It can be seen that the increase of spacing between acoustic columns leads to a potent deterioration of the noise level. It sets limits on the admitted ratio of the spacing from the piezotransducer part length about 10 – 14%. The results of the S/N_0 value calculations are presented in Table 4.

Experimental AO cell was created with piezotransducer divided into 8 parts.

Measurements of intensity of diffraction across AO cell allow by the acousto-optic method to receive distribution of acoustic amplitude along piezotransducer length.

The measurement of this distribution has shown the non-uniformity of acoustic amplitude distribution. This should be taken into account during the manufacture of AO cell's voltage divider since acoustic amplitude along AO cell has appeared varying about 20% on.

In a reality, the capacities connected to piezotransducer's sections inaccurately coincide with optimal values. The calculations show that in this scheme the errors appearing in the capacity selection process influences insignificantly on the magnitude of side lobes. The error about 10% from the optimal value of each capacity change the maximal side lobe not more than on 1.6 dB.

In a considered model piezotransducer was substituted by a capacity measured at low frequency. This approximation is rather rough, as the theory shows, since the equivalent piezotransducer scheme is complicated. But it is possible to present this scheme as parallel jointed resistance and capacity depending from frequency. This substitution is possible since a value of the piezotransducer capacity on low frequency is equal to capacity value on the resonance frequency.

As a result, experimental AO cell with voltage divider provides close to optimal distribution of acoustic amplitude was manufactured.

As the carried out investigation testified, the application of the apodized piezotransducer makes it possible to suppress the AO cell transmission function's side lobes substantially. The transmission function depends considerably on the shape of acoustic amplitude distribution along the piezotransducer. The proposed method of electronic control of transmission function in tunable acousto-optic filter is simple, effective and relatively inexpensive.

3. ACKNOWLEDGMENT

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