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Response of Acousto-Optic Delay Line to Rectangular Input Signal

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Abstract—It is researched an influence of cross section size of incident to lightsensitive photoreceiver surface radiation on pulse shape in acousto-optic delay line with direct detection. Corresponding transient characteristic was obtained, it was used for output response analysis to input pulse signal with different duration.

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Acousto-optic delay lines (AODL) are applied for smoothly regulated signal delays, for time frames calibration with required parameters, etc. They are the bases of temporal signal distortion devices [1]. There are applied AODL with direct detection [2] and AODL of heterodyne types [3]. AODL with direct detection are applied for smoothly controlled videosignals delay, AODL of heterodyne type are used for smoothly controlled radiosignals delay.

Structural electrical chart of AODL with direct detection is shown in Fig 1. Its main unit is acousto-optic modulator (AOM), which is a photoelastic medium (PEM), to its one side an electrical- acoustic converter (EAC) is connected. The EAC converts input radio frequency signal into elastic wave (EW), which spreads into PEM with speed approximately 10^5 times less than speed of wave propagation. Beam of light falls on acousto-optic cell on the angle θ_0. As a result of interrelation with elastic and optic waves, a part of this beam deviates, i.e. diffracts.

There are AODL using diffraction mode of Raman- Nat and Bragg [2]. Main difference of Raman-Nat's diffraction in contrast to Bragg's diffraction is nonsymmetrical appearance of diffraction peaks, when light angle θ_0 on PEM surface changes. If $\theta_0 = \pm\theta_B$ where θ_B is Bragg's angle, diffraction effects of higher order disappear with EW frequency increase, light beam of zero and first orders prevail. Light intensity I_1 of first order is defined by following expression [4]

$$I_1 = I_0 \sin^2 \sqrt{\eta}, \tag{1}$$

where I_0 is intensity of incident on PEM wave

$$\eta = (\pi^2 M_2 P_a L_0) / (2\lambda^2 H_0) \tag{2}$$

is diffraction efficiency;

$$M_2 = n^6 p^2 / (\rho \upsilon^3) \tag{3}$$

is quality factor of material, L_0 is length of EAC (depth of acousto-optic interaction), λ is light wavelength, H_0 is width of EAC, n, ρ, p are refraction factor, density and photoelastic interaction constant.

As a rule, $\eta \ll 1$. Thus, expression for deflected beam intensity (first diffraction order) can be written as:

$$I_1 = I_0 \eta. \tag{4}$$