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Selection of Modulation Type in Acousto-Optic Delay Line with Direct Detection

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Abstract—This paper presents the physical and mathematical interpretation for the sequence of the response formation at the output of the acousto-optic delay line direct detection for various forms of connected to the terminals electro-acoustic transducer of high-frequency vibration. It has been shown that for the chosen design the intensity of light, which is incident on the photosensitive surface of the photodetector, varies only in the case of a change of acoustic power in the photoelastic medium. This eliminates the possibility of using the angular modulation for the transfer of video signal spectrum in the range of operating frequencies of the acousto-optic modulator in acousto-optic delay line with direct detection. In order to provide such a possibility it is recommended to install on the path of the deflected light a reference indicator, which converts the changes in the angle of diffraction into corresponding changes in the intensity of light, which is incident on the photosensitive surface of the photodetector. The proposed design is investigated for square and circular apertures of the light beam. It has been determined that best results are achieved in the case of the light beam with a square aperture and with a uniform distribution of power flow therein. We present the main results of experimental studies that confirm the effectiveness of the proposed design.

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1. BACKGROUND INFORMATION, PROBLEM STATEMENT AND ITS STATE

The properties of the acousto-optic effect are used for the development of numerous devices and systems for the processing of electrical signals [1]. These devices include acousto-optic delay lines (AODL) [2], which provide continuously controlled delay of broadband electrical signals and can be used for the correction of time-base errors of signals [3], for the formation of video and radio pulses with parameters different from the initial values [4] etc.

There are AODLs with direct detection and of the heterodyne type [4]. AODLs of the first type are used for video signals processing, and AODLs of the second type are utilized for radio signals processing.

According to the structural electrical circuit of AODL with direct detection (Fig. 1), the processed video signal $u_{\text{in}}(t)$ modulates the oscillation of high frequency generator (HFG). The modulated high frequency oscillation with the carrier frequency Ω is applied to the terminals of attached to the edge of photoelastic medium (PEM) electro-acoustic transducer (EAT) with length L and width H. Note that depending on the operating frequency, the thickness of the EAT may be from several microns to several millimeters.

The cell, which consists of PEM and of attached to its edge EAT, is called acousto-optic modulator (AOM). The bandwidth of AOM is 40–60% of the center frequency, which may be chosen in the range from tens of megahertz to several gigahertz.

All types of AODLs with direct detection require the HFG oscillations modulation for the translation of spectrum of the processed video signal $u_{\text{in}}(t)$ in the range of the operating frequencies of AOM.

The purpose of this research is the investigation of the possibilities and the peculiarities of the utilization of various modulation types in AODL with direct detection, as well as the drawing up recommendations on their use for the solution of specific problems.

In order to solve this problem, let us consider the sequence of the physical processes that lead to the formation of the response at the output of AODL.

EAT excites in PEM an acoustic wave with the length $\Lambda = 2\pi\upsilon / \Omega$, frequency Ω, power P_{a} with the propagation velocity υ, which is approximately 10^5 times less than the propagation velocity of the