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Improved two-channel laser Doppler flowmeter

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***Abstract* – Noise in the differential-channel setup of a laser Doppler flowmeter was studied. Formation of false spectral components in the output signal due to electrical signals beating was found out. The improved block-diagram of the flowmeter allowing to reduce the noise was developed.**

Keywords - Laser Doppler Flowmetry; two-channel scheme; false spectrum; signals beating; sensitivity.

I. INTRODUCTION

Laser Doppler Flowmetry (LDF) is a noninvasive method for research the blood microcirculation [1]. Signal processing algorithm in LDF is based on the model [2], in which the blood flow is calculated with the use of the first-order moment of the power spectral density of a flowmeter's output electrical signal. The most widely used differential two-channel scheme of flowmeters [3] has some drawbacks. The aim of this study is to develop the improved block diagram of the instrument.

II. MATERIALS AND METHODS

Noise in the differential-channel setup of the Russian LDF instrument "Lakk-02" was studied. The electrical scheme of it was tested in order to detect noise sources. Special attention was paid to a differential amplifier (DA) and its preceding units (DIV), where the normalization of variable (ac) components of the signal on the dc current occurs (Fig.1).

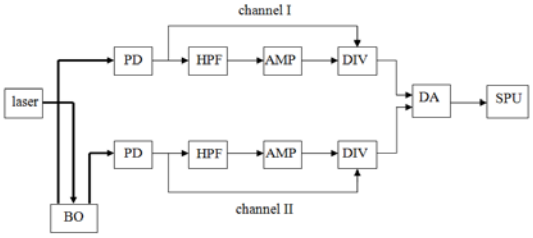

Fig. 1. Block diagram of the differential channel setup of LDF instrument "Lakk-02". BO - biological object, PD - photodetector, HPF - high pass filter, AMP - amplifier, DIV - divider, DA - differential amplifier, SPU - signal processing unit.

III. THE RESULTS AND DISCUSSION

Low- and high-frequency beatings were detected in the output signal in DA (Fig. 2). This leads to the formation of false spectral components of the output signal [4], which is the cause of diagnostic errors in LDF. The reason of the beatings is the presence of the residual ac components in normalizing signals, which after division and subtraction of two signals in DA start to appear. In addition, it was found out, that parts of

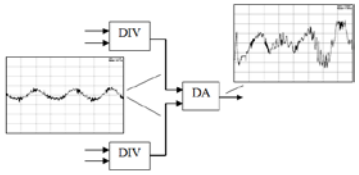

Fig. 2. Signal waveforms registered before and after DA in the scheme.

the useful signal correlated in both channels are suppressed in DA decreasing the diagnostic tool's sensitivity. To eliminate these drawbacks it was proposed to add low pass filters (LPF) in the scheme as well as to include a white reference material (RM) in one of the channels (Fig. 3). LPFs don't transmit variable ac signals to DIVs, therefore the false beatings are not formed in the output signal. Simulating the optical properties of biological tissue without blood, RM provides uncorrelated reference signal in the channel 1. It enhances the total sensitivity of the instrument.

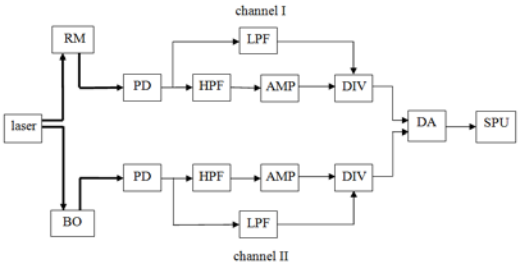

Fig. 3. Improved two-channel scheme of the LDF instrument.

IV. CONCLUSION

The differential-channel setup of flowmeters used in LDF has some drawbacks which lead to false spectral components in the output signal and to a reduced sensitivity of the instrument. Additional low pass filters in the scheme as well as a white reference material in one of the channels allow us to improve the instrument.

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