Digital Filters for Power Spectral Density Estimation of Heart Rhythm

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Abstract - **In this paper digital filters for a real-time estimation of the power spectral density of stationary components of a heart rhythm are considered.**

Keywords – **Heart rhythm, monitoring system, human functional state, power spectral density, stationary component.**

I. INTRODUCTION

Increasing of complexity of human-machine automation systems in different branches of living activity necessitated the problem of control and evaluation of reliability of a human operator as one of the most important element of such systems [1]. Nowadays the estimation of power spectral density of heart rhythm is considered as one of the most informative and accurate methods of evaluation the human functional state [2]. The hearth rhythm is a variable, nonstationary sequence of values of electrocardiosignal RR-intervals, particularly with a periodically stationarity. Under suppose about a relatively long with specific conditions of a working time of an operator the filter method for analysis of the power spectral density of rhythmosignals previously was considered [3].

In this paper the main concept of digital filters development for an automatic real-time monitoring system of the human functional state is presented.

II. PARAMETRIC SPECTRUM OF HEART RHYTHM

The main feature of the heart rhythm monitoring system is that heart rhythm is non-stationary and is considered as periodically correlated stochastic process (PCSP) under breath systems influence of a working man. This determines the structure of the monitoring system.

Periodically correlated discrete stochastic process represent via stationary components $\xi_k(n)$, like in [4]:

$$\xi(n) = \sum_{k \in Z} \xi_k(n) \exp\left(ik \frac{2\pi}{N_K} n \right) \quad (1)$$

where N_K - period of correlation of sequence. So, when hearth rhythm sequence is PCSP, than its stationary component $\xi_k(n)$ is a special sample with capture of selection from $\xi(n)$ through N_K samples.

Heart rhythm sequence $\xi(n)$ is represented in frequency domain via power spectral density (PSD) of stationary components $\xi_k(n)$ - parametric spectrum $S(\omega, n)$ that is periodic with period N_K.

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Parametric spectrum $S(\omega, n)$ estimations are obtained using filter banks [3, 5]. Each filter bank consists of N_K digital filters, but instead of Chebyshev pass-band filters [3], digital filters with the structure shown on Fig.1 are considered.

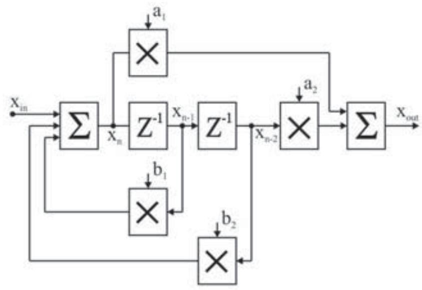

Fig.1 Structure scheme of digital filter used for PSD estimation.

Each filter in the bank has resonant frequency ω_i and bandwidth $\Delta\omega = const$. Transmission function of the filter is like in [6]:

$$H(Z) = \frac{a_1 + a_2 Z^{-1}}{1 - b_1 Z^{-1} - b_2 Z^{-2}} \quad (2)$$

Coefficients b_1 and b_2 of each digital filter are determined using [6]. Coefficients a_1 and a_2 (let $a_1 = -a_2$) are determined by normalization requirement : $|H(j\omega_i)| = 1$.

III. CONCLUSION

Application of the filter method for estimation of PSD of the heart rhythm sequence allows us for provide of its a long time analysis with low mean square errors in the time interval. Considered structure of digital filter provide us better effectiveness comparatively to Chebyshev pass-band filters.

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