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APPROXIMATION OF AMPLITUDE-FREQUENCY RESPONSES OF MINIMUM-PHASE RECURSIVE DIGITAL BAND-PASS FILTERS

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The paper considers a method of treatment and an example to the problem of approximation of AFR of digital recursive band-pass filters with any ratio between powers of the numerator and denominator of the transfer function polynomials and for a prescribed function of guaranteed attenuation in the rejection band.

The transfer functions of recursive digital filters (RDF) are described by rational fractions with real-valued coefficients [1]

$$H(z)=\frac{\sum_{i=0}^{N} b_i z^{-i}}{1+\sum_{i=1}^{M} a_i z^{-i}}. \qquad (1)$$

Fraction (1) has $N + M + 1$ variable parameters (coefficients b_i and a_i), which can be used for approximation of prescribed frequency responses of filters to be synthesized. The number of delay (memory) elements, in the case of direct realization of transfer function (1), is equal to the largest value among N and M.

The transfer functions of RDF will be represented by two functions:

$$H_1(z)=b_0\left(1+\alpha_1 z^{-1}\right)\left(1+\alpha_2 z^{-1}\right)\prod_{i=1}^{m}\left(1+\gamma_i z^{-1}+z^{-2}\right);$$
$$H_2(z)=\prod_{i=1}^{M/2}\left(1+\alpha_{i1} z^{-1}+\alpha_{i2} z^{-2}\right), H(z)=H_1(z)/H_2(z), \qquad (2)$$

where M is an even number. Setting $z = e^{jx} = \cos x + j\sin x$ (where $x = \omega T$, $T = 1/2f_d$ is the quantization interval), we find the complex transfer function $H(jx) = H_1(jx)/H_2(jx)$, where

$$H_1(jx)=b_0 e^{-jmx}\cdot 2^m \prod_{i=1}^{2}\left(1+\alpha_i \cos x - j\alpha_i \sin x\right)\cdot\prod_{i=1}^{m}\left(0.5\gamma_i+\cos x\right),$$

$$H_2(jx)=e^{-jMx/2}\prod_{i=1}^{M/2}\left[\alpha_{1i}+(1+\alpha_{2i}\cos x)+j(1-\alpha_{2i}\sin x)\right].$$

The amplitude-frequency response

$$H(x)=\left|H(jx)\right|=\sqrt{H(jx)H(-jx)}=\sqrt{Q(x)/Q_1(x)},$$

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