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DESIGN METHOD OF FIR DIGITAL FILTERS WITH SPECIFIED GROUP DELAY ERRORS USING SUCCESSIVE PROJECTION

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Abstract. *This paper presents a design method of FIR digital filters that meet simultaneously magnitude and group delay specifications using a successive projection method. Generally, the design problem of FIR digital filters with low group delay is expressed as the minimization problem of the complex magnitude error, which includes the magnitude and phase information, and it is minimized instead of the group delay error. Therefore, the group delay characteristics of the filter obtained by solving such a design problem may be distant from the desired group delay. In the proposed method, we define separately the approximation problems of the magnitude and the group delay characteristics, and these two approximation problems are solved alternately using successive projection method. As a result, the proposed method allows the direct approximation of the group delay characteristics, and it can also restrict the group delay characteristics within the preselected allowable errors. The usefulness of the proposed method is verified through some design examples.*

Keywords: Group delay response, Maximum allowable errors, FIR filters, Successive projection method, Filter design

1. **Introduction.** A number of methods for the design of finite-impulse response (FIR) digital filters have been developed during the past three decades or more [1-3, 5-19]. FIR digital filters are widely used in several fields of image processing, waveform transmission, etc., in which phase distortion is a problem, because perfect linear phase filters can easily be realized and are inherently stable. For the Chebyshev approximation of such filters, J. H. McClellan et al. proposed an excellent algorithm well-known as *Remez algorithm* [2]. However, the group delay of perfect linear phase FIR filters may become unacceptably large when high-order filters or narrow transition bands are required because the resulting delay at the output of the perfect linear phase FIR filter is half of the filter order. This causes a fall of processing speed since the hardware required for filtering and a computational cost become large. The linear phase condition is not generally needed in the transition bands and the stopbands.

Several methods for designing low group delay FIR filters, which have an approximately linear phase in the passbands, have been suggested previously [7-16]. The design problem of such filters is usually expressed as the minimization problem of the complex magnitude error, which includes the magnitude and phase information, and it is minimized instead of the group delay error. Therefore, the group delay characteristics of the filter obtained by these methods may be distant from the desired group delay, especially in the vicinity