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A HEURISTIC APPROACH TO SP2 TERM ALLOCATION FOR FIR FILTER BASED ON LEAST MEAN SQUARE CRITERIA

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Abstract. *Discussion is made upon optimum (or at least better) allocation of a given number of signed power of two (SP2) digits in the multiplicative coefficients contained in a linear phase finite impulse response (FIR) filter under design. It is known, however, that the optimality involves an NP-hard problem and which makes a practical solver procedure next to impossible to be realized. One actual and promising resolution may be the use of heuristics, including the work due to Lim et al.* [5] *based on a numerical sensitivity analysis. The purpose of this paper is to propose a more direct way of heuristic allocation aiming the optimal filter design with continuous relaxation to the coefficients concerned. Numerical experiments illustrate almost uniformly better results than those of Lim et al. in view of mean square errors from the desired filter characteristics.*
Keywords: Digital filter, Optimization, Integer programming, Approximation

1. **Introduction.** Multiplier-free realization of FIR filters with discrete coefficients has been attracting many works including [1-8], in the past three decades, where each coefficient is a canonical signed digit (CSD) number represented as a summation of signed power of two (SP2) terms. CSD is a well-known representation form for binary numbers with ternary digit set $\{-1, 0, 1\}$ "canonical" in the sense that any non-zero digit is always followed by 0 and leads the filter logic networks to be simple and efficient.

Optimal CSD FIR filter design given the total number of nonzero SP2 terms for all the coefficients involves an integer programming (IP) problem which belongs to a known class of NP-hard problems [9]. In order to overcome this difficulty, a number of design methods have been proposed by using CSD coefficients with equal numbers of nonzero SP2 terms, while Lim *et al.* [5] and some other researchers have demonstrated clear advantages in different number allocation of terms.

The heuristic method due to Lim *et al.* [5] takes an indirect way for determination of the numbers of terms based on a sensitivity analysis. Our method presented here aims directly at reducing differences in frequency response between designed and desired filter