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ORIGINAL ARTICLE

Design of near-perfect-reconstructed transmultiplexer using different modulation techniques: A comparative study

A. Vishwakarma [a], A. Kumar [a,*], G.K. Singh [b,c]

[a] PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Jabalpur 482005, MP, India
[b] Indian Institute of Technology Roorkee, Roorkee 247667, Uttarakhand, India
[c] Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

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Inter-symbol interference (*ISI*)

Abstract In this paper, an efficient iterative method for design of near-perfect reconstructed transmultiplexer (NPR TMUX) is proposed for the prescribed roll-off factor (*RF*) and stop band attenuation (A_s). In this method, windowing technique has been used for the design of prototype filter, and different modulation techniques have been exploited for designing multi-channel transmultiplexer (TMUX). In this method, inter-channel interference (*ICI*) is iteratively minimized so that it approximately reduces to ideal value zero. Design example is given to illustrate the superiority of the proposed method over earlier reported work. A comparative study of the performance of different modulation techniques for designing TMUX is also presented.

1. Introduction

Multirate signal processing is useful for all branches of natural and social science, which involve data acquisition and analysis (Mitra, 2001; Vaidyanathan, 1993). Multirate system such as the filter bank is a bank of low pass, high pass and band pass filters; these filters are employed to cover a complete band in the frequency range. The filter banks consist of delay elements, down samplers and up samplers, and work in two modes; first is analysis/synthesis mode and second is synthesis/analysis mode. First mode or structure corresponds to the filter bank (Zhao et al., 2013a; Zhao and Swamy, 2013; Boukabou et al., 2013; Zhang et al., 2011), which is used in source coding such as data compression, subband coding and the second mode corresponds to a transmultiplexer (TMUX) (Vetterli, 1990; Vaidyanathan and Vrcelj, 2000; Parker, 2007; Jian and Zaichen, 2009), which is used in channel equalization, channel coding etc.

TMUX refers to a system that converts time the multiplexed signal to a frequency multiplexed signal, and finally to the time multiplexed signal (TDM–FDM–TDM). Due to TMUX, higher processing rate is achieved and the system cost

* Corresponding author.
E-mail addresses: amitvishwakarma2625@gmail.com (A. Vishwakarma), anilkdee@gmail.com (A. Kumar), gksngfee@gmail.com (G.K. Singh).
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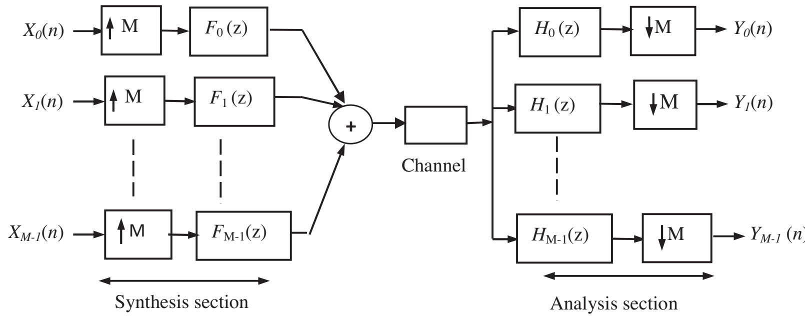

Figure 1 A block diagram of transmultiplexer system Kumar et al. (2013).

is also decreased (Vetterli, 1990; Vaidyanathan and Vrcelj, 2000; Parker, 2007; Jian and Zaichen, 2009). Therefore, a number of efficient TMUX systems have been developed to minimize the system cost, overall computational complexity needed to design a TMUX system. In the early stage of research, TMUX systems were designed using non-DFT based Freeny et al. (1971) and DFT based Cruz-Roldan et al. (2012) and Lim et al. (2005)) methods. In the non DFT based approach (Freeny et al., 1971), analog filters were employed that cause a large interference between adjacent channels of TMUX, while the DFT based technique for designing TMUX systems (Cruz-Roldan et al., 2012; Lim et al., 2005) employs Fast Fourier Transform (FFT), which results in fast implementation of TMUX and efficient channel equalization (Parker, 2007; Jian and Zaichen, 2009). DFT based filters have a main lobe and side lobes. Main lobe interferes with adjacent channels and side lobes spread all over the spectrum band. Due to that, selectivity of DFT based TMUX is limited, and it is not very suitable for narrow band applications (Umehara et al., 2006). To get high selective filters, cosine modulation technique (Vaidyanathan, 1993) is employed which reduces the design complexity of TMUX because the first prototype filter is designed and then, other analysis/synthesis filters are generated using the cosine modulation technique (Manoj and Elias, 2009a; Soni et al., 2010a,b, 2013). So, design complexity is equal to design of a prototype filter plus modulation overhead. To achieve faster implementation of the TMUX system, modulation is done by fast Discrete Cosine Transform (DCT) (Vaidyanathan, 1993). Several cosine modulation based algorithms have been proposed for designing of TMUX. A detailed discussion on cosine modulation and applications of cosine modulated filter banks have been given in Manoj and Elias (2009a) and Soni et al. (2010a,b, 2013)) and reference therein.

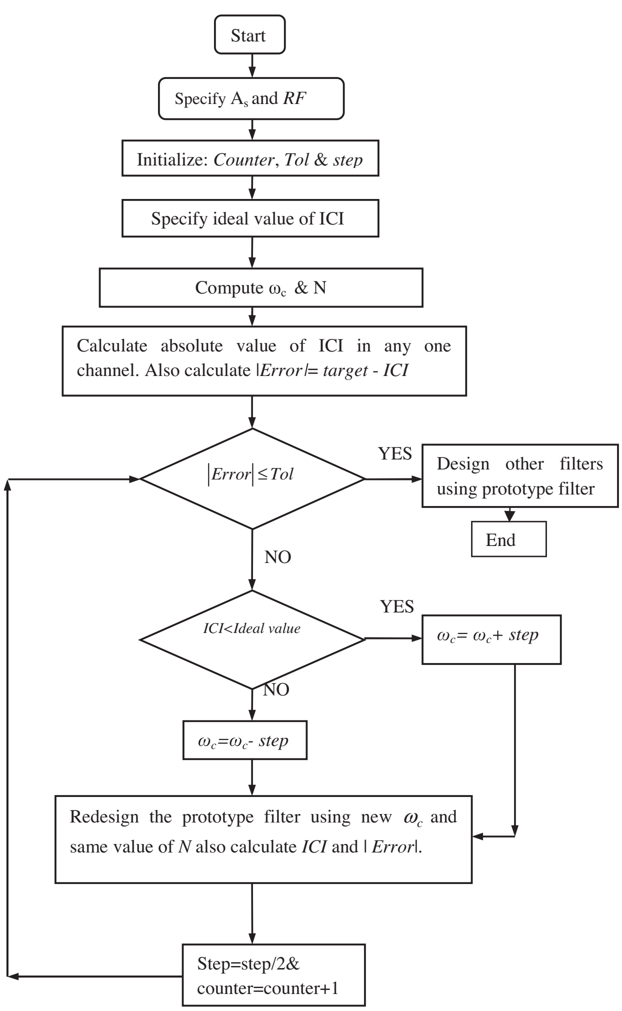

Figure 2 Flowchart of the proposed optimization algorithm.

First iterative method for designing Pseudo QMF banks was proposed by Creusere and Mitra (1995) based on linear optimization, and it has been further modified in Zhao et al. (2013b), Lin and Vaidyanathan (1998), Martin et al. (2004), Kumar et al. (2011a,b), Kumar and Kuldeep (2012) and Berger and Antoniou (2007). Later on, this algorithm was used to design cosine modulated TMUX, while in Manoj and Elias (2009b, 2012), artificial bee colony (ABC) algorithm and genetic algorithm (GA) have been used for designing TMUX. Recently, several design methods (Soni et al., 2013; Hoc et al., 2005; Ribeiro et al., 2009) have been proposed and evaluated for the design of TMUX systems based on optimization and non-optimizations. But still, there is no such iterative technique reported in the literature that can reduce the computation time, converge in a low number of iterations, and can also reduce inter-channel interference (*ICI*), which can be used for filter banks with larger taps. Authors have proposed an optimized algorithm in Cruz-Roldan et al. (2003) and Martin et al. (2003) for designing TMUX with the windowing technique based on the algorithm given in Creusere and Mitra (1995).

2. Overview of transmultiplexer (TMUX) system

Fig. 1 shows the synthesis/analysis subsystem of the TMUX system. In the synthesis section, M input signals are first interpolated by a factor of M. After that, output of the