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Efficient Muti Stage IFFT Architecture for Multi Carrier System

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Abstract:

This paper presents an efficient multi stage IFFT architecture for multi carrier system in OFDM. An existing layered inverse Fast Fourier Transform (IFFT) structure is transformed to a multistage layered IFFT structure where data symbols can input at different stages of the IFFT. We first showthat part of the IFFTin the transmitter of an OFDM system can be shifted to the receiver, while a conventional one-tap frequency-domain equalizer is still applicable.

The proposed IFFT algorithms to enable interference-free symbol recovery with simple linear equalizers. Applications of the proposed schemes in multiple access communications are investigated. Simulation results demonstrate the effectiveness of the proposed schemes in improving bit-error-rate performance.

Keywords:

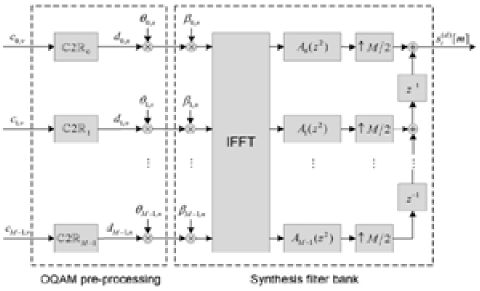
IFFT, multicarrier systems, verilog,OFDM.

INTRODUCTION:

DURING the past couple of decades, multicarrier modulation,specifically the orthogonal frequency division multiplexing (OFDM) [1], has become the de facto choice for high data rate wireless communications. OFDM has triumphedin a variety of applications, ranging from digital audio and video broadcasting standards (DAB, DVB) to wireless local and metropolitan area standards (WLAN, WMAN). More recently, it has been chosen as the air interface technique in the emerging cellular standards of evolved UMTS terrestrial radioaccess long term evolution (E-UTRA LTE) [2] and worldwide interoperability for microwave access (WiMAX) [3].

In the context of wideband transmission, the success of OFDM is a consequence of the numerous advantages it offers. Especially,it enables reduced receiver complexity by elegantly combating the inter-symbol interference due to frequency selective multipath channel through cyclic symbol extensions. Moreover,inherent flexibility to control the subcarrier allocations provides reconfigurability well appreciated in data rate and service adaptation.Among the benefits we can also count the simplicity of the concept and the low-complexity implementation thro the fast Fourier transform (FFT). Within this framework, there is a growing interest towards more advanced multicarrier modulation techniques, particularly those based on filter banks [5]. Filter bank-based multicarrier (FBMC) modulation techniques have shown potential to improve the spectral efficiency both by enabling transmission without redundant cyclic prefix and du to reduced frequency domain guard bands [6]. Furthermore,due to the ability to provide significantly enhanced frequency selectivity, they are considered particularly well suited for the challenging tasks of spectrum sensing [7] and secondary multiplexing [8] in CR terminals. In this paper, we present a novel method to generate frequency-compact (with sharp spectral decay behavior) FBMC uplink waveforms. The obtained results bring the proposed method forward as an attractive and appropriate technique for multiplexing in Crterminals.

CIRCUIT DESCRIPTION:



Efficient implementation of the transmitter processing in the FBMC/OQAM transmultiplexer.denotes the delay at the high rate before downsampling by .Further, and denote the lengths of the synthesis and analysis prototype filter, respectively.

In the conventional TMUX design, and we have and In order to guarantee downsampling at correct phase (at the maximum points of the received pulses) at the receiver, it is required that is some multiple of the downsampling factor .It can be observed that there are only two values of that directly fulfill this requirement, i.e., and .

However, also other values of can be made equally applicable by adding an extra delay into the TMUX configuration (see TMUXmodel in Fig. 1). In this case and can be made a multiple of by setting where stands for the modulo operation. The extra delay can be included either at the output of the synthesis bank or at the input of the analysis bank as suggested in [15]. For example, in the case of , the required extra delay of can straightforwardly be implemented by inserting an additional zero coefficient to the beginning of the impulse response of the optimized prototype filter.

B. FBMC/OQAM Signal Model:

An efficient implementation structure for the transmitter processing is shown in Fig. 2. The pre-processing section is structurally similar to the offset quadrature amplitude modulation.(OQAM) modulation [16]. Therefore, we refer hereafter to this concept asFBMC/OQAM.Theabbreviation stands for a complex-to-real mapping, expressible as even odd.where the real and imaginary part of a complex valued QAM symbol are separated and passed forward successively in time and in alternating order from a subchannel to another. This effectively increases the sampling rate by a factor of two.

Thephase mapping between the real-valued data sequence and the input samples of the synthesis bank is carried out by mixing with a sequence1Moreover, the filter length-dependent multipliers are due to the applied modulation sequence in While the IFFT performs the necessary modulation, the subcarrier pulse shaping, induced by the prototype filter, can be efficiently implemented through polyphase decomposition based on type-1polyphase filters of form , for Here, denotes

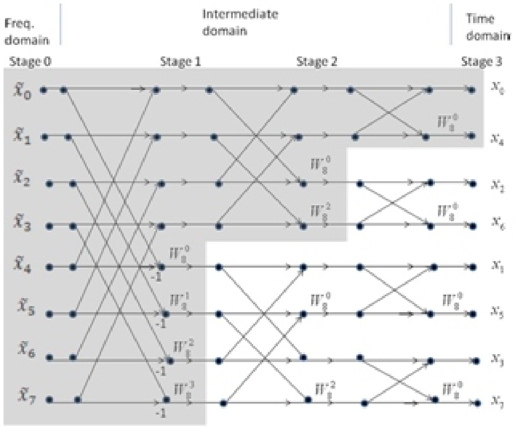


Fig.2. the multistage layered IFFT structure

Consider a system with reference to Fig. 1 where the IFFT is split to the shadowed part and the rest , and the symbols are input to and at different stages. Note that the split is not completely random.

The condition of uniqueness needs to be satisfied where uniqueness means that given any frequency-domain signal as the input to , the output fromcan be uniquely determined. If a (nested) D&C algorithm is split, computations corresponding to S1 and S2 in the D&C algorithm will always be allocated to .

We have the following theorem as answer to the question above.Theorem 1: Let denote two concatenated partial IFFTs split from one complete IFFT satisfying the uniqueness condition, and is the first part of the IFFT. Let denote the symbols input to the partial IFFT .

In a multipath channel,the signal can be recovered at the receiver by a conventional one-tap frequency domain OFDM equalizer, followed by thepartial IFFT transform . Proof: Let denote the time-domain signal corresponding to . Assume that a guard interval, either zero padding or cyclic prefix, is appended to .

The received signal after removing the guarding interval can be represented aswhere is the DFT matrix, is a circulant channel matrix with its first column being , and is a diagonal matrix with diagonal elements being the Fourier transform of .Applying DFT to generates-Therefore, similar to OFDMsystems, a linear one-tap equalizer,such as zero-forcing or minimum meansqre error(MMSE)

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Input: $k = 0$, $n \in [0, N-1]$, $\mathcal{V}_0 = \{0, 1, \cdots, N-1\}$;
while $k < \log_2 N + 1$ or allocation is incomplete do
    If inputs at stage $k$ are needed, $\mathcal{U}_k = \{\ell N/2^k + p\}$
    for $p = 0, 1, \cdots, N/2^k - 1$, $\ell \in [0, 2^k - 1]$ and
    $\ell N/2^k + p \in \mathcal{V}_k$;
    $k = k + 1$, $\mathcal{V}_k = \mathcal{V}_{k-1} - \mathcal{U}_{k-1}$, which means to
    remove location indexes in $\mathcal{U}_{k-1}$ from $\mathcal{V}_{k-1}$;
end
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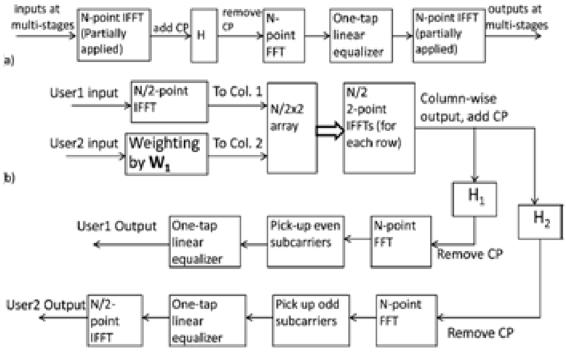
equalizer, can be applied to obtain an estimate for the frequencydomain signal.Since is the intermediate-domain signal of and the uniqueness condition holds, we only need to apply , the other part of IFFT to the estimate of , to recover .From the theorem above, we can see that part of the IFFT is equivalently shifted from the transmitter to the receiver. This generalizes and extends the results in Different choices of and can lead to different receiver designs. In some cases, a symbol will see interfering signals from other symbols at different stages. For example, symbols input in the frequency domain and time domain simultaneously will cause interference to each other. Recovering symbols in this case requires complex and advanced receivers such as joint maximum likelihood estimator.Next, we investigate IFFT split schemes which can guarantee an interference-free recovery with simple linear receivers.

MULTIPLE ACCESS COMMUNICATION:



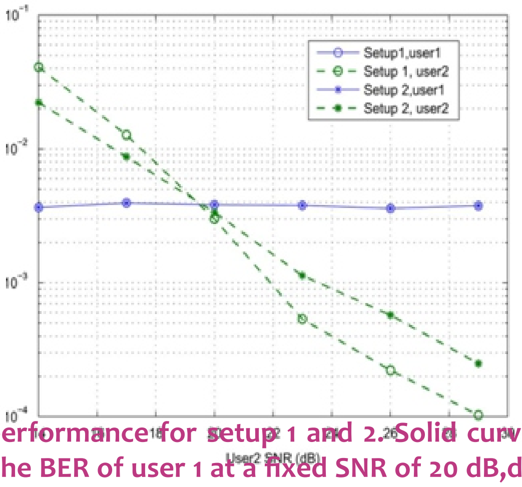
There can be various applications by enabling symbols to input at different stages. One promising application is to exploit the many combinations of input spots at different stages and locations.for secure communications. Different combinations can be pre-defined and information inputs are hopped on these combinations. Without knowing the hopping pattern, intruders are hard to retrieve the correct data. The hopping pattern can be similarly defined to the pseudo-random frequency hopping and direct spreading sequences.

Another important application is in multiple access communications. Generally, a user can have inputs at any locations and stages in a given split scheme. Here,we propose special allocations where each user only has inputs at the same stage, and the allocated stage depends on the user's SNR.

SIMULATION RESULTS:

We consider an OFDM system of , with a guard interval of 16. For , we can have 7 stages. Complex Gaussian channels with 16 independent multipath taps are simulated,and we assume perfect channel estimation. We consider the downlink of a two-user system. In the first setup, using split scheme 2, the input sets of the two users are given by and . In the second setup, both users are at stage 0, using even and odd subcarriers, corresponding to a conventional OFDMA system.

Both setups can be implemented in a fixed transceiver architecture as shown in Fig. 2(a), while a simplified equivalent structure for Setup 1 is shown in Fig. 2(b). In the simulation, user 1's mean SNR is fixed as 20 dB, and user 2's SNR varies. Both users use 64QAM and 2/3-rate convolutional coding. For user 2in the first setup, MMSE receiver isapplied, and in other cases ZF equalizer is applied as it is already the optimal linear receiver for conventional OFDM systems.Fig. 3 shows the BER results. User 1 has almost identical BER in the two setups, which indicates that its signal is not affected by the signal at a different stage. User 2's BER curves cross at 20 dB, and the first setup outperforms the second at higher SNR values. This shows that to achieve better performance,we can allocate user 2 to stage 5 if SNR is higher than 20 dB, and stage 0 otherwise.



BER performance for setup 1 and 2. Solid curves denote the BER of user 1 at a fixed SNR of 20 dB,dashed curves show how BER varies with SNR

CONCLUSION:

This letter proposes a multistage layered IFFT structure where data symbols can be input at different stages simultaneously and simple linear equalizers can be applied to estimate the symbols at the receiver. This novel multistage structure provides various options and flexibility in system design, and it is very promising for future broadband communications.Efficient implementation of the proposed system demands newIFFT architecture which allows symbols to be input in the intermediate domain without compromising the performance.

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