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Improved OFDM by Cancellation Carrier Frequency Offset in GFDM Based on Multi-Carrier Modulation for Future Machine To Machine Systems

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ABSTRACT

Due to its attractive properties, generalized frequency division multiplexing is recently being discussed as a candidate waveform for the fifth generation of wireless communication systems (5G). generalized frequency division multiplexing is introduced as a generalized form of the widely used orthogonal frequency division multiplexing modulation scheme and since it uses only one cyclic prefix for a group of symbols rather than a CP per symbol, it is more bandwidth efficient than OFDM. In this paper, propose novel modem structures for generalized frequency division multiplexing by taking advantage of the particular structure in the modulation matrix. Our proposed transmitter is based on modulation matrix scarification through application of fast Fourier transform to reduce the implementation complexity.

A unified demodulator structure for matched filter, zero forcing and minimum mean square error receivers is also derived. The proposed demodulation techniques harness the special block circulate property of the matrices involved in the demodulation stage to reduce the computational cost of the system implementation. Our derived the closed forms for the zero forcing and minimum mean square error receiver filters. Additionally, our algorithms do not incur any performance loss as they maintain the optimal performance. The computational costs of our proposed techniques are analyzed in detail and are compared with the existing solutions that are known to have the lowest complexity. It is shown that through application of our structures a substantial amount of computational complexity reduction can be achieved.

Keywords: Charging recommendation system, Electric vehicle, Energy management, Real-time range estimation model, State of charge estimation.

INTRODUCTION

Fifth generation (5G) networks will face new challenges that will require a higher level of flexibility from the physical layer (PHY). 3D and 4k video will push the throughput and spectral efficiency. Tactile Internet will demand latencies at least one order of magnitude smaller than what fourth generation (4G) can achieve. Machine type communication (MTC) will require loose synchronization, low power consumption and a massive number of connections. Wireless Regional Area Network (WRAN) needs to cover wide areas to provide Internet access in low populated regions. The future mobile networks must have a flexible PHY to address several different scenarios. Generalized Frequency Division Multiplexing (GFDM) is a recent waveform that can be engineered to address various use cases.

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GFDM arranges the data symbols in a time-frequency grid, consisting of M sub symbols and K subcarriers, and applies a circular prototype filter for each subcarrier. GFDM can be easily configured to cover other waveforms, such as Orthogonal Frequency Division Multiplexing (OFDM) and Single Carrier Frequency Domain Multiple Access (SC-FDMA) as corner cases. The subcarrier filtering can reduce the out-of-band (OOB) emissions, control peak to average power ratio (PAPR) and allows dynamic spectrum allocation. GFDM, with its block-based structure, can reuse several solutions developed for OFDM, for instance, the concept of a cyclic prefix (CP) to avoid inter-frame interference. Hence, frequency-domain equalization can be efficiently employed to combat the effects of multipath channels prior to the demodulation process. With these features, GFDMcan address the requirements of 5G networks.

RELATED WORK

A low-complexity carrier frequency offset compensation algorithm based on the minimum mean square error criterion for uplink orthogonal frequency division multiple access systems. Carrier frequency offset compensation with a minimum mean square error filter generally requires an inverse operation on an interference matrix whose size equals the number of subcarriers. [1] Thus, the computational complexity becomes prohibitively high when the number of subcarriers is large. To reduce the complexity, the conjugate gradient method which iteratively finds the minimum mean square error solution without the inverse operation. [5]

[2] Orthogonal frequency division multiple access where different subcarriers are allocated to different users, has been adopted for the uplink of several standards and has attracted a great deal of attention as a result. However, orthogonal frequency division multiple access is highly sensitive to carrier frequency offset between the transmitter and receiver. In the uplink, different carrier frequency offsets due to different users can adversely affect subcarrier orthogonally. [6, 7, 12]

Multiple carrier frequency offsets present in the uplink of orthogonal frequency division multiple access systems adversely affect subcarrier orthogonality and impose a serious performance loss. The application of time domain receiver windowing to concentrate the leakage caused by carrier frequency offsetss to a few adjacent subcarriers with almost no additional computational complexity. This allows us to approximate the interference matrix with a quasi-banded matrix by neglecting small elements outside a certain band which enables robust and computationally efficient signal detection. [7, 3]

A novel multi-carrier modulation scheme for broadband power line communication is presented. The novel architecture is based on the Filtered Multitone modulation concept. However, the novel modulation scheme uses the circular convolution instead of the linear convolution in the filtering operations. This new architecture as Cyclic Block Filtered Multitone Modulation. [8, 9]

The investigate fast-convolution based highly tunable multirate filter bank configurations. Based on FFT-IFFT pair with overlapped processing, they offer a way to tune the filters' frequency-domain characteristics in a straightforward way. Different subbands are easily configurable for different bandwidths, center frequencies, and output sampling rates, including also partial or full-band nearly perfect-reconstruction systems. [13]

PROPOSED METHOD

Future wireless communication systems are demanding a more flexible physical layer. Generalized frequency division multiplexing is a block filtered multicarrier modulation scheme proposed to add multiple degrees of freedom and to cover other waveforms in a single framework. In this paper, generalized frequency division multiplexing modulation and demodulation is presented as a frequency-domain circular convolution, allowing for a reduction of the implementation complexity when MF, ZF and minimum mean square error filters are employed as linear demodulators. [4]

The frequency-domain circular convolution shows that the DFT used in the generalized frequency division multiplexing signal generation can be seen as a precoding operation. This new point-of-view opens the possibility to use other unitary transforms, further increasing the generalized frequency division multiplexing flexibility and covering a wider set of applications.

The following three precoding transforms are considered in this paper to illustrate the benefits of precoded generalized frequency division multiplexing: (i) Walsh Hadamard Transform; (ii) CAZAC transform and; (iii) Discrete Hartley Transform. The PAPR and symbol error rate of these three unitary transform combined with generalized frequency division multiplexing are analyzed as well. [10, 11]

Block diagram

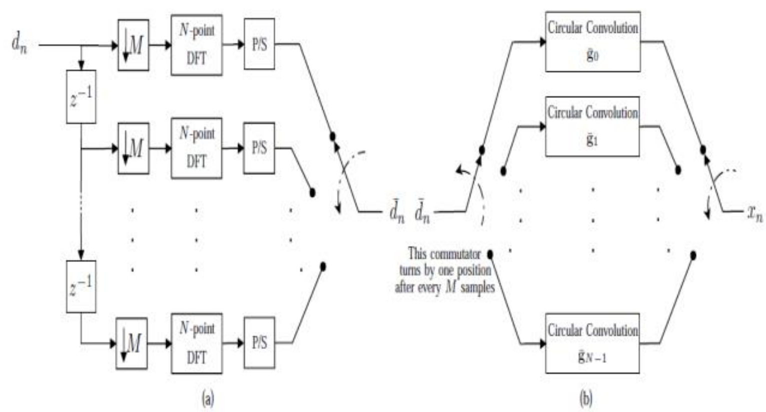

Fig1. Concatenation of (a) and (b) show the implementation of the proposed GFDM transmitter

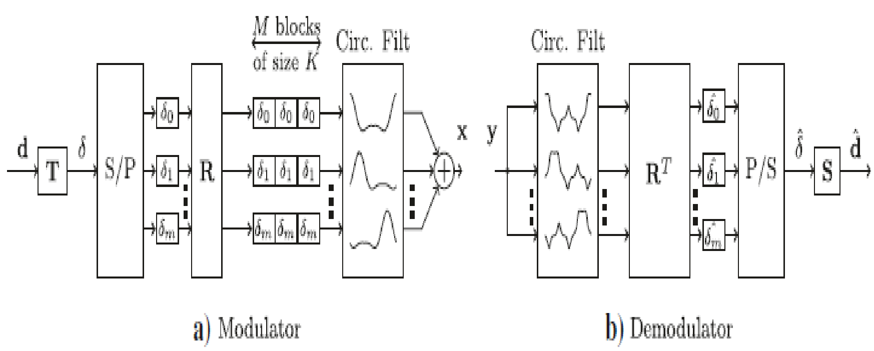

Fig2. Concatenation of (a) and (b) show the implementation receiver block diagram

SYSTEM MODEL

Precoding performance analysis the main advantage of the precoding schemes presented in this section is that each subcarrier carries a linear combination of all data symbols from a given sub symbol. This procedure spreads the information over all subcarriers, allowing the receiver to exploit frequency diversity. Since the columns and rows of the precoding matrices are orthogonal to each other, the data symbols can be recovered on the receiver side without self-interference introduced by the precoding operation. Therefore, the precoding generalized frequency division multiplexing schemes experience a performance gain over conventional generalized frequency division multiplexing in frequency-selective channels, as can be seen in Fig. 4. The parameters used for simulation are presented in Table 3.

Es is the average energy per symbol of the quadrature amplitude modulation constellation, RT is the.Throughput efficiency reduction due to CP, N0 is the noise.

SPACE

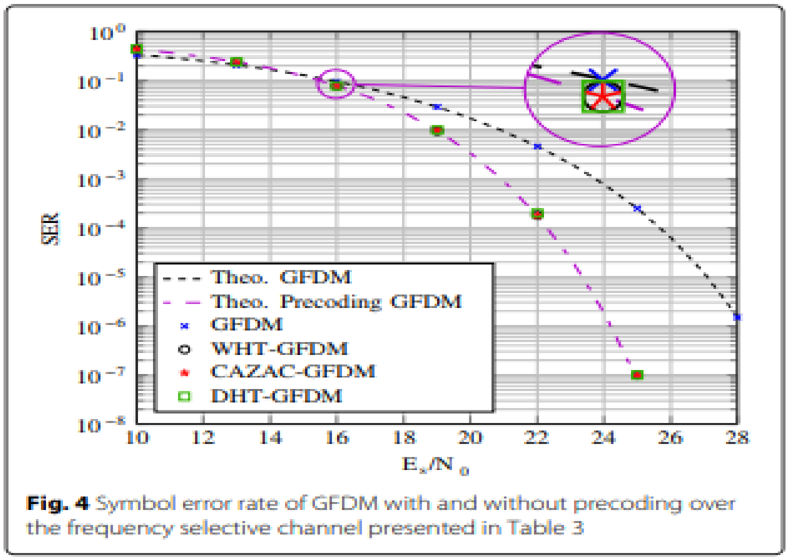

Fig3. The Frequency Selective Channel

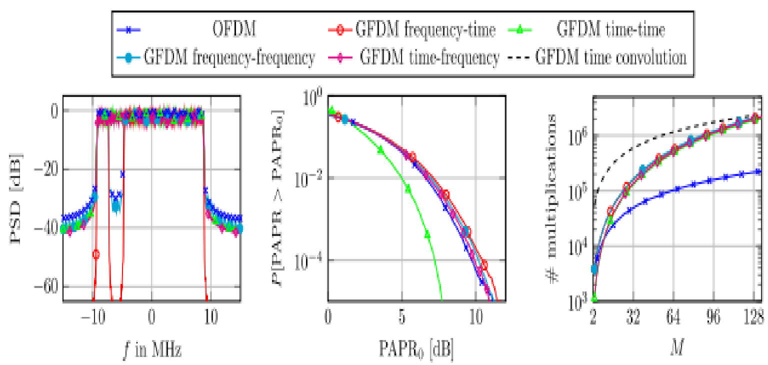

Fig4. PSD

GFDM Transmitter Design

One can realize that direct multiplication of the matrix A to the data vector d is a complex operation which demands (MN)2 complex multiplications. Therefore, complexity will be an issue for practical systems as the number of subcarriers and/or the parameter M increases. Accordingly, a low complexity implementation technique for generalized frequency division multiplexing transmitter has to be sought.

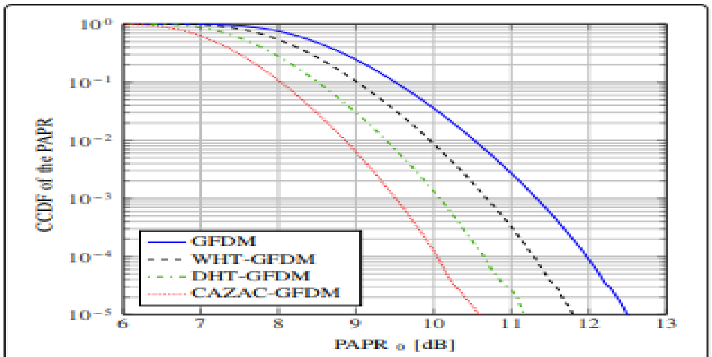

Fig. 5 CCDF of the GFDM PAPR with and without precoding

Fig5. CCDF oftheGFDM with and without precoding

x = Ad = AFHbFbd

GFDM Transmitter Implementation

In this subsection, implementation of the designed generalized frequency division multiplexing transmitter in Section III-A is discussed. Generalized frequency division multiplexing modulation, based on our design, can be summarized into two steps.

1) M number of N-point DFT operations, i.e., application of N-point DFT to each individual generalized frequency division multiplexing symbol which includes N subcarriers. This can be efficiently implemented by taking advantage of the fast Fourier transform algorithm.
2) N number of M-point circular convolution operations. Therefore, the first and second steps of our generalized frequency division multiplexing transmitter can be implemented by cascading, respectively. The blocks P/S convert the parallel FFT outputs to serial streams.

GFDM Receiver Implementation

Low complexity ZF and MMSE receivers for GFDM systems. It is worth mentioning that our solutions are direct and hence lower complexity of these receivers comes for free as they do not result in any performance loss, thanks to the special structure of the matrix AHA. The characteristics of AHA will be discussed in the next subsection and then we will derive our proposed receivers on the basis of those traits.

CONCLUSION

Low complexity modulation and demodulation techniques for generalized frequency division multiplexing systems. The proposed techniques exploit the special structure of the modulation matrix to reduce the computational cost without incurring any performance loss penalty. In our proposed transmitter, block DFT and IDFT matrices were used to make the modulation matrix sparse and hence reduce the computational burden. Low complexity MF, ZF and minimum mean square error demodulators by block diagonalization of the matrices involved. It was shown that through this block diagonalization, a substantial amount of complexity reduction in the matrix inversion and multiplication operations can be achieved. A unified demodulator structure based on MF, ZF and minimum mean square error criteria was derived. The closed form expressions for the ZF and minimum mean square error receiver filters were also obtained.

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