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Research Article

Filter Based Interference Mitigation in Multi Band-OFDM

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Abstract: This study aims at to mitigate the interference between the primary user and secondary user in the wireless environment. This becomes necessary task because with the growing demand for bandwidth for wireless connectivity, it has become essential to come up with innovative solutions to tackle the demand. Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) offers a compelling answer for higher bandwidth and data rate requirements. The performance of multi band OFDM has been tarnished by narrow band interference due to the existence of primary users in the UWB spectrum. This occurs due to the leakage of spectral interference power. Despite the fact that Multiband OFDM has the inherent capability to mitigate the interference, independent mitigation techniques become necessary when the interference level is too high. In this study, interference mitigation is carried out by filtering action at the receiver. Results of simulation are compared to analyze the performance of the filters. Further steps have been taken out to enhance the performance of multiband OFDM system which in turn will be helpful in mitigating the interference.

Keywords: Discrete Wavelet Transform (DWT), filters, Multi Band-Orthogonal Frequency Division Multiplexing (MB-OFDM), narrow band interference, Ultra Wide Band (UWB)

INTRODUCTION

Wireless technology has increased enormously in the past few years. Ultra Wide Band technology provides an effective solution for supporting high data rates (Standard ECMA-368, 2007; FCC Rules, 2002). UWB has a different dimension to transmit the data by using the RF spectrum. UWB makes use of frequencies extending from 3.1 to 10.6 GHz in which each band can have a bandwidth of more than 500 MHz depending on its central frequency (Ning and Yuanping, 2006). Although the spectrum is said to be unlicensed, there are few licensed users such as Wimax, Wifi and Radio astronomy of Japan causing interference to the secondary users. Hence it is the responsibility of the secondary users to reduce this interference for efficient communication (Timothy *et al*., 2007).

The leading MB-OFDM technology of UWB has the ability to shape the spectrum to mitigate the interference. The entire frequency range is partitioned into several bands of 528 MHz each and the data is sent over several multiple carriers with OFDM modulation (Wu and Nassar, 2005). Since the carriers are orthogonal to each other, the data can be overlapped resulting in efficient utilization of the spectrum (Coulson, 2006). The system uses QAM modulation with 128 point Fast Fourier transform (FFT) along with zero padding (Balakrishnan *et al*., 2003). In addition the FFT part of the system is alternated with discrete wavelet transform. DWT with multi-resolution capability offers lot of advantages than FFT. Like FFT it offers orthogonal property which makes it more suitable to replace FFT with DWT.

The proposed study aims at replacing the Fast Fourier Transform (FFT) part of the multiband OFDM system with discrete wavelet transform which offers lot of advantages than FFT. Next to combat the interference between the primary and secondary users filtering technique is adopted at the receiver side of the multiband OFDM system and their performance is analyzed.

SYSTEM MODEL

The system model is depicted by Fig. 1. Input data undergoes several processes before being transmitted to the receiver. Input data bits are first passed through the scrambler where the original data is converted into a pseudo-random sequence. This avoids inter-channel interference and noise during their transmission. Hence the scrambler is used to uniformly redistribute zeros and ones. The scrambled bits are then encoded using a convolution encoder (Avila *et al*., 2012). A convolution encoder with a rate of half is implemented which encodes two bits for each input bit. The coded bits are then interleaved to provide robustness against burst error. The interleaved bits are modulated. The modulation scheme is chosen based on the error rate of the scheme and the data rate of the modulation scheme. In this study three modulations schemes namely Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation

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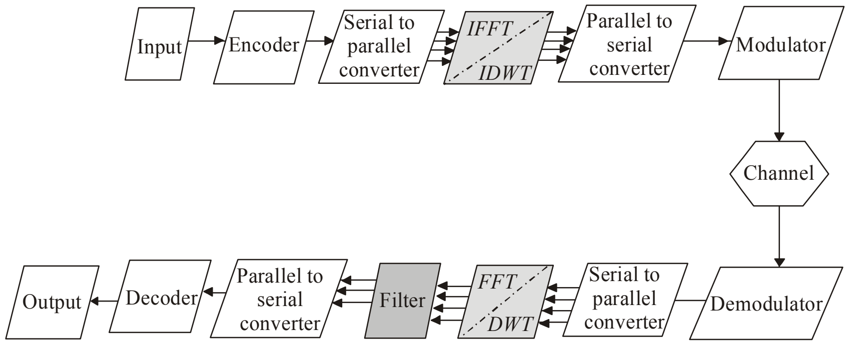

Fig. 1: Block diagram of multiband OFDM system

(QAM) and analyzed and compared (Bernard and Pabitra, 2001). QAM is used because it ensures high data rate. The interference caused by side bands is reduced. Two digital data streams along with two carrier waves that are 90° out of phase with each other are transmitted.

Binary Phase Shift Keying (BPSK) is the modulation scheme in which phase of carrier varies by 180° for binary one and binary zero. The distance between signal points is higher because it transmits either binary one or binary zero at an instant. Higher is the distance between signal points lesser is the error and hence this modulation scheme is more suited for high noisy environment.

Quadrature Phase Shift Keying (QPSK) is the most widely used modulation scheme in wireless communication. In QPSK two bits make one symbol, hence it supports moderate data rats and the probability of error is also less when compared to QAM.

The resulting waves are summed converting the data bits into symbols. IFFT is done after modulation to generate MB-ODFM symbols:

$$s(n) = \frac{1}{N} * \sum s(F) * e^{(j*2*\pi/N)kn} \quad (1)$$

On the receiver, FFT is performed. The symbols of MB-OFDM are converted into Data stream:

$$s(F) = \sum s(n) * e^{(-j*2*\pi/N)kn} \quad (2)$$

Once FFT is done, demodulation is performed. Demodulated bits are then deinter leaved whose process is the inverse of inter leaver. The de-interleaved bits are decoded and then descrambled.

Narrowband interference: Narrowband Interference (NBI) is a disturbance that affects the system due to electro-magnetic induction or electro-magnetic radiation (Maurice, 2010). This interference may be due to the presence of co-existing systems such as Wi-fi, Wi-Max etc. The performance of the MB-OFDM system is degraded by the presence of NBI. Filter is introduced prior to the demodulation process and the original signal is retrieved (Burak *et al*., 2006). Several filtering techniques are adopted to mitigate Narrow Band Interference in the system and retrieve the original signal from the received signal.

Butterworth filters are maximally flat response in the pass band and its poles lies only on the circle. They have good phase response but poor roll off rate. This led to the usase of filter known as chebyshev filter (Politi and Fosatti, 2010). They are known for their speed since they are carried out by recursion rather than convolution. So they produce fewer errors when compared to the previous filter. They are either analogue or digital filters. In this study digital chebyshev filters are used. They have faster roll-off when compared to Butterworth filters with ripples in passband. This filter has one of the sharpest pass band cut-off characteristics and a very large group delay. Chebyshev type II has flat pass band response and equiripple response in the stop band. Notch filter passes all frequencies except certain frequencies (Felicja, 2007). They have Q factor. Elliptic filters have an equal behavior in both pass band and stop band. They have sharp cut off but at the same time they have non-linear phase response.

Discrete Wavelet Transform (DWT) better than Fast Fourier Transform (FFT) because it gives faster results and computation time is lesser. DWT is based on sub-band coding and satisfies the orthogonally property. It can also segregate the finest details of the signal. The signal can be subdivided into the component wavelets using discrete wavelet transform. DWT can also compress and remove unwanted noise from the signal. Unlike FFT which gives only frequency resolution, DWT gives both time and frequency resolution (Avila and Thenmozhi, 2012b).

RESULTS AND DISCUSSION

The results are obtained using MATLAB tool. Simulation is performed between Signals to Noise Ratio (SNR) versus Bit Error Rate (BER).

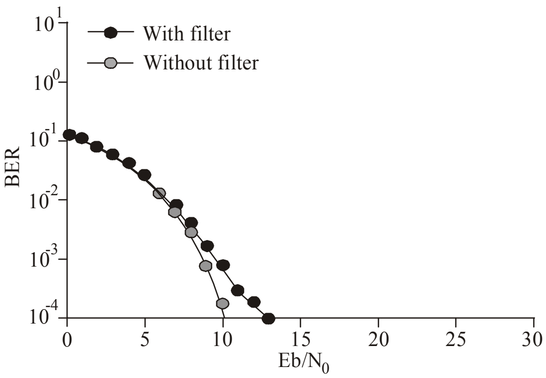

Fig. 2: Comparison between no filter and filter

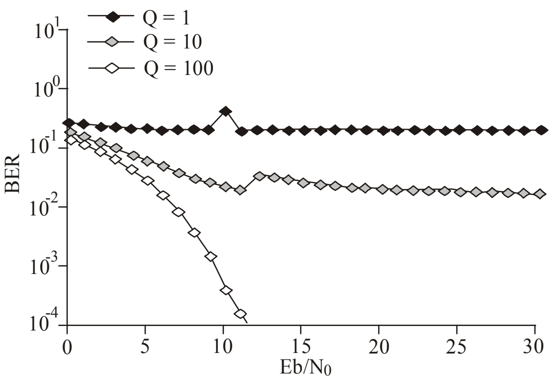

Fig. 3: Comparison between q values of notch filter

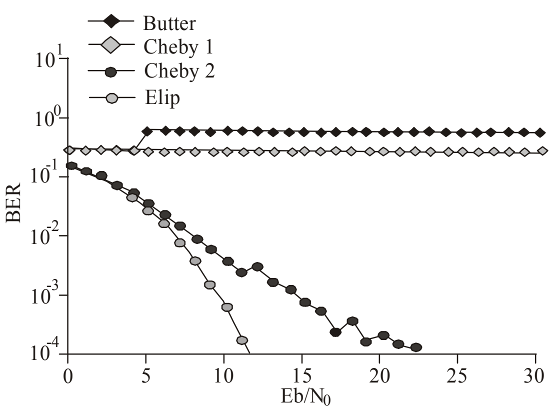

Fig. 4: Comparison between various filters

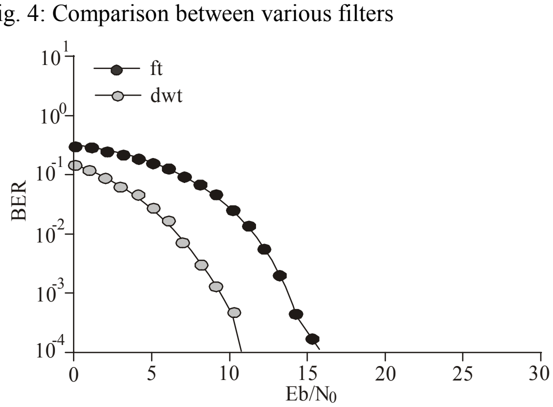

Fig. 5: Comparison between multiband OFDM system with FFT and DWT

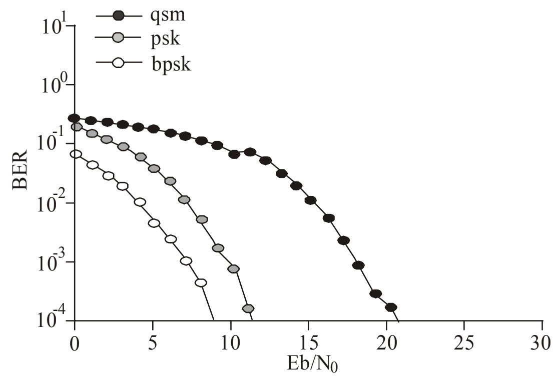

Fig. 6: Comparison between various modulation schemes

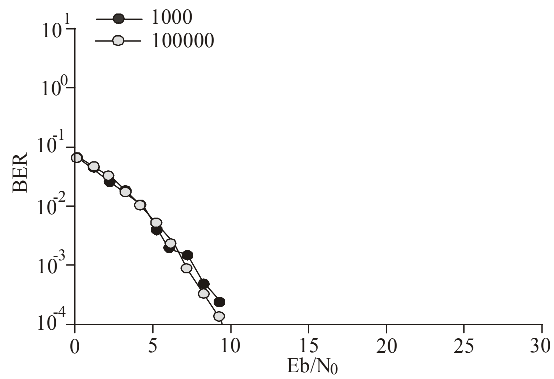

Fig. 7: Comparison between data rates

Figure 2 gives comparison between the multiband OFDM system with filter and multiband OFDM system without filter. From the figure it is clear that the performance of the system improves with filtering action in the presence of narrow band interference. For a given BER of 10^{-4} there is an improvement in Eb/N_0 value.

Figure 3 shows the comparison between various values of Q of notch filter. As the value of Q increases the sharpness of the peak increases and so better results are obtained. Comparison between Q = 1 and Q = 100 shows that there is a great improvement is BER and Eb/N_0.

Figure 4 shows the comparison between various filters. Here Butterworth filter, chebyshev I filter, chebyshev II filter, Elliptical filters are compared. From the figure it is evident that elliptical filter offers better results because it has sharp cut-off and can notch off frequencies in an effective manner.

Figure 5 gives a comparison between multiband OFDM with FFT and multiband OFDM with DWT. From the graph it is clear that the system with DWT offers more advantage than the system with FFT. DWT is better it offers more local information to process. Here elliptical filters are used for filtering purpose. For a given BER of 10^{-4} there is at least 3 to 4 dB difference in Eb/N_0 when compared with the system with FFT and DWT.

Figure 6 gives a comparison between various modulations schemes used in the multiband OFDM system. Here elliptical filter is used for filtering out the interference. From the graph it is clear that BPSK modulation scheme is less error prone when compared to other modulation schemes. Usage of BPSK scheme helps to cancel the narrow band interference in an effective way.

Figure 7 gives a comparison between various data rates of the multiband OFDM system. From the graph it is clear that as the data rate increases better BER could be achieved. As the data rate we have more data's to process and this improves the accuracy of the system.

CONCLUSION

In this research work the narrowband interference affecting the performance of the multiband OFDM is mitigated through filtering action. The performance of various filters is analyzed and it is concluded that elliptical filters offers good results because it has sharp cut-off when compared to other filters. Further the FFT block of the multiband OFDM system is replaced with DWT of enhance the system performance. Also the results are analyzed by varying the modulation schemes. All these enhancement techniques and filtering actions make's multiband OFDM system a fruitful solution for high noisy scenario.

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