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Modified Channel Shortener Filter Using Enhance Spectral Efficiency for OFDM System

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Abstract: *In this paper, a modified CSF (MCSF) structure that exploits the null-space of an under-determined system of equations, and provides independent equivalent channels to the receiver. The SE of the MCSF is shown to be generally higher than the full-CP system when the chosen CP length is significantly smaller than the channel delay spread.*
Keywords: *cyclic prefix(CP).spectral efficiency(SE)*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) is multicarrier modulation technique, used in nearly all new a popular wireless communication standards. OFDM transform sa frequency selective channel into large number of parallel flat fading channels. Inter carrier interference (ICI) can be mitigated by preserving the orthogonality between these parallel sub-channels.

Inter carrier interference (ICI) can be mitigated by preserving the orthogonality between these parallel sub-channels. To maintain orthogonality, cyclic prefix (CP)is inserted in every OFDM symbol. The minimum length of CP required [1] is equal to the channel memory length to mitigate the inter block interference (IBI). Thus to mitigate IBI and ICI a common CP of sufficient length is employed to accommodate all users.

The larger CP results in throughput loss which can be sufficient. For example, in a 10 MHz, 1024 point FFT based WIMAX (IEEE802.16e) system the symbol duration is about102.4 µsec and CP length is 1/8 of this which is about 12.8µsec. In a typical urban deployment with cells of radius 1 km, the maximum delay spread (CIR length) may only be 2 to 5µsec.

Therefore, substantial saving in overhead can be accrued if the CP length is reduced to say 4 or 5 µsec. If however ,this shortened CP is not sufficient for a fraction of the users in the cell, such link will experience IBI. To combat IBI, a time domain prefilter (called as channel shortening prefilter)can be used at the receiver to shrink the channel impulse response (CIR) within the CP length. Hence CSP can be used to mitigate the IBI and ICI caused due to a shorter length CP. Channel shortening prefilter algorithms have been well studied in literature for single input single output (SISO) transmission systems . The three major approaches are used to design the CSP for SISO transmission systems. The first approach minimizes the mean-squared error (MMSE), where error is the difference between the received symbol and desired symbol .

In design of CSP is based on channel impulse response, which minimizes the energy of CIR outside the CP length. In the authors design an equivalent channel, which is the cascade of the channel and pre-filter, with no taps outside the CP length. This method also gives the better bit error rate (BER) performance than the approaches.In addition, the inserted redundant pilots have much higher average power than the normal OFDM data, thus the equivalent Signal to Noise Ratio (SNR) at the receiver will be reduced if the identical transmitted signal power is permitted. Such SNR loss can be slightly alleviated by changing the positions of the redundant pilots or adding more pilots in the frequency domain but the effect is not obvious.

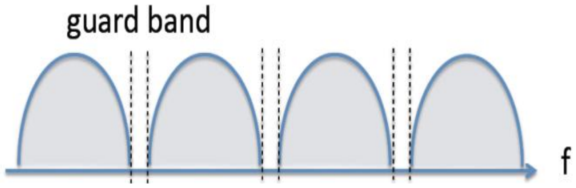
OFDM reduces the computational cost of the receiver by using a cyclic prefix (CP) as a guard interval . The spectral efficiency of an OFDM system depends also on the CP length, which is used to combat the inter-block-interference (IBI)and inter-carrier-interference (ICI). The CP length must be greater than or equal to the delay spread of the channel impulse response (CIR) in order to avoid IBI and ICI.

If the FDM system above had been able to use asset of subcarriers that were orthogonal to each other, a higher level of spectral efficiency could have been achieved. The guard bands that were necessary to allow individual demodulation of subcarriers in an FDM system would no longer be necessary.

The use of orthogonal subcarriers would allow the subcarriers' spectra to overlap, thus increasing the spectral efficiency. As long as orthogonality is maintained, it is still possible to recover the individual subcarriers' signals despite their overlapping spectrums. If the dot product of two deterministic signals is equal to zero, these signals are said to be orthogonal to Orthogonality can also be viewed from the standpoint of stochastic processes.

Given a specific time and location, TR pre coding has been 35mathematically proved to be the optimum in the sense that it 36maximizes the amplitude of the field at that time and location . It is then called spatiotemporal matched filter because 38it is analogous to a matched filter both in time and space. It 39is also called transmit matched filter since the matched filter 40is put at the transmitter side.

- A/D. Convert analog signals to digital symbols for processing.
- Synchronization. Due to the clock difference between transmitter and receiver, a synchronization algorithm is needed to find the first sample in the OFDM frame.
- Remove cyclic prefix. This block simply removes the cyclic prefix added in the transmitter.
- Symmetrical FFT. Data are transformed back to frequency-domain using FFT. Then the complex conjugate mirror added in the transmitter is removed.
- Channel estimation. The estimation is achieved by pilot frames.
- Channel compensation. The channel estimation is used to compensate for channel distortion.
- Bit loading. The receiver computes the bit allocation and send it to the transmitter.



Frequency Division Multiplexing

II. Implementation Of An OFDM System

The idea behind the analog implementation of OFDM can be extended to the digital domain by using the discrete Fourier Transform (DFT) and its counterpart, the inverse discrete Fourier Transform (IDFT). These mathematical operations are widely used for transforming data between the time-domain and frequency-domain. These transforms are interesting from the OFDM perspective because they can be viewed as mapping data onto orthogonal subcarriers

For example, the IDFT is used to take in frequency-domain data and convert it to time-domain data. In order to perform that operation, the IDFT correlates the frequency-domain input data with its orthogonal basis functions, which are sinusoids at certain frequencies. This correlation is equivalent to mapping the input data onto the sinusoidal basis functions

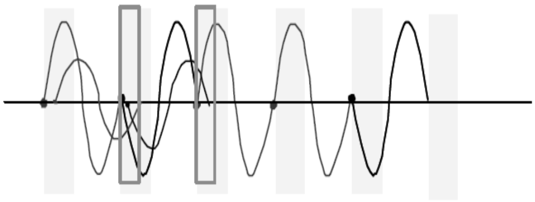
In practice, OFDM systems are implemented using a combination of fast Fourier Transform (FFT) and inverse fast Fourier Transform (IFFT) blocks that are mathematically equivalent versions of the DFT and IDFT, respectively, but more efficient to implement. An OFDM system treats the source symbols (e.g., the QPSK or QAM symbols that would be present in a single carrier system) at the transmitter as though they are in the frequency-domain..

These symbols are used as the inputs to an IFFT block that brings the signal into the time domain. The IFFT takes in N symbols at a time where N is the number of subcarriers in the system. Each of these N input symbols has a symbol period of T seconds. Recall that the basis functions for an IFFT are N orthogonal sinusoids. These sinusoids each have a different frequency and the lowest frequency is DC. Each input symbol acts like a complex weight for the corresponding sinusoidal basis function.

Thus, the IFFT block provides a simple way to modulate data onto N orthogonal subcarriers. The block of N output samples from the IFFT make up a single OFDM symbol. The length of the OFDM symbol is NT where T is the IFFT input symbol period mentioned above. After some additional processing, the time-domain signal that results from the IFFT is transmitted across the channel. At the receiver, an FFT block is used to process the received signal and bring it into the frequency domain. Ideally, the FFT output will be the original symbols that were sent to the IFFT at the transmitter. When plotted in the complex plane, the FFT output samples will form a constellation, such as 16-QAM. However, there is no notion of a constellation for the time-domain signal.

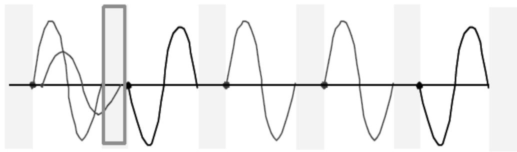
III. Multipath Channels And The Use Of Cyclic Prefix

A major problem in most wireless systems is the presence of a multipath channel. In a multipath environment, the transmitted signal reflects off of several objects. As a result, multiple delayed versions of the transmitted signal arrive at the receiver. The multiple versions of the signal cause the received signal to be distorted. Many wired systems also have a similar problem where reflections occur due to impedance mismatches in the transmission line. A multipath channel will cause two problems for an OFDM system. The first problem is inter symbol interference.



intersymbol interference

This problem occurs when the received OFDM symbol is distorted by the previously transmitted OFDM symbol. The effect is similar to the inter symbol interference that occurs in a single- carrier system. However, in such systems, the interference is typically due to several other symbols instead of just the previous symbol; the symbol period in single carrier systems is typically much shorter than the time span of the channel, whereas the typical OFDM symbol period is much longer than the time span of the channel.



Guard band

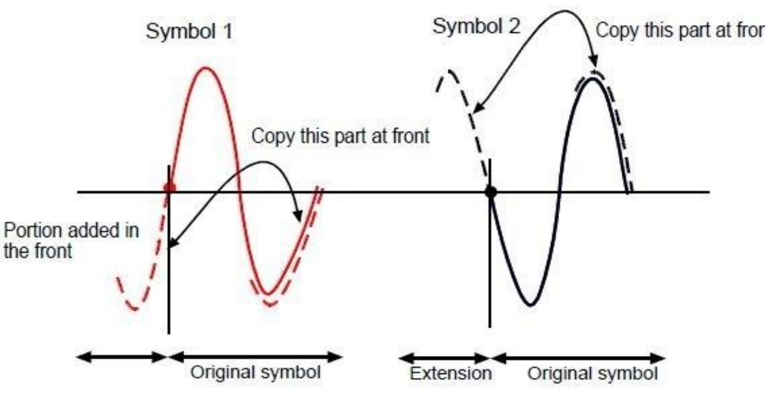
The second problem is unique to multicarrier systems and is called Intra symbol Interference. It is the result of interference amongst a given OFDM symbol's own subcarriers. The next sections illustrate how OFDM deals with these two types of interference.

Assume that the time span of the channel is LC samples long. Instead of a single carrier with a data rate of R symbols/ second, an OFDM system has N subcarriers, each with a data rate of R/N symbols/second Because the data rate is reduced by a factor of N, the OFDM symbol period is increased by a factor of N. By choosing an appropriate value for N, the length of the OFDM symbol becomes longer than the time span of the channel.

IV. Cyclic Prefix (CP)

The cyclic prefix means introduction of guard interval between each symbol to reduce the inter-symbol interference (ISI) caused by delay spread in the transmission channel, the CP achieved by taking a copy of the last portion of the data symbol appended to the front of the symbol during the guard interval & this data portion must be at least 15% of the data length .

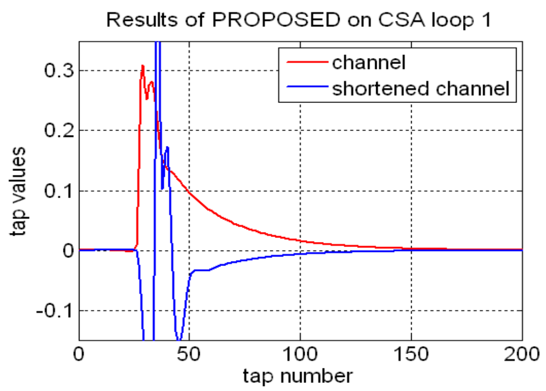
As shown in the figure. The CP adds redundancy through repetition of the signal rather than by adding any new information. When the CP is added, it's guarantees that the symbol will be undistorted for at least its nominal symbol in the presence of multipath and this allows the receiver to avoid the frequency domain ICI while at the same time avoiding all time domain ISI due to multipath. And also by adding the CP to our original signal and transmitting through the same channel, we can obtain the desired circular convolution which makes it easier to recover the signal after the FFT at receiver.



V. Simulation Results and Discussion

Tap number and Tap value are used in this graph. We consider normal channel and shortened channel. Normal channel starting is constant some variation so increase and constant. Shortened channel is also starting constant tap value is increase but same constant of output.

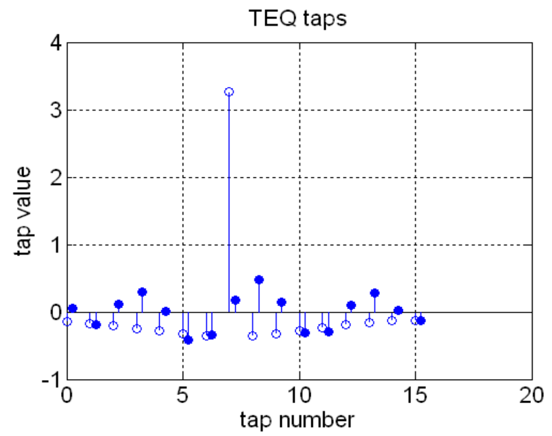
Bit rate over CSA test loop channel impulse responses to provide a performance tradeoff.



Tap number and Tap value are used in this graph. Tap means channel. Tap number and Tap value are some stage is tap value is increase TEQ means time domain equalizer.

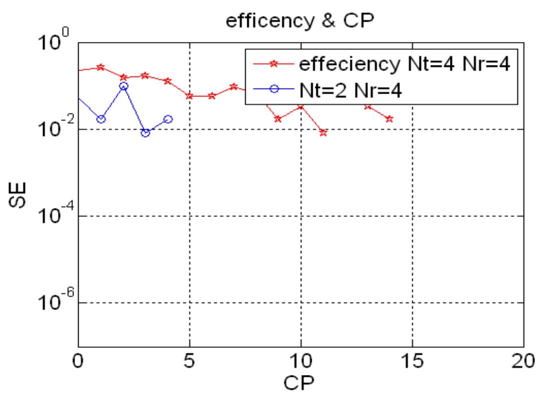
The same for all single TEQ designs, hence it does not vary value are gives for the original implementation of channels.

Total number of bandwidth in channel divided in value. Minimum and maximum of signal at certain stage value is high and then low or high.



Cyclic prefix and Spectral efficiency are used in graph. Efficiency is increase and Cyclic prefix is reduced. So bandwidth is reduced.

MCSF improves the BLER performance with an increment in the number of transmit. MCSF with short CP gives 2db and 0.5 db gain of BLER performance when compared with full CP systems.



VI. Conclusion

A modified CSF structure which can provide a higher SE by revealing multiple linearly independent equivalent channels at the receiver. When the CP duration is a large fraction of OFDM symbol duration, this MCSF has not only a higher SE but also provides up to 2 dB gain. In future work using uplink and downlink in transmitter and receiver. Receiver side cost is reduced .Because in paper receiver side on filter so cost is high and output some noise.

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