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A Novel Modulation Technique Algorithms on Channel Coding and decoding

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) hasgained increased interest due to its robustness against multipathinterference and high spectrum efficiency. OFDM is asuitable candidate for high data rate transmission with forwarderror correction (FEC) methods over wireless channels. In thispaper, the system throughput of a working OFDM system hasbeen enhanced by channel coding technique like Reed Solomoncode& Turbo Code. Forward Error Correcting codes are a newclass of codes that can achieve exceptional error performanceand energy efficiency at low signal-to-noise ratio. The simulation is made with the development of Models in theSIMULINK & computer program written in MATLAB sourcecode on the random data under additive white Gaussian noise(AWGN) channel. The simulation results of estimated Bit errorrate (BER) show that the implementation of RS code with ½ -rated under QPSK modulation technique is highly effective tocombat inherent interference in the communication system.Fordecoding of Turbo code, MAP decoding algorithm is used. Incase of Turbo code BER performance is substantially improvedby increasing number of iterations used in the decoding process.

Keywords: Channel Coding, Channel, decoding Algorithms, Modulation Technique etc.

1. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. Some of the main advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. OFDM is symbol based, and can be thought of as a large number of low bit rate carriers transmitting in parallel. All these carriers transmitted using synchronized time and frequency, forming a single block of spectrum.

This is to ensure that the orthogonal nature of the structure is maintained.

However, in the present study, an effort has been made merely to concatenate the various channel encoding codes to improve the reliable reception performance of an OFDM wireless communication system under different digital modulation schemes such as QPSK, 32-QAM, 64-QAM. In almost all applications of multi-carrier modulation, satisfactory performance cannot be achieved without the addition of some form of channel coding. In wireless systems subjected to fading, extremely high signal-to-noise ratios are required to achieve reasonable error probability. In addition, interference from other wireless channels is frequently severe. If channel coding is applied, the performance of OFDM is expected to be significantly improved through time diversity of channel coding as well as through inherent frequency diversity of the OFDM [1] [2].

2. Related Work

Orthogonal frequency division multiplexing (OFDM) is nowadays widely used for achieving high data rates as well as combating multipath fading in wireless communications. In this multi-carrier modulation scheme data is transmitted by dividing a single wideband stream into several smaller or narrowband parallel bit streams. Each narrowband stream is modulated onto an individual carrier. The narrowband channels are orthogonal vis-à-vis each other, and are transmitted simultaneously. In doing so, the symbol duration is increased proportionately, which reduces the effects of inter-symbol interference (ISI) induced by multipath Rayleigh-faded environments. The spectra of the subcarriers overlap each other, making OFDM more spectral efficient as opposed to conventional multicarrier communication schemes.

A. OFDM message

The OFDM message is generated in the complex baseband. Each symbol is modulated onto the corresponding subcarrier using variants of phase shift keying (PSK) or different forms of quadrature amplitude modulation (QAM). The data symbols are converted from serial to parallel before data transmission. The frequency spacing between adjacent subcarriers is $N\pi2$, where N is the number of subcarriers. This can be achieved by using the inverse discrete Fourier transform (IDFT), easily implemented as the inverse fast Fourier transform (IFFT) operation. As a result, the OFDM symbol generated for an N-subcarrier system translates into N samples, with the ith sample being

$$Xi = \sum_{n=0}^{N-1} Cn \exp\left\{j \frac{2\pi in}{N}\right\}, 0 \le i \le N-1$$

At the receiver, the OFDM message goes through the exact opposite operation in the discrete Fourier transform (DFT) to take the corrupted symbols from a time domain form into the frequency domain. In practice, the baseband OFDM receiver performs the fast Fourier transform (FFT) of the receive message to recover the information that was originally sent[2].

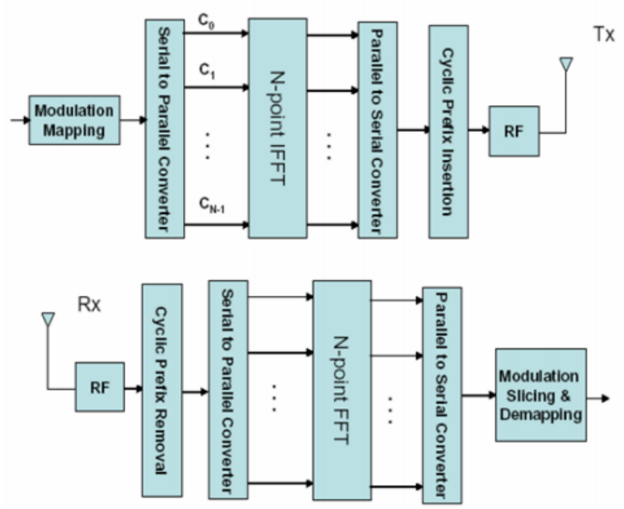

Figure 1 Basic OFDM System Architecture.

B. Interference

In a multipath environment, different versions of the transmitted symbol reach the receiver at different times. This is due to the fact that different propagation paths exist between transmitter and receiver. As a result, the time dispersion stretches a particular received symbol into the one following it. This symbol overlap is called intersymbol interference, or ISI. It also is a major factor in timing offset. One other form of interference is intermarried interference or ICI. In OFDM, successful demodulation depends on maintaining orthogonality between the carriers. We demodulate a specific subcarrier N at its spectral peak, meaning that all the other carriers must have a corresponding zero spectra at the nth center frequency (frequency domain perspective). Frequency offsets lead to this criterion not being met. This condition can seriously hinder the performance of our OFDM system. Graph 3.1 below shows that when the decision is not taken at the correct center frequency (i.e. peak) of carrier considered, adjacent carriers factor in the decision making, thus reducing the performance of the system [2].

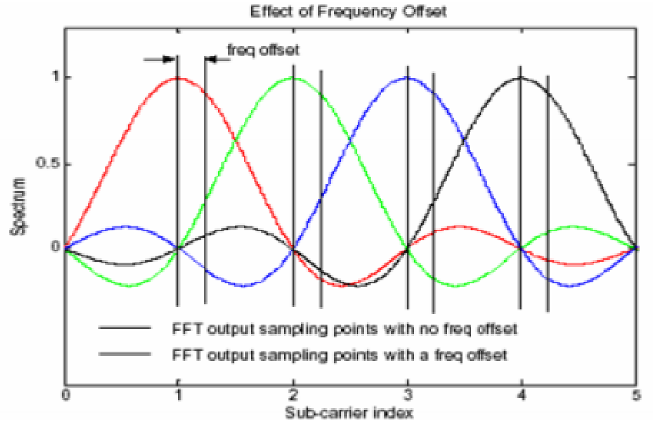

Figure 2 Effect of Frequency Offset (Maintaining Orthogonality).

C. The Cyclic Prefix

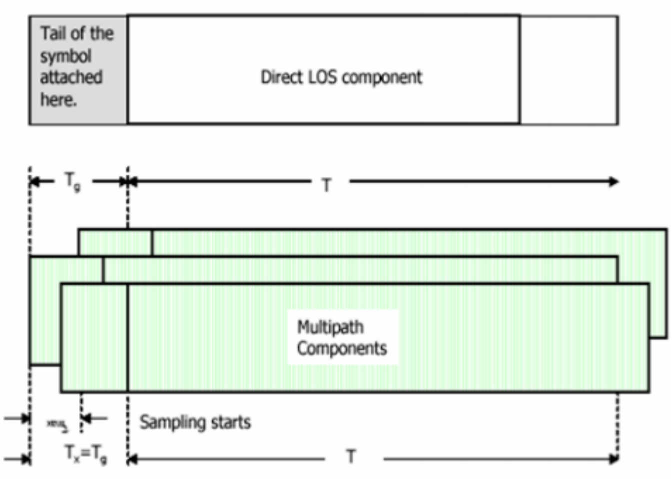

Figure 3. Cyclic Prefix.

OFDM demodulation must be synchronized both in the time domain as well as in the frequency domain. Engineers have found a way to ensure that goal by adding a guard time in the form of a cyclic prefix (CP) to each OFDM symbol. The CP consists in duplicates of the end samples of the OFDM message relocated at the beginning of the OFDM symbol. This increase the length T_{sym} of the transmit message without altering its frequency spectrum.

$$T_{sym} = CP + T_{data}N$$

Where T_{data} is the duration of one data symbol, and N the number of carriers. The receiver is set to demodulate over a complete OFDM symbol period, which maintains orthogonality. As long as the CP is longer than the channel delay spread, τ_{max}, the system will not suffer from ISI. The CP is to be added after the FFT operation at the transmitter and removed prior to demodulation. The figure below who's the deteriotiation in performance when the CP is closely matched by the delay spread. The signal constellation is less tightly grouped, no doubt a sign of less than accurate decoding.

3. Implementation

OFDM with forward error correction methods is most suitable scheme to transmit information efficiently BER using the Convolution code in the presence of the fading channel is shown is explained briefly in the review paper [8]. A type of Convolution code, called turbo codes that enable the reduction of errors in noisy channels without the need to increase the signal power. A turbo code consists three distinct part namely encoder, interleave and decoder .The performance of turbo code depend on the design & implementation of all the three part. A typical turbo encoder uses parallel concatenated convolution codes (PCCC) in which data bits are coded by two or more recursive systematic convolution (RSC) coders separated by an interleave. Turbo code uses two same block of decoders, the decisions from one component decoder are passed as input to another decoder and this process is iteratively done for several times to get more reliable decisions. The high bit error correction power of turbo code originates from the interleaving at the encoder and iterative decoding using extrinsic information at the decoder [8] Turbo coded AOFDM (TC AOFDM) system combines the good features of AOFDM with that of turbo code. Using the iterative property of turbo codes, a large coding gain is achieved with respect to an un-coded system.

3.1 TURBO ENCODER:

A Turbo encoder is built using parallel concatenation of two recursive systematic Convolution code separated by an interleave. A typical turbo encoder is shown in figure 1. The binary input data sequence is represented by $\mathbf{d_k}$= $\mathbf{(d_1, d2\ldots d_N)}$The input sequence is passed into the input of the first RSC coder, which generates $Y_{k-1.}$ For the second RSC, the data sequence is interleaved using random interleave in which the bits are output in a pseudo-random manner. The interleaved data sequence is passed to a second RSC encoder, generate bit stream$\mathbf{Y_{k2}}$The output code sequence of the turbo encoder is a multiplexed (and possibly punctured) stream consisting of systematic code bits$\mathbf{X_k}$.along with the parity bits of first and second encoders, Y_{k1} and $\mathbf{Y_{k2}}$.

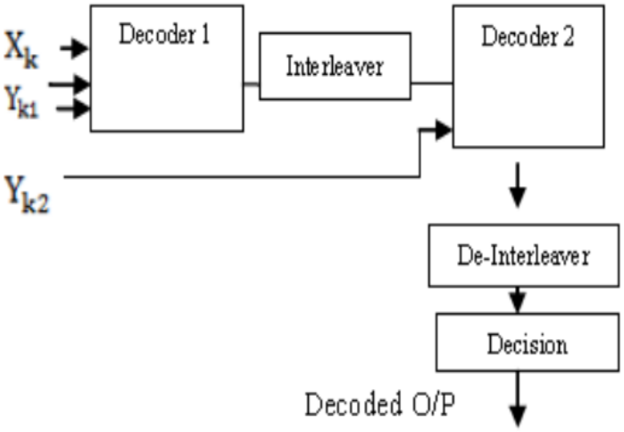

Figure 4: Turbo Decoder.

4. Experimental Work

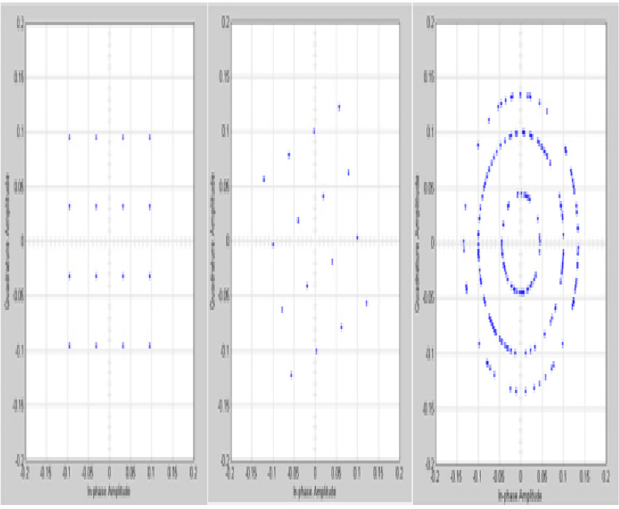

Fig 5: An ideal 16 QAM scatter plot (left) impaired by a phase offset (middle) and a frequency offset (right).

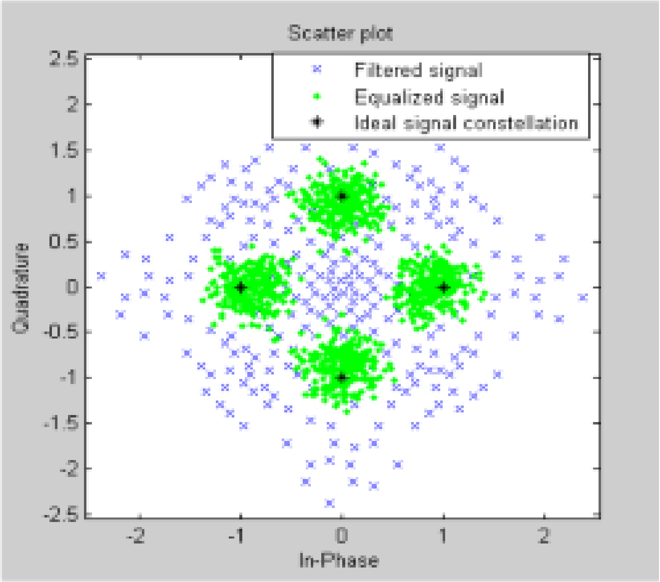

Fig 6: Scatter plot of a QPSK signal that shows the signal before and after equalization, as well as the ideal signal constellation.

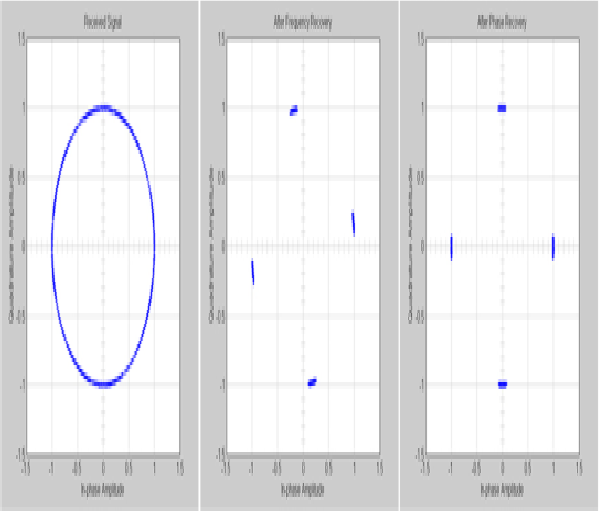

Fig 7: Received signal scatter plot (left), after frequency recovery (middle), and after phase recovery (right).

5. Conclusion

To conclude, this major project gives the detail knowledge of a current key issue in the field of communications named Orthogonal Frequency Division Multiplexing (OFDM). We focused our attention on turbo codes and their implementation. We described the encoder architecture. In our case, the code is the result of the parallel concatenation of two identical RSCs. The code can be punctured in order to fulfill bit rate requirements. The decoder succeeded in its duty thanks to the decoding algorithms that it is built around. We focused mainly on the study of the MAP.

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