DCT LAB PROJECT

DESIGN AND IMPLEMENTATION OF OFDM TRANSCEIVER SYSTEM

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INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is used commonly in digital wireless communication systems because of important features such as high data rate transmission efficiency with high bandwidth capability and stability concerning the multi-path delay which takes place in a digital communication system.

An innovative strategy is significantly employed in both wired and wireless communication systems.

In Wireless Communication System (WCS), challenging tasks are to maintain more Sub Carriers (SCs) and provide the satisfying Quality of Service (QoS) requirements corresponding to the Bit Error Rate (BER) in the frequency spectrum.

An Orthogonal Frequency Multiplexing Division (OFDM) scheme maximizes the system capacity as well as diversity gain through merging the antenna arrays at the receiver as well as a transmitter in time-variant along with frequency selective channels.

In the present research work, the significant objectives are highlighted on reducing information loss, Peak to Average Power Ratio (PAPR) reduction in both carrier and data signals, Bit Error Rate (BER) which has to be within the threshold, and Signal to Noise Ratio (SNR) analysis in Multiple Input Multiple Output OFDM signals.

The main objective of OFDM system be about to divide maximum rate of data into small data rates, after that transfer of these data in parallel employing numerous orthogonal SCs which is also known as Parallel Transmission.

This Parallel Transmission technique involves the time period of data symbol rises therefore reduces the correlative amount of scattering of period affected by delay which happen in multipath spread.

An OFDM is possible to use in multiplexing strategy or modulation technique. The approach of utilizing parallel data transmission as well as OFDM was introduced in the mid period of 1860s. U S patent was filled but has issued during January 1970. Currently in conventional parallel data transmission system, entire signal bandwidth or frequency band is separated into number of frequency sub channels which are non-overlapping 1.

All frequency sub channels are modified along with distinct symbol after that the sub channels are frequency multiplexed. By this the overlapping spectral can be reduced, Inter Carrier Interference (ICI) is minimized to better extent, channels are removed from SCs thus leads to ineffective support of the enable spectrum 2.

MODULATION AND DEMODULATION OF OFDM

The OFDM systems are effectively combined with all SCs and monitored to sustain the orthogonality of the carriers. Hence, OFDM generates an efficient spectrum depending on modulation, demodulation scheme and inputs. Each of the carrier is transmitting the assigned data to the particular destination. After that, in consequence of modulation scheme the required amplitude as well as carrier phase is estimated. The general modulation techniques used in OFDM systems are Binary Phase Shift

Keying (BPSK) which is used for wide frequency range, Quadrature Amplitude Modulation (QAM) In which bandwidth is doubled, and etc. The selected amplitude signal is converted into time domain signal, and this is done by using Inverse Fast Fourier Transform (IFFT). IFFT scheme efficiently performs the time domain signal transformations and maintains the orthogonality in carriers 3. The FFT method helps in converting time domain signal to frequency domain signal. This transformation helps to find the equivalent waveform and produces the mean orthogonal sinusoidal components. In time domain signal, the frequency spectrums are indicated by amplitudes and phase of sinusoidal components of the data symbol. The IFFT transformation method does reverse process of FFT. The general structure of modulation and demodulation process of OFDM is presented in the Figure 1.1.

Abbildung in dieser Leseprobe nicht enthalten

Figure 1.1 General Structure of Modulation and Demodulation components of OFDM System

The modulation and demodulation process of OFDM system includes several significant components and it’s described in the following sections.

- OFDM Transmitter

The modulation is the variations in signal waves that are transmitted over communication medium or channel to reduce noise effect and it is represented in Figure 1.1. This process involves determining the received data which is demodulated; after receiving the primary data. OFDM transmitter attained through data modulation as well as appropriate modulation strategy. So that averting the Inter Symbol Interference (ISI) and give a Cyclic Prefix (CP) is delivered to constellations or signal.

- Communication Channel

The vision of communication is to support information exchange between devices. A communicator encodes the data as well as then transfers the data through a channel to the different communicator after that they decode the data.

- OFDM Receiver

In modulation strategy, an input data is improved against the modulated symbols and signal is received by the receiver. In this condition, the received data symbols are initially given to the low pass filter as well as CP is eliminated. The Fast Fourier Transform of the data signal is taken then the receiving of signal completed with the process of entering to the serial to parallel converter.

- Inter Symbol Interference (ISI)

ISI is the process in which distortion of a signal consisting of single symbol restricts with subsequent symbols. This phenomenon is undesirable condition as the prior symbols have same influence as noise, therefore creating the signal transmission with lesser amount of reliability. The term ISI is normally affected through propagation or built in non linear frequency reaction of channel affecting sequential symbol leading to distortion.

- Inter Carrier Interference (ICI)

In digital OFDM system, ICI is one of the significant problem to diminish the transmission performance. The ICI causes the loss of orthogonality among the neighboring SCs also, and observe the interferences between the SCs.

- Inverse Fast Fourier Transform (IFFT)

An operation of OFDM in the baseband frequency domain is the modified QPSK data symbol that are served towards the SCs which are orthogonal. An IFFT method is a linear transformation, which is applied in OFDM system with no difficulty since the receiver end consists of FFT and due to attain input data at the receiver end based on frequency domain.

MATLAB CODES OF OFDM

```
% OFDM Code
% No.of Carriers: 64
% coding used: Convolutional coding
% Single frame size: 96 bits
% Total no. of Frames: 100
% Modulation: 16-QAM
% No. of Pilots: 4
% Cylic Extension: 25%(16)

close all
clear all
clc


%%
% Generating and coding data
t_data=randi(9600,1)';
x=1;
si=1; %for BER rows
%%
for d=1:100;
data=t_data(x:x+95);
x=x+96;
k=3;
n=6;
```

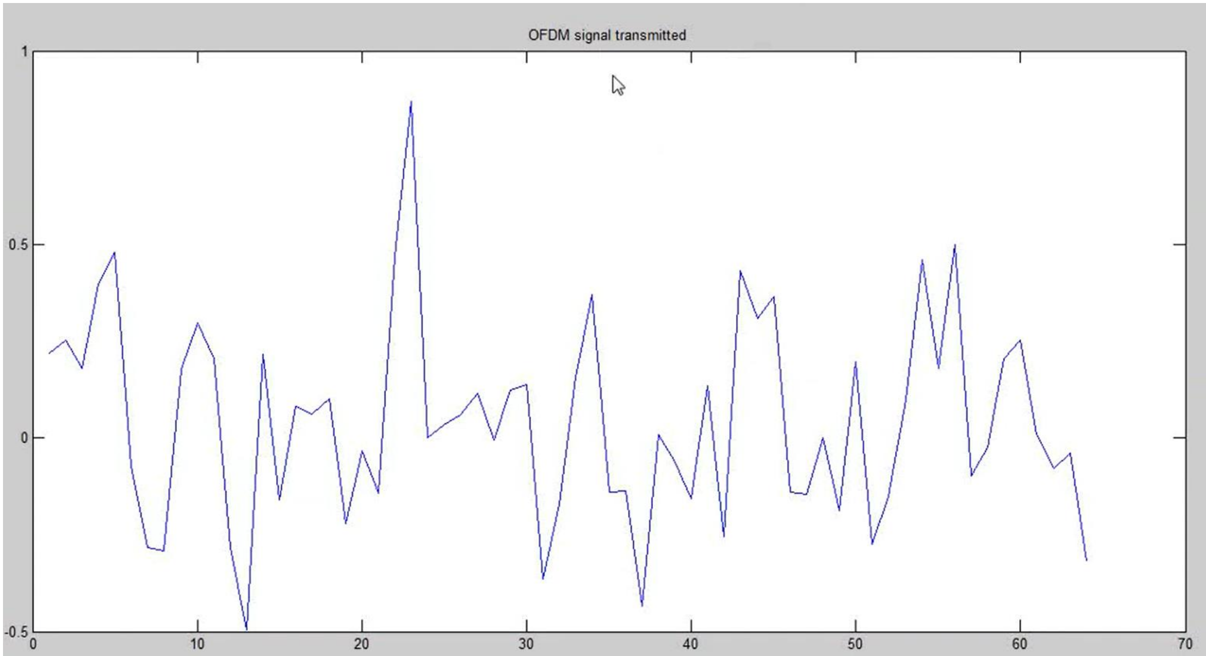
```
s1=size(data,2);  % Size of input matrix
j=s1/k;

%%
% Convolutionally encoding data
constlen=7;
codegen = [171 133];    % Polynomial
trellis = poly2trellis(constlen, codegen);
codedata = convenc(data, trellis);



%%
%Interleaving coded data

s2=size(codedata,2);
j=s2/4;
matrix=reshape(codedata,j,4);

intlvddata = matintrlv(matrix',2,2)'; % Interleave.
intlvddata=intlvddata';


%%
% Binary to decimal conversion

dec=bi2de(intlvddata','left-msb');


%%
%16-QAM Modulation

M=16;
y = qammod(dec,M);
% scatterplot(y);


%%
% Pilot insertion

lendata=length(y);
pilt=3+3j;
nofpits=4;

k=1;

for i=(1:13:52)

    pilt_data1(i)=pilt;

    for j=(i+1:i+12);
        pilt_data1(j)=y(k);
        k=k+1;
    end
end

pilt_data1=pilt_data1';   % size of pilt_data =52
pilt_data(1:52)=pilt_data1(1:52);    % upsizing to 64
pilt_data(13:64)=pilt_data1(1:52);   % upsizing to 64
```

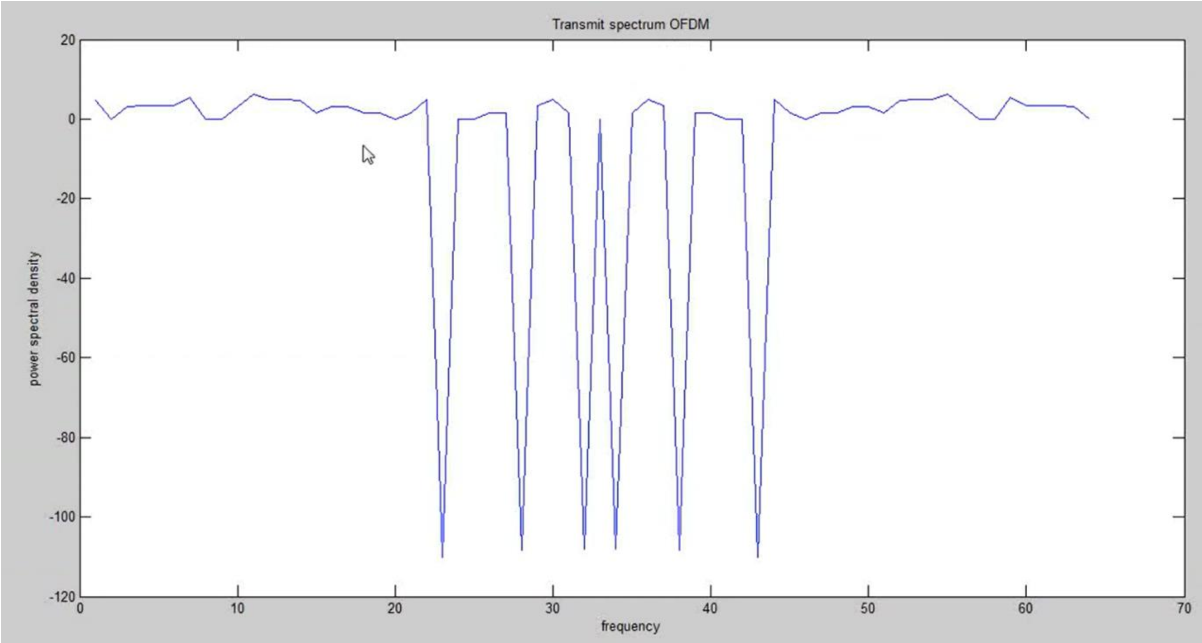
```
for i=1:52

    pilt_data(i+6)=pilt_data1(i);

end


%%
% IFFT

ifft_sig=ifft(pilt_data',64);


%%
% Adding Cyclic Extension

cext_data=zeros(80,1);
cext_data(1:16)=ifft_sig(49:64);
for i=1:64

    cext_data(i+16)=ifft_sig(i);

end


%%
% Channel

 % SNR

 o=1;
for snr=0:2:50

ofdm_sig=awgn(cext_data,snr,'measured'); % Adding white Gaussian Noise
% figure;
% index=1:80;
% plot(index,cext_data,'b',index,ofdm_sig,'r'); %plot both signals
% legend('Original Signal to be Transmitted','Signal with AWGN');


%%
%                   RECEIVER
%%
%Removing Cyclic Extension

for i=1:64

    rxed_sig(i)=ofdm_sig(i+16);

end


%%
% FFT

ff_sig=fft(rxed_sig,64);

%%
```

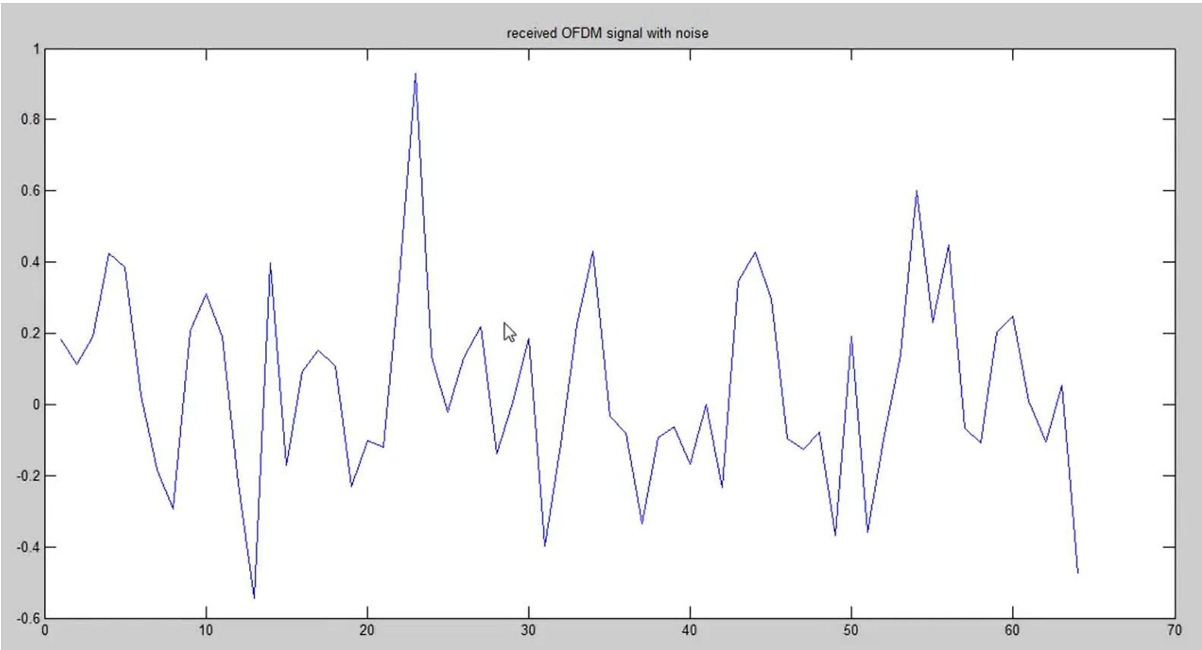
```
% Pilot Synch


for i=1:52

    synched_sig1(i)=ff_sig(i+6);

end

k=1;

for i=(1:13:52)

    for j=(i+1:i+12);
        synched_sig(k)=synched_sig1(j);
        k=k+1;
    end
end

% scatterplot(synched_sig)


%%
% Demodulation
dem_data= qamdemod(synched_sig,16);


%%
% Decimal to binary conversion

bin=de2bi(dem_data','left-msb');
bin=bin';


%%
% De-Interleaving


deintlvddata = matdeintrlv(bin,2,2); % De-Interleave
deintlvddata=deintlvddata';
deintlvddata=deintlvddata(:)';




%%
%Decoding data
n=6;
k=3;
decodedata =vitdec(deintlvddata,trellis,5,'trunc','hard');  % decoding datausing
veterbi decoder
rxed_data=decodedata;

%%
% Calculating BER
rxed_data=rxed_data(:)';
errors=0;
```

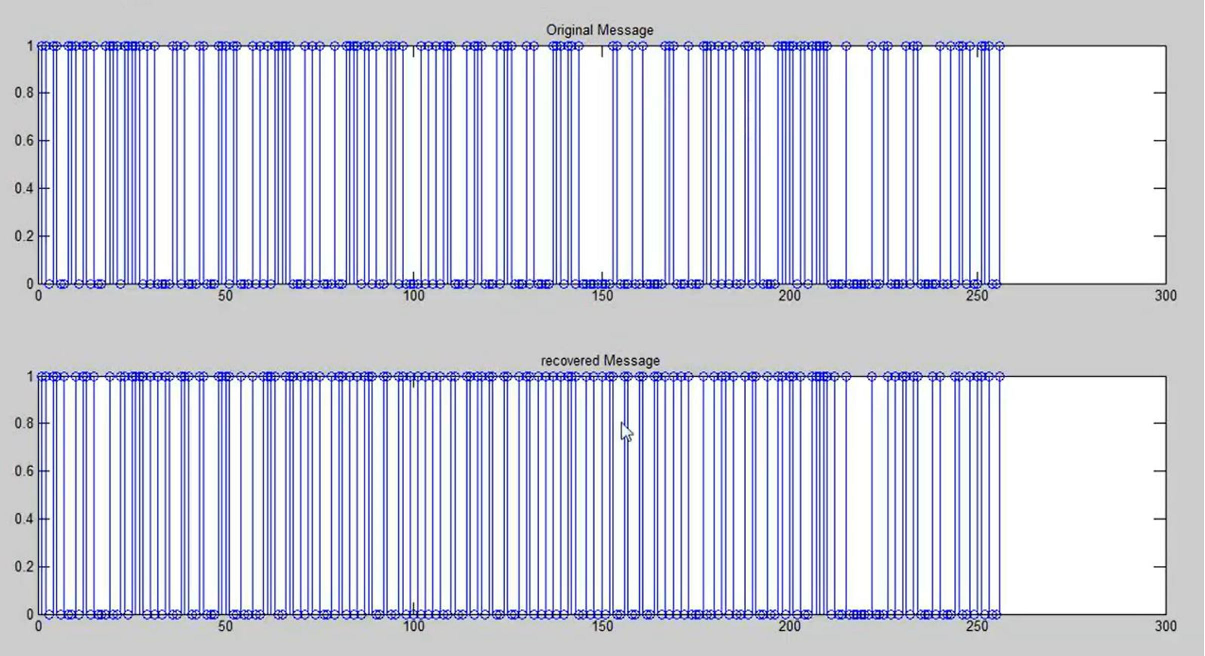
```
c=xor(data,rxed_data);
errors=nnz(c);

% for i=1:length(data)
%
%
%     if rxed_data(i)~=data(i);
%         errors=errors+1;
%
%     end
% end


BER(si,o)=errors/length(data);
o=o+1;

 end % SNR loop ends here
 si=si+1;
end % main data loop

%%
% Time averaging for optimum results

for col=1:25;        %%%change if SNR loop Changed
    ber(1,col)=0;
for row=1:100;


        ber(1,col)=ber(1,col)+BER(row,col);
    end
end
ber=ber./100;

%%
figure
i=0:2:48;
semilogy(i,ber);
title('BER vs SNR');
ylabel('BER');
xlabel('SNR (dB)');
grid on
```

MATLAB OUTPUTS OF OFDM




Transmit spectrum OFDM
power spectral density
frequency


received OFDM signal with noise



ADVATAGES OF OFDM

Leading advantage of OFDM system is less rate of modulations are least sensitive to multipath in signals. An improved method forward several less rate data streams in parallel transmission than forwarding individual high rate wave 4. A few OFDM system benefits are addressed below,

- **Saving of Bandwidth**

The SCs overlap with each other due to its orthogonality feature. An overlapping of SCs, utilization of bandwidth decreased significantly as well as minimizes the use of guard bands which place significant role in separation of SCs.

- **Easy to implement Modulation and Demodulation**

“Data Transmission” is a term which is effectively executed using FFT as well as IFFT without using of group modulators at the source end as well as de modulators at the destination end.

- Easy Equalization

In OFDM system, the wideband communication channel is separated into number of flat fading sub channels. This results in decreasing the difficulties which take place in equalization at the receiver side. By this it is possible to achieve maximum probable decoding with feasible complications.

- Susceptible to Frequency Selective Fading

The capacity of parallel transmission (every SCs signal have limited bandwidth in comparison with total signal bandwidth) OFDM is very sensitive towards frequency selecting channel fading. The OFDM system converts a frequency selective fading channel into number of flat fading sub channels.

DISADVANTAGES OF OFDM

The disadvantages are as follows:

• The OFDM signal has a noise like amplitude with a very large dynamic range; hence it requires RF power amplifiers with a high peak to average power ratio.

• It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT.

• It is sensitive to Doppler shift.

• It requires linear transmitter circuitry, which suffers from poor power efficiency.

• It suffers loss of efficiency caused by cyclic prefix.

CONCLUSION

OFDM has promising future in wireless networks and mobile communications. Growth in number of worldwide customers for wireless networks and ever-increasing demand for large bandwidth has given birth to this technology. OFDM is already playing an important role in WLAN and will be part of MAN too. In coming years, it will surely dominate the communication industry. Also, Wimax and 802.20 use OFDM-MIMO, which is emerging as the main technology for future cellular packet data networks, including 3GPP long-term evolution and 3GPP2 air interface evolution as well. Although OFDM has proven itself with packet-based data, it is not yet clear whether the technology can either handle large numbers of voice customers or work with voice and data as well as CDMA.

THANK YOU