BigCat Wireless - EC401
Assignment 4

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1. Calculate bandwidth required to live stream a cricket match with Full HD resolution (1920x1080 pixels) in raw format at 30 fps (frames/sec) using OFDM modulation and 16-QAM symbol mapping. Assume we are going to use 1024-point IFFT (Hint: in a colour video each pixel is represented with 3 Bytes)

1920 x 1080 pixels with each pixel represented by 3 bytes = 24 bits:

$$\begin{aligned} 1\ s &= 30\ frames \\ &= 30 * 1920 * 1080 * 24\ bits \\ &= 1492992000\ bits \\ &= 373248000\ symbols\ (16 - QAM\ symbol = 4\ bits) \end{aligned}$$

Since we use 1024-point IFFT, number of subcarriers = 1024

$$\begin{aligned} 1\ s &= \frac{373248000}{1024} \\ &= 364500\ OFDM\ symbols \end{aligned}$$

For 1 symbol, time period is 2.74 μs

Since we use 1024-point IFFT, number of subcarriers = 1024

$$\begin{aligned} BW &= 364.5\ KHz * 1024 \\ Required\ Bandwidth &= 373.24\ MHz \end{aligned}$$

2. Calculate the duration of cyclic prefix required to overcome multipath time spreading in a OFDM communication system with input bit rate of 5 Mbps and uses 512 pt IFFT. Based on analysis of wireless channel its has been found that the worst multipath component is 6.14 km.

Input bit rate = 5Mbps

Number of subcarriers = 512

Worst case distance = 6.14 km

Multipath time spreading = $\frac{6.14*10^3}{3*10^8} = 20.4\mu s$

Thus guard interval must be greater than $20.4\mu s$

Assumimg 16 QAM symbols are used, we get

$$1\ s = 5 * 10^6 bits \quad = 1.25 * 10^6 QAM symbols = \frac{1.25 * 10^6}{512} OFDM symbols \quad = 2.44 * 10^3 OFDM symbols$$

For 1 symbol, time period is 0.41 μs

For cyclic prefix, we take $\frac{1}{10}$ of symbol time, which is 0.041 ms

Guard interval (0.041 ms) is greater than multipath time spread (0.0204 ms)

3. Create an OFDM system: Use MATLAB or Python code only to create (no Simulink) Calculate the following:

- *Bit Error Rate*

Plot the following figures:

- *Transmitted spectrum*
- *Received Constellation*

```
% ofdm_simulation.m
M = 16; %Modulation order
k = log2(M); %Number of bits per symbol
n = 51200; %Number of data samples

data = randi([0 1], n, 1); %n samples

dataInput = reshape(data, length(data)/k, k);
dataSym = bi2de(dataInput);
dataMod = qammod(dataSym,M);

dataParallel = reshape(dataMod, 512, []); %Serial to parallel
dataOFDMmod = ifft(dataParallel, 512, 1);  %IFFT
txData = reshape(dataOFDMmod, [], 1);
dataChannel = awgn(txData, 18, 'measured'); %SNR = 18 dB
rxData = reshape(dataChannel, 512, []);
dataOFDMdemod = fft(rxData, 512, 1); %FFT
dataSerial = reshape(dataOFDMdemod, 1, []); %Parallel to Serial
scatterplot(dataSerial);
dataDemod = qamdemod(dataSerial, M)';

%calculate BER
recdataSym = de2bi(dataDemod);
recdata = reshape(recdataSym,[], 1);
[numerr, ber] = biterr(data, recdata);
fprintf("Bit Error Rate = %.6f\n", ber)

%Spectrum of Tx Signal
fs = 20000000;
[Pxx,W] = pwelch(txData',[],[],4096,fs);
```

```
figure;
plot([-2048:2047]*fs/4096,10*log10(fftshift(Pxx)),'b');
grid;hold on;
xlabel('Frequency (MHz)')
ylabel('Power Spectral Density')
hold off;
```

Output:
Bit Error Rate = 0.000117

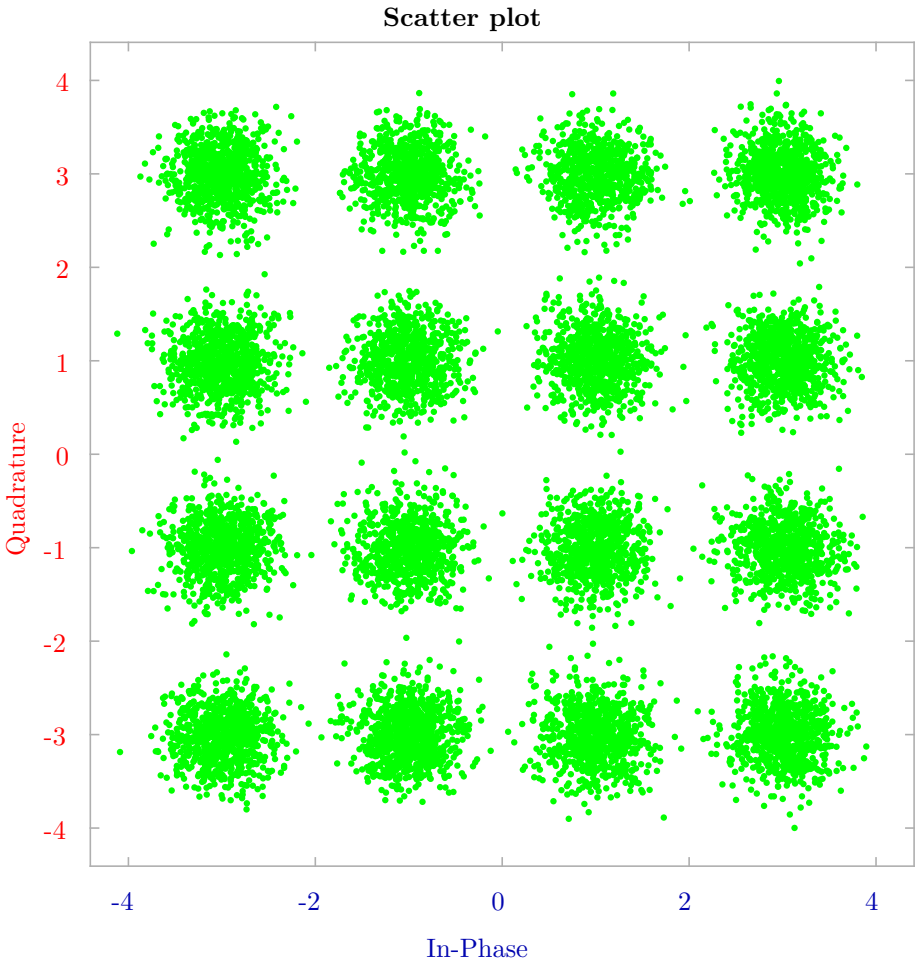

Figure 1: Constellation Diagram of received signal

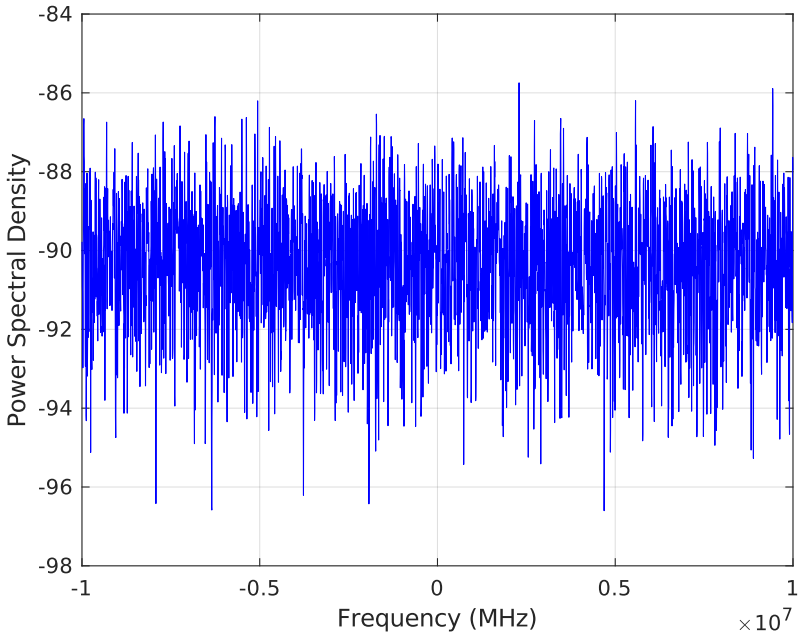

Figure 2: Spectrum (PSD) of transmitted signal (Note spectrum shown is without any subcarrier modulation)