HKUSTx: ELEC1200.2x A System View of Communications: From Signals to...

LAB 5 - TASK 2 (3/3 points)

In this task, you will learn how to implement the Quadrature Phase-Shift Keying (QPSK).

```
% initalization
Fs=1e6;               % sampling frequency
Fc=1e5;               % carrier frequency for message 1
Fcutoff = 25e3;       % cutoff frequency of low pass filter
Fc2=Fc;     % carrier frequency for message 2
SPB=20;               % samples per bit
Ts = 1/Fs;            % sample period

textmsg1 = sprintf('%s\n%s\n%s',...
    'It was the best of times, it was the worst of times',...
    'it was the age of wisdom, it was the age of foolishness,',
    'it was the epoch of belief,');
textmsg2 = sprintf('%s\n%s\n%s',...
    'Lorem ipsum dolor sit amet, at vivamus erat lectus a augue
    'eget a diam aliquam consectetuer, vivamus ad wisi hac posu
    'praesent tincidunt vel.');
```

Correct

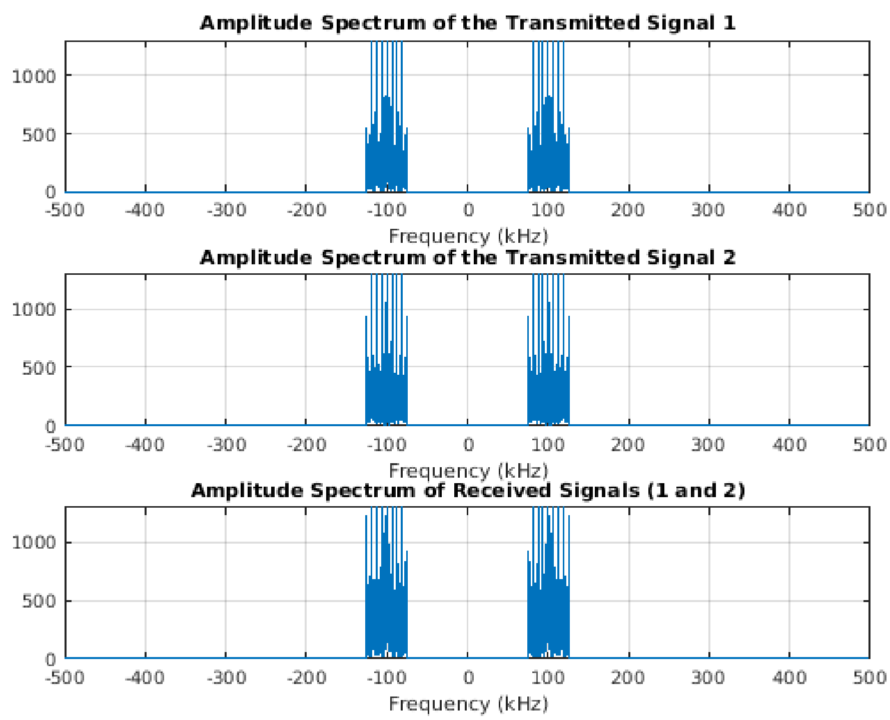
```
% % % % % transmitter % % % % % % % %

% Create a bitstream from the the input text
bs = text2bitseq(textmsg2);
% Frame and encode bitstream at SPB samples per bit, add training
sequence
wave2 = format_bitseq(bs,SPB);
% change waveform from varying between 0 and 1 to -1 and 1
wave2 = 2*wave2 - 1;
% add the lowpass filter
wave2=lowpass(wave2, Fs, Fcutoff);
% create vector of sample times
t = Ts * [0:(length(wave2)-1)];
% modulate by sine wave carrier
tx_wave2=wave2.*sin(2*pi*Fc*t);


% % % % % receiver % % % % % % % % % %

% mix with sinusoidal carrier with frequency Fc
wave_r2 = rx_wave.*sin(2*pi*Fc*t);
wave_r2 = lowpass(wave_r2, Fs, Fcutoff);
msg_r2 = waveform2text(wave_r2,SPB);
```

Figure 1



Original Message 1:
It was the best of times, it was the worst of times
it was the age of wisdom, it was the age of foolishness,

it was the epoch of belief,
Recovered Message 1:
It was the best of times, it was the worst of times
it was the age of wisdom, it was the age of foolishness,
it was the epoch of belief,
Num of Bit-Error: 0

Original Message 2:
Lorem ipsum dolor sit amet, at vivamus erat lectus a augue,
eget a diam aliquam consectetuer, vivamus ad wisi hac posuere,
praesent tincidunt vel.
Recovered Message 2:
Lorem ipsum dolor sit amet, at vivamus erat lectus a augue,
eget a diam aliquam consectetuer, vivamus ad wisi hac posuere,
praesent tincidunt vel.
Num of Bit-Error: 0

You have used 1 of 10 submissions

INSTRUCTIONS

In the previous task, we studied binary phase-shift keying (**BPSK**) modulation scheme, which uses two phases to represent two binary information. In this task, we will study the implementation of Quadrature Phase-Shift Keying (**QPSK**), which uses four phases to represent information.

Using QPSK we can send two bits of information at the same time. These two bits can either come from the same bit sequence (e.g. bits n and n+1) or from two independent bit sequences. In this task, we will consider the latter situation. We treat QPSK modulation as parallel streams of BPSK modulation signals. In particular, we use two waveforms $d_1(t)$ and $d_2(t)$ encoding different binary (0/1) message signals and use them to modulate carrier waves with different phases: $\cos(2\pi F_c t)$ and $\sin(2\pi F_c t)$, respectively, where t represents time and F_c represents carrier frequency. The transmitted signal is given by:

$$x(t) = [2d_1(t) - 1]\cos(2\pi F_c t) + [2d_2(t) - 1]\sin(2\pi F_c t)$$

In the equation above, the first message modulates a cosine function while the second message modulates a sine function.

The MATLAB code in the above window is a correct implementation of the communication system in the previous task. Two text messages are transmitted using BPSK modulation and frequency division multiplexing. The first message is transmitted using a carrier with frequency **Fc** and occupies the frequency range between **Fc**-**Fcutoff** and **Fc**+**Fcutoff**. The second message is transmitted using a carrier with frequency **Fc2 = Fc + 2*Fcutoff**, and occupies the frequency range from **Fc**+**Fcutoff** to **Fc**+**3*Fcutoff**. Thus, together the two messages occupy a bandwidth of 4*Fcutoff, ranging from **Fc-Fcutoff** to **Fc+3*Fcutoff**. If you run the initial code, Figure 1 shows the amplitude spectra for the transmitted signals of messages 1 and 2, and the amplitude spectrum of the received signal as three subplots.

Given that QPSK modulation can transmit twice as much information as BPSK using the same bandwidth, your task is to halve the transmission bandwidth required to transmit both text messages simultaneously by replacing BPSK modulation with QPSK modulation. It turns out that the BPSK transmitter used to transmit the first message is already equivalent to the I (in-phase) channel of a QPSK system with carrier frequency **Fc**. Thus, you only need to modify the code so that the second message is transmitted over the Q (quadrature) channel. The first step is to replace the command **tx_BPSK** with the lower level code for BPSK modulation by referring to the code in Task 1, and then modifying this code so that message 2 is also transmitted at frequency **Fc**, but with a carrier that is a sine wave, rather than a cosine wave. The second task is to modify the receiver code for message 2 correspondingly.

Please, revise the code between the lines

% % % % Revise the following code % % % %

and

% % % % Do not change the code below % % % %

Do not change other parts of the code. Note that there are two places where you need to modify the code (the transmitter and the receiver). Also, do not use the functions **tx_QPRK**, **rx_QPRK**, and do not change the variables **tx_wave1**, **wave_r1**.

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