

EECS 562
Homework 6

1. (Concept: FDM)

Given a baseband bandwidth of 300 kHz for signals $x_1(t)$, $x_2(t)$, $x_3(t)$ $x_M(t)$, i.e., $B_i=300$ kHz for each signal x_i $i=1\dots M$. These signals are modulated using DSB-SC modulation. The modulated DSB-SC signals are combined using FDM with assigned RF spectrum of 180 MHz.

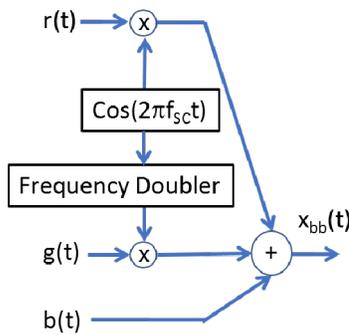
- a. Assuming no guard band find M.
- b. Assuming a 10 KHz guard band find M.

2. (Concept: Guard bands)

What are guard bands and why are they needed?

3. (Concept: Using FDM to form a composite baseband signal)

All the colors can be formed from the combination of the Red, Green and Blue. To transmit a color video signal, it takes three colors signals, i.e., $r(t)$, $g(t)$ and $b(t)$. Assume the baseband bandwidth of $r(t)$, $g(t)$ and $b(t)$ is 4 Mhz. A composite baseband signal $x_{bb}(t)$ is generated using the system shown with $f_{s_c}=10$ Mhz.



- a. What is the baseband bandwidth?
- b. The composite baseband signal $x_{bb}(t)$ is transmitted using DSB-SC, what is the required RF bandwidth?
- c. A coherent (synchronous) detector is required to recover composite baseband signal $x_{bb}(t)$ from the received DSB-SC RF signal. TRUE or FALSE.
- d. A coherent (synchronous) detector is required to recover $r(t)$ from the composite baseband signal $x_{bb}(t)$ signal. TRUE or FALSE.
- e. A coherent (synchronous) detector is required to recover $b(t)$ from the composite baseband signal $x_{bb}(t)$. TRUE or FALSE.
- f. What is the width in Hz of the guard bands used in this system?
- g. Draw a block diagram of the receiver.

4. (Concept: Relationship between the length of the IFFT and the number of subcarriers)

What is the maximum number of subcarriers carrying data for a system with a symbol time of $1/120000$ and an IFFT length 4096?

5. (Concepts: Properties of TDMA/OFDMA systems, calculation of user bit rates, and the time/frequency resource grid)

A system uses OFDM with a 20 MHz channel bandwidth in the downlink, the OFDM symbol time is $T=1/120000$ sec. There are 2400 occupied subcarriers. Assume this system uses 7 OFDM symbols per

time slot and 20 time slots per frame.

- Why is the OFDM symbol time = $1/\text{subcarrier spacing}$?
- If all subcarriers (1-2400) use 1024-QAM in all 20 time slots (1-20) what is the total transmission bit rate for this system.

User A is assigned subcarriers 1 - 2400 using 1024-QAM for 10 time slots, i.e., time slots 1-10.

User B is assigned subcarriers 1 - 1200 using 64-QAM for 10 time slots, i.e., time slots 11-20.

User C is assigned subcarriers 1201 - 2400 using 16-QAM for the 10 time slots, i.e., time slots 11-20.

- What is user A's bit rate b/s?
- What is user B's bit rate b/s?
- What is user C's bit rate b/s?

6. (Concept: Demonstrating orthogonality and the receiver structure)

Let the subcarrier spacing and OFDM symbol time, be, $\Delta f = 240$ kHz and $T = 1/\Delta f$. Here each subcarrier transmits 256-QAM.

Map bits 1110011 $\rightarrow s_1(t) = \cos(2\pi f_c t) + \sin(2\pi f_c t)$ $0 < t < T$

Map bits 1110101 $\rightarrow s_2(t) = -3\cos(2\pi(f_c + \Delta f)t) + \sin(2\pi(f_c + \Delta f)t)$ $0 < t < T$

The signal $s(t) = s_1(t) + s_2(t)$ $0 < t < T$ is transmitted.

Assume the carrier frequency, $f_c = 900$ Mhz.

- What is the bit rate of $s(t)$ in b/s.
- Show that $s_1(t)$ and $s_2(t)$ are orthogonal over $0 < t < T$.
- Sketch a receiver structure for $s_2(t)$, what is the complex symbol at the receiver output?

7. (Concepts: Bit rate of OFDM systems,)

To deploy their LTE system ($\Delta f = 15$ kHz) a telecommunications company has leased a 15.36 MHz channel of which 13.515 MHz is bandwidth occupied with data transmission. Assume that every subcarrier uses 64-QAM.

- How many subcarriers are modulated with data?
- What is the downlink bit rate?
- What is the length of IFFT?
- Why is there a difference between the leased a 15.36 MHz channel and then only using 13.515 MHz for data transmission?

8. (Concept: Comparing bandwidth requirement of FDM, Baseband TDM/PAM and Baseband TDM/PCM)

Your company has purchased access to 400 MHz of RF spectrum. How many users can be supported using the following multiplexing techniques? Each user has a baseband bandwidth of 500 kHz.

Clearly state any assumptions.

- FDM/DSB-SC
- Baseband TDM/PAM then DSB-SC
- Baseband TDM/PCM with 4 bits/sample then BPSK.

9. (Concepts: FDMA and TDMA)

What is the difference between FDMA and TDMA?

10. (Concepts: FDD and TDD)

What is the difference between FDD and TDD?