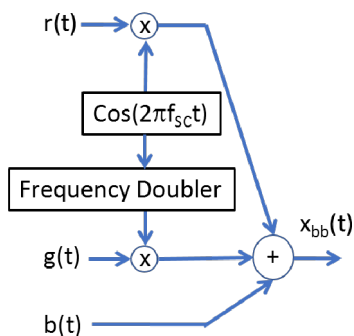


EECS 562
Homework 6

1. Given a baseband bandwidth of 200 kHz for signals $x_1(t)$, $x_2(t)$, $x_3(t)$ $x_M(t)$, i.e., $B_i=200$ kHz for each signal x_i $i=1...M$. These signals are modulated using DSB-SC modulation. The modulated DSB-SC signals are combined using FDM with assigned RF spectrum of 90 MHz.
 - a. Assuming no guard band find M.
 - b. Assuming a 10 KHz guard band find M.
2. What are guard bands and why are they needed?
3. 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 $f_{sc}=11$ 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. How many subcarriers are used for a system with a symbol time of $1/15000$ and an IFFT length 512?
5. A system uses OFDM with a 20 MHz channel bandwidth in the downlink, the OFDM symbol time is $T=1/15000$ sec with a subcarrier separation of 15kHz. There are 1200 occupied subcarriers. Assume this system uses 7 OFDM symbols per time slot and 20 time slots per frame.
 - a. Why is the OFDM symbol time = $1/\text{subcarrier spacing}$?
 - b. If all subcarriers (1-1200) use 64 -QAM in all 20 time slots (1-20) what is the total transmission bit rate for this system.

User A is assigned subcarriers 1 - 1200 using 64-QAM for 10 time slots, i.e., time slots 1-10.
User B is assigned subcarriers 1 - 600 using 16-QAM for 10 time slots, i.e., time slots 11-20.

User C is assigned subcarriers 601 - 1200 using QPSK (4-QAM) for the 10 time slots, i.e., time slots 11-20.

- c. What is user A's bit rate b/s?
- d. What is user B's bit rate b/s?
- e. What is user C's bit rate b/s?

6. In LTE the OFDM symbol time, $T = 1/15000 \text{ sec} = 1/\Delta f$; $\Delta f = 15 \text{ kHz}$. Here each subcarrier transmits 64-QAM.

Map bits 110011 $\rightarrow s_1(t) = \cos(2\pi(f_c + \Delta f)t) + \sin(2\pi(f_c + \Delta f)t)$ $0 < t < T$

Map bits 110101 $\rightarrow s_2(t) = -3 \cos(2\pi(f_c + 3\Delta f)t) + \sin(2\pi(f_c + 3\Delta f)t)$ $0 < t < T$

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

Assume the carrier frequency, $f_c = 900 \text{ MHz}$.

- a. What is the bit rate of $s(t)$ in b/s.
 - b. Show that $s_1(t)$ and $s_2(t)$ are orthogonal over $0 < t < T$.
 - c. Sketch a receiver structure for $s_2(t)$, what is the complex symbol at the receiver output?
7. To deploy their LTE system a telecommunications company has leased 13.515 MHz of occupied bandwidth which supports 901 downlink subcarriers. Assume that every subcarrier uses 64-QAM. What is the downlink bit rate?
8. Your company has purchased access to 100 MHz of RF spectrum. How many users can be supported using the following multiplexing techniques? Each user has a baseband bandwidth of 250 kHz. Clearly state any assumptions.
- a. FDM/DSB-SC
 - b. Baseband TDM/PAM then DSB-SC
 - c. TDM/PCM with 8 bits/sample.
9. Explain the role of the IDFT and DFT in the generation and demodulation of OFDM signals.
10. What is TDMA?
11. What is TDD?
12. What is a Time/Frequency resource grid.
13. For a system with a symbol time of $1/15000$ and an IFFT length 1024 what is the RF bandwidth in MHz?