Final Exam ESE 471

May 5 or 11, 2016

Your Name: Solutions

Your ID #: _____

Show your work in detail to get the full credit. There are 4 problems, each with 25 points.

Please indicate your attendance in the class, since the midterm. (Check one.)

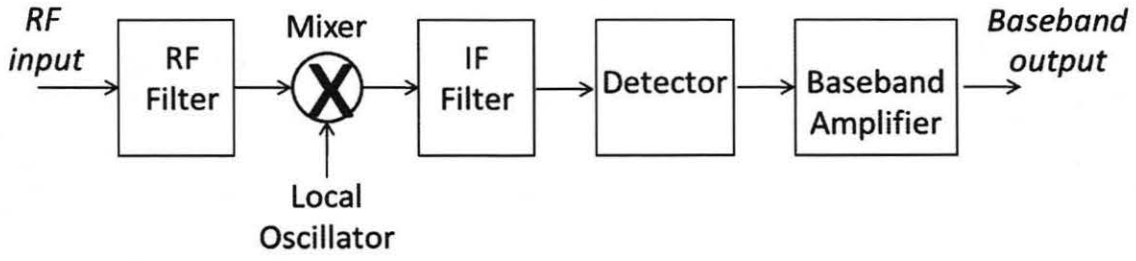
___ I have not missed any lectures, other than the ones that I informed Professor Min beforehand.

___ I missed 1-3 lectures.

___ I missed 4-5 lectures.

___ I missed more than 5 lectures.

1. An FM radio is tuned to receive an FM broadcasting station of frequency, f_c = 96.9 MHz. The radio is of the superheterodyne type (as shown below) with the location oscillator (LO) operating on the high side of the 96.9 MHz input and using a 10.7 MHz IF filter. What is the LO frequency, f_{LO}? What is the image frequency, f_{Imange}? If the FM signal has a bandwidth of 200 kHz (that is ± 100 kHz around f_c), what is the passband frequency range for the RF filter, and what is the passband frequency range for the IF filter?



$f_{LO} = 96.9 + 10.7 = 107.6$ MHz

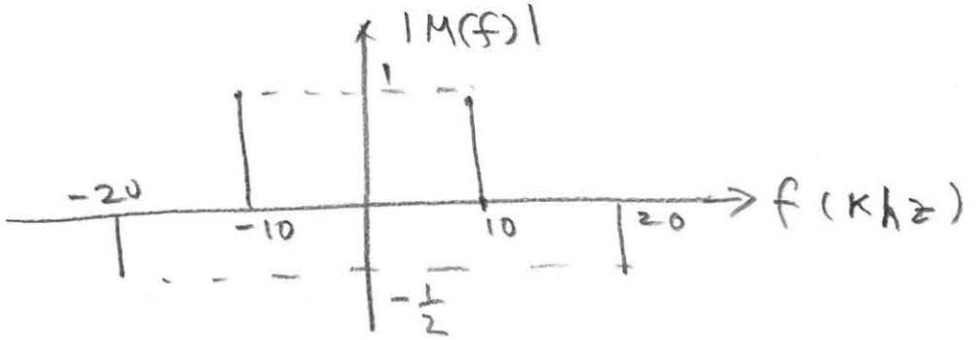
$f_{Emage} = f_c + 2f_{IF} = 96.9 + 2(10.7) = 118.3$ MHz

Pass band fequency for RF: from 96.8 MHz to 97.0 MHz

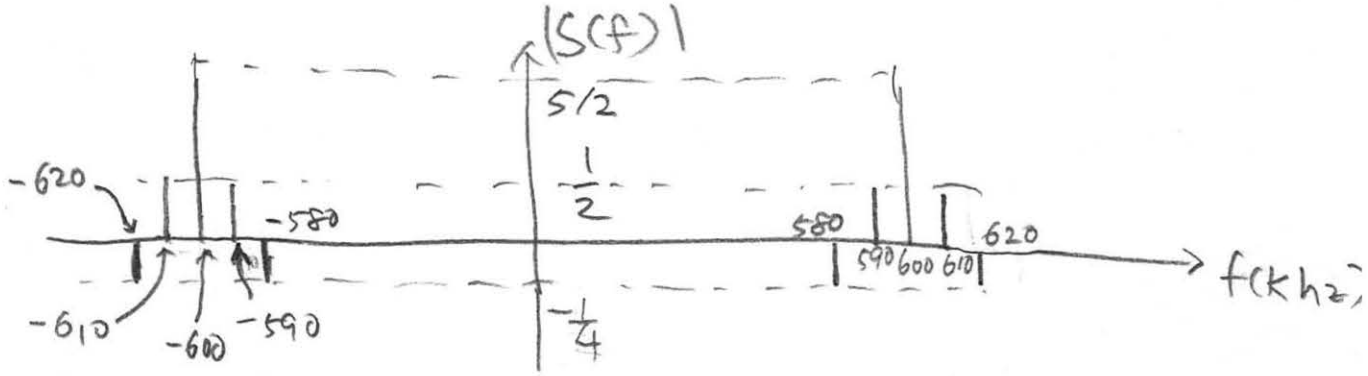
Passband fegeray for IF: from 10.6 MHz to 10.8 MHz

2. The message signal $m(t) = 2\cos(20\pi t) - \cos(40\pi t)$, where the unit of time is milliseconds, is amplitude modulated using a carrier frequency f_c of 600 kHz. The AM signal is given by $s(t) = 5\cos(2\pi f_c t) + m(t)\cos(2\pi f_c t)$. Determine the Fourier transform *S(f)* of *s(t)* and sketch *S(f)*. What is the transmission bandwidth for *s(t)*.

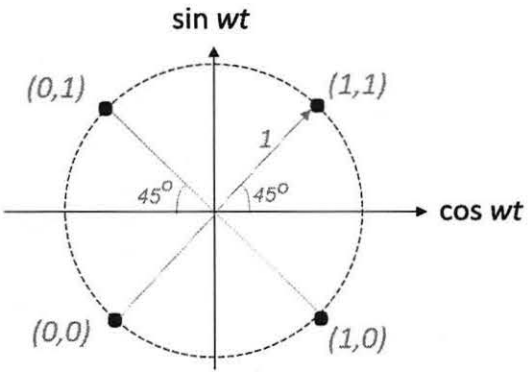
$$M(f) = \delta(f-10) + \delta(f+10) - \tfrac{1}{2}\delta(f-20) - \tfrac{1}{2}\delta(f+20)$$



$$S(f) = \tfrac{5}{2}\delta(f-f_c) + \tfrac{5}{2}\delta(f+f_c) + \tfrac{1}{2}M(f-f_c) + \tfrac{1}{2}M(f+f_c)$$

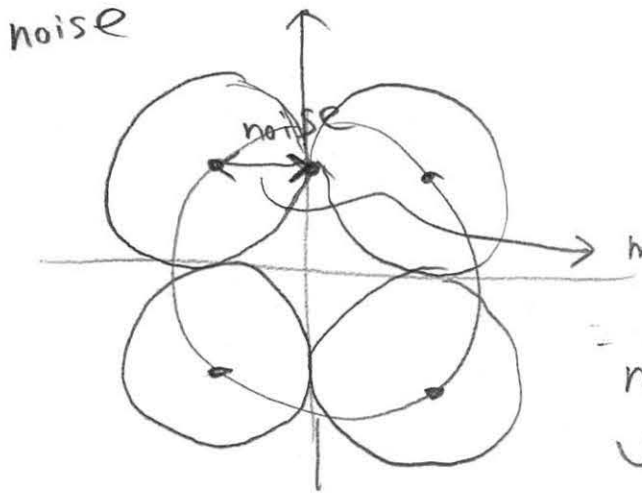


3. The following figure shows the QPSK constellation used in group assignment #3. What is the signal power? (Hint: the distance from the origin is the amplitude of the signal.) At what power level of noise, does an error occur? (Hint: noise is added around each constellation position. If the magnitude of the noise is too large, the resulting position away from a constellation position becomes closer to a neighboring constellation position than the initial constellation, and an error occurs.)



QPSK Constellation

Each constellation position is a unit distance away
⇒ signal power of
$(1)\cos(\omega t+\theta) \Rightarrow \frac{1}{2}$



magnitude of noise = $\frac{1}{\sqrt{2}}$

noise power at this max value = $\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{2}$

4. Consider the eight bit data 11010011. Generate a 3-bit cyclic redundancy code using the generator polynomial $x^3 + 1$. (Hint: long division of the data by 1001.) Show the transmitted bit sequence. Explain the process used at the receiver to determine if an error occurred.

```
      11001
    ---------
1001 | 11010011
       1001
    ---------
       100001 1
       1001
    ---------
         00101 1
          1001
    ---------
           010
           ~~~
           CRC
```

Transmitted bits: 11010011010

data CRC

at the receiver: 11 bits received, use the first 8 bits to generate a CRC using the same polynomial X^3+1. Compare the generated CRC with the last 3 received bits. If they are equal, no error. If they are different, error.