8.5 QUIZ QUESTION 1 (1/1 point)

Suppose the frequencies of the cosines used to be modulated by the baseband signal and to demodulate the received signal are *not* identical. Which of the following is/are true?

- [ ] After demodulation, the two copies of the signal at baseband obtained by multiplying by the complex exponentials at postive and negative frequencies cancel each other.
- [x] After demodulation, the two copies of the signal at baseband obtained by multiplying by the complex exponentials at postive and negative frequencies are not aligned at zero. ✔
- [x] The received signal at baseband is a distorted version of the original baseband signal. ✔
- [ ] No signal appears at the baseband.

✔

Note: Make sure you select all of the correct options—there may be more than one!

EXPLANATION

Suppose that the frequency of the modulating cosine is f_1 and the frequency of the demodulating cosine is $f_2 \neq f_1$. After multiplication, there is a cosine at $f_1 - f_2$. This leads to two complex exponentials at $\pm(f_1 - f_2)$, rather than a single component at zero frequency. This gives two copies of the original signal slightly displaced from each other. When combined, this leads to distortion in the original signal.

You have used 1 of 2 submissions

8.5 QUIZ QUESTION 2 (1/1 point)

Suppose that at the transmitter, the signal to be transmitted, $m(t)$, modulates the carrier $\cos(2\pi f_0 t)$. Suppose that the received signal $x(t) = m(t) \cdot \cos(2\pi f_0 t)$ is demodulated by mixing with a signal that has a slight phase offset with respect to the carrier, $\cos(2\pi f_0 t + \frac{\pi}{4})$. Thus, after mixing, the signal is given by

$$d(t) = m(t) \cdot \cos(2\pi f_0 t) \cdot \cos(2\pi f_0 t + \tfrac{\pi}{4})$$

Assume that after mixing, the signal is low pass filtered to remove the components introduced by mixing at $2f_0$ and $-2f_0$.

Week 4 Quiz due Nov 23, 2015 at 15:30 UTC

8.6 Lab 4 - Modulation
Lab due Nov 23, 2015 at 15:30 UTC

- MATLAB download and tutorials
- MATLAB Sandbox

Which one of the following is true about the recovered signal at baseband.

- ○ It disappears.
- ○ It has a spectrum that is the sum of two copies of the original spectrum that are shifted slightly in frequency in opposite directions.
- ◉ It is equal to the original signal $m(t)$, only scaled by approximately 0.35. ✔
- ○ It is equal to the original signal $m(t)$, only flipped in sign.

EXPLANATION

Since $\cos(A+B) = \cos(A)\cos(B) - \sin(A)\sin(B)$

$$\begin{aligned} d(t) &= m(t)\cdot\cos(2\pi f_0 t)\cdot\cos(2\pi f_0 t + \frac{\pi}{4}) \\ &= m(t)\cdot\cos(2\pi f_0 t)\cdot\Big(\cos(2\pi f_0 t)\cos(\frac{\pi}{4}) + \sin(2\pi f_0 t)\sin(\frac{\pi}{4})\Big) \\ &= m(t)\,\Big(0.5\cos(\frac{\pi}{4}) + 0.5\cos(2\pi(2f_0 t))\cos(\frac{\pi}{4}) + \cos(2\pi f_0 t)\sin(2\pi f_0 t)\sin(\end{aligned}$$

Since $\cos(A)\sin(B) = 0.5\sin(A+B) + 0.5\sin(A-B)$ and $\sin(0) = 0$,

$$\cos(2\pi f_0 t)\sin(2\pi f_0 t) = 0.5\sin(2\pi(2f_0 t)).$$

Thus,

$$d(t) = 0.5\cos(\tfrac{\pi}{4})m(t) + m(t)\cdot\big(0.5\cos(2\pi(2f_0 t))\cos(\tfrac{\pi}{4}) + 0.5\sin(2\pi(2f_0 t))\sin(\cdot$$

The second term is removed by filtering, leaving only

$$d(t) = 0.5\cos(\tfrac{\pi}{4})m(t) \approx 0.35m(t)$$

You have used 2 of 2 submissions