Student ID: _____

February 15, 2019 – 9:00 AM
Duration: 50 minutes

ENEL 471 - Winter 2019
1st Midterm Exam

Notes:

- This exam is closed book and closed notes.
- Non-programmable calculators are allowed.
- The exam duration is 50 minutes.
- The exam is composed of 2 Problems and 3 pages. All the problems are independent.
- Please write your name and ID# in each page

Student ID: _____
Student name: _____

February 15, 2019 – 9:00 AM
Duration: 50 minutes

Problem 1 [10 pts]

A lower sideband SSB-SC signal is generated by multiplying a 660 kHz cosine carrier with amplitude $A_c = 1$, by the message signal $m(t) = \sin(4000\pi t)$ and filtering out the upper sideband.

1. Determine the expression of the frequency domain representation of this lower-sideband SSB-SC signal. *[3 pts]*
2. Sketch the frequency spectrum of this lower-sideband SSB-SC signal. Show all frequencies and amplitudes of interest. *[3 pts]*
3. Determine the time domain expression for this lower-sideband SSB-SC signal. *[2 pts]*
4. Propose a demodulator to recuperate the message m(t) from this lower sideband SSB-SC signal. Provide the expression of all the input and output signals and the cutoff frequencies of any filter used. *[2 pts]*

(1) $M(f) = \frac{1}{2j}\delta(f - 2000) - \frac{1}{2j}\delta(f + 2000)$

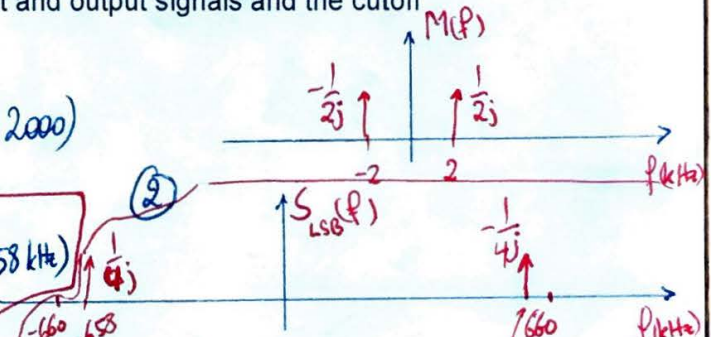
3 pts

$$S_{LSB}(f) = \frac{-1}{4j}\delta(f - 658\,\text{kHz}) + \frac{1}{4j}\delta(f + 658\,\text{kHz})$$

($658\,\text{kHz}$ or $(f_c - f_m)$)

1 pt on keeping only the lower side band (2 impulses)
1 pt on correct frequencies of impulses
1 pt on correct amplitudes

(2)



3 pts

1 pt on number of impulses
1 pt on correct freq
1 pt on correct amplitude

(3) $S_{LSB}(t) = -\frac{1}{2}\sin\left(2\pi(f_c - f_m)t\right)$

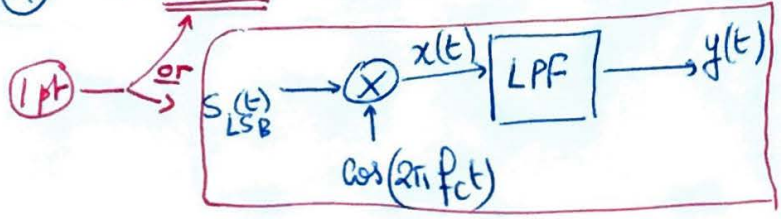
2 pts

or

$S_{LSB}(t) = -\frac{1}{2}\sin\left(2\pi(658\,\text{kHz})t\right)$

(4) A Coherent demodulator can be used to get back the message $m(t)$

1 pt



$$x(t) = S_{LSB}(t)\cdot\cos(2\pi f_c t) = -\frac{1}{2}\sin\left(2\pi(f_c - f_m)t\right)\cdot\cos(2\pi f_c t)$$

0.5 pt $y(t) = \frac{1}{4}m(t)$

0.5 pt → LPF cut off freq should be any freq $\geq \frac{2\,\text{kHz}}{(f_m)}$ and $\leq \frac{1318\,\text{kHz}}{(2f_c - f_m)}$

Student ID: _____

Student name: _____

February 15, 2019 – 9:00 AM
Duration: 50 minutes

Problem 2 [10 pts]

An AM signal has the form:

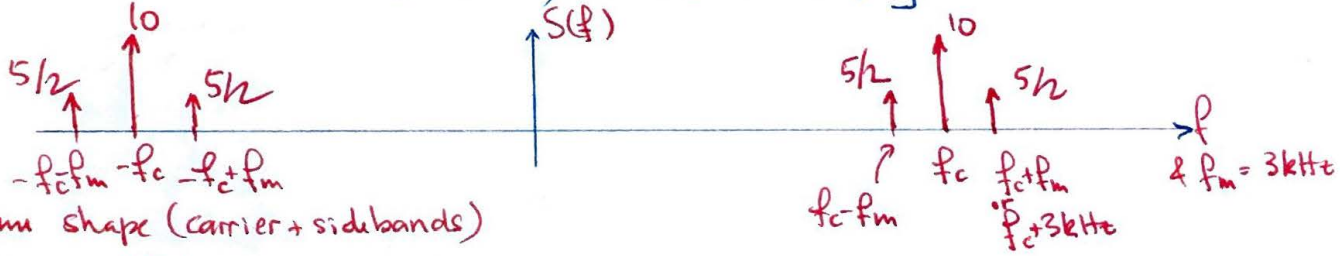
$$s(t) = \left[20 + 10\cos(6000\pi t)\right]\cos(2\pi f_c t)$$

Where $f_c = 10^5$ *Hz*

1. Sketch the spectrum of s(t). *[3 pts]*
2. Determine the power in each of the frequency components. *[3 pts]*
3. Determine the modulation index. *[2 pts]*
4. Determine the sidebands' power, the total power, and the ratio of the sidebands power to the total power (the power efficiency of this modulation). *[2 pts]*

1- $S(f) = 10\left[\delta(f-f_c) + \delta(f+f_c)\right] + \frac{5}{2}\left[\delta\left(f-(f_c-f_m)\right) + \delta\left(f-(f_c+f_m)\right) + \delta(f+f_c-f_m) + \delta(f+f_c+f_m)\right]$

(3 pts) →



1 pt : Spectrum shape (carrier + sidebands)

1 pt : Correct amplitudes

1 pt : correct frequencies.

2- $s(t) = 20\cos(2\pi f_c t) + 5\cos\left(2\pi(f_c - 3kHz)t\right) + 5\cos\left(2\pi(f_c+3kHz)t\right)$

(3 pts)

- 1 pt: Power @ $f_c = \frac{(20)^2}{2} = 200$ Watt
- 1 pt: Power @ $(f_c - f_m)$ or $(f_c - 3kHz) = \frac{(5)^2}{2} = 12.5$ Watt
- 1 pt: Power @ $(f_c + f_m)$ or $(f_c + 3kHz) = \frac{(5)^2}{2} = 12.5$ Watt

3- Modulation index: $\mu = \frac{10}{20} = 50\%$ ← (2 pts)

4- $P_{sidebands}$ = Power @ $(f_c - f_m)$ + Power @ $(f_c + f_m)$ = 25 Watt ← (1 pt)

$P_{total} = P_{sidebands} + P_{carrier} = 25 + 200 =$ 225 Watt

$\eta = P_{sidebands}/P_{total} = \frac{25}{225} = \frac{1}{9} = 0.11$ ← (1 pt)