Student ID: _____

March 14, 2018 – 9:00 AM
Duration: 50 minutes

ENEL 471 - Winter 2018
2nd 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 5 pages. All the problems are independent.
- Please write your name and ID# in each page

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Problem 1 [10 pts]

The sinusoidal modulating wave:

$$m(t) = 2\cos(6000\pi t)$$

is applied to a phase modulator with phase sensitivity k_p = 0.1 radian per volt. The unmodulated carrier wave has frequency f_c = 1 MHz and amplitude A_c = 1 volt.

a- Determine the instantaneous frequency of this PM signal and sketch it versus time.
b- Determine the time domain expression of this PM signal and sketch it versus time.
c- Determine the maximum frequency deviation Δf and the modulation index β.
d- Determine the expression of the frequency spectrum of the resulting PM signal and sketch it. **Show all amplitudes and frequencies of interest**.
e- Construct a phasor diagram of this PM modulated signal.

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Problem 2 [10 pts]

A carrier wave of amplitude A_c = 2 volt and frequency f_c = 100 kHz is FM modulated by the message $m(t) = A_m \cos(2f_m \pi t)$, where A_m = 1 volt and f_m = 1 kHz. The frequency sensitivity of the FM modulator is k_f is 2 kHz per volt.

a- What is the time domain expression of the FM modulated signal?
b- Determine the maximum frequency deviation Δf and the modulation index β
c- Determine the transmission bandwidth of this FM signal using Caron's rule.
d- Determine the bandwidth by transmitting only those side frequencies whose amplitude exceed 1 percent of the unmodulated carrier amplitude. (Use the table below)
e- Sketch the frequency spectrum of the modulated signal. **Show only the sidebands within the bandwidth calculated in d-. Indicate all the frequencies and amplitudes of interest**. (Use the table below)

Values of the Bessel Functions $J_n(\beta)$

	$\beta = 1$	$\beta = 2$	$\beta = 3$	$\beta = 4$
$n = 0$	0.7652	0.2239	-0.2601	-0.3971
$n = 1$	0.4401	0.5767	0.3391	-0.066
$n = 2$	0.1149	0.3528	0.4861	0.3641
$n = 3$	0.0196	0.1289	0.3091	0.4302
$n = 4$	0.0025	0.034	0.132	0.2811
$n = 5$		0.007	0.043	0.1321
$n = 6$		0.0012	0.0114	0.0491
$n = 7$			0.0025	0.01518
$n = 8$				0.004

Trigonometric Identities

$$\cos(a+b)=\cos(a)\cos(b)-\sin(a)\sin(b)$$
$$\cos(a-b)=\cos(a)\cos(b)+\sin(a)\sin(b)$$
$$\sin(a+b)=\sin(a)\cos(b)+\cos(a)\sin(b)$$
$$\sin(a-b)=\sin(a)\cos(b)-\cos(a)\sin(b)$$
$$\cos(a)\cos(b)=\frac{1}{2}\left[\cos(a-b)+\cos(a+b)\right]$$
$$\sin(a)\sin(b)=\frac{1}{2}\left[\cos(a-b)-\cos(a+b)\right]$$
$$\sin(a)\cos(b)=\frac{1}{2}\left[\sin(a+b)+\sin(a-b)\right]$$
$$\cos\left(a+\frac{\pi}{2}\right)=-\sin(a)$$
$$\cos\left(a-\frac{\pi}{2}\right)=\sin(a)$$
$$\sin\left(a+\frac{\pi}{2}\right)=\cos(a)$$
$$\sin\left(a-\frac{\pi}{2}\right)=-\cos(a)$$

Taylor series first order approximation of trigonometric functions

If $a \ll 1$ rad
Then: $\cos(a)\simeq 1$
$\sin(a)\simeq a$

Properties of the Bessel Functions of the First Kind

$$J_n(\beta)=\frac{1}{2\pi}\int_{-\pi}^{\pi}\exp\left(j\beta\sin(\theta)-jn\theta\right)d\theta$$
$$J_{-n}(\beta)=(-1)^n J_n(\beta)$$