Quiz 1

Communication Systems (EE 308), Autumn'19

August 29, 2019; Total: 10 marks; Time: 55 minutes

Note:

- *You are allowed to use any result discussed in class without proof. For all other results, a proof needs to be provided.*

QUESTION 1 (0.5 + 0.5 + 0.5 + 0.5 = 2 MARKS)

An angle modulated signal has the form:

$$u(t) = 100\cos\left[2\pi f_c t + 4\sin(2000\pi t)\right],$$

where $f_c = 10$ MHz.

(a) Determine the average transmitted power.

(b) Determine the peak phase deviation.

(c) Determine the peak frequency deviation.

(d) Is this an FM or a PM signal? Explain.

QUESTION 2 (0.5 + 1 + 0.5 = 2 MARKS)

A SSB AM signal is generated by modulating an 800-kHz carrier by the signal:

$$m(t) = \cos(2000\pi t) + 2\sin(2000\pi t).$$

The amplitude of the carrier is $A_c = 100$.

(a) Determine the Hilbert transform of the signal $m(t)$, say $\hat{m}(t)$.

(b) Determine the time domain expression for the lower sideband of the SSB AM signal.

(c) Determine the magnitude spectrum of the lower sideband SSB signal.

QUESTION 3 (2 MARKS)

Suppose a given signal $g(t)$ and a frequency-modulated signal $s(t)$ are applied to a multiplier and the output $g(t)s(t)$ is fed into a filter of impulse response $h(t)$. Suppose $s(t)$ and $h(t)$ are linear FM signals whose instantaneous frequencies vary at opposite rates, as shown by:

$$s(t) = \cos\left(2\pi f_c t - \pi k t^2\right),$$

$$h(t) = \cos\left(2\pi f_c t + \pi k t^2\right),$$

where k is a constant. Show that the envelope of the filter output is proportional to the amplitude spectrum of the input signal $g(t)$ with kt playing the role of frequency f.

QUESTION 4 (0.5 + 1.5 = 2 MARKS)

Let the carrier be given by $c(t) = 10\cos(2\pi f_c t)$ and the message signal be $\cos(20\pi t)$. Assume that this message signal is used to frequency modulate the carrier with frequency sensitivity $k_f = 50$.

(a) Find the modulated signal.

(b) Suppose we define the transmission bandwidth of the FM signal to be the width of the smallest band that contains at least 98% of the modulated signal power. Find the transmission bandwidth. Use the table of Bessel functions of the first kind provided in Fig. 1.

QUESTION 5 (1.5 + 0.5 = 2 MARKS)

A VSB signal is modulated by $m(t) = 3\cos(6\pi \times 10^3 t) + 5\cos(16\pi \times 10^3 t)$. The carrier frequency is 100 kHz and carrier amplitude is 1. The VSB filter (at the transmitter) is:

$$H(f) = \begin{cases} 0.5\left[\frac{f-f_c}{f_0} + 1\right], & \text{for } (f_c - f_0) \leq |f| \leq (f_c + f_0), \\ 1, & \text{for } (f_c + f_0) \leq |f| \leq f_{max}, \\ 0, & \text{otherwise}, \end{cases}$$

where $f_c = 100$ kHz is the carrier frequency, $f_0 = 5$ kHz, and $f_{max} = 150$ kHz.

(a) Determine the VSB signal.

(b) Determine the power in the VSB signal.

Modulation index	Sideband																
	Carrier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.00	1.00																
0.25	0.98	0.12															
0.5	0.94	0.24	0.03														
1.0	0.77	0.44	0.11	0.02													
1.5	0.51	0.56	0.23	0.06	0.01												
2.0	0.22	0.58	0.35	0.13	0.03												
2.41	0	0.52	0.43	0.20	0.06	0.02											
2.5	−0.05	0.50	0.45	0.22	0.07	0.02	0.01										
3.0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01										
4.0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02									
5.0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02								
5.53	0	−0.34	−0.13	0.25	0.40	0.32	0.19	0.09	0.03	0.01							
6.0	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02							
7.0	0.30	0.00	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02						
8.0	0.17	0.23	−0.11	−0.29	−0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03					
8.65	0	0.27	0.06	−0.24	−0.23	0.03	0.26	0.34	0.28	0.18	0.10	0.05	0.02				
9.0	−0.09	0.25	0.14	−0.18	−0.27	−0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01			
10.0	−0.25	0.04	0.25	0.06	−0.22	−0.23	−0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01		
12.0	0.05	−0.22	−0.08	0.20	0.18	−0.07	−0.24	−0.17	0.05	0.23	0.30	0.27	0.20	0.12	0.07	0.03	0.01

Fig. 1. Table of Bessel functions of first kind.