MANSOURA UNIVERSITY | Jan. 2013 | 3rd. YEAR COM. ENGINEERING
FACULTY OF ENGINEERING | COMMUNICATION THEORY (1)
DEPT. OF ELECT. & COMM. ENG. | TIME ALLOWED = 3 HRS

Answer ALL Questions (total Mark =100 equally distributed between 5 questions)

I-a) Prove Parseval's theorem for energy signal and power signal

b) For the full-wave rectified sinusoid $f_T(t)$ shown in Fig. 1, find the Fourier transform and plot its spectrum.

II- a) A particular version of A.M. stereo uses quadrature multiplexing. Specifically, the carrier $A\cos\omega_C t$ is used to modulate the sum signal $f_1(t) = V_O + f_L(t) + f_R(t)$, where V_O is a D.C. offset included for the purpose of transmitting the carrier components. The quadrature carrier $A\sin\omega_C t$ is used to modulate the difference signal $f_2(t) = f_L(t) - f_R(t)$

i) Show that an envelope detector may be used to recover the sum $f_L(t) + f_R(t)$ from the quadrature multiplexed signal.

ii) Show that a coherent detector can recover the difference $f_L(t) - f_R(t)$

iii) How are the desired f_L and f_R finally obtained?

b) A cellular communication system transmits DSB-SC signal $f(t)\cos\omega_C t$, two types of detectors may be used at the receiver:

i- A coherent detector with locally generated carrier $A\cos[(\omega_C + \Delta\omega)t + \psi]$, prove an expression for the demodulator output.

ii- An envelope detector with a sufficient amount of carrier ($A\cos[(\omega_C + \Delta\omega)t + \psi]$) injected at the receiver. Prove an expression for the demodulator output. Does the distortion in the envelope-detected output caused by errors in the inserted carrier ($A\cos[(\omega_C + \Delta\omega)t + \psi]$) is similar to that found in the synchronous demodulator in part (i)? comment.

III-a) A sinusoidal message signal $f(t) = kCos2\pi \times 1000t$ is modulated using a carrier frequency of $f_C = 100KHz$ to produce amplitude modulation (DSB-LC). The total power content of the modulated signal is 8KW and each sideband has a power of 1KW.

i) Find the time-domain representation of the modulated signal

ii) Sketch the frequency spectrum $\Phi_{AM}(\omega)$

iii) Estimate the modulation index.

b) A periodic signal consists of the exponentially decreasing waveform e^{-at} , $0 \le t < T$ repeated every T seconds. A given signal f(t) is multiplied by this periodic signal. Determine an expression describing the time waveform and the spectrum of the resulting A.M. signal if all components except those centered at $\pm\omega_C, \omega_C = 2\pi/T$ are discarded. Repeat the previous part if a periodic sequence of unit impulses spaced T second apart with one impulse at t=0

IV-a) Derive a time domain expression for linear F.M. and a time domain expression for nonlinear F.M., then show how the band width is calculated in each case?

b) A carrier wave is frequency modulated using a sinusoidal signal of frequency f_m and amplitude a_m

i) Determine the possible values of the modulation index β for which the carrier component of the modulated F.M. signal is reduced to zero

ii) For f_m= 1 KHz and increasing a_m starting from zero volts, it is found that the carrier component is reduced to zero for the first time when a_m=2volts. Determine the frequency sensitivity factor k_f of the modulator. Also determine the value of a_m for which the carrier component is reduced to zero for the second time.

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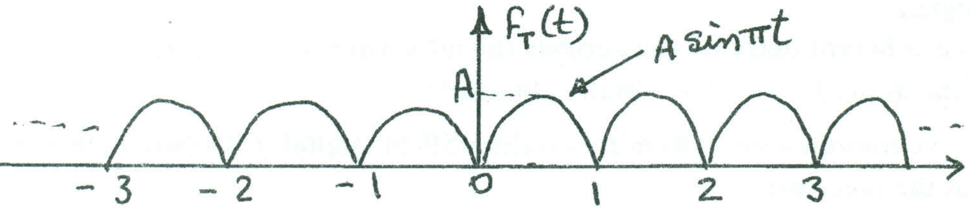
iii) If the average output power is 200 watts into 50 Ω resistive load for no modulation, determine the average power in the first and in the second order side bands when the carrier component of the modulated signal is reduced to zero for the first time.

V-a) With the aid of mathematical expressions and vector diagrams, explain the phase discriminator (Foster-Seeley) for F.M. detection.

b) Design an F.M. broadcast station to deliver an un-modulated carrier power of 20W across an antenna resistive load of 30 Ω. Make sure that when the modulating signal is given as $f(t) = 10\ \cos\ 3000\pi t$, the modulation index is 5. For your design determine: (i) the modulator constant k_f, (ii) the peak amplitude of the upper and lower first order side band and their phases relative to the un-modulated carrier, (iii) the ratio of the average power in the sum of the third and fourth side bands to the power in all side bands excluding the carrier, and (iv) the bandwidth reduction factor in case the peak amplitude of f(t) is reduced to 2 volts (use Carson's rule).

GOOD LUCK Prof. Fayez W. Zaki

Fig. 1



$J_n(X)$

X	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	.01						
.4	.57	.54	.21	.05	.01						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	.01					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	-.10	.47	.46	.24	.08	.02	.01				
.8	-.19	.41	.48	.27	.11	.03	.01				
3.0	-.26	.34	.49	.31	.13	.04	.01				
.2	-.32	.26	.48	.34	.16	.06	.02				
.4	-.36	.18	.47	.37	.19	.07	.02	.01			
.6	-.39	.10	.44	.40	.22	.09	.03	.01			
.8	-.40	.01	.41	.42	.25	.11	.04	.01			
4.0	-.40	-.07	.36	.43	.28	.13	.05	.02			
.2	-.38	-.14	.31	.43	.31	.16	.06	.02	.01		
.4	-.34	-.20	.25	.43	.34	.18	.08	.03	.01		
.6	-.30	-.26	.18	.42	.36	.21	.09	.03	.01		
.8	-.24	-.30	.12	.40	.38	.23	.11	.04	.01		
5.0	-.18	-.33	.05	.36	.39	.26	.13	.05	.02	.01	
.2	-.11	-.34	-.02	.33	.40	.29	.15	.07	.02	.01	
.4	-.04	-.35	-.09	.28	.40	.31	.18	.08	.03	.01	
.6	.03	-.33	-.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	-.31	-.20	.17	.38	.35	.22	.11	.05	.02	.01
6.0	.15	-.28	-.24	.11	.36	.36	.25	.13	.06	.02	.01
.2	.20	-.23	-.28	.05	.33	.37	.27	.15	.07	.03	.01
.4	.24	-.18	-.30	-.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	-.12	-.31	-.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	-.07	-.31	-.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	-.00	-.30	-.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	-.28	-.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	-.25	-.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	-.21	-.27	-.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	-.16	-.29	-.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	-.11	-.29	-.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	-.06	-.29	-.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	-.00	-.27	-.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	-.25	-.22	.04	.27	.34	.28	.18	.10
.8	-.04	.26	.10	-.22	-.25	-.01	.24	.34	.29	.20	.11
9.0	-.09	.25	.14	-.18	-.27	-.06	.20	.33	.31	.21	.12
.2	-.14	.22	.18	-.14	-.27	-.10	.16	.31	.31	.23	.14
.4	-.18	.18	.22	-.09	-.27	-.14	.12	.30	.32	.25	.16
.6	-.21	.14	.24	-.04	-.26	-.18	.08	.27	.32	.27	.17
.8	-.23	.09	.25	.01	-.25	-.21	.03	.25	.32	.28	.19
10.0	-.25	.04	.25	.06	-.22	-.23	-.01	.22	.32	.29	.21