BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Department of Electrical and Computer Engineering
Second Semester, 2018/2019
COMMUNICATION SYSTEMS, ENEE339
Second Exam, April 30, 2019
Time Allowed: 80 Minutes.

Name: ....

ID: ....

Section: ....

solution

Question #	SOC	Max Grade	Achieved
1		15	
2		20	
3		10	
4		10	
Total		55	

Opening Remarks:

- This is a 80-minutes exam. Calculators are allowed. Books, notes, formula sheets, and other aids are not allowed.
- You are required to show all your work and provide the necessary explanations everywhere to get full credit.

Problem#1 [15 Points]

Answer each of the following questions with **True** or **False**

1)(T) A diode, capacitors and resistors are used to build a simple envelop detector,

2)(F) Over modulation occurs when the modulation index is less than one

3)(T) The frequency of the carrier of AM modulator should be much greater than the message bandwidth

4)(F) The maximum power efficiency of Normal Amplitude Modulation is $66.6\bar{6}\%$.

5)(F) Bandwidth of DSB-SC modulated signal is less than the Bandwidth of Normal Amplitude modulated signal.

6)(F) Envelop Detector and Low Pass Filter are used to demodulate DSB-SC modulated signals.

7)(T) Coherent detector is used to demodulate DSB-SC modulated signal

8)(T) The bandwidth of Upper Single Side Band (USSB) modulated signal is equal to the bandwidth of the Lower Single Side Band (LSSB) modulated signal.

9)(F) Voltage Controlled Oscillator is used to generate an Upper Single Side Band (USSB) modulated signal

10)(F) In Wideband Band FM Modulation, the modulation index is very small (<<<1).

11)(T) The average power of an FM modulated signal is constant.

12)(T) To demodulate an FM modulated signal, we use a differentiator, envelop detector and a capacitor.

13)(T) In Super heterodyne receiver, the center frequency of the Band Pass filter is fixed regardless of the frequency of the signal to be modulated.

14)(F) In Quadrature Carrier Multiplexing, two message signals are modulated using different carrier frequency (f_{c1} and f_{c2}).

15)(F) Increasing the modulation index of Frequency Modulator reduce the 90% power bandwidth of the modulated signal.

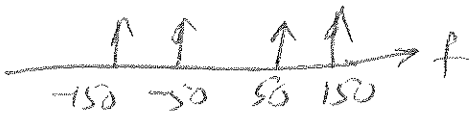
Problem#2 [20 Points]

The message sign $m(t) = 2cos(2\pi 50t)cos(2\pi 100t)$ along with the carrier signal $c(t) = 2cos(2\pi 1000t)$ are applied to a modulator that generates the double sideband suppressed carrier signal $s(t)$

(4) a) Determine the bandwidth of $m(t)$ in Hz.

$m(t) = 2\cos(2\pi 50t)\cos(2\pi 100t) = \cos(2\pi 50t) + \cos(2\pi 150t)$

$BW = 150\ Hz.$



(4) b) Determine the time-domain expression of the modulated signal $s(t)$.

$s_{DSB-SC}(t) = m(t)c(t) = 4\cos(2\pi 50t)\cos(2\pi 100t)\cos(2\pi 1000t)$

(4) c) Determine the bandwidth of the transmitted signal in Hz.

$BW_{DSB-SC} = 2BW_{m(t)} = 2 \times 150 = 300\ Hz.$

(4) d) Determine the power efficiency (η).

$$\eta \text{ of DSB-SC} = \frac{P_{\text{side bands}}}{P_{\text{total}}} = 100\%$$

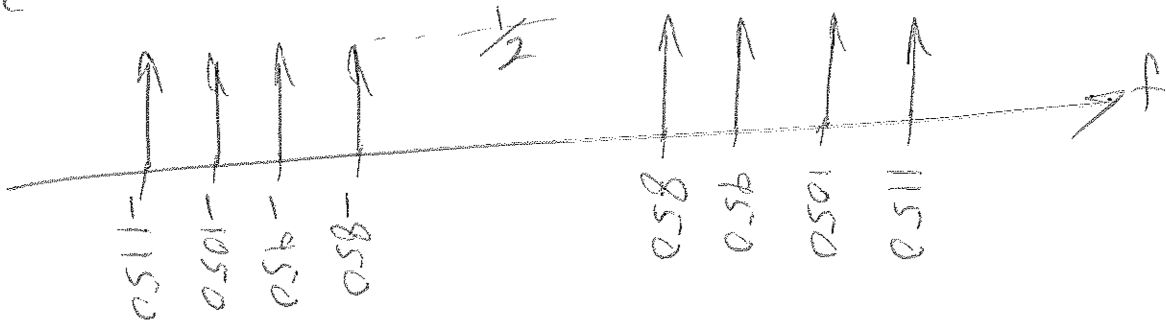
(4) e) Plot the power spectral density of the modulated signal $s(t)$.

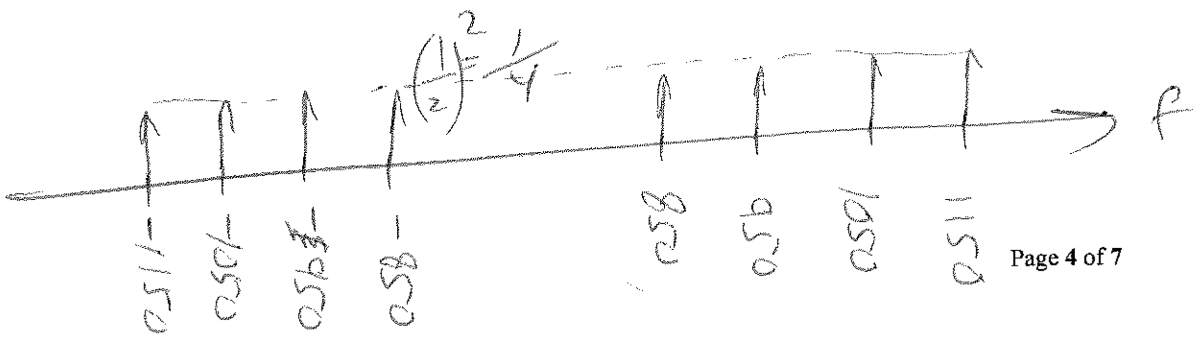
$$s_{DSB-SC}(t) = m(t)\, 2\cos(2\pi\, 1000 t)$$

$$= [\cos(2\pi\, 50 t) + \cos(2\pi\, 150 t)]\, 2\cos(2\pi\, 1000 t)$$

$$= \cos(2\pi\, 950 t) + \cos(2\pi\, 1050 t) + \cos(2\pi\, 850 t) + \cos(2\pi\, 1150 t)$$

$|S_{DSB-SC}(f)|$





Problem#3 [10 Points]

Consider the FM modulated signal $s(t) = 10cos(2\pi 10Kt + 1.2sin(2\pi 100t) + 0.6sin(2\pi 200t))$

(6) a) Find the instantaneous frequency of s(t)

$\theta(t) = 2\pi 10Kt + 1.2 sin(2\pi 100t) + 0.6 sin(2\pi 200t)$

$f_i(t) = \frac{1}{2\pi} \frac{d\theta(t)}{dt} = 10K + 120 cos(2\pi 100t) + 120 cos(2\pi 200t)$

(4) b) Find the peak frequency deviation of s(t).

frequeny dediation = $f_i(t) - f_c = 120[cos(2\pi 100t) + cos(2\pi 200t)]$

peak frequeny deviation $= \Delta f = Max[120(cos 2\pi 100t) + cos(2\pi 200t)]$

$Max(cos(\ )) = 1 \rightarrow \Delta f = 120(1+1) = 240 Hz.$

Problem#4 [10 Points]

Consider the FM modulated signal $s(t) = 10cos(2\pi 10Kt + 0.6sin(2\pi 200t))$

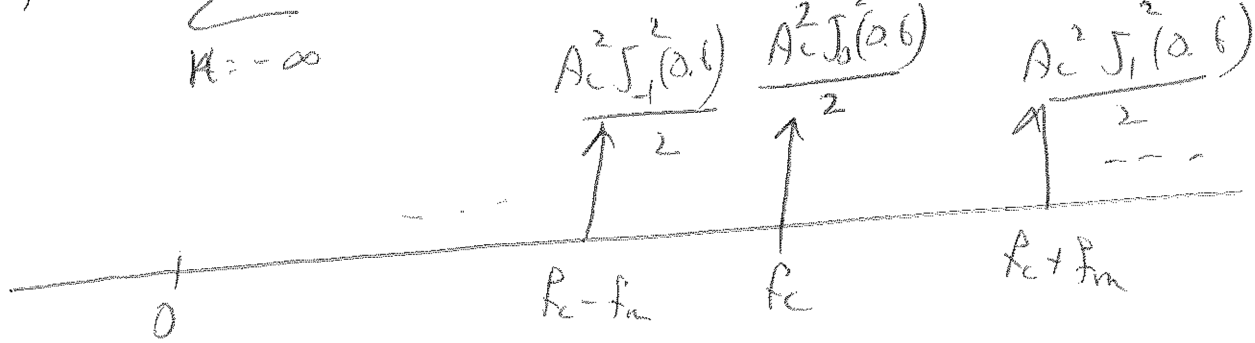
a) Use Carson's rule to determine the bandwidth of s(t)

$$BW_c = 2(\beta+1) f_m = 2(0.6+1)\,200 = 3.2 \times 200 = 640\,Hz.$$

$$\beta = 0.6$$

b) Find the 98% power bandwidth of s(t).

$$S_{FM}(f) = \sum_{n=-\infty}^{\infty} A_c J_n(\beta) \cos(2\pi (f_c + n f_m) t)$$



$$P_{total} = \frac{A_c^2}{2} = \frac{10^2}{2} = 50 \text{ watts.}$$

$98\%\ P_{total} = 49$ watts.

$$P_{f_c} \Rightarrow \frac{A_c^2}{2} J_0^2(0.6) = 50 * 0.831744 = 41.5872 < 49 \text{ watts.}$$

$$P_{f_c} + P_{f_c - f_m} + P_{f_c + f_m} \Rightarrow \frac{A_c^2 J_0^2(0.6)}{2} + \frac{2 A_c^2 J_1^2(0.6)}{2} = 41.5872 + 100 * 0.08219684 = 49.806889 > 49 \text{ watts}$$

$$\text{so } BW_{98\%} = (f_c + f_m) - (f_c - f_m) = 2 f_m = 2 * 200 = 400\ Hz.$$

Table of Bessel Functions

β	$J_0(\beta)$	$J_1(\beta)$	$J_2(\beta)$	$J_3(\beta)$	$J_4(\beta)$	$J_5(\beta)$	$J_6(\beta)$	$J_7(\beta)$	$J_8(\beta)$	$J_9(\beta)$	$J_{10}(\beta)$
0	1	0	0	0	0	0	0	0	0	0	0
0.1	0.9975	0.0499	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.2	0.9900	0.0995	0.0050	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.3	0.9776	0.1483	0.0112	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.4	0.9604	0.1960	0.0197	0.0013	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.5	0.9385	0.2423	0.0306	0.0026	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.6	0.9120	0.2867	0.0437	0.0044	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.7	0.8812	0.3290	0.0588	0.0069	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.8	0.8463	0.3688	0.0758	0.0102	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
0.9	0.8075	0.4059	0.0946	0.0144	0.0016	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.7652	0.4401	0.1149	0.0196	0.0025	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1.1	0.7196	0.4709	0.1366	0.0257	0.0036	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
1.2	0.6711	0.4983	0.1593	0.0329	0.0050	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000
1.3	0.6201	0.5220	0.1830	0.0411	0.0068	0.0009	0.0001	0.0000	0.0000	0.0000	0.0000
1.4	0.5669	0.5419	0.2074	0.0505	0.0091	0.0013	0.0002	0.0000	0.0000	0.0000	0.0000
1.5	0.5118	0.5579	0.2321	0.0610	0.0118	0.0018	0.0002	0.0000	0.0000	0.0000	0.0000
1.6	0.4554	0.5699	0.2570	0.0725	0.0150	0.0025	0.0003	0.0000	0.0000	0.0000	0.0000
1.7	0.3980	0.5778	0.2817	0.0851	0.0188	0.0033	0.0005	0.0001	0.0000	0.0000	0.0000
1.8	0.3400	0.5815	0.3061	0.0988	0.0232	0.0043	0.0007	0.0001	0.0000	0.0000	0.0000
1.9	0.2818	0.5812	0.3299	0.1134	0.0283	0.0055	0.0009	0.0001	0.0000	0.0000	0.0000
2	0.2239	0.5767	0.3528	0.1289	0.0340	0.0070	0.0012	0.0002	0.0000	0.0000	0.0000
2.1	0.1666	0.5683	0.3746	0.1453	0.0405	0.0088	0.0016	0.0002	0.0000	0.0000	0.0000
2.2	0.1104	0.5560	0.3951	0.1623	0.0476	0.0109	0.0021	0.0003	0.0000	0.0000	0.0000
2.3	0.0555	0.5399	0.4139	0.1800	0.0556	0.0134	0.0027	0.0004	0.0001	0.0000	0.0000
2.4	0.0025	0.5202	0.4310	0.1981	0.0643	0.0162	0.0034	0.0006	0.0001	0.0000	0.0000
2.5	-0.0484	0.4971	0.4461	0.2166	0.0738	0.0195	0.0042	0.0008	0.0001	0.0000	0.0000
2.6	-0.0968	0.4708	0.4590	0.2353	0.0840	0.0232	0.0052	0.0010	0.0002	0.0000	0.0000
2.7	-0.1424	0.4416	0.4696	0.2540	0.0950	0.0274	0.0065	0.0013	0.0002	0.0000	0.0000
2.8	-0.1850	0.4097	0.4777	0.2727	0.1067	0.0321	0.0079	0.0016	0.0003	0.0000	0.0000
2.9	-0.2243	0.3754	0.4832	0.2911	0.1190	0.0373	0.0095	0.0020	0.0004	0.0001	0.0000
3	-0.2601	0.3391	0.4861	0.3091	0.1320	0.0430	0.0114	0.0025	0.0005	0.0001	0.0000
3.1	-0.2921	0.3009	0.4862	0.3264	0.1456	0.0493	0.0136	0.0031	0.0006	0.0001	0.0000
3.2	-0.3202	0.2613	0.4835	0.3431	0.1597	0.0562	0.0160	0.0038	0.0008	0.0001	0.0000
3.3	-0.3443	0.2207	0.4780	0.3588	0.1743	0.0637	0.0188	0.0047	0.0010	0.0002	0.0000
3.4	-0.3643	0.1792	0.4697	0.3734	0.1892	0.0718	0.0219	0.0056	0.0012	0.0002	0.0000
3.5	-0.3801	0.1374	0.4586	0.3868	0.2044	0.0804	0.0254	0.0067	0.0015	0.0003	0.0001
3.6	-0.3918	0.0955	0.4448	0.3988	0.2198	0.0897	0.0293	0.0080	0.0019	0.0004	0.0001
3.7	-0.3992	0.0538	0.4283	0.4092	0.2353	0.0995	0.0336	0.0095	0.0023	0.0005	0.0001
3.8	-0.4026	0.0128	0.4093	0.4180	0.2507	0.1098	0.0383	0.0112	0.0028	0.0006	0.0001
3.9	-0.4018	-0.0272	0.3879	0.4250	0.2661	0.1207	0.0435	0.0130	0.0034	0.0008	0.0002
4	-0.3971	-0.0660	0.3641	0.4302	0.2811	0.1321	0.0491	0.0152	0.0040	0.0009	0.0002
4.1	-0.3887	-0.1033	0.3383	0.4333	0.2958	0.1439	0.0552	0.0176	0.0048	0.0011	0.0002
4.2	-0.3766	-0.1386	0.3105	0.4344	0.3100	0.1561	0.0617	0.0202	0.0057	0.0014	0.0003
4.3	-0.3610	-0.1719	0.2811	0.4333	0.3236	0.1687	0.0688	0.0232	0.0067	0.0017	0.0004
4.4	-0.3423	-0.2028	0.2501	0.4301	0.3365	0.1816	0.0763	0.0264	0.0078	0.0020	0.0005
4.5	-0.3205	-0.2311	0.2178	0.4247	0.3484	0.1947	0.0843	0.0300	0.0091	0.0024	0.0006
4.6	-0.2961	-0.2566	0.1846	0.4171	0.3594	0.2080	0.0927	0.0340	0.0106	0.0029	0.0007
4.7	-0.2693	-0.2791	0.1506	0.4072	0.3693	0.2214	0.1017	0.0382	0.0122	0.0034	0.0008
4.8	-0.2404	-0.2985	0.1161	0.3952	0.3780	0.2347	0.1111	0.0429	0.0141	0.0040	0.0010
4.9	-0.2097	-0.3147	0.0813	0.3811	0.3853	0.2480	0.1209	0.0479	0.0161	0.0047	0.0012
5	-0.1776	-0.3276	0.0466	0.3648	0.3912	0.2611	0.1310	0.0534	0.0184	0.0055	0.0015