ELG3175: Introduction to Communication Systems, Winter 2024, © S. Loyka

Assignment #4

Due: Feb. 9, 11:30am, SITE C0136 (the tutorial). Hard copies only. Late/electronic/email submissions will **not** be accepted.

1) The output signal from a conventional AM modulator is $x(t) = 5\cos 1800\pi t + 20\cos 2000\pi t + 5\cos 2200\pi t$.

(a) Determine the message signal $m(t)$ and the carrier $c(t)$; what is the carrier amplitude? frequency?

(b) Determine the modulation index.

(c) Determine the power in the sidebands, the power in the carrier and the power efficiency.

2) The message signal $m(t) = 2\cos 400t + 4\sin(500t + \pi/3)$ modulates the carrier signal $c(t) = A\cos(8000\pi t)$, using DSB-SC amplitude modulation. Find the time domain and frequency domain representation of the modulated signal and plot the spectrum (as it would appear on a spectrum analyzer) of the modulated signal. What is the power of the modulated signal?

3) An AM signal has the form $u(t) = [20 + 2\cos(3\cdot 10^3\pi t) + 10\cos(6\cdot 10^3\pi t)]\cos 2\pi f_c t$, where $f_c = 10^5\,Hz$.

(a) Sketch the (voltage) spectrum of $u(t)$.

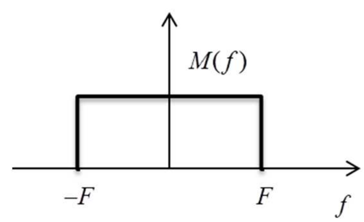
(b) Determine the power in each of frequency components.

(c) Determine the modulation index.

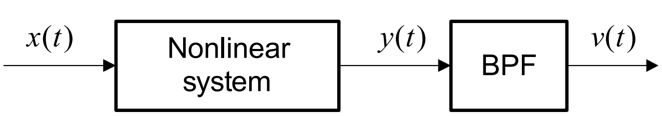
(d) Determine the power in the sidebands, the total power, and the ratio of the sidebands power to the total power.

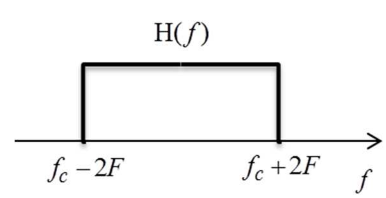
4) Suppose the signal $x(t) = m(t) + \cos 2\pi f_c t$ is applied to a nonlinear system whose output is $y(t) = x(t) + x^2(t)/2$.

(a) Determine and sketch the spectrum (as it would appear on a spectrum analyzer) of $y(t)$ when the double-sided spectrum $M(f)$ of $m(t)$ is as shown in the figure and $f_c > 4F$.



(b) Consider this nonlinear system with an ideal BPF connected to its output as show in the figure below. The frequency response $H(f)$ of this BPF is also shown. Find the output $v(t)$ (you may assume that $4F < f_c$).





5) The two signals $m_1(t)$ and $m_2(t)$, shown in Figure 1 (a) and (b), modulate a carrier signal $c(t) = A\cos 2\pi f_0 t$ using DSB-SC. Precisely plot the resulting modulated signals as a function of time and discuss their differences and similarities.

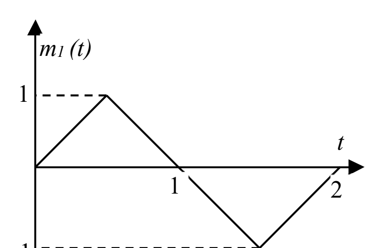


Figure 1(a)

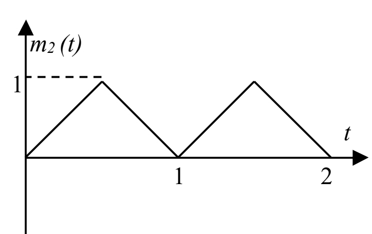


Figure 1(b)

6) A DSB-modulated signal $u(t) = Am(t)\cos 2\pi f_c t$ is mixed (multiplied) with a local carrier $v(t) = \cos(2\pi f_c t + \theta)$ and the output is passed through an ideal LPF with a bandwidth slightly larger than the bandwidth of the message $m(t)$. Denoting the power of the signal at the output of the LPF by P_{out} and the power of the modulated signal by P_U, find and plot P_{out} / P_U as a function of θ for $0 \le \theta \le \pi$.

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All spectra should be sketched as they would appear on a spectrum analyzer.
Please include in your solutions all the intermediate results and their numerical values (if applicable). **Detailed solutions with explanations are required**, not just the final answers/equations; **all symbols used must be defined**, including units used, if applicable (e.g. f = frequency [Hz]). Missing explanations, symbol definitions/units will be penalized. Your answers should demonstrate the full extent of your knowledge and the latter will determine your marks.

Plagiarism (i.e. "cut-and-paste" from a student to a student, other forms of "borrowing" the material for the assignment) is absolutely unacceptable and will be penalized. Each student is expected to submit his own solutions. If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.

Please read appropriate chapters of the textbook first, study all the examples, attempt to do them with the closed book. Remember the learning efficiency pyramid!

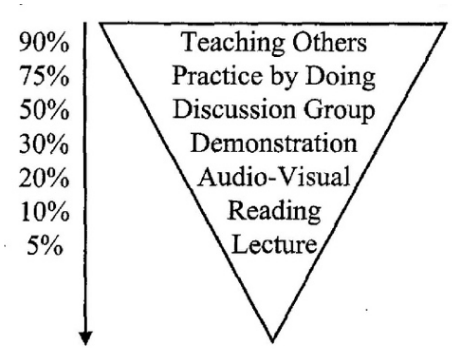

Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.