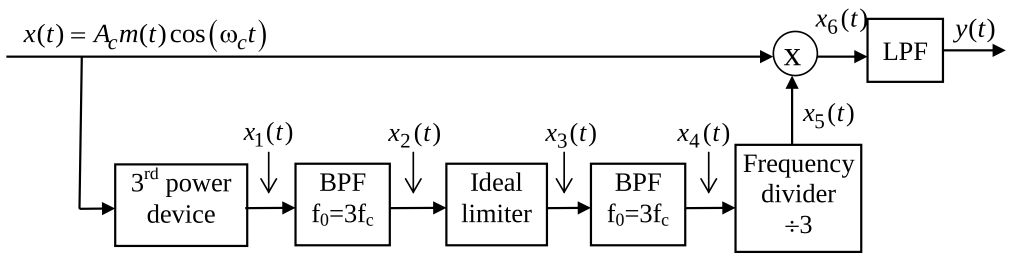
ELG3175: Introduction to Communication Systems, Winter 2024, © S. Loyka

Assignment #5

Due: Mar. 1 (Fri.)**, 11:30am,** SITE C0136 (the tutorial). Hard copies only. Late/electronic/email submissions will **not** be accepted.

1) An inexperienced engineer has designed the following DSB-SC demodulator:

a) Find $x_1(t)$- $x_6(t)$ and $y(t)$. Is it a demodulator? Why? b) Consider a special case of $m(t) = \sin \Omega t, \Omega << \omega_c$ and sketch m(t) and y(t) on the same graph. Are they the same? Assume that the amplitude of y(t) is 1. Note: 3rd power device has the following input-output characteristic: $x_{out}(t) = x_{in}^3(t)$. Ideal limiter input-output characteristic is $x_{out}(t) = \text{sign}\left(x_{in}(t)\right)$.

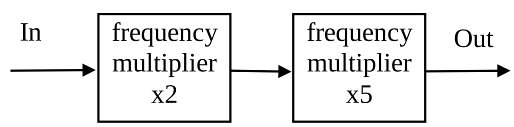


2) The normalized signal $m_n(t)$ has a bandwidth of 10 kHz and its power is 0.4 W. The carrier $A\cos 2\pi f_0 t$ has a power of 100 W. (a) If $m_n(t)$ modulates the carrier using DSB-SC amplitude modulation, what will be the bandwidth and the power content of the modulated signal? (b) If the modulation scheme is conventional AM with modulation index of 0.8, what will be the answer to part a? (c) If modulation is FM with with $k_f = 5 \cdot 10^3$, what will be the answer to part a?

3) An angle modulated signal has the form $u(t) = 20\cos[2\pi f_c t + 4\sin 2000\pi t]$ where $f_c = 10MHz$. (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.

4) The carrier $c(t) = A\cos 2\pi 10^6 t$ is angle modulated (PM or FM) by the sinusoid signal $m(t) = 2\cos 2000\pi t$. The deviation constants are $k_p = 1.5 rad/V$ and $k_f = 3000 Hz/V$. (a) Determine β_f and β_p. (b) Determine the bandwidth in each case using Carson's rule. (c) Plot the spectrum of the modulated signal in each case (plot only those frequency components that lie within the bandwidth derived in part b.) (d) If the amplitude of $m(t)$ is decreased by a factor of two, how would your answers to part a-c change? (e) If the frequency of $m(t)$ is increased by a factor of two, how would your answers to part a-c change?

5) Consider the following wideband FM modulator. Assume that there are appropriate bandpass filters in the 1st and 2nd multipliers. The input to the modulator is a narrowband FM signal with the peak frequency deviation $\Delta f = 2$ kHz and the message is $m(t) = 5\sin(10^4 \pi t)$. (a) Find the frequency separation of the components in the FM signal spectrum at the output of the 1st multiplier. (b) Find the peak frequency deviation at the output of the 1st multiplier. (c) Repeat (a) and (b) for the output of the 2nd multiplier and find the bandwidth of the output wideband FM signal.



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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!

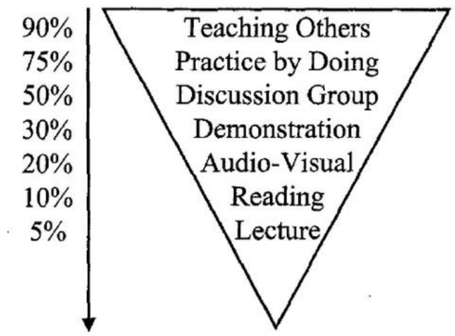

Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.