Problems – LM

1. A modulating signal with its bandwidth between f_{mm}=2 kHz and f_{mM} = 15 kHz and A=1V has to be transmitted in the frequency band [200, 220 kHz] using a LM.
a) Establish the type of modulation that should be employed and compute its parameters (the values of f_c and the required bandwidth). How many variants could be used?
b) Compute the parameters of the filter(s) (f_0, the -3dB bandwidth, its order) that has to be employed for one the variants selected above.

2. The solution established at 1., has to be modulated at first on the intermediate frequency f_1 = 40 kHz.
a) Establish the filter's order to keep only the desired side-band and attenuate the other side-band with 30 dB.
b) Compute the translation frequency f_2 used to translate this side-band on the f_c established at 1.a). What is the order of the filter employed to attenuate the undesired side-band with 30 dB?

3. A DSB-SC signal with f_c = 1MHz and a modulating signal $g(t) = A\cdot\sin(2\pi\cdot 150\text{kHz}\cdot t)$ should be generated using an unbalanced-chopper modulator.
a) Write the operational equations of the modulator, draw the spectrum at the chopper's output and establish the output filter parameters (f_0, BW).
b) What is the minimum value of f_c for which the signal modulated with this method could still be theoretically demodulated?

4. A bipolar rectangular signal of frequency f_m and amplitude V is approximated by its first three non-zero harmonics. It should be SSB-sup modulated on a carrier with frequency f_c and amplitude A > 1.5V, A = V_{ref}, using the Hilbert transform modulation. Write the mathematical expression of the modulated signal in shape that would express its spectral components. Particularize f_m = 10 kHz and f_c = 200 kHz.

5. A DSB-C or DSB-SC tarnsmission has its f_c = 100 kHz and f_m ranging within [0,5;4,5] kHz.
a) Write the operational equations and draw the block diagram of the carrier rceovery circuit that uses the quadratic method.
b) Establish the parameters of the filters employed (f_0, BW, order n) to attenuate the undesired spectral components with M dB (M=30) w.r.t. the level of the desired spectral components.
c) Could this method be applied for the SSB modulation? Justify by theoretical proof.

6. Consider a DSB-C or DSB-SC transmission with f_c = 100 kHz and a bipolar rectangular modulating signal generated by its first three non-null harmonics, having f_m =200 Hz. The demodulation is performed by the product coherent method.
a) Compute the expression of the demodulated signal if the local carrier is recovered with a phase offset $\Phi(t) = 2\pi\cdot 10\cdot t$. How would the demoudulated signal look in the time domain?
b) The same question for $\Phi(t) = \pi/60$.
c) Solve points a) and b) if the SSB-sup is used.

7. Compute the improvement factor ρ of the signal/noise ratio inserted by the coherent demodulation of the LM signal (DSB-C, DSB-SC and SSB); $\rho = \dfrac{\left.\frac{P_s}{P_z}\right|_o}{\left.\frac{P_s}{P_z}\right|_i}$; where P_s denotes the signa power, while P_z the noise power, $_i$ stands for input and $_o$ for output. Particularize for the modulating signal $g(t) = \cos\omega_m t$ and for the bipolar rectangular signal of the frequency f_m which is generated by its first three non-null harmonics.

8. Consider a LM-SSB modulated signal with an f_c carrier frequency and a g(t) modulating signal.
a) What are the requirements imposed to the spectrum of the modulating signal, so that a correct SSB signal could be obtained?
b) Write the equations that describe the coherent demodulation of an LM-SSB and draw the block diagram of the demodulator. Explain the roles and parameters of each block.
c) If the local carrier has a frequency shift of df, compute its effects upon the demodulated signal, i.e. upon its amplitude and phase..