## Problems FM

**1**.

**a)** An FM signal with $f_{mM}$ = 15 kHz, $\beta$=3,6 and $f_c$=2,7 MHz has to be generated using the Armstrong mathod. Compute the modulator parameters $f_c'$, $\beta'$ $\Delta f'$ and the ones of the output filter.

**b)** Compute the minimum frequency of the generated signal's spectrum that has to be attenuated by upper side of the output pass-band filter?

**c)** Write the operational equations and compute the parameters of the circuit that translates the signal modulated at on the channel carrier frequency $f_{chan}$ = 96 MHz. How many options do you have?

**2.**

**a)** Write the operational equation of a non-coherent MF demodulator, with $f_c$ and $\beta$, modulated by f(t), if from the principle structure of the demodulator, one takes out the block that removes the parasitic amplitude modulation. How would the demodulated signal be modified? Particularize the result obtained for $f(t) = \sin\omega_m t$. Assume that the envelope of the modulated signal is A(t).

**b)** If $\beta$ = 3, $f_c$ = 1 MHz, $f_m$ = 20 kHz, and a coherente multiplire-based envelope detection is employed, compute the minimum frequency of the spectral components that have to be attenuated by the output low-pass filter.

**3**.

An FM modulated signal received on the channel-carrier frequency $f_{c1}$= 88.2 MHz has to be translated on the intermediary frequency $f_i$= 10.7 MHz

**a)** Write the equation that describes the frequency translation and compute the value of $f_t$ and the parameters of the filter employed. How many options are available and what sistematic error could occur?

**b)** How many carrier frequencies can be translated on $f_i$ with the method described at a)? Justify by computation.

**c)** Knowing that the CCIR frequency band for the FM transmissions is [87.5; 108MHz], compute the minimum value of $f_i$ so that the image frequency would not belong to the CCIR band. Poit out the role of the imput ban-pass filter, specific to the bandwidth of the desired standard.

**d)** Knowing that the bandwidth allocated by the OIRT standard is [66-74] MHz, that the FM receivers have at their inputs two band-pass filters, one for CCIR and one for OIRT, that allow the transition of the whole frequency band of the selected standard, and that both CCIR and OIRT should be received only by switching between the two input filters, show why by using $f_i$ = 10.7 MHz as intermediary frequency (on which the FM demodulation is performed) the rejection of the image frequency can still be accomplished. Point out the the role of the input BP filter, specific to the desired frequency band, and compute the range of values of $f_t$ to cover both satndards.

**e)** Should the translation frequency signal (on $f_t$) be synchronized to the received signal (on $f_c$)? Justify by computation and show how is the expression of the translated signal modified in case of a frequncy offset, $f_{treal}= f_{tideal} + df$.

**f)** Compute the expression of the demodulated signal if df, defined at e) is $\neq 0$. How is the demodulated signal affected if $|df|$ has a small value? But if df$|$ equals 25% of $BW_{FM}$?

**4**.

Consider an FM signal with $f_{mM}$ = 15 kHz, $\Delta f_M$ = 50 kHz, received with a power of $1V^2/R_i$ and a noise power density $N_0 = 0.00033\ V^2/(kHz \cdot R_i)$ after the input BP filter. Compute the value of the $SNR_0$ at the demodulator's output.

Use:

$$P(R(t) < V_0) \approx 1 \Rightarrow \eta = \frac{\rho_o}{\rho_i} = k_3 \cdot 3 \cdot \beta^2 \cdot \frac{BW_{FM}}{2 \cdot f_{mM}}; \quad \text{for } \rho_i > 10 \Rightarrow$$

$$SNR_0[dB] = 8.5dB + 10\lg(3 \cdot \beta^2 \cdot \frac{BW_{FM}}{2 \cdot f_{mM}}) + SNRi\,[dB]; \text{ for } SNR_i > 10dB;$$

**5.**

Consider the digital generation of the FM signal using its complex envelope, q4 (14) and (15) from the lecture notes. Show how the complex envelope could be generated recursively without using a tabular computation of the cos x and sin x values. Which would be the smallest value of the sampling frequency $f_e$? Hint: use the approximations $\sin x \approx 1$ and $\cos x \approx 1$.

**6.**

Consider a FM transmission with $f_c$ = 91,6 MHz, $\Delta f_M$ = 50 kHz and $f_{mM}$ = 15 kHz.

**a)** Compute the chopping frequency and the BP-filter parameters ($f_c$ and $\Delta f$) required to translate the received FM modulated signal on the intermediate frequency $f_i$ = 10,7 MHz. How many possible values does $f_{chopp}$ have?

**b)** Is there any central frequency that could be demodulated simultaneously with the desired one? Justify by computation.