Fundamentals of Communication

Practical 2
Frequency Modulation using Matlab

Objectives

The objectives of this practical are:

- To get familiar, at a high level, with the various frequency modulation and demodulation techniques.
- To observe the time domain and frequency domain characteristics of various frequency modulation systems.

Requirements

- This practical requires some preparation, in terms of theoretical background as well as the use of the tools (Matlab, the m-files, etc. . .).
- To observe the time domain and frequency domain characteristics of various amplitude modulation systems.
- You are required to do all the preparation needed to implement the algorithms.
- You can discuss the practical with others students in the class, but you are required to undertake the Matlab simulation on your own and submit your own report.
- The report should include the following:
  - A signed honour pledge.
  - Your name and student number.
  - All the m-files used in the simulation.
  - An abstract, a short introduction and background, results and discussion, and conclusion.

- The report should be submitted in *two ways* before the deadline (26 September 2022 by 16h00) as follows:
  - A hard copy: at the reception of the School.
  - A soft copy: uploaded on the course website.

Exercises

The baseband message signal given by

$$m(t) = \begin{cases} 2\text{sinc}(100\text{t}) + 10\text{t} & 0 \leq t \leq 0.05 \\ 2\text{sinc}(100\text{t}) + (1 - 10\text{t}) & 0.05 \leq t \leq 0.1 \\ 0 & \text{otherwise} \end{cases}$$

modulates the carrier $c(t) = \cos(2\pi f_c t)$ when $f_c = 1000$ Hz and the modulation index is $\beta_f = 5$. The modulated signal is given by

$$u(t) = A_c \cos\left(2\pi f_c t + 2\pi k_f \int_{\infty}^{t} m(\tau)\text{d}\tau\right).$$

1. Plot the message signal $m(t)$ and its amplitude spectrum $M(f)$.
2. Make reasonable assumptions and then plot the FM signal $u(t)$ and its spectrum $U(f)$.
3. Determine the bandwidth, and the range of the instantaneous frequency of $u(t)$. Explain any assumptions that you make.
4. Demodulate the FM signal $u(t)$ to obtain the baseband message signal and compare the result with the original baseband message signal. The FM signal can be demodulated by first finding the phase of $u(t)$ and then differentiated to yield $m(t)$. You can use any other demodulation method if you prefer. Use the MATLAB function *unwrap.m* to undo the effect of 2π-phase foldings. Comment on how well the demodulated message signal matches the original message baseband signal $m(t)$.
5. Add noise to $u(t)$ to form a signal $y(t) = u(t) + n(t)$, where $n(t)$ is narrowband bandlimited noise with variance =0.05. Repeat step 4 above to demodulate the noisy signal $y(t)$. Comment on how well the demodulated message signal matches the original message baseband signal $m(t)$.