COMMUNICATION THEORY, Exercise 6, Fall 2023

1. The instantaneous frequency of an FM-modulated signal varies between f_{min} = 99.98 MHz and f_{max} = 100.02 MHz when the modulating signal is a sine wave with f_m = 3 kHz.

   Determine the following:

   a) carrier frequency
   b) carrier swing
   c) frequency deviation
   d) modulation index
   e) general spectrum shape
   f) signal bandwidth

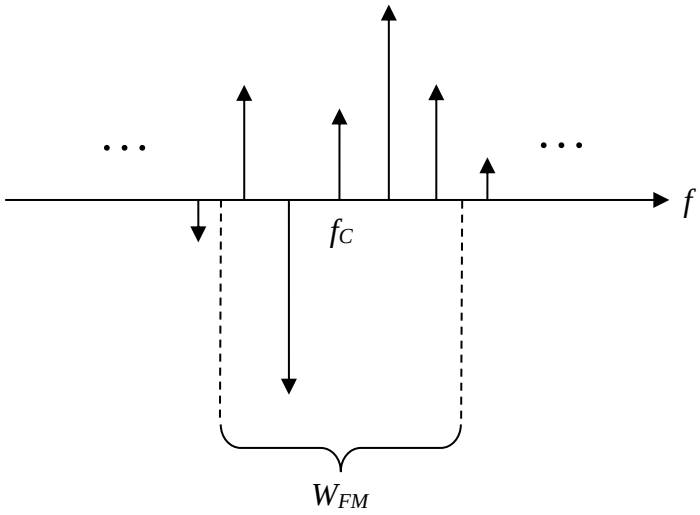
2. The spectrum of an FM signal using modulation index $\beta = 2$ is shown in the picture below.

   a) Calculate how much of the total signal power lies within the given band W_{FM}
   b) Compare the given band W_{FM} with the bandwidth estimations from the Carson's rule and the low-distortion rule

   Hint: you can use the following Matlab function to find the spectrum lines:

```
besselj((0:5)',2)=

0.2239
0.5767
0.3528
0.1289
0.0340
0.0070
```



3. A signal with normalized power results in signal-to-noise ratio at the destination equal to $(S/N)_D$ = 20 dB when it is transmitted using AM with modulation index $\mu = 1$.

   In order to achieve a better $(S/N)_D$ the modulation is switched to FM, and the bandwidth is adjusted accordingly, while all other transmission parameters are kept the same.

   a) Determine the largest usable deviation ratio D
   b) Calculate the improvement on $(S/N)_D$ when using FM instead of AM

4. A receiver employs the superheterodyne principle to down-convert a received signal with bandwidth W = 250 kHz and center frequency f_C = 940.2 MHz, using an intermediate frequency f_{IF} = 70 MHz.

   a) Calculate the needed local oscillator frequency to perform the first down-conversion
   b) If the center frequency f_C is more generally variable between 935-960 MHz, calculate the needed tuning range of the local oscillator
   c) Find the frequency location of the image band