

Exercise 1

Spectrum estimation



Aalto University
School of Electrical
Engineering

ELEC-E5410 Signal processing for communications

General Guidelines

- **min 50% points of the exercises required in the scale 0-100%**
- **Groups of 1-2 persons**
 - Sign up in MyCourses
- **If several groups return the same code without declaring cooperation (or similar code, changing names of the variables etc. doesn't count), the max. number of points/group becomes 100%/ #similar submissions**
- **Approved Exercise 1 required to be able to get the RTL-SDR**
 - You can still use your own hardware if you like

General Guidelines

- Download Matlab from download.aalto.fi
- Return .m files
- Return **the .pdf** made by Matlab's `publish()` with the results
 - Not .html + several .pngs or some other awkward format

Task

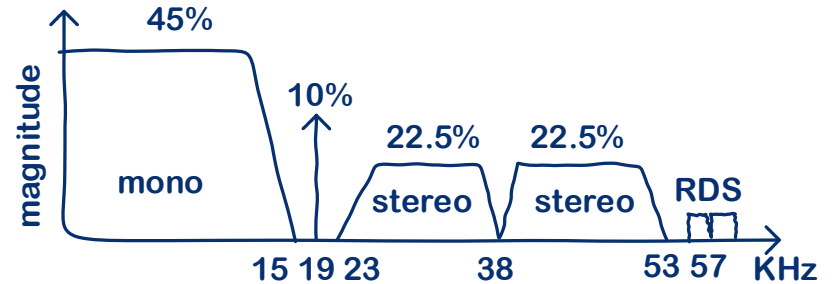
- **Write your own spectrum estimator that imitates Matlab's spectrumAnalyzer as closely as possible. Read the documentation of spectrumAnalyzer**
 - Default parameters of spectrumAnalyzer can be changed or left as is
- **Template hd_spectrum.m and spectrum_signal.mat are in Aalto Git**
- **The template DOES NOT work as such**
- **Functions/scripts starting with "rw_" are not in Git and they are the ones you do yourself**



Test signal

- Recorded FM mono radio transmission of YLE Puhe

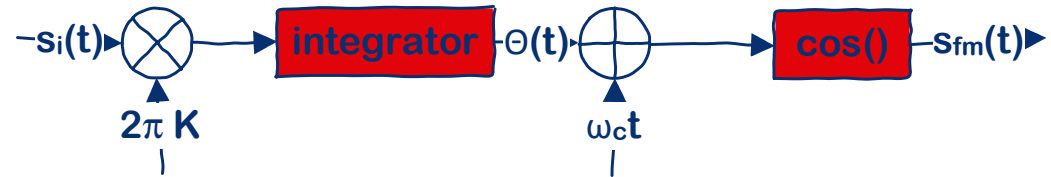
FM radio signal



One-sided magnitude spectrum

Frequency modulation (FM)

- Real (no quadrature part) and non-linear modulation
- The transmitted signal becomes



$$s_{fm}(t) = A \cos(\omega_c t + \theta(t))$$

- The phase is obtained by

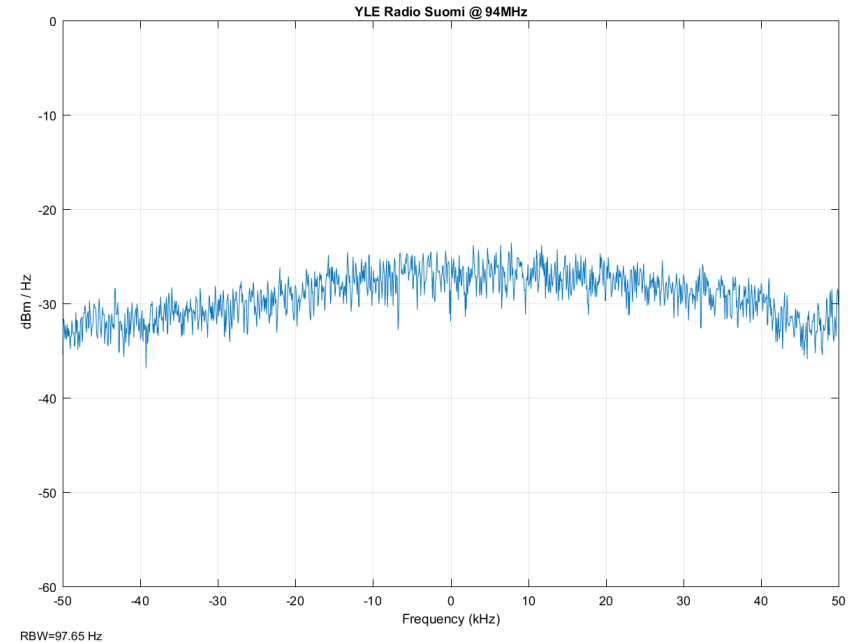
$$\theta(t) = 2\pi K \int_{-\infty}^t s_i(t) dt$$

A = amplitude
K = modulation constraint
 $s_i(t)$ = information signal

- Without input, FM modulator sends the unmodulated carrier
- Speech signal has silent periods, so therefore YLE Puhe

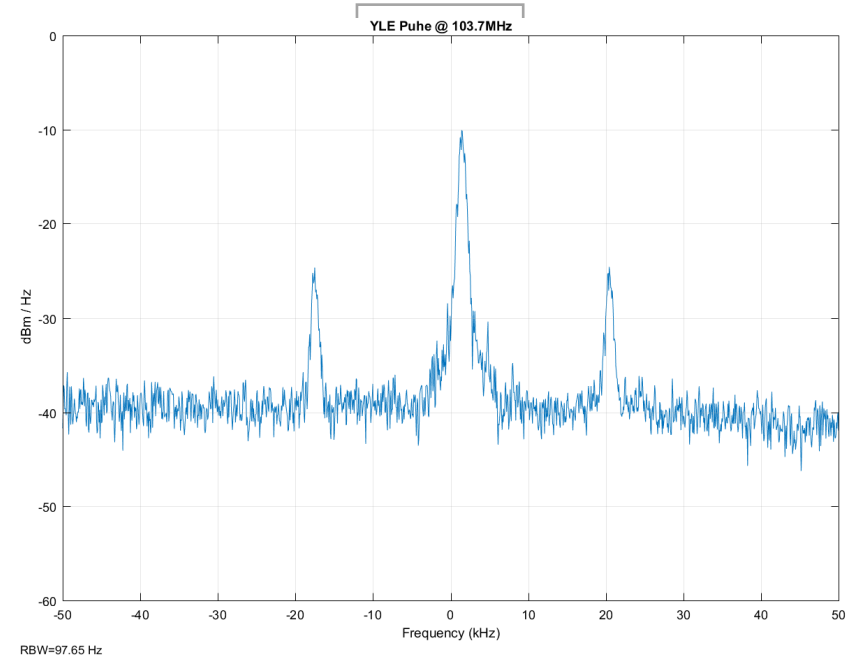
FM signal

- The received FM signal may not resemble the sketch at all
- The source signal (music) is wide band and the strong FM modulated source signal masks the carriers (center frequency and stereo carrier at 19 KHz offset



FM signal

- The carriers may appear, though, when the level of the input signal is low
- Speech is better than music



Matlab functions

<u>barthannwin</u>	Modified Bartlett-Hann window
<u>bartlett</u>	Bartlett window
<u>blackman</u>	Blackman window
<u>blackmanharris</u>	Minimum 4-term Blackman-Harris window
<u>bohmanwin</u>	Bohman window
<u>chebwin</u>	Chebyshev window
<u>enbw</u>	Equivalent noise bandwidth
<u>flattopwin</u>	Flat top weighted window
<u>gausswin</u>	Gaussian window
<u>hamming</u>	Hamming window
<u>hann</u>	Hann (Hanning) window
<u>kaiser</u>	Kaiser window
<u>nuttallwin</u>	Nuttall-defined minimum 4-term Blackman-Harris window
<u>parzenwin</u>	Parzen (de la Vallée Poussin) window
<u>rectwin</u>	Rectangular window
<u>taylorwin</u>	Taylor window
<u>triang</u>	Triangular window
<u>tukeywin</u>	Tukey (tapered cosine) window

Can use	Don't use
fft	pwelch
xcorr	periodogram
fftshift	pcov

There are Matlab functions for several different PSD estimators, but using those ready-made functions does not give points

Report

- **Return your Matlab code (.m) and a pdf made by Matlab's publish function**
- **The document must contain the algorithms and the parameters**