Sampling and aliasing
Amplitude modulation

Signals and codes (SK)

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Exercise 3

Exercise content

- Aliasing
  - Computing aliases and folded aliases of sinusoids
- Amplitude modulation
  - Plotting signals
  - Plotting the spectrum

Exercises

Exercise 03_1: Sampling, aliasing and folding of sinusoids – creating a script

Consider continuous time sinusoid with fundamental frequency f_0 = 100 Hz, phase shift $\Phi = \pi/3$ and amplitude $A = 1$.

Create a script, that will plot original signal, its aliases and folded aliases. Perform the following steps:

a) Define the parameters:

```
amp=1; %amplitude of original signal
f0=100; % frequency [Hz] of original signal
phi0=pi/3; %phase shift [rad] of original signal
fs=120; %sample frequency for sampling the original signal
oversampling=100; %for plotting aliases
noT=5; %number of periods of original signal to be ploted
i_alias = 1; %which ith alias will be ploted
i_fold = 1; %which ith folded alias will be ploted
```

b) Plot the following graphs in one figure:

1. Original sinusoid in black (use *t_dense* time, use LineSpec '-k')
2. Original sinusoid stem plot in red (use *t_dense* time, use LineSpec '-r')
3. *i_alias*th signal in blue dashed line (use LineSpec '--b') with stating respective frequency in legend
4. *i_fold*th signal in cyan dashed line (use LineSpec '--c') with stating respective frequency in legend

c) State frequencies f0 and fs within the title of figure from subtask b)

Exercises

Exercise 03_2: Sampling, aliasing and folding of sinusoids – using created script

Consider continuous time sinusoid with fundamental frequency f_0 = 100 Hz, phase shift $\Phi = \pi/3$ and amplitude A = 1, the same as in exercise 03_1.

Use the script created in exercise 03_1 to show

a) correct sampling with fs = 800 Hz within 1 period, show 1st alias and 1st folded alias

b) correct sampling with fs = 800 Hz within 1 period, show 2nd alias and 2nd folded alias.

   1. Find a formula for frequency *f_i_alias* in terms of *f0*, *i_alias* and *fs*
   2. Find a formula for frequency *f_i_fold* in terms of *f0*, *i_fold* and *fs*

c) sampling with Nyquist rate fs = 200 Hz within 3 periods, show 1st alias and 1st folded alias

d) undersampling with fs = 180 Hz within 5 periods, show 1st alias and 1st folded alias. Which signal would be reconstructed? What is the relationship between reconstructed signal and original signal? (*correct answer: original signal is 1st folded alias of the reconstructed signal*).

e) undersampling with fs = 80 Hz within 5 periods, show -1st alias and -1st folded alias. Which signal would be reconstructed? What is the relationship between reconstructed signal and original signal?

Exercises

Exercise 03_3: Amplitude modulation types and their spectrum

Consider amplitude modulated signals, create a script, that will plot the modulating signal, carrier signal , modulated signal and spectrum of modulated signal according to the instructions below.

a) Define the parameters:

```
sig_modulating_a=1; % amplitude
sig_modulating_f=10; % frequency, enter integer
sig_modulating_p=pi/4; % initial phase
sig_carrier_a=1;
sig_carrier_f=100; % frequency, enter integer multiple of sig_modulating_f
sig_carrier_p=0;
m=0.8; %modulation depth
fs=10000; % sample frequency of plotting
noT=5; %periods of modulating signal to be plotted
modulation_type='AMDSB'; % enter 'AMDSB'  or 'AMDSBSC'
```

b) Determine modulating signal, carrier signal and modulated signal and plot them above one another in one figure.

c) Use and modify scripts from the Exercise 02_1 to plot the spectrum of modulated signal. The figure shall contain 4 plots side by side: (1.) modulated signal, (2.) magnitudes of Fourier coefficients {ak}, (3.) phases of {ak} and (4.) synthesised signal (just for verifying purposes)