Multirate Signal Processing

Seminar 3

To be presented:
even week – 17.06.21
odd week – 24.06.21

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Homework assignment

Improve the filters from Homework 2 (everything else stays the same as in HW2):

a) **Design a new window** (using optimization) to achieve optimal attenuation and transition band (number of taps = 32)
   Hint: use 32 random coefficients as starting point of your optimization routine, define error function which has to be minimized.

b) Plot frequency and impuls responses of your window

c) Use ideal impulse response (sinc) for filter implementation

d) Using Modulation method with modulation function $N(n)=\cos\left(n\frac{\pi}{N}(k+0.5)\right)$ to implement LP, BP1, BP2, HP filters
   (The band pass filters should be such that all subbands have the same bandwidth)

e) Plot corresponding frequency and impuls responses VS previous filters to evaluate your improvement.

Homework assignment

- Listen to the downsampled subband 0
- Listen to the reconstructed signal
- Plot frequency responses of the original and reconstructed signals to see the difference (alias components?)

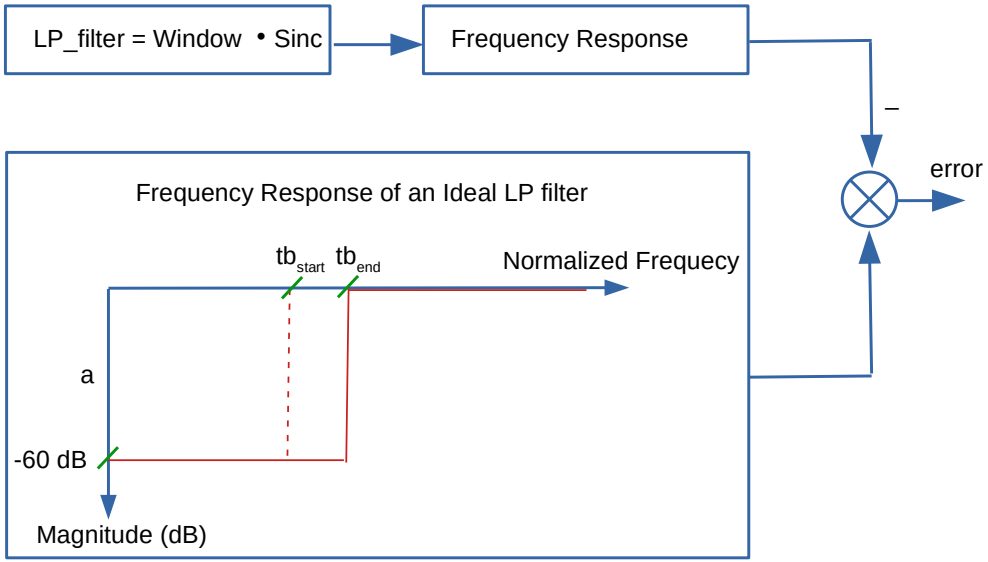
Hints:

- Please refer to Lecture slides #6, page 17 “Conclusion”

Optimization Example

```
import numpy as np
import scipy.optimize as optimize

#Example for 2 unknowns, args: function-name, starting point, method:

def functionexamp(x):
  #x: array with 2 variables

  y=np.sin(x[0])+np.cos(x[1])
  return y

xmin=optimize.minimize(functionexamp,[-1.0,-3.0], method='CG')

#Alternative solution: sciopt.fminbound
print xmin
```

Optimization Structure Tips



Optimize (find) coefficients for the *Window* function in such a way that:

1. Attenuation factor as smaller as possible: $a < -60\ dB$
2. Transition band as smaller as possible: $tb_{end} - tb_{start} \rightarrow 0$
3. Cut off frequency, which starts from tb_{end}, has to be defined according to your Downsampling factor
4. The difference between Ideal LP filter and your resulting *LP_filter* has to be as smaller as possible: *error* $\rightarrow 0$

All aforementioned parameters have to be implemented in the code!!!