GIERM 22/23. Course: Digital Signal Processing

Lab 2. Digital Filter Design

Objectives: Design of FIR-GLP filters by windowing. Classical windows. Kaiser windows.

Set-up:

Add a new folder *PDS_practica2* in the students' working folder. Set the folder *PDS_practica2* as the *working folder* in MATLAB. The following files must be in the folder:

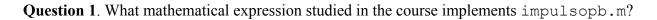
ра	rametros21.m	parametros22.m	parametros23.m
pr	actica21.m	practica22.m	practica23.m

- The file parametros2x.m has the parameters of the simulation number x.
- The file *practica2x.m* runs the simulation number x and plots the result in a number of figures.

2.1. Analysis of FIR-GLP filters obtained by classical windows

In the working folder we can find the function impulsopb.m. Its program code and description in ENGLISH are shown below.

Program code 1. impulsopb.m





Using the function impulsopb.m write a 'script' named analizaFIR.m which computes the coefficients of a FIR-GLP filter by windowing and represents its impulse response and its frequency response with M=51 and $\omega_C=0.4\pi$ and rectangular window. The program code is:

```
M = 51;
n=0:M;
Wc = 0.4;
ventana= rectwin(M+1);
h = impulsopb(M, Wc, ventana);
figure(1)
stem(n,h,'filled');
figure(2)
freqz(h,1,4096);
```

Question 2. Check that the impulse response and the frequency response are as expected.

The MATLAB's script with name practica21.m computes the coefficients of a low pass filter with rectangular window and parameters given in parametros21.m (M=50, $\omega_{\rm C}$ =0.4 π) and plots the frequency response in both linear and log scale.

Run practica21.m.

Program code 2. parametros21.m

```
% -----
% parametros21
% -----
Wc=0.4;
M=50;
ventana = ones(M+1,1); %rectangular
%ventana = hamming(M+1);
```

Question 3. Using a zoom on the plot check that the maximum ripple in both bands agrees with the theoretical value.

Note: the ripple in the pass band (dB)= $20\log(1+\delta_1)$; ripple in the reject band (dB)= $-20\log(\delta_2)$

Theoretical attenuation in the reject band (dB)
Attenuation in the reject band according to the plot (dB)
Theoretical attenuation in the pass band (dB)
Attenuation in the pass band according to the plot (dB)

	Does the ripple level change? (Yes/No)
	Does the transition band width change? (Yes/No)
	Justification:
	gain the initial parameters $M=50$ and $\omega_{C}=0.4\pi$ and change the window ('ventana') to Hamming in ametros21.m. Run again practica21.m.
	stion 5. Using zoom over the plot, verify that the maximum ripple in the attenuation band is that deted by the theory.
	Ripple in the attenuation band according to the theory (dB) Ripple in the attenuation band according to the plot (dB)
_	
_	Ripple in the attenuation band according to the plot (dB) stion 6. Has the ripple changed when compared with the rectangular window? Has changed the ition band width?. Justify your answer.
_	Ripple in the attenuation band according to the plot (dB) stion 6. Has the ripple changed when compared with the rectangular window? Has changed the
_	Ripple in the attenuation band according to the plot (dB) stion 6. Has the ripple changed when compared with the rectangular window? Has changed the ition band width?. Justify your answer. Has the ripple changed? (Yes/No)
_	Ripple in the attenuation band according to the plot (dB) stion 6. Has the ripple changed when compared with the rectangular window? Has changed the ition band width?. Justify your answer. Has the ripple changed? (Yes/No) Has changed the transition band width? (Yes/No)

2.2. Design of FIR-GLP filters using classical windows

In the MATLAB's script practica22.m. a FIR-GLP low pass filter is designed using classical windows and frequency response is represented. In the file parametros22.m the design parameters are set. Especifically, the following filters are designed $\omega_P=0.4\pi$, $\omega_S=0.5\pi$ and A=20, 40, 50 and 70.

Run practica22.m.

Program code 3. parametros22.m

Question 7. Annotate the value of M obtained in each case. What is the effect on M of a change of ω_P to 0.45π ? Justify your answer. Check it after running practica22.m with the new value of ω_P .

Effect on M (Increase/Decrease)	
Justification:	

2.3. Design of FIR-GLP filters by the Kaiser method

The MATLAB's script practica23.m designs a FIR-GLP low pass filter using the Kaiser window and represents the frequency response. In the file parametros23.m the design parameters are set. Especifically, the following filters are designed: $\omega_P=0.4\pi$, $\omega_S=0.5\pi$ and A=20, 40, 50 and 70.

Run practica23.m.

Program code 4. parametros23.m

Question 8. Check that the attenuation in the reject band are those predicted by the Kaiser formulae. Annotate below and also check that \mathbf{M} and \mathbf{beta} are consistent with those obtained by the Kaiser formulae.

A	20	40	50	70
M				
beta				