FIR

COLLABORATORS

	TITLE : FIR	

ACTION	*NAME*	*DATE*	*SIGNATURE*
WRITTEN BY		January 17, 2023	

REVISION HISTORY

NUMBER	DATE	DESCRIPTION	NAME

Contents

Chapter 1

FIR

1.1 Contents

```
                The Finite Impulse Response Filter Designer V1.2
Copyright by Harald Zottmann
20‘th of July 1996


Contents
```


1.2 Installation

1. Installation

This is the fourth Aminet Release of the FilterDesigner.
Install the FIR Filter Designer V1.2 using the script
located in this directory.

AmigaOS 2.x or up is required. A fast processor should
help also ;-)

1.3 Purpose

2. Purpose

The problem of designing finite impulse response (FIR) digital filters experienced great activity in the early 1970's. Most of this work was directed at the problem of optimal filter design, in the weighted Chebyshev sense. The algorithm for this program, by McClellan, Parks and Rabiner, will design the optimal Chebyshev approximation for linear phase filters. The Chebyshev optimization is done very efficiently by means of the Remez exchange algorithm, and this particular FIR filter design program has found wide use.

The filter design process is always a compromise among filter length, transition width and passband / stopband deviation (in the bandpass case). Not all of these specifications can be choosen arbitrarily.

1.4 FIR filter design

3. FIR filter design

Select the filter parameters or load a filter specification file (#?.FIR). Click on the design button and wait until the filter is designed. This can take up to some minutes if you use a standard Amiga and many filter taps (> 32).

Note that standard FIR filters should not have more than about 64 taps. This program however supports a filter length up to 512 taps (in the registered version).

In many cases, the result of the design of higher degree filters (>64 taps) produces wrong data. Be aware of that numerical problem, due to limited math precision, and verify your filter design.

If you are experienced in designing digital FIR filters, these long filters are an option for very high precise FIR filters, with deviation of more than -150 dB.

The resulting filter parameters will be stored in an ASCII-file. The name and the path of this file can be specified by a
tooltype

of the program.

Please use one of the standard text viewers to have a look at this log file.

If you select invalid filter parameters, the program will not do anything, except display a flashing screen.

Parameter Description

Filter-Type: Bandpass
Differentiator
Hilbert Transformator

Filter-Length: 3 to 128 (512 in the registered version)

Grid-Density: 2 to 32 (internal optimization value)

Bands: 1 to 10 (number of the defined bands)

From: Lower frequency of the specified Band

To: Upper frequency of the specified Band

Value: 0.0 to 1.0 (you can also use higher values than 1.0)
0.0 means stopband
1.0 means passband

Weight: Weight for optimization. This value defines how hard the program tries to meet the value for the respective band.

Note that the frequency value is relative to the sampling frequency. Load
example
files (#?.FIR) for
better understanding. The bands have to be sorted in ascending order.

The value for grid is needed only for the internal optimization algorithm. Usually, the value 16 is best for all purposes, but you can "play" with this value to get a better result.

1.5 Prism

4. Prism

Prism is the program module that displays the previous designed filter in the frequency domain (Global-Mode).

Parameter Description

```
Global-Mode:        Frequency-Domain
                    Time-Domain
                    No Dimension

Sample-Frequency:   >0.0 (1.0 for normalized display)

Display 1:          Absolute        - sqrt (im^2 + re^2)
                    Phase           - atan (im / re)
                    Corrected Phase - atan (im / re) + x
                    Real            - re
                    Imaginary       - im
                    Nothing         - guess what ?

Display 2:          Same as Display 1

X-Axis:             X-Linear  (Min...Max)
                    X-Log     (Min...Max)

Y1-Axis             Y1-Linear (Min...Max)
                    Y2-Log    (Min...Max)

Y2-Axis             Same as Y1-Axis

                    Note  that if  Min and Max are both  0  for  the Y-Axis, the
                    graph will  be autoscaled by the program. If you resize  the
                    Prism Data window or change the  settings, click the  Redraw
                    gadget to update the display.

                       Press  the   SPACE  bar  to  invoke  the
                 tooltype
                   defined
                    external viewer, to view the log file for the latest design.
```

1.6 Tooltype settings

```
5. Tooltype settings


DEBUG=ON                If a  math error occurs during  the  optimization,
                        the  program  gives  an  error  report.

DEBUG=OFF               No  error  report  to  be  generated.


VERBOSE=ON              The  program  tells  you  what  it currently does.

VERBOSE=OFF             No  verbose  output.


OUTPUT=T:FIRDesign.LOG  This is the  filename of  the  log  file, which is
                        generated  during the  optimization.  It shows the
                        calculated  filter  taps,  the  parameters and the
```

deviation for the selected bands.

VIEWER=MORE — Here you can select your favourite text viewer.

INVOKEVIEWER=ALWAYS — The viewer is always invoked when Prism starts up.

INVOKEVIEWER=NEVER — The viewer is never invoked.

INVOKEVIEWER=SPACE — The viewer is only invoked if you press the SPACE bar, while using Prism.

1.7 Example

```
                Example of a
               Bandpass
                Filter-Type     Bandpass
Filter-Length   55
Grid-Density    16
Bands           5

          From   To     Value   Weight
Band 01   0      0.05   0       10
Band 02   0.1    0.15   1       1
Band 03   0.18   0.25   0       3
Band 04   0.3    0.36   1       1
Band 05   0.41   0.5    0       20
```

```
Example of a
               Differentiator
                Filter-Type     Differentiator
Filter-Length   32
Grid-Density    16
Bands           1

          From   To     Value   Weight
Band 01   0      0.5    1       1
```

```
Example of a
               Hilbert
                Transformator

Filter-Type     Hilbert Transformator
Filter-Length   20
Grid-Density    16
Bands           1

          From   To     Value   Weight
```

```
Band 01  0.05   0.5    1       1
```

1.8 Future Enhancements

```
                6. Future Enhancements


If enough  Amiga  users  are interested in the FIRDesigner,
i will add the  following  enhancements  to  this  program:

  - Filter design  by using  different optimization methods
  - Filtering  of  sound  samples
  - 1 dimensional and 2 dimensional  filtering of  pictures
  - The  Filter
              library
                is  your  task ...


Feel free  to send  me  suggestions,  bug report s and your
personal wish list. Only feedback keeps this project alive.
```

1.9 Copyright

```
7. Copyright


This program is  SHAREWARE !!!  Please  register  if you use
it frequently.  You  will get a  keyfile  that  enables  the
program to calculate  filters up to a length of 512 taps !!!
This  version  is  limited  to  128 taps,  which  should  be
enough  for  normal   applications.  Moreover  the numerical
output for the filter taps is more precise in the registered
version and the annoying shareware requesters are suppressed.
Use the  ORDERFORM  to register.  Thank you for your support.


  Harald Zottmann
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  40822 Mettmann (Germany)

  Internet: harald.zottmann@ntc.nokia.com
```

1.10 Thanks

```
8. Thanks



   James H. McClellan
```

Thomas W. Parks
Lawrence R. Rabiner

for the development of a powerful FORTRAN-Program which is able to design
"Optimum Finite Impulse Response Linear Phase Digital Filters"

1.11 References

9. References

Below is a small collection of related books and articles on
Finite Impulse Response Filters:

W. Hess
Digitale Filter
Teubner Studienbücher
ISBN 3-519-16121-4

J.H. McClellan
Programs for Digital Signal Processing
Edited by the DSP Committee IEEE ASSPS
IEEE Press NY 1979

J.H. McClellan, T.W. Parks, L.R. Rabiner
A Computer Program for Designing Optimum FIR Linear Phase Digital Filters
IEEE Transactions on Audio and Electroacoustics
Vol. AU-21, No.6, December 1973

Oppenheim/Schafer
Zeitdiskrete Signalverarbeitung
R.Oldenbourg Verlag 1992
ISBN 3-486-21544-2

1.12 History

10. History

Date	Version	Type	Comments
20/07/96	V1.20	Release	Fourth AMINET Release - ToolType support - Filterlength now up to 512 taps - Internal improvements

```
                                - Displays floating point errors
                                - View log file with external viewer
                                - Displays also the corrected phase

  01/05/96  V1.10    Release   Third AMINET Release
                                - Versions for: MC 68000
                                                MC 68020
                                                MC 68040
                                - Updated the installer script
                                - Now compatible with AudioLab16
                                - Grids in the Prism window
                                - Some redesigns and optimizations
                                - Fixed Bug with too small workbench

  29/11/95  V1.01    Release   Second AMINET Release
                                - Fixed several Enforcer Hits
                                - Fixed Bug with not updating gadgets
                                - Recompiled with SAS/C V6.56
                                - Less Shareware Requesters
                                - Installer Script
                                - Added Pattern in Filerequester
                                - More Examples

  21/07/95  V1.00    Release   First AMINET Release
```

1.13 Output for Bandpass.FIR

```
DEVIATION =   0.000734
DEVIATION =   0.006316
DEVIATION =   0.021567
DEVIATION =   0.026203
DEVIATION =  -0.032680
DEVIATION =  -0.034435
DEVIATION =  -0.034448
DEVIATION =  -0.034448


FINITE IMPULSE RESPONSE (FIR)
LINEAR PHASE DIGITAL FILTER DESIGN
FILTER TYPE: BANDPASS FILTER
FILTER LENGTH = 55


******* IMPULSE RESPONSE *******

H(  1) =  1.066267E-03 = H( 55)
H(  2) =  6.377732E-03 = H( 54)
H(  3) =  3.575602E-03 = H( 53)
H(  4) = -9.067776E-03 = H( 52)
H(  5) = -9.090722E-03 = H( 51)
H(  6) =  2.915573E-03 = H( 50)
H(  7) =  3.963771E-03 = H( 49)
H(  8) =  1.117204E-02 = H( 48)
H(  9) =  1.164679E-02 = H( 47)
H( 10) = -9.963073E-03 = H( 46)
```

```
H( 11) = -9.238414E-03 = H( 45)
H( 12) = -2.040640E-02 = H( 44)
H( 13) = -1.946051E-02 = H( 43)
H( 14) =  3.124302E-02 = H( 42)
H( 15) =  6.304561E-03 = H( 41)
H( 16) = -2.048280E-02 = H( 40)
H( 17) =  6.574080E-03 = H( 39)
H( 18) = -1.120240E-03 = H( 38)
H( 19) =  4.195695E-02 = H( 37)
H( 20) =  3.578428E-02 = H( 36)
H( 21) =  3.474480E-02 = H( 35)
H( 22) =  7.149640E-02 = H( 34)
H( 23) = -1.713883E-01 = H( 33)
H( 24) = -1.825505E-01 = H( 32)
H( 25) =  7.405902E-02 = H( 31)
H( 26) = -1.031742E-01 = H( 30)
H( 27) =  2.571671E-02 = H( 29)
H( 28) =  3.781355E-01 = H( 28)
```

	BAND 1	BAND 2	BAND 3	BAND 4
LOWER BAND EDGE	0.000000	0.100000	0.180000	0.300000
UPPER BAND EDGE	0.050000	0.150000	0.250000	0.360000
DESIRED VALUE	0.000000	1.000000	0.000000	1.000000
WEIGHTING	10.000000	1.000000	3.000000	1.000000
DEVIATION	0.003444	0.034448	0.011482	0.034448
DEVIATION IN DB	-49.256573	0.294179	-38.798996	0.294179

	BAND 5
LOWER BAND EDGE	0.410000
UPPER BAND EDGE	0.500000
DESIRED VALUE	0.000000
WEIGHTING	20.000000
DEVIATION	0.001722
DEVIATION IN DB	-55.277172

EXTREMAL FREQUENCIES--MAXIMA OF THE ERROR CURVE

0	0.243616	0.032366	0.044642
0.1	0.108929	0.126786	0.142411
0.18	0.18558	0.197857	0.213482
0.243616	0.25	0.3	0.312277
0.350223	0.36	0.41	0.41558
0.445714	0.463571	0.481428	0.5

```
################################################

 1.066267E-03
 6.377732E-03
 3.575602E-03
-9.067776E-03
-9.090722E-03
 2.915573E-03
 3.963771E-03
 1.117204E-02
```

```
 1.164679E-02
-9.963073E-03
-9.238414E-03
-2.040640E-02
-1.946051E-02
 3.124302E-02
 6.304561E-03
-2.048280E-02
 6.574080E-03
-1.120240E-03
 4.195695E-02
 3.578428E-02
 3.474480E-02
 7.149640E-02
-1.713883E-01
-1.825505E-01
 7.405902E-02
-1.031742E-01
 2.571671E-02
 3.781355E-01
 2.571671E-02
-1.031742E-01
 7.405902E-02
-1.825505E-01
-1.713883E-01
 7.149640E-02
 3.474480E-02
 3.578428E-02
 4.195695E-02
-1.120240E-03
 6.574080E-03
-2.048280E-02
 6.304561E-03
 3.124302E-02
-1.946051E-02
-2.040640E-02
-9.238414E-03
-9.963073E-03
 1.164679E-02
 1.117204E-02
 3.963771E-03
 2.915573E-03
-9.090722E-03
-9.067776E-03
 3.575602E-03
 6.377732E-03
 1.066267E-03
```

1.14 Output for Differentiator.FIR

```
DEVIATION =   0.001310
DEVIATION =   0.005829
DEVIATION =   0.006130
DEVIATION =   0.006202
```

```
FINITE IMPULSE RESPONSE (FIR)
LINEAR PHASE DIGITAL FILTER DESIGN
FILTER TYPE: DIFFERENTIATOR
FILTER LENGTH = 32


******* IMPULSE RESPONSE *******

H(  1) = -6.271307E-04 = -H( 32)
H(  2) =  8.563357E-04 = -H( 31)
H(  3) = -4.241865E-04 = -H( 30)
H(  4) =  3.990139E-04 = -H( 29)
H(  5) = -4.343722E-04 = -H( 28)
H(  6) =  4.996944E-04 = -H( 27)
H(  7) = -5.963505E-04 = -H( 26)
H(  8) =  7.327703E-04 = -H( 25)
H(  9) = -9.300249E-04 = -H( 24)
H( 10) =  1.227003E-03 = -H( 23)
H( 11) = -1.701281E-03 = -H( 22)
H( 12) =  2.527233E-03 = -H( 21)
H( 13) = -4.160115E-03 = -H( 20)
H( 14) =  8.129457E-03 = -H( 19)
H( 15) = -2.253910E-02 = -H( 18)
H( 16) =  2.026653E-01 = -H( 17)


                    BAND 1
LOWER BAND EDGE     0.000000
UPPER BAND EDGE     0.500000
DESIRED SLOPE       1.000000
WEIGHTING           1.000000
DEVIATION           0.006202

EXTREMAL FREQUENCIES--MAXIMA OF THE ERROR CURVE

        0.001953        0.5             0.066406        0.099609
        0.164063        0.197266        0.230469        0.263672
        0.330078        0.363281        0.394531        0.427734
        0.486328        0.5



################################################

-6.271307E-04
 8.563357E-04
-4.241865E-04
 3.990139E-04
-4.343722E-04
 4.996944E-04
-5.963505E-04
 7.327703E-04
-9.300249E-04
 1.227003E-03
-1.701281E-03
 2.527233E-03
```

```
-4.160115E-03
 8.129457E-03
-2.253910E-02
 2.026653E-01
-2.026653E-01
 2.253910E-02
-8.129457E-03
 4.160115E-03
-2.527233E-03
 1.701281E-03
-1.227003E-03
 9.300249E-04
-7.327703E-04
 5.963505E-04
-4.996944E-04
 4.343722E-04
-3.990139E-04
 4.241865E-04
-8.563357E-04
 6.271307E-04
```

1.15 Output for Hilbert.FIR

```
DEVIATION =   0.004165
DEVIATION =   0.016426
DEVIATION =   0.020038
DEVIATION =   0.020556


FINITE IMPULSE RESPONSE (FIR)
LINEAR PHASE DIGITAL FILTER DESIGN
FILTER TYPE: HILBERT TRANSFORMATOR
FILTER LENGTH = 20


******* IMPULSE RESPONSE *******

H(  1) =  1.602632E-02 = -H( 20)
H(  2) =  1.417333E-02 = -H( 19)
H(  3) =  2.045249E-02 = -H( 18)
H(  4) =  2.873692E-02 = -H( 17)
H(  5) =  3.985263E-02 = -H( 16)
H(  6) =  5.533331E-02 = -H( 15)
H(  7) =  7.854278E-02 = -H( 14)
H(  8) =  1.182376E-01 = -H( 13)
H(  9) =  2.066413E-01 = -H( 12)
H( 10) =  6.347561E-01 = -H( 11)


                    BAND 1
LOWER BAND EDGE     0.050000
UPPER BAND EDGE     0.500000
DESIRED VALUE       1.000000
WEIGHTING           1.000000
DEVIATION           0.020556
```

```
EXTREMAL FREQUENCIES--MAXIMA OF THE ERROR CURVE

        0.05            0.24375         0.103125        0.146875
        0.24375         0.29375         0.346875        0.396875
        0.5


################################################

 1.602632E-02
 1.417333E-02
 2.045249E-02
 2.873692E-02
 3.985263E-02
 5.533331E-02
 7.854278E-02
 1.182376E-01
 2.066413E-01
 6.347561E-01
-6.347561E-01
-2.066413E-01
-1.182376E-01
-7.854278E-02
-5.533331E-02
-3.985263E-02
-2.873692E-02
-2.045249E-02
-1.417333E-02
-1.602632E-02
```

1.16 Filter Library

```
  11. Filter Library


  If you  have designed  good filters for special purposes,
  you  can send  them to  me via e-mail,  including a short
  description, for  example about  the  application you use
  them in, or special characteristics. I  will then include
  them in a  filter library and  distribute  them  together
  with the program. Remember to send only the #?.FIR files,
  saved by this  program, so  other people  can modify your
  filters.



  Thanks...(e-mail: harald.zottmann@ntc.nokia.com)
```