

Electronic Filter Design Quick Reference Brochure

Link to [ElecFilDes](#)

ElecFilDes is a program for the design of active, passive, digital, and switched capacitor filters. It is an update, for Windows XP, Windows 7, and Windows 8, of a program that has been used for over 20 years. It implements all the filters described in the book “Electronic Filter Analysis and Design”, ISBN 0-89006-616-7. All analog filters can be saved in PSPICE compatible files for independent simulation.

Introduction:

Once the program is installed, the opening screen will appear similar to the screen below. Values, that are automatically inserted into the text boxes, are taken from the immediate previous design, but other previous saved designs can be opened, and/or modified, for repeat design and analysis.

The screenshot shows the ElecFilDes software interface. The menu bar includes File, Analysis, Specialty Filters, and Coils. The main window contains several sections:

- Filter Type Selection:** Three boxes with radio buttons for Active, Passive, Digital, and Switched Capacitor; Lowpass, Bandpass, Bandstop, and Highpass; and Butterworth, Tchebyscheff, Inverse Tchebyscheff, and Elliptic.
- Filter Order:** A text box containing '3' and a 'Recommend' button.
- Passband Edge Cutoff Frequency:** A text box containing '1000'.
- Passband Ripple:** A text box containing '1'.
- Type Sampling Frequency:** A text box containing '10000'.
- Advanced Filter Options:** A box with radio buttons for IIR Bilinear, FIR Equiripple, and FIR Window.
- Action Buttons:** A vertical column of buttons on the right side: Continue (green), Clear (light green), Calculator (light green), Open (light green), Save (light green), and Quit (red).

Active Filters

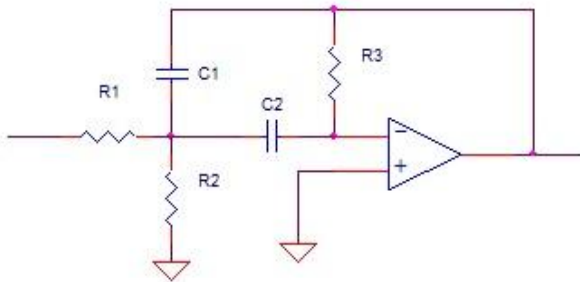
ElecFilDes has a variety of active topologies that include cascadable sections up to order 40. All active filters are available in lowpass, bandpass, bandstop and highpass configurations for Butterworth, Tchebyscheff, Inverse Tchebyscheff, and Elliptical (Cauer) bandpass characteristics.

Example active filters are shown below.

The Multiple Feedback (MFB) topology.

THE QUADRATIC FUNCTION FOR STAGE 2 OF 3 IS
(2272.931 S) / (1 S^2+ 1049.176 S+ 4.029575E+07)

Q= 6.050363

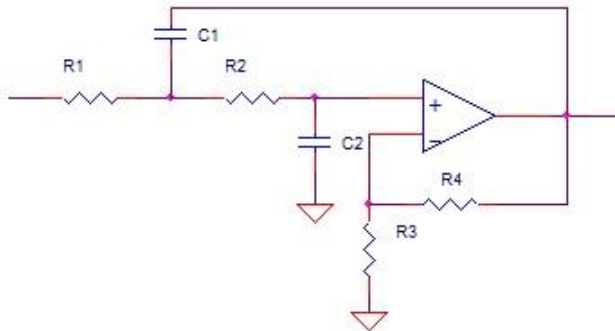


R1= 43996.07 ohms
R2= 1341.54 ohms
R3= 190625.8 ohms
C1= 0.01 uf
C2= 0.01 uf

The VCVS topology

THE QUADRATIC FUNCTION FOR STAGE 2 OF 2 IS
 $(3.924962E+07) / (1 S^2 + 3104.966 S + 3.924962E+07)$

Q= 2.01772



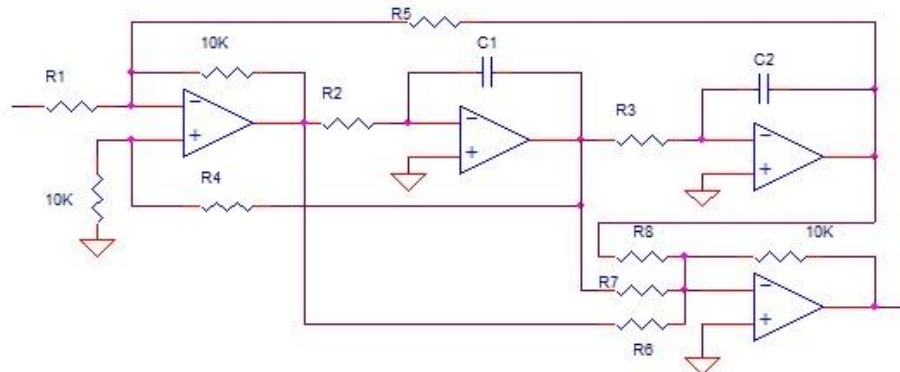
R1 = 5971.435 ohms R2 = 1939.381 ohms
 R3 = INFINITY R4 = 0
 C1 = 0.22 uf
 C2 = 0.01 uf

The State Variable Topology

THE QUADRATIC FUNCTION FOR STAGE 1 OF 3 IS
 $(1 S^2 + 7.895683E+07) / (1 S^2 + 68943.56 S + 7.895683E+07)$

Q= 0.1288846

R1= 9942.303
 R2= 1458.874
 R3= 87318.34
 R4= 19942.4
 R5= 9942.303
 R6= 10058.03
 R7= INFINITY
 R8= 10000
 C1= 0.01 uf
 C2= 0.01 uf



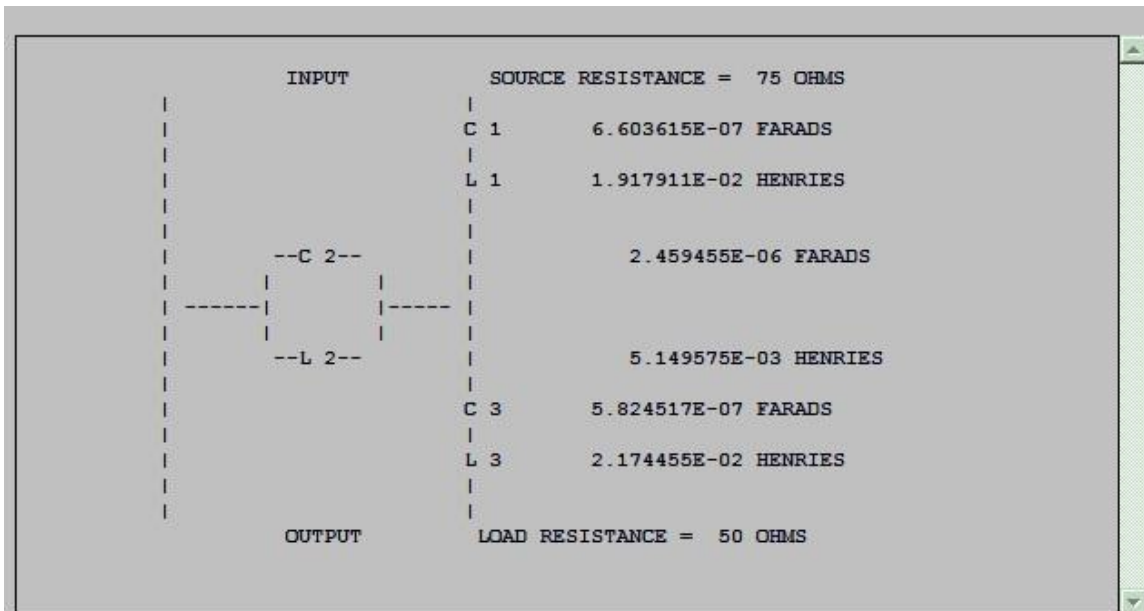
A stable differential topology for very high Q active filters.

THE QUADRATIC FUNCTION FOR STAGE 2 OF 2 IS
 $(3.924962E+07) / (1 S^2 + 3104.966 S + 3.924962E+07)$ Q= 2.01772

R1= 7133.286
 R2= 4700
 R3= 7133.286
 R4= 4700
 R5= 1596.181
 R6= 1596.181
 R7= 99121.77
 R8= 49560.88
 R9= 99121.77
 R10= 100000
 C1= 0.1 uf
 C2= 0.1 uf

Passive Filters

Available in Butterworth, Tchebyscheff, and Elliptic configurations, these filters offer the option for unequal termination, except for the elliptic. Lowpass, bandpass, bandstop, and highpass topologies are fully supported.

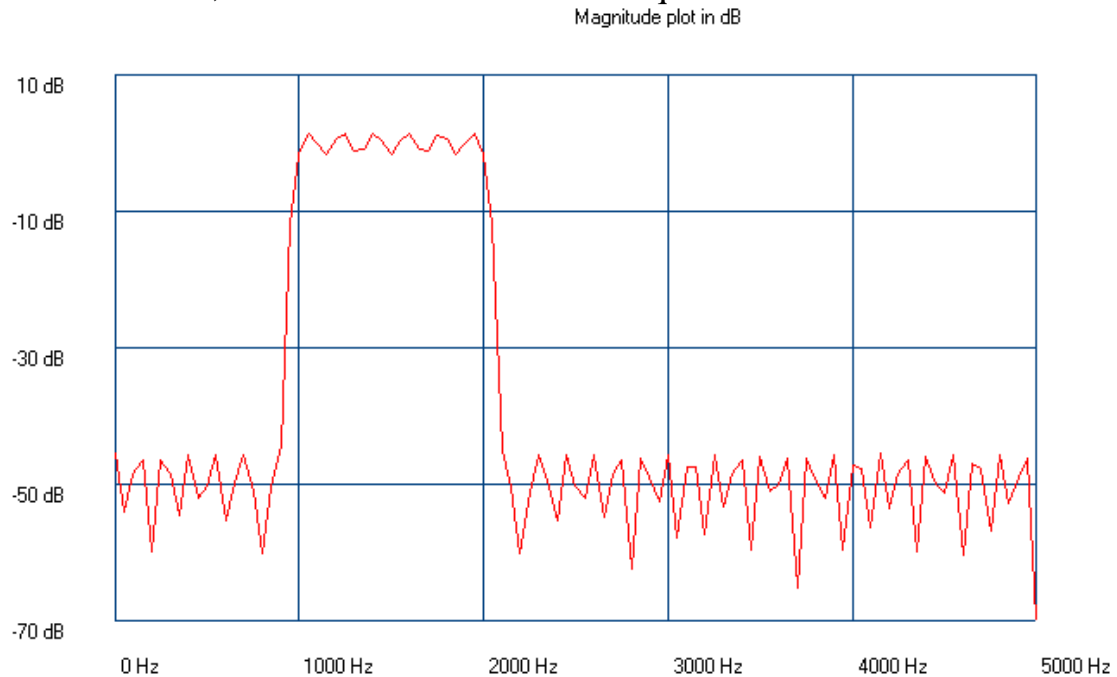


Digital Filters

Variations include

1. IIR transform of any analog filter, using the bi-linear transform
2. FIR window filters to order 512
3. FIR equiripple filters, using the Remex exchange algorithm, to order 512

For FIR filters, the post-design quantization can be changed from 32 bits, down to 4 bits, to show the effects of finite quantization.



Output graph for a 128 length Remez exchange design

For FIR window filters, the following window types are supported

- Rectangular Window
- Triangular Window
- Hamming Window
- Hanning Window
- Generalized Hamming
- Kaiser Window

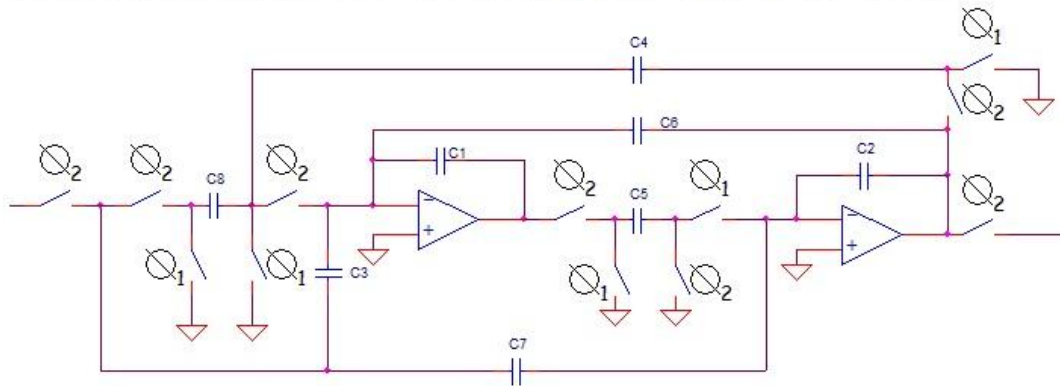
In addition to filter coefficients, all window coefficients are available and can be saved.

Switched Capacitor Filters

A single design, based on the Martin and Sedra biquad, is including in this package.

THE QUADRATIC FUNCTION FOR STAGE 1 OF 3 IS

$$(0.3859434 Z^{-2} + 0.7718867 Z^{-1} + 0.3859434) / (1 Z^{-2} + 1.472501 Z^{-1} + 1.382557)$$



C2= 3.58228E-12 C5= 2.906377E-12 C7= 1E-12
 C1= 2.932104E-12 C4= 2.378876E-12 C6= 1E-12
 C8= 0 C3= 0

Stage 1 of 3 for a Martin and Sedra switched capacitor design.

Options

1. A utility to allow for the estimation of the filter order is included.

Calculate Required Filter Order

Type Sampling Frequency In Hertz

F1

F2

Analog

Digital

Lowpass

Bandpass

Bandstop

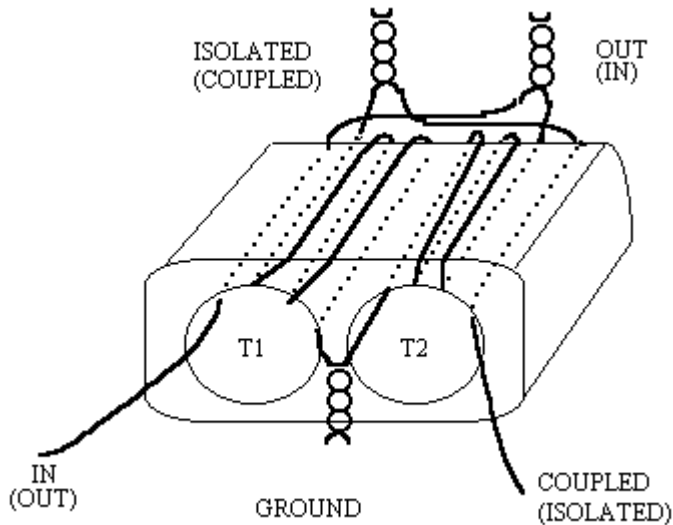
Highpass

Maximum Passband Attenuation In dB

Minimum Stopband Attenuation In dB

REQUIRED IIR BUTTERWORTH ORDER	= 98.28593	USE ORDER = 99
REQUIRED IIR TCHEBYSCHIEFF I ORDER	= 19.48171	USE ORDER = 20
REQUIRED IIR TCHEBYSCHIEFF II ORDER	= 19.48171	USE ORDER = 20
REQUIRED IIR ELLIPTIC FILTER ORDER	= 7.614478	USE ORDER = 8
EQUI RIPPLE FIR FILTER LENGTH	= 173	ESTIMATED WORD LENGTH = 16

2. RF directional coupler design utility can be used to determine the number of turns for a given coupling loss.



3. Image parameter designs, based on techniques from the 1930s, are included.

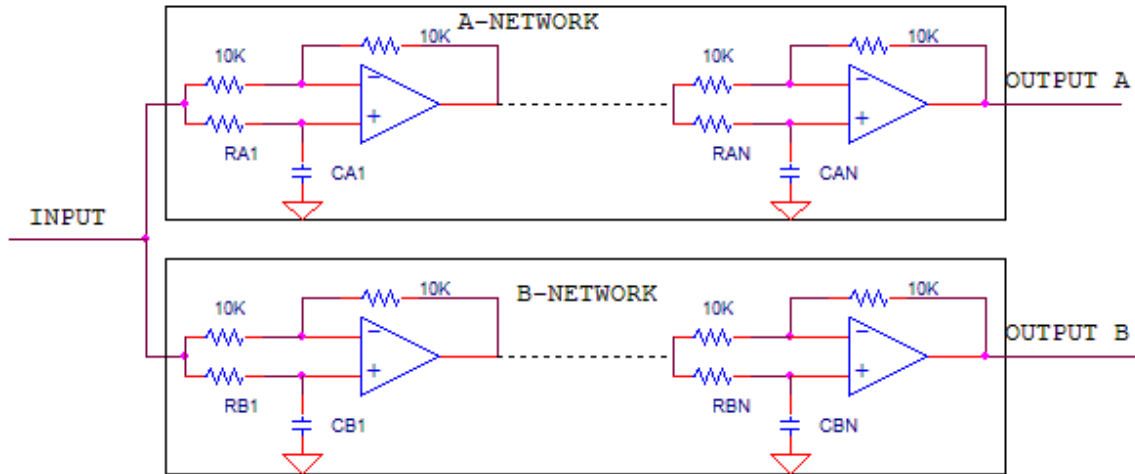
The screenshot shows a software window titled "Image Parameter" with a subtitle "Image Parameter Filter Design: (C) Copyright Ellis Electronics, Inc.". The interface includes several radio button options for filter types and shunt/series configurations, along with input fields for design parameters.

<input checked="" type="radio"/> Lowpass	Number Of Constant-K T Sections (1-20)	<input type="text"/>
<input type="radio"/> Bandpass	Number Of M-Derived T Sections (0-5)	<input type="text"/>
<input type="radio"/> Bandstop	Type Cutoff Frequency In Hz	<input type="text"/>
<input type="radio"/> Highpass		
<input checked="" type="radio"/> Shunt	Type Terminating Resistances In Ohms	<input type="text"/>
<input type="radio"/> Series		

Buttons at the bottom: Calculate, Clear, Return To Main Menu

4. For the 90 degree phase splitters for active network, data can be entered in terms of a) order of each section, or b) required dB sideband rejection, or c) maximum allowed phase deviation from 90 degrees.

THIS PROGRAM SYNTHESIZES TWO ALL-PASS NETWORKS SUCH THAT FOR A GIVEN INPUT, THE OUTPUTS TRACK WITH A CONSTANT 90 DEGREE PHASE DIFFERENCE. THESE TWO NETWORKS WILL BE DENOTED AS A-NETWORK & B-NETWORK.

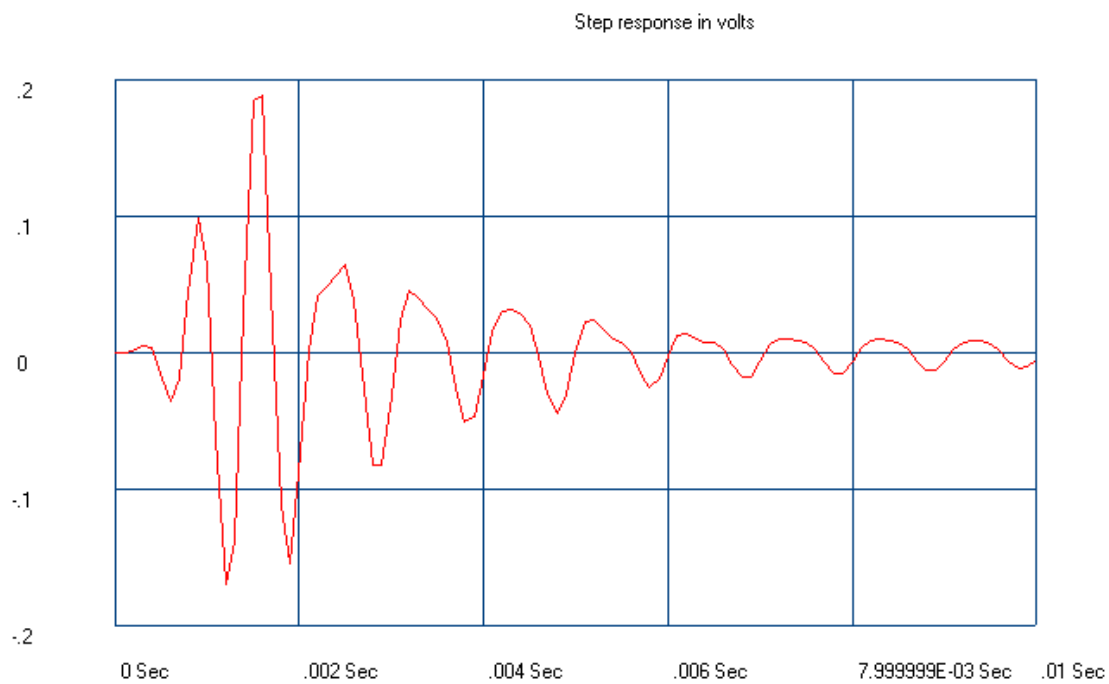


5. An experiment group delay equalizer is being developed, and is in the Beta testing stage. This option currently only determines the equalizer poles and zeroes for active lowpass filters. Linearized Newton method is used for equiripple approximation. The follow graph shows the group delay of a 7th order Tchebyscheff lowpass filter when cascaded with 12th order group delay equalizer.



Group delay equalization of 7th order Tchebyscheff lowpass.

6. Inverse Laplace transforms can be obtained on any analog filter up to order 12. These include the time domain output for either impulse, or step, response in equation, and graphical form. An example step function response is given below. The analytical equations used to plot this step response follow the graph.



Partial Fraction Expansion / Inverse Laplace Transforms

Step Response Calculation

The Degree of the Numerator = 5

The Degree of the Denominator = 10

The NORMALIZED Numerator Coefficients Are

S^0 0

S^1 0

S^2 0

S^3 0

S^4 0

S^5 .1228267

The NORMALIZED Denominator Coefficients Are

S⁰ 32
S¹ 14.98912
S² 93.51053
S³ 33.87583
S⁴ 101.4269
S⁵ 26.50409
S⁶ 50.71343
S⁷ 8.468957
S⁸ 11.68882
S⁹ .9368201
S¹⁰ 1

THE DENOMINATOR TERMS IN THE PARTIAL FRACTION
EXPANSION ARE

S + 0
S² + 376.2989 S + 3.972809E+07
S² + 1159.41 S + 5.132221E+07
S² + 1818.94 S + 7.895683E+07
S² + 1783.698 S + 1.214714E+08
S² + 747.868 S + 1.569213E+08

THE RECONSTRUCTED DENOMINATOR COEFFICIENTS ARE

0	S ⁰
32	S ¹
14.98912	S ²
93.51053	S ³
33.87583	S ⁴
101.4269	S ⁵
26.50409	S ⁶
50.71343	S ⁷
8.468957	S ⁸
11.68882	S ⁹
.9368201	S ¹⁰
1	S ¹¹

THE RESPECTIVE RESIDUES ARE

7.836823E-03
-237.9758S + 1948271
373.4926S + -7118877
-.8486907S + 1.258984E+07
-372.3636S + -1.160822E+07
237.6878S + 4044475

THE ERROR IN THE PARTIAL FRACTION EXPANSION IS

1.636595E-11 %

Time In Seconds For Time Domain Evaluation = .01

THE TIME DOMAIN FUNCTION FOR $t > 0$ IS

1.247269E-06*e^(0*t)
-3.787503E-02*e^(-188.1494*t)*COS(6300.213*t)+.050348*e^(-
188.1494*t)*SIN(6300.213*t)
5.944319E-02*e^(-579.7048*t)*COS(7140.458*t)+-.1634998*e^(-
579.7048*t)*SIN(7140.458*t)
-1.350733E-04*e^(-909.4702*t)*COS(8839.101*t)+.2267039*e^(-
909.4702*t)*SIN(8839.101*t)
-.0592635*e^(-891.8489*t)*COS(10985.26*t)+-.163369*e^(-
891.8489*t)*SIN(10985.26*t)
3.782919E-02*e^(-373.934*t)*COS(12521.24*t)+5.027877E-02*e^(-
373.934*t)*SIN(12521.24*t)