Software Tools for Ham Radio Electronics

K8VFO

February 7, 2019

- ✓ These are all free to use
- ✓ There are many more available
- ✓ This is a quick overview of my favorites
- ✓ If interest in more detail, a more in-depth presentation can be done

Software Tools for Ham Radio Electronics

- RF Filter Design
- Impedance Matching
- Schematic and Printed Circuit Design
- Circuit Simulation
- Antenna Design
- Audio Signal Analysis
- Toroid Inductors

Software Tools for Ham Radio Electronics

RF Filter Design

- *OptLowPass Filter Designer* (Tonne Software) [Windows]
- *SVC Filter Designer* (Tonne Software) [Windows]
- *Elsie* (Tonne Software) [Windows]
- *Crystal Filter Design* (DJ6EV) [Windows]

OptLowpass

Quick and easy low pass filters for Hams

Welcome to OptLowpass !

OptLowpass

The transmitter output lowpass filter designer
for the serious radio amateur

Select one:

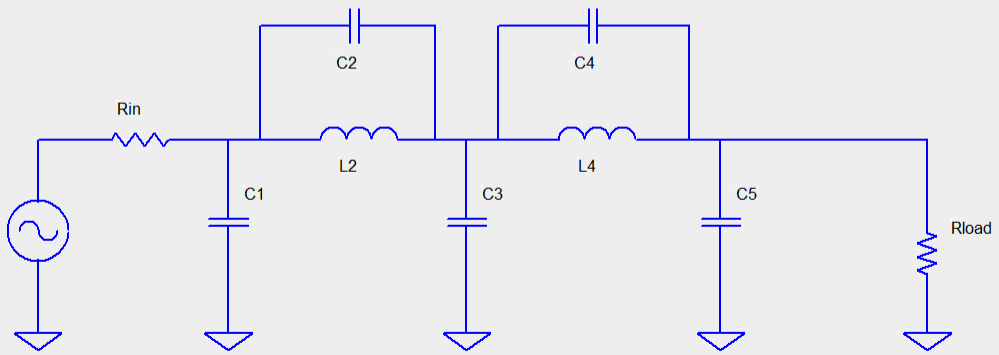
- 2 meter band
- 6 meter band
- 10 meter band
- 12 meter band
- 15 meter band
- 17 meter band
- 20 meter band
- 30 meter band
- 40 meter band
- 60 meter band
- 80 meter band
- 160 meter band
- 600 meter band
- 2200 meter band

- Last session
- Design Wizard
- Exit / End

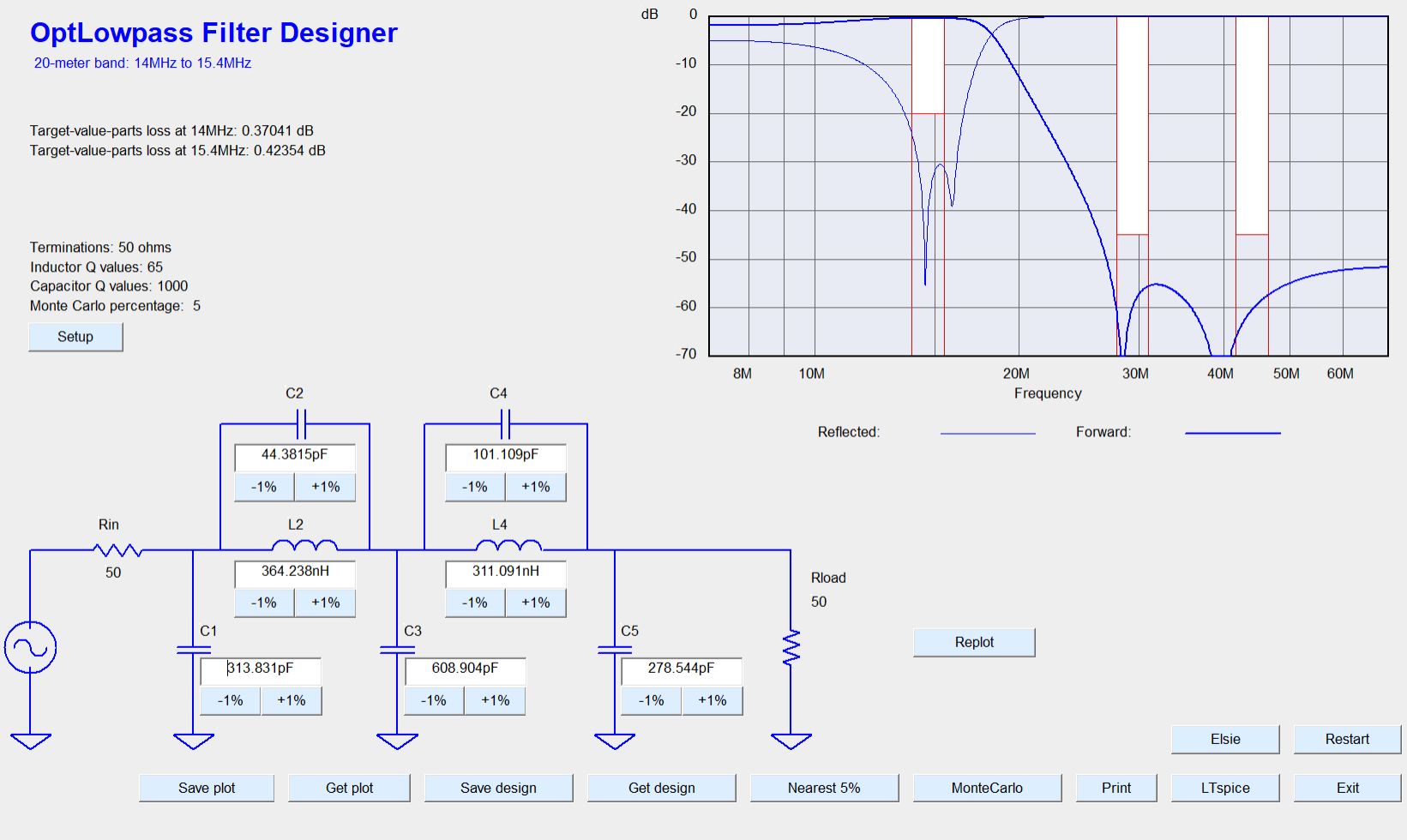
Version 2.05

www.TonneSoftware.com

This program is based on the author's article "Harmonic Filters, Improved" which was in the September/October 1998 issue of QEX, an ARRL publication.



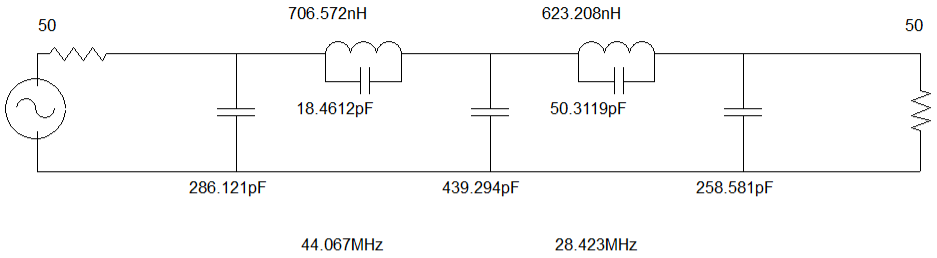
OptLowpass


OptLowpass Filter Designer
20-meter band: 14MHz to 15.4MHz
Target-value-parts loss at 14MHz: 0.37041 dB
Target-value-parts loss at 15.4MHz: 0.42354 dB
Terminations: 50 ohms
Inductor Q values: 65
Capacitor Q values: 1000
Monte Carlo percentage: 5
Setup
dB
0
-10
-20
-30
-40
-50
-60
-70
8M
10M
20M
30M
40M
50M
60M
Frequency
Reflected:
Forward:
C2
44.3815pF
-1%
+1%
C4
101.109pF
-1%
+1%
Rin
50
L2
364.238nH
-1%
+1%
L4
311.091nH
-1%
+1%
Rload
50
C1
313.831pF
-1%
+1%
C3
608.904pF
-1%
+1%
C5
278.544pF
-1%
+1%
Replot
Elsie
Restart
Save plot
Get plot
Save design
Get design
Nearest 5%
MonteCarlo
Print
LTspice
Exit

SVC Filter Designer

Quick and easy low pass and high pass filter design.

Design page



Order
- 3
- 4
- (•) 5
- 6
- 7

Bandwidth
(ripple)

Hz:
14.15MHz

Topology
- (•) C-input lowpass
- L-input lowpass
- C-input highpass
- L-input highpass

Family
- Butterworth
- Chebyshev
- (•) Cauer
- Bessel
- Tonne

Display responses

Exit

Inductor Q
- (•) Infinite
- Other

1M

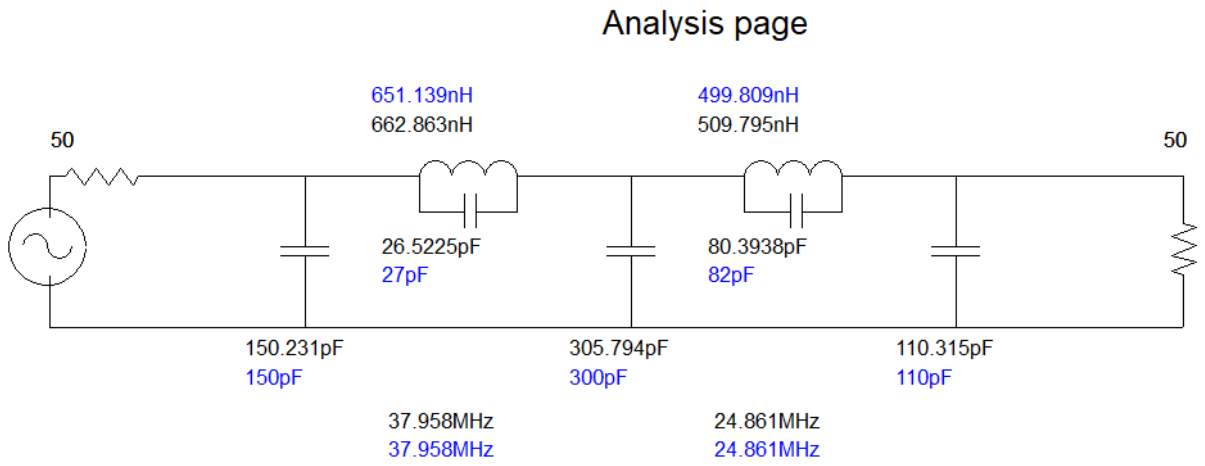
Impedance
- (•) 50 ohms
- Other

50

Passband ripple
- .01 dB (RF)
- .044 dB (RF)
- (•) .200 dB (AF)

Stopband depth
- 30 dB
- 40 dB
- 50 dB
- (•) 60 dB

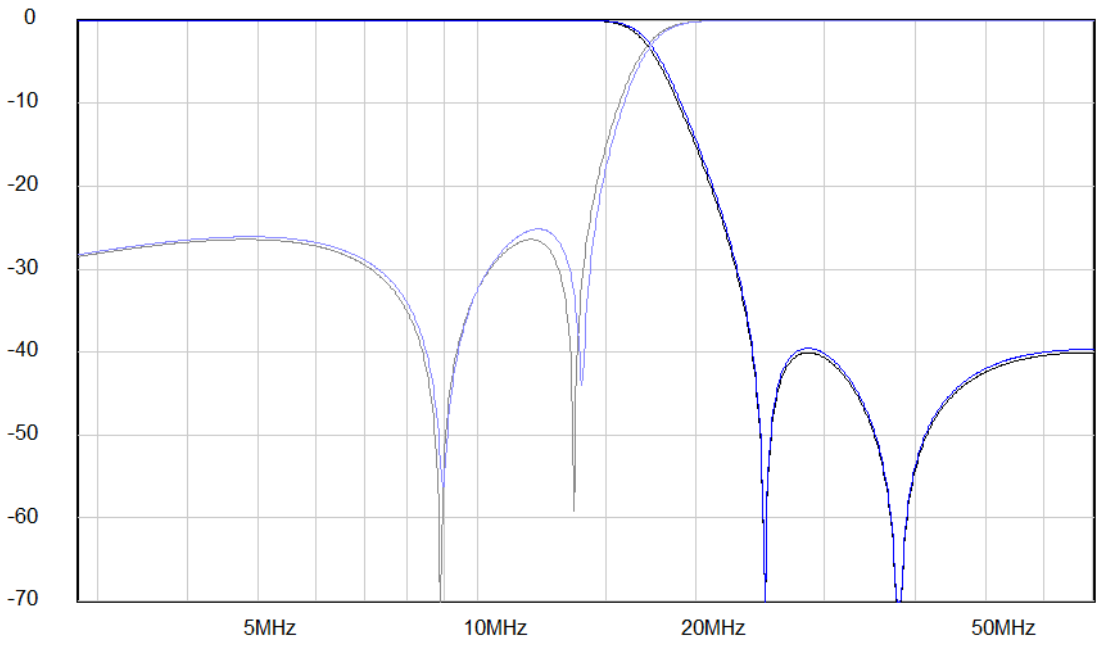
SVC Filter Designer



Transmission, dB: >
Exact values
5% C values
5% L values

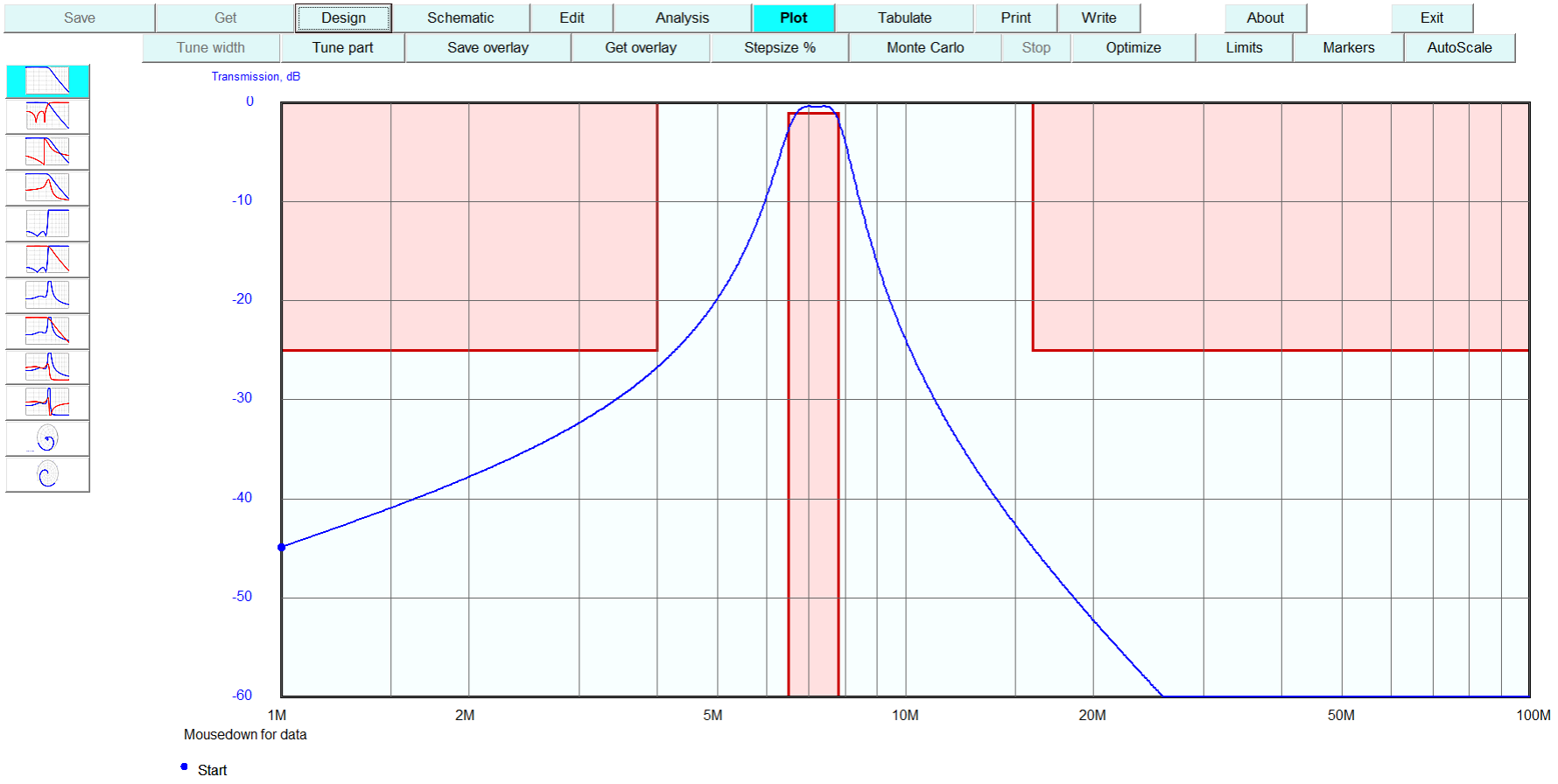
Reflection, dB: >
Exact values
5% C values
5% L values

Cursor on plot
for data readout

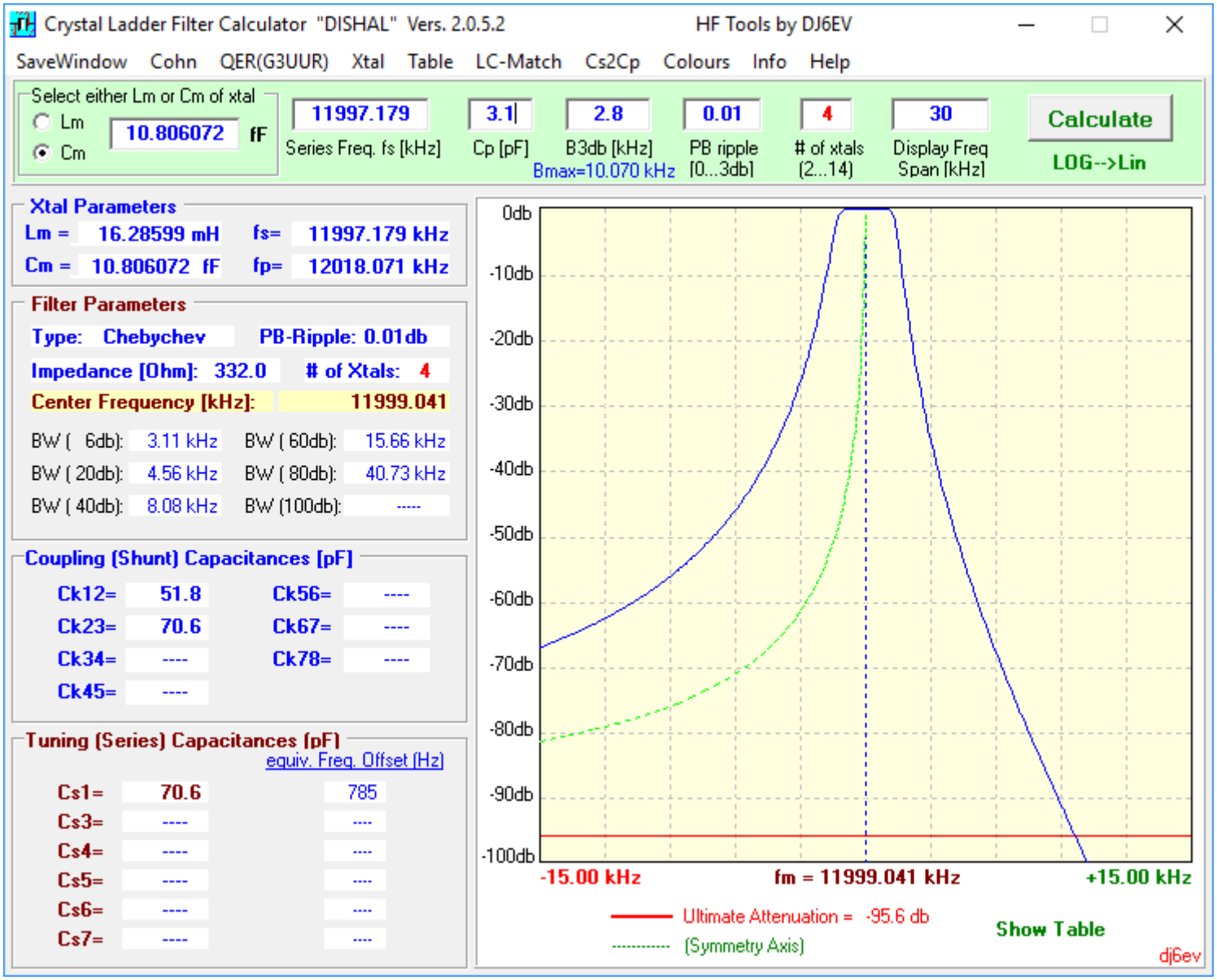


Elsie

- Powerful tool for filter design
- You set the limits, Elsie does the rest!



DISHAL Crystal Ladder Filter Calculator



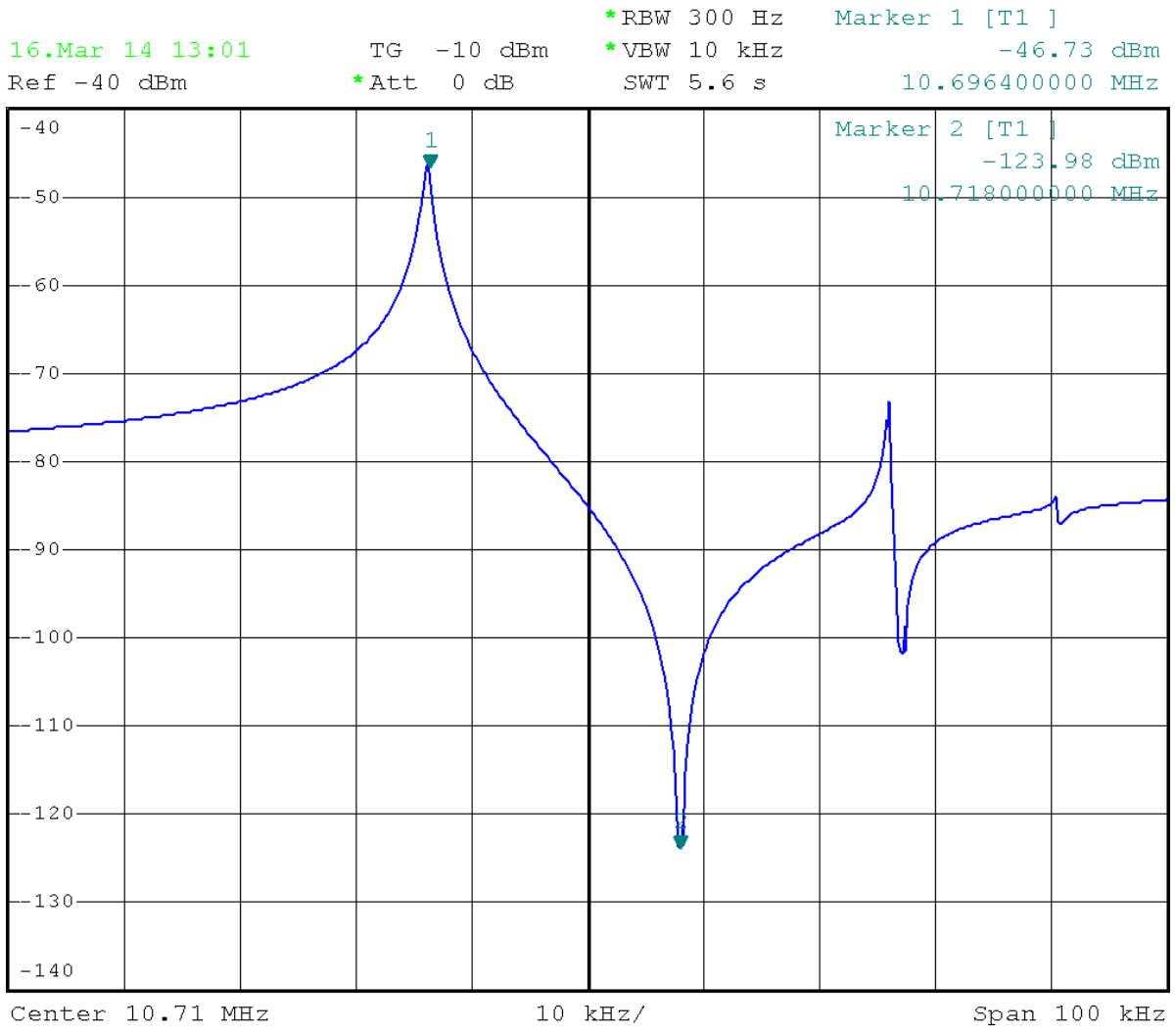
DISHAL Crystal Ladder Filter Calculator

Measure:

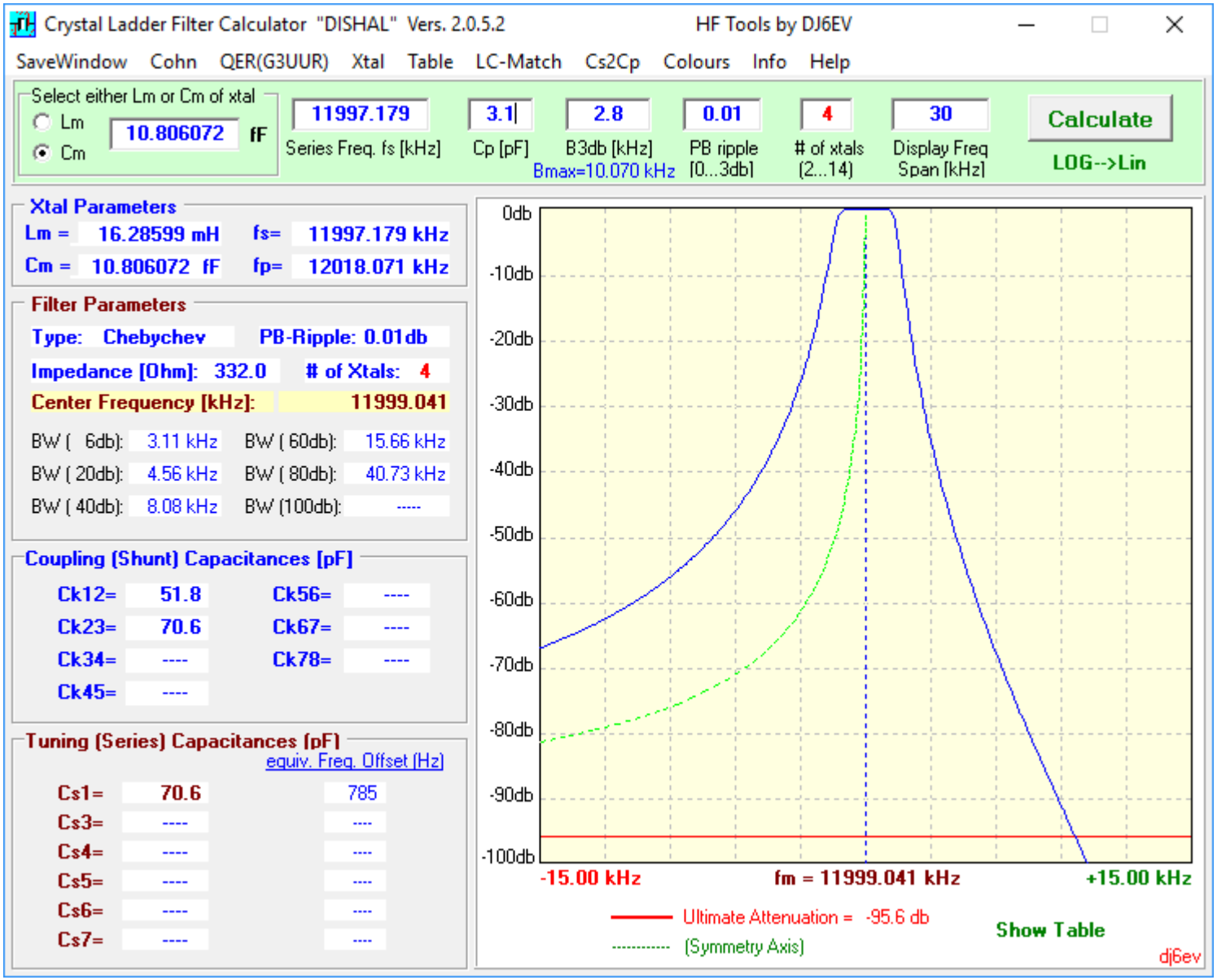
- Fs
- Fp
- 3dB BW
- Cp

Calculate:

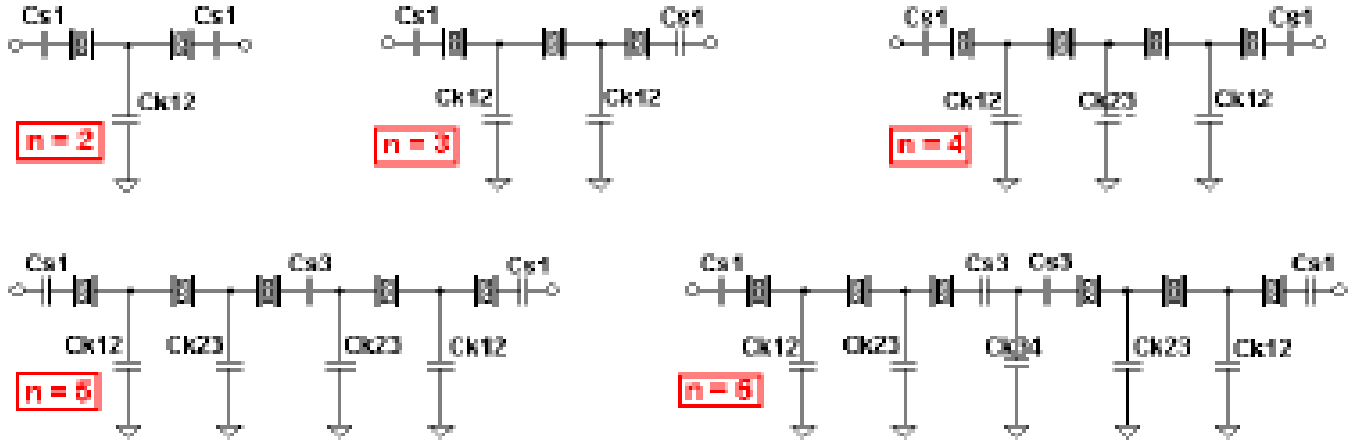
- Lm or Cm



DISHAL Crystal Ladder Filter Calculator



DISHAL Crystal Ladder Filter Calculator



Software Tools for Ham Radio Electronics

Impedance Matching

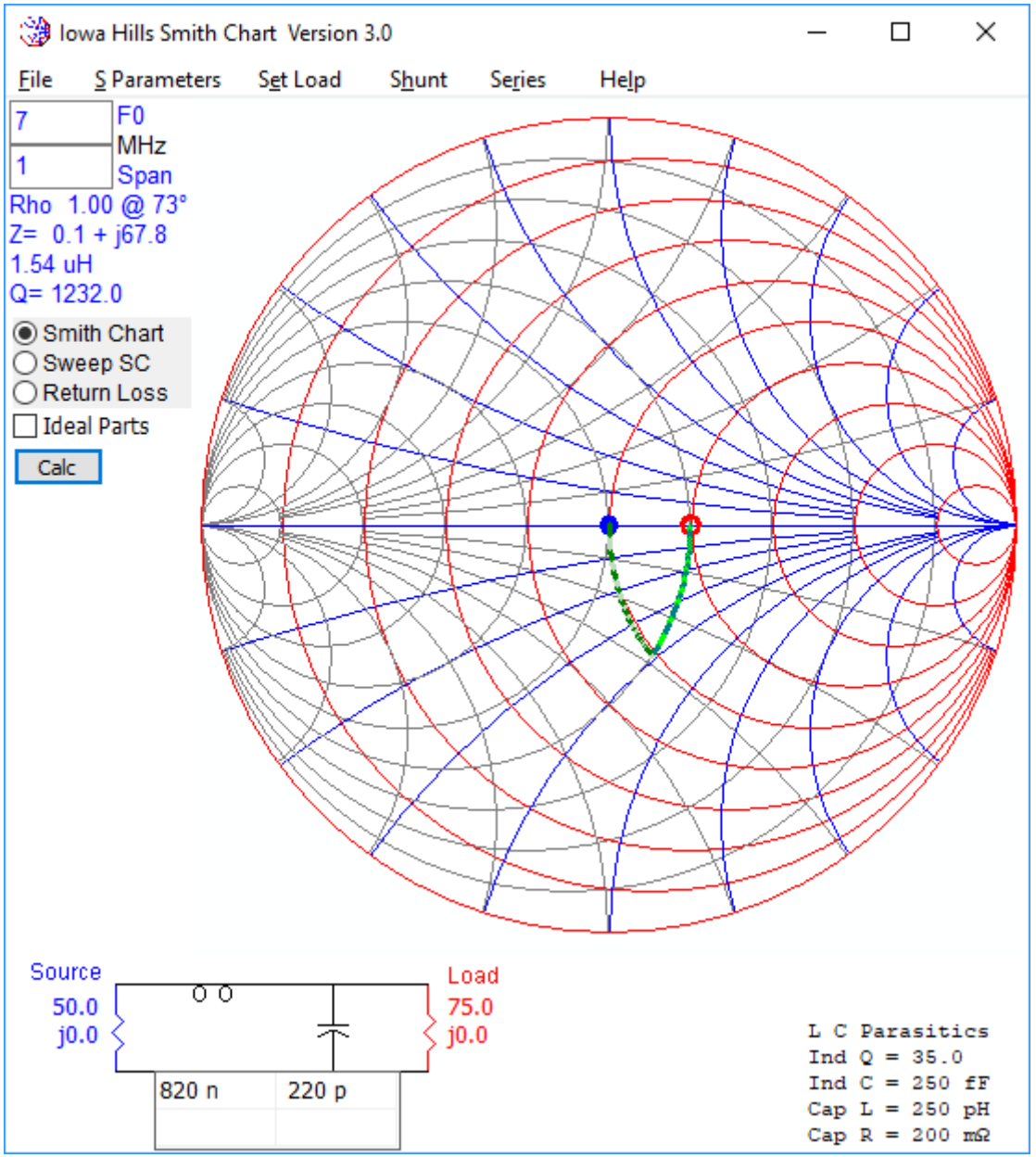
Smith Chart

- Iowa Hills Software
- Windows
- Iowa Hills Software also has some good filter design tools

Iowa Hills Smith Chart

Smith Charts can be daunting – but this tool makes it easy

Start with simple impedance matching – read help file to do more complex stuff



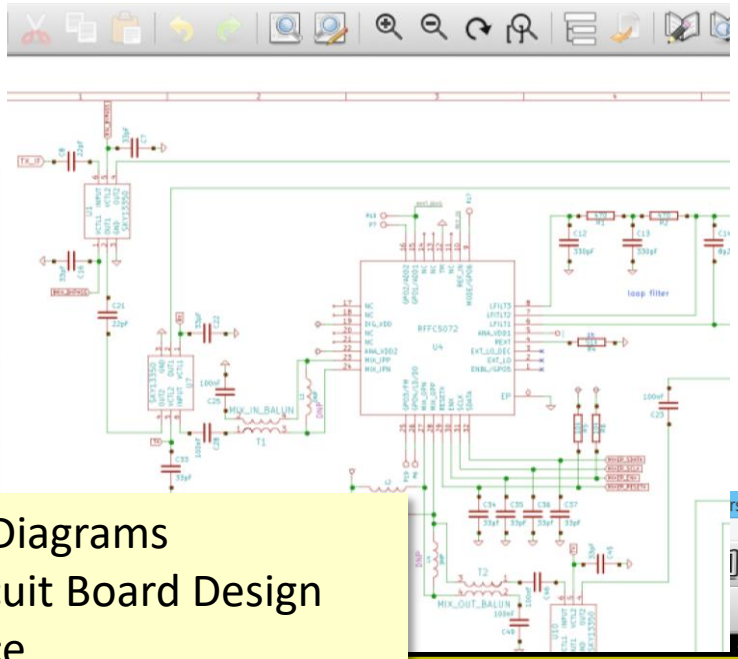
Software Tools for Ham Radio Electronics

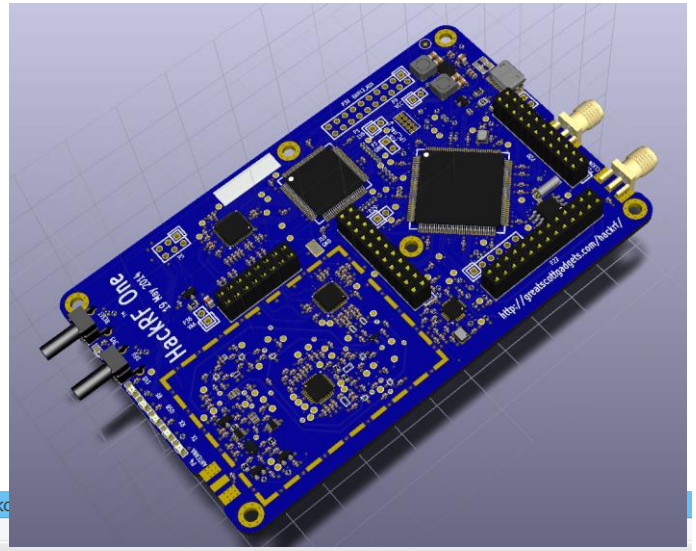
Schematic and PCB Design

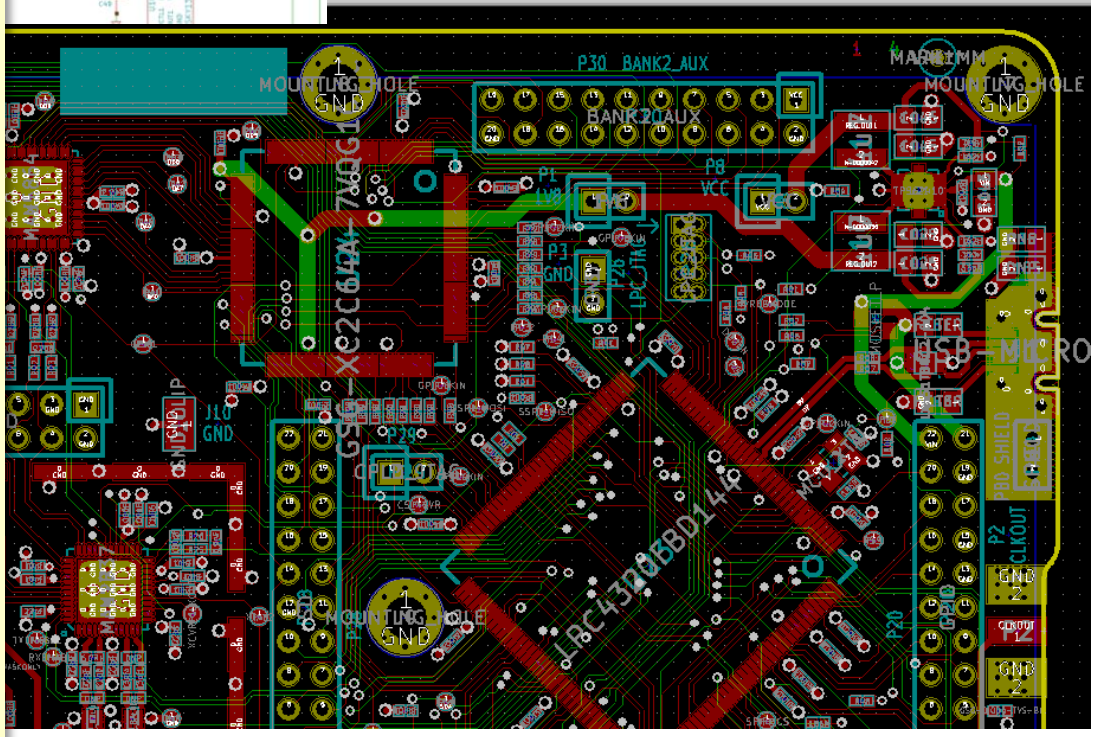
KiCad
Public License

- Windows, Linux, Mac
- Schematic Diagrams
- PCB Layout

KiCad





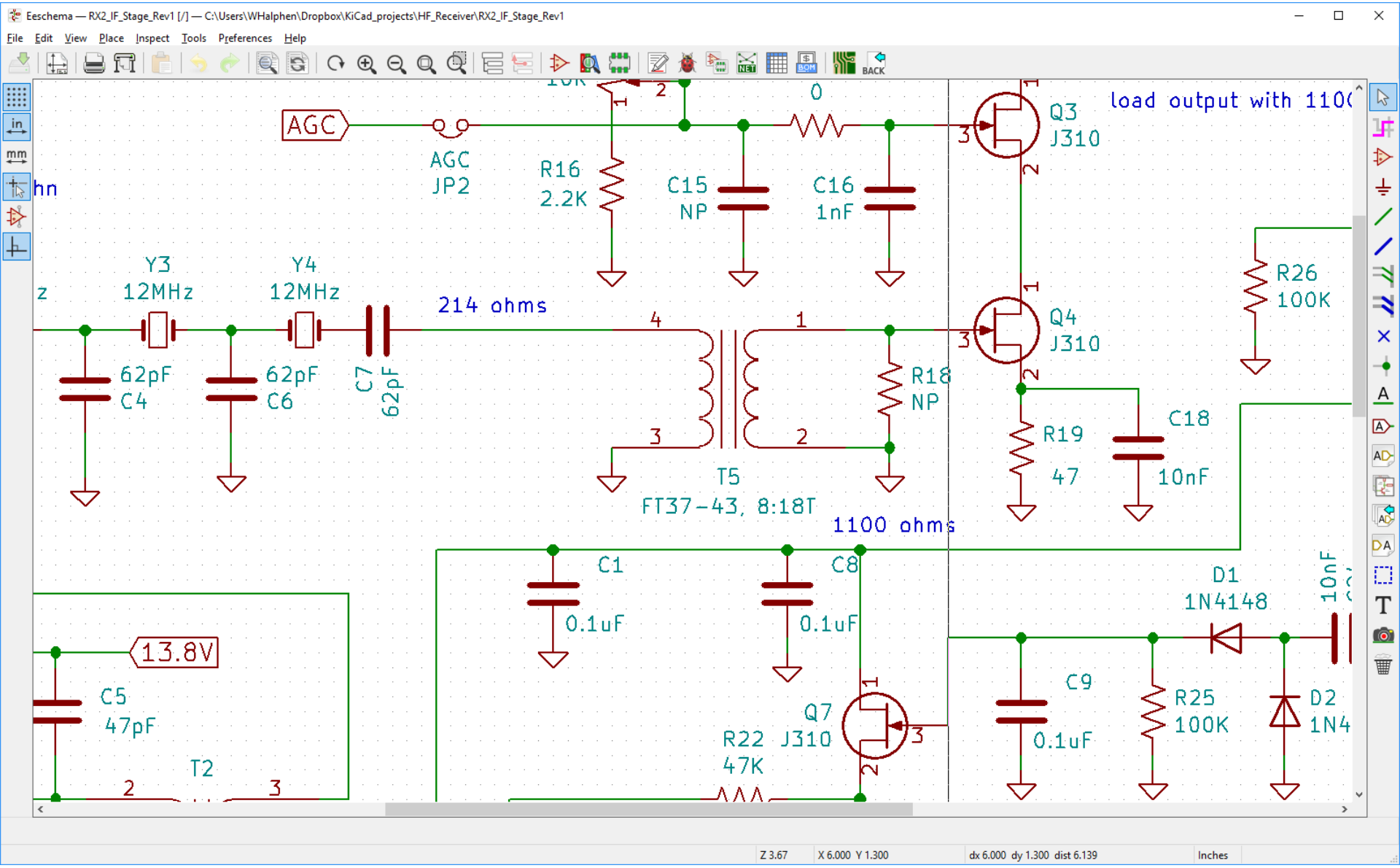


Schematic Diagrams
Printed Circuit Board Design
Open Source
Very Active Development with Major Corporate Support:

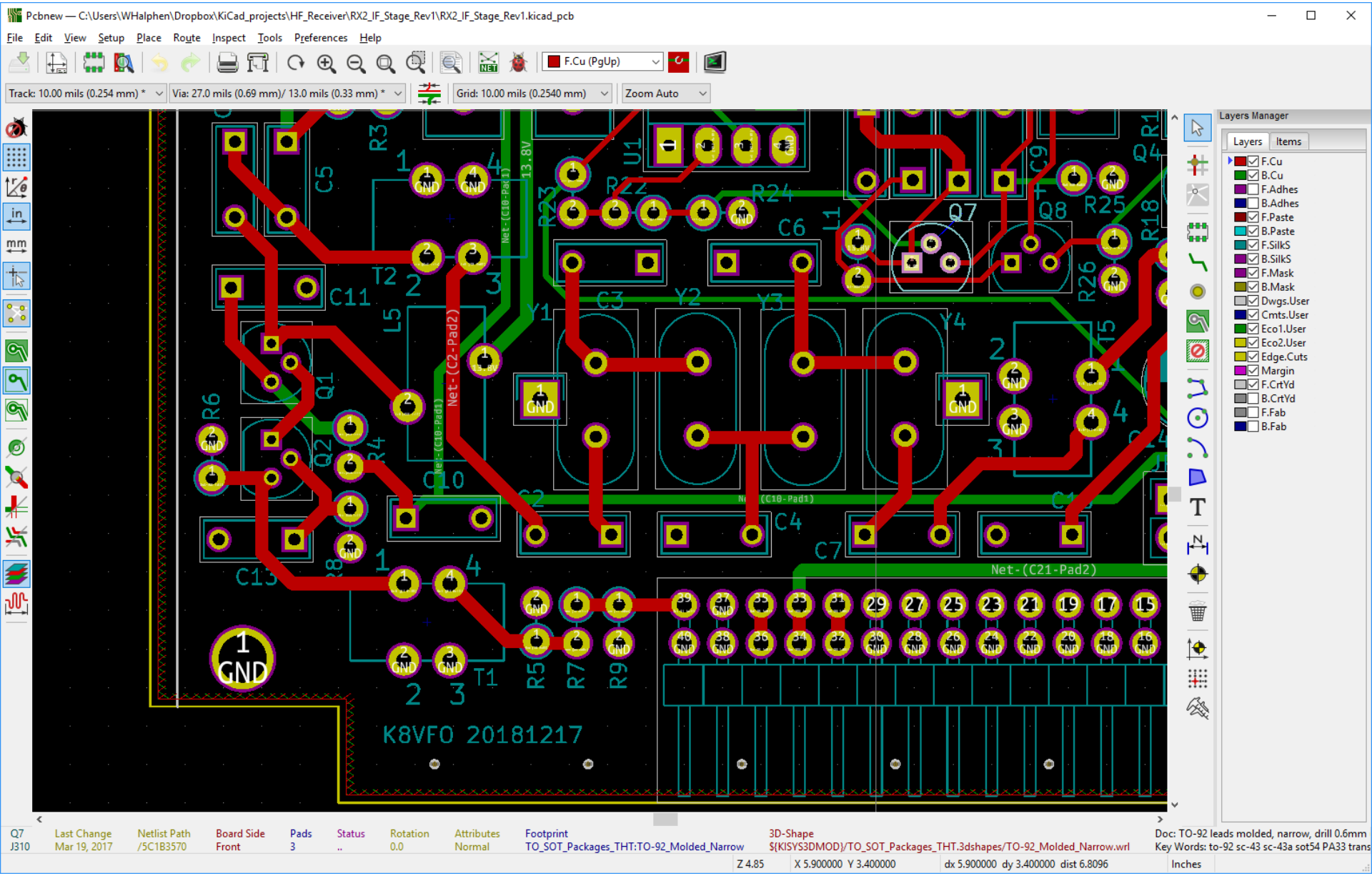
- University of Grenoble
- SoftPLC
- CERN (European Organization for Nuclear Research)
- Raspberry Pi Foundation
- Arduino LLC
- Digi-Key Electronics

Runs on Windows, Linux,

KiCad


Eeschema — RX2_IF_Stage_Rev1 [/] — C:\Users\WHalphen\Dropbox\KiCad_projects\HF_Receiver\RX2_IF_Stage_Rev1
File Edit View Place Inspect Tools Preferences Help
AGC
AGC
JP2
R16
2.2K
C15
NP
C16
1nF
0
Q3
J310
load output with 110
Y3
12MHz
Y4
12MHz
214 ohms
62pF
C4
62pF
C6
C7
62pF
T5
FT37-43, 8:18T
R18
NP
Q4
J310
R26
100K
R19
47
C18
10nF
1100 ohms
C1
0.1uF
C8
0.1uF
D1
1N4148
13.8V
C5
47pF
T2
Q7
J310
R22
47K
C9
0.1uF
R25
100K
D2
1N4
Z 3.67
X 6.000 Y 1.300
dx 6.000 dy 1.300 dist 6.139
Inches

KiCad


Pcbnew — C:\Users\WHalphen\Dropbox\KiCad_projects\HF_Receiver\RX2_IF_Stage_Rev1\RX2_IF_Stage_Rev1.kicad_pcb
File Edit View Setup Place Route Inspect Tools Preferences Help
F.Cu (PgUp)
Track: 10.00 mils (0.254 mm) *
Via: 27.0 mils (0.69 mm)/ 13.0 mils (0.33 mm) *
Grid: 10.00 mils (0.2540 mm)
Zoom Auto
Layers Manager
Layers
Items
F.Cu
B.Cu
F.Adhes
B.Adhes
F.Paste
B.Paste
F.SilkS
B.SilkS
F.Mask
B.Mask
Dwgs.User
Cmts.User
Eco1.User
Eco2.User
Edge.Cuts
Margin
F.CrtYd
B.CrtYd
F.Fab
B.Fab
Net-(C21-Pad2)
K8VFO 20181217
Q7
J310
Last Change
Mar 19, 2017
Netlist Path
/5C1B3570
Board Side
Front
Pads
3
Status
Rotation
0.0
Attributes
Normal
Footprint
TO_SOT_Packages_THT:TO-92_Molded_Narrow
3D-Shape
${KISYS3DMOD}/TO_SOT_Packages_THT.3dshapes/TO-92_Molded_Narrow.wrl
Doc: TO-92 leads molded, narrow, drill 0.6mm
Key Words: to-92 sc-43 sc-43a sot54 PA33 trans
Z 4.85
X 5.900000 Y 3.400000
dx 5.900000 dy 3.400000 dist 6.8096
Inches

Software Tools for Ham Radio Electronics

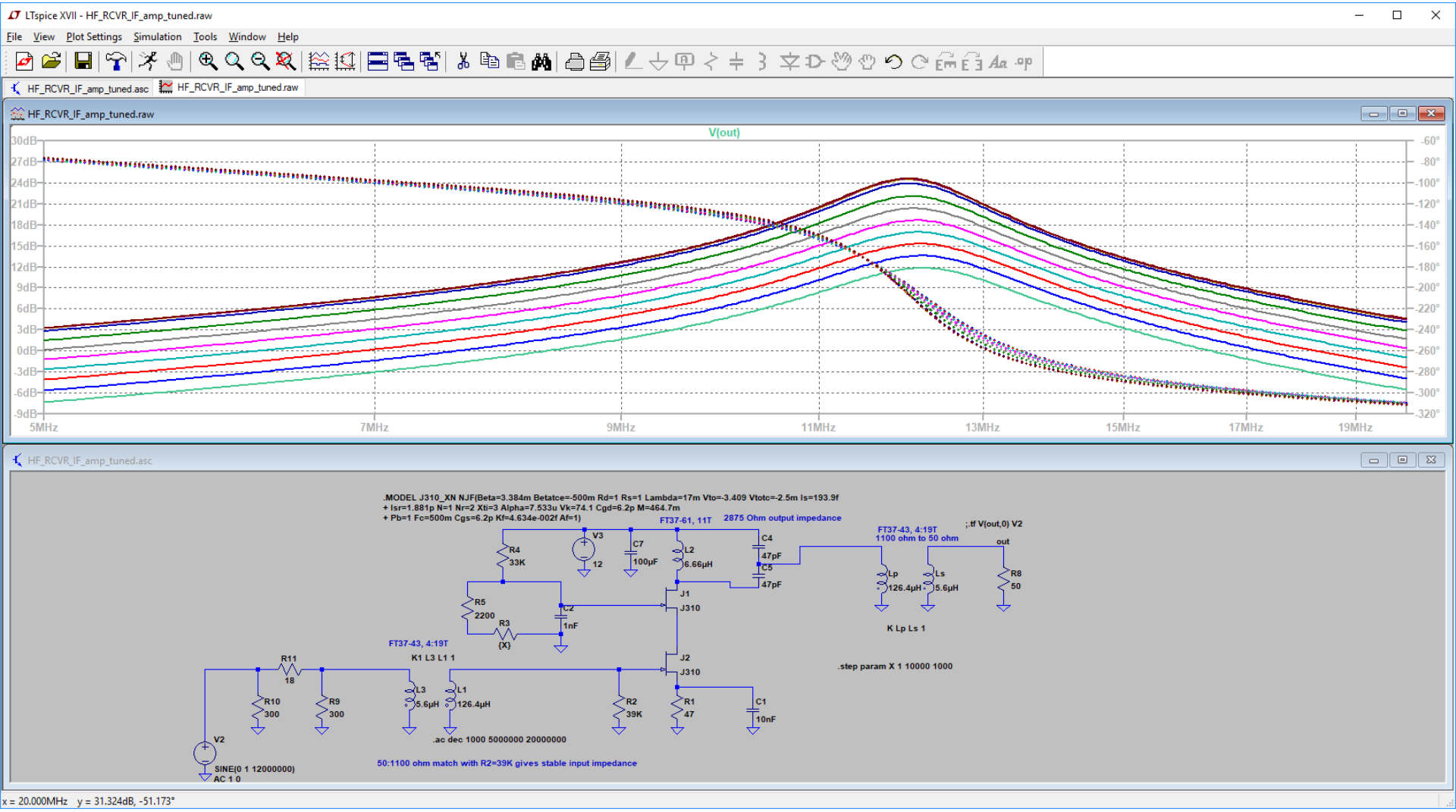
Circuit Simulation

LTspice
Linear Technology Corporation (owned by Analog Devices)
Windows, Linux, Mac

- Circuit Simulation

LTspice

Circuit simulation tool



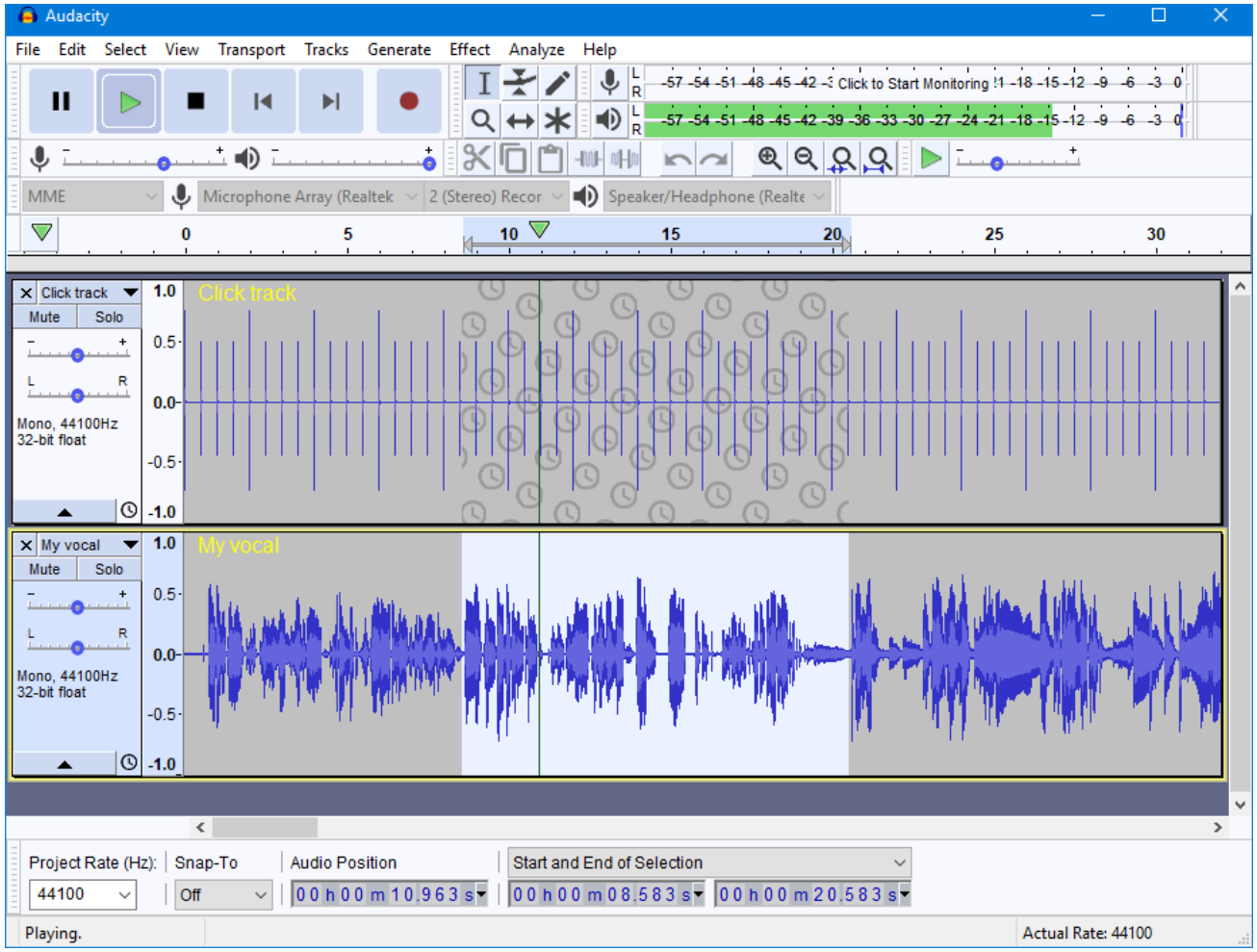
Software Tools for Ham Radio Electronics

Audio Analysis

Audacity
Public License
Windows, Linux, Mac

- Audio Recording
- Audio Editing
- Audio Analysis

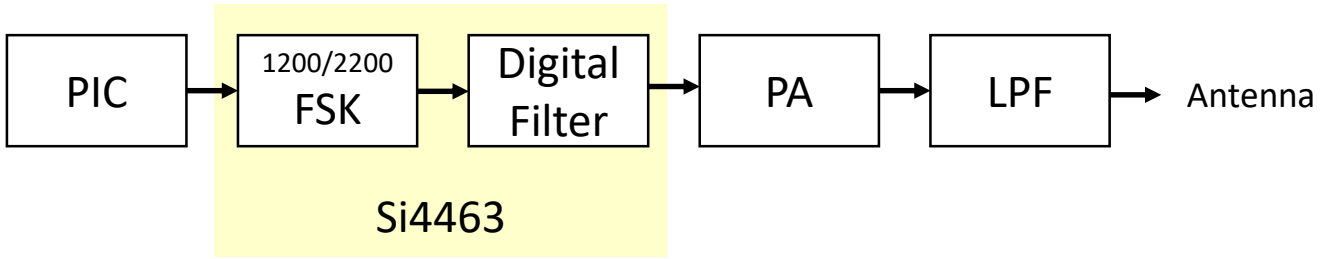
Audacity – audio recording, editing, and analysis



- recording and evaluating demodulated signals
- digital signal investigation
- audio spectrum analysis
- see what you sound like, tweak your audio stages

Example use of Audacity

- during design of a Finite Impulse Response Digital Filter
- for 1200 baud RF modem
- to use AX.25 in an APRS transmitter



- repurpose the digital filter in a Si446x ISM transmitter chip for APRS
- APRS uses Bell 202 1200 baud modem standard
- Audio-FSK using 1200 Hz and 2200 Hz tones

➔ need pre-emphasis on the 2200 Hz tone

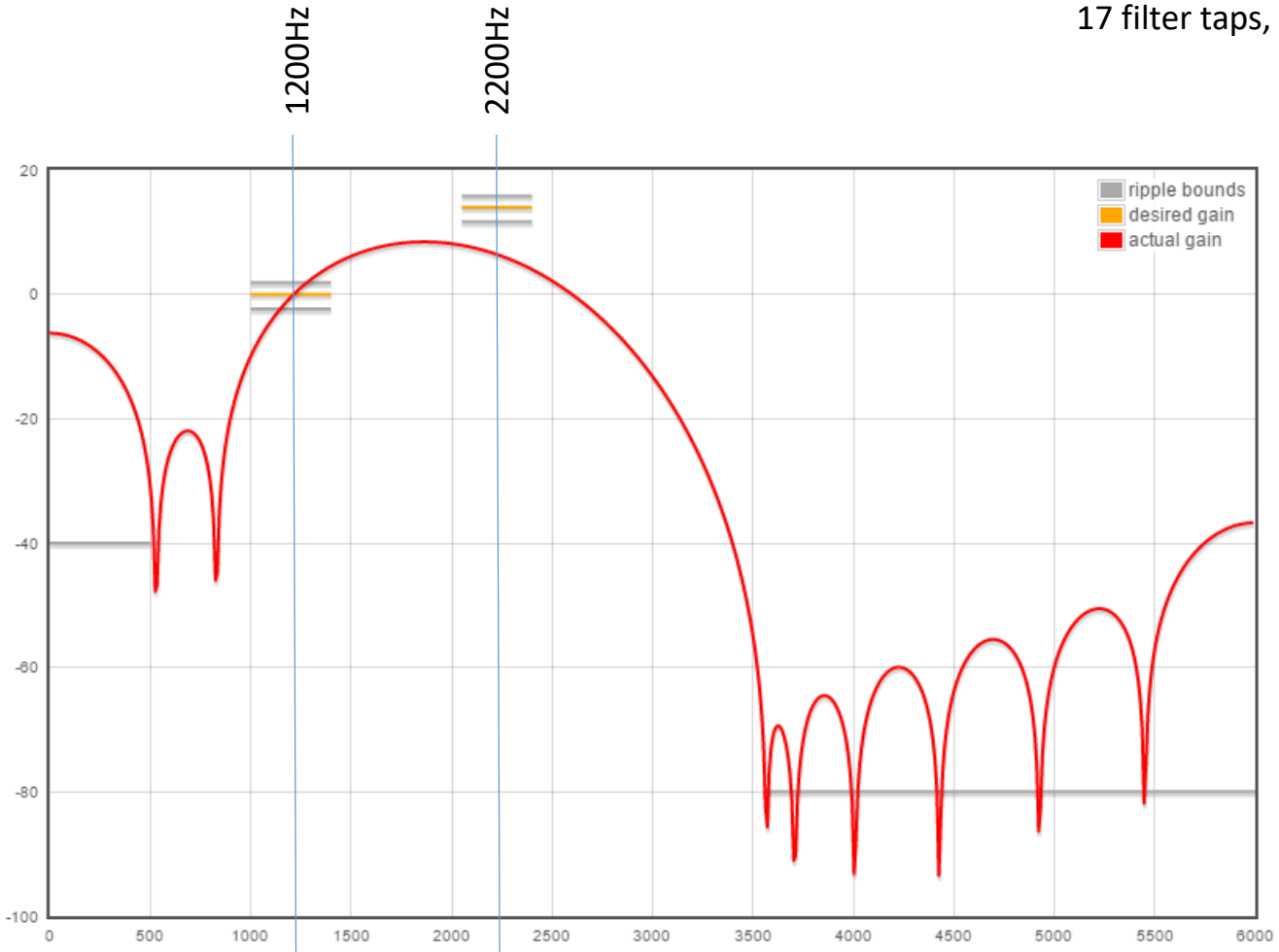
➔ need smooth transition between tones – no discontinuities

➔ attenuate audio harmonics

- digital filter defined by nine numbers feeding into the filter algorithm
- how to evaluate the results? look at the received/ demodulated waveform

Finite Impulse Response Filter Design for Si446x Transmitter

Alternative: 12KHz sample rate,
17 filter taps, 2BPF response



sampling frequency: 12000 Hz

* 0 Hz - 500 Hz
  gain = 0
  desired attenuation = -40 dB
  actual attenuation = -6.25

* 1000 Hz - 1400 Hz
  gain = 1
  desired ripple = 5 dB
  actual ripple = 14.5

* 2050 Hz - 2400 Hz
  gain = 5
  desired ripple = 5 dB
  actual ripple = 10

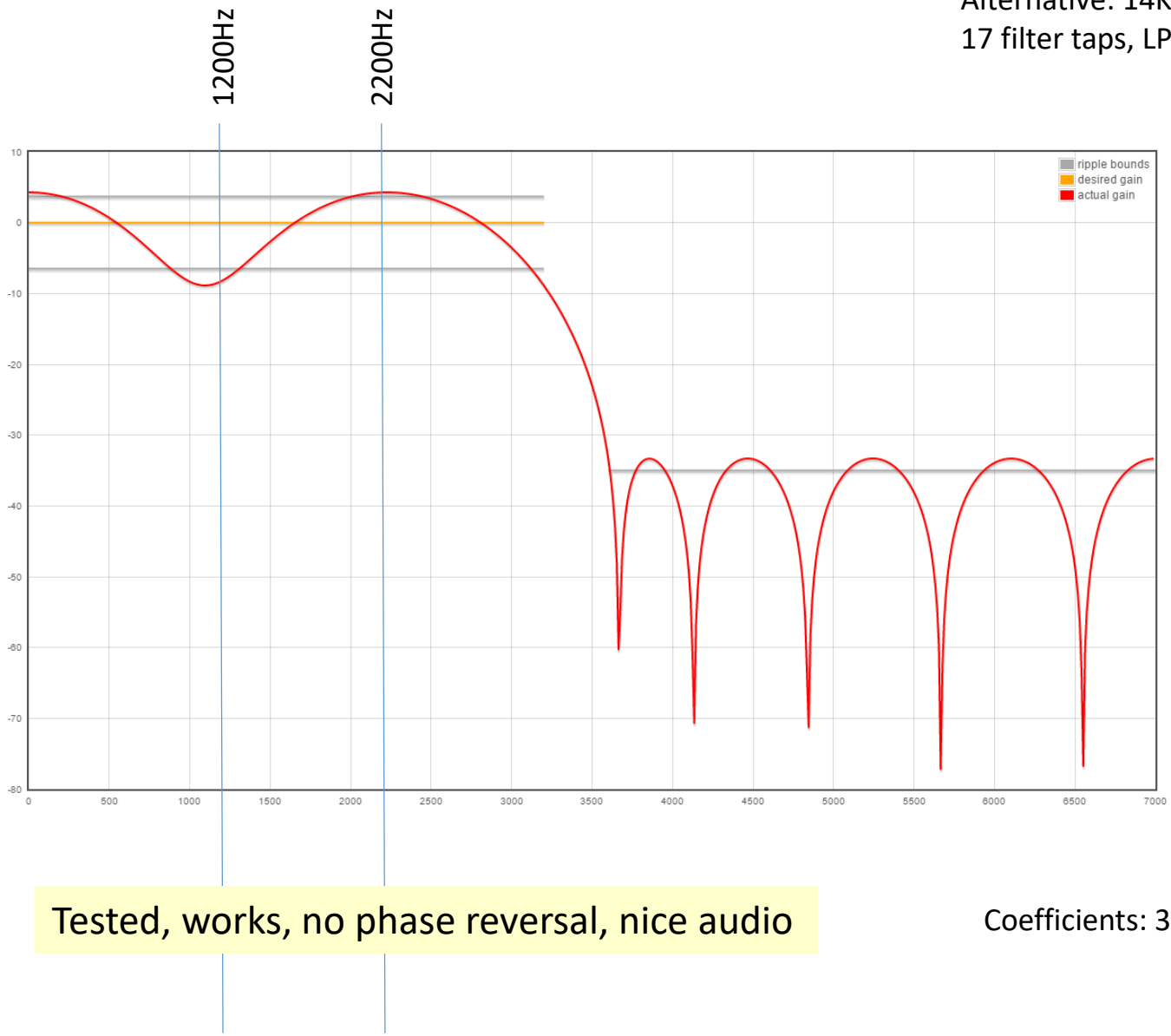
* 3550 Hz - 6000 Hz
  gain = 0
  desired attenuation = -80 dB
  actual attenuation = -36.7

Coefficients: 9, 30, 48, 22, -50, -99, -46, 76, 142

Phase reversal issue

Finite Impulse Response Filter Design for Si446x Transmitter

Alternative: 14KHz sample rate,
17 filter taps, LPF response



sampling frequency: 14000 Hz

* 0 Hz - 3200 Hz
  gain = 1
  desired ripple = 10 dB

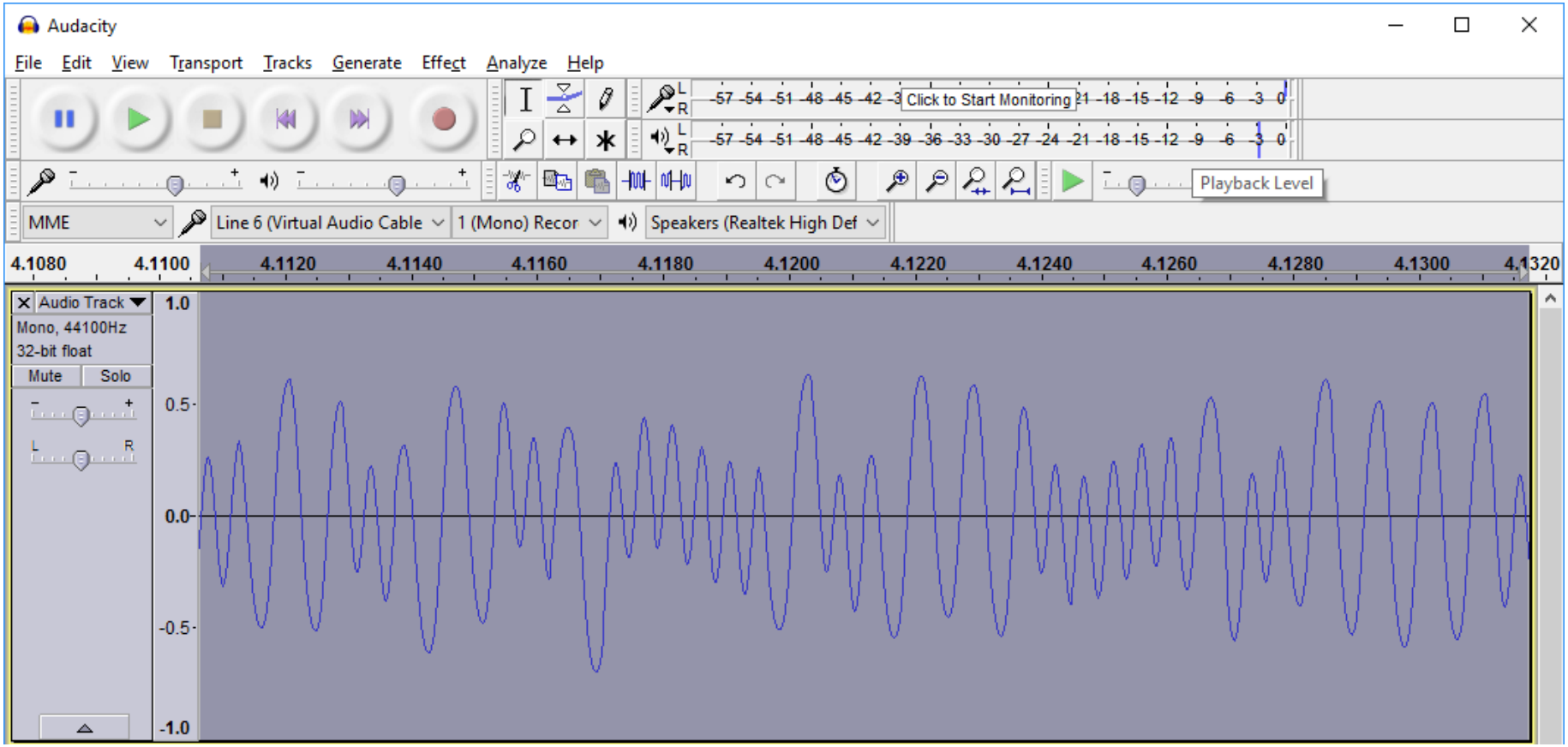
* 3600 Hz - 7000 Hz
  gain = 0
  desired attenuation = -35 dB

Tested, works, no phase reversal, nice audio

Coefficients: 3,24,42,32,-9,-33,5,83,123

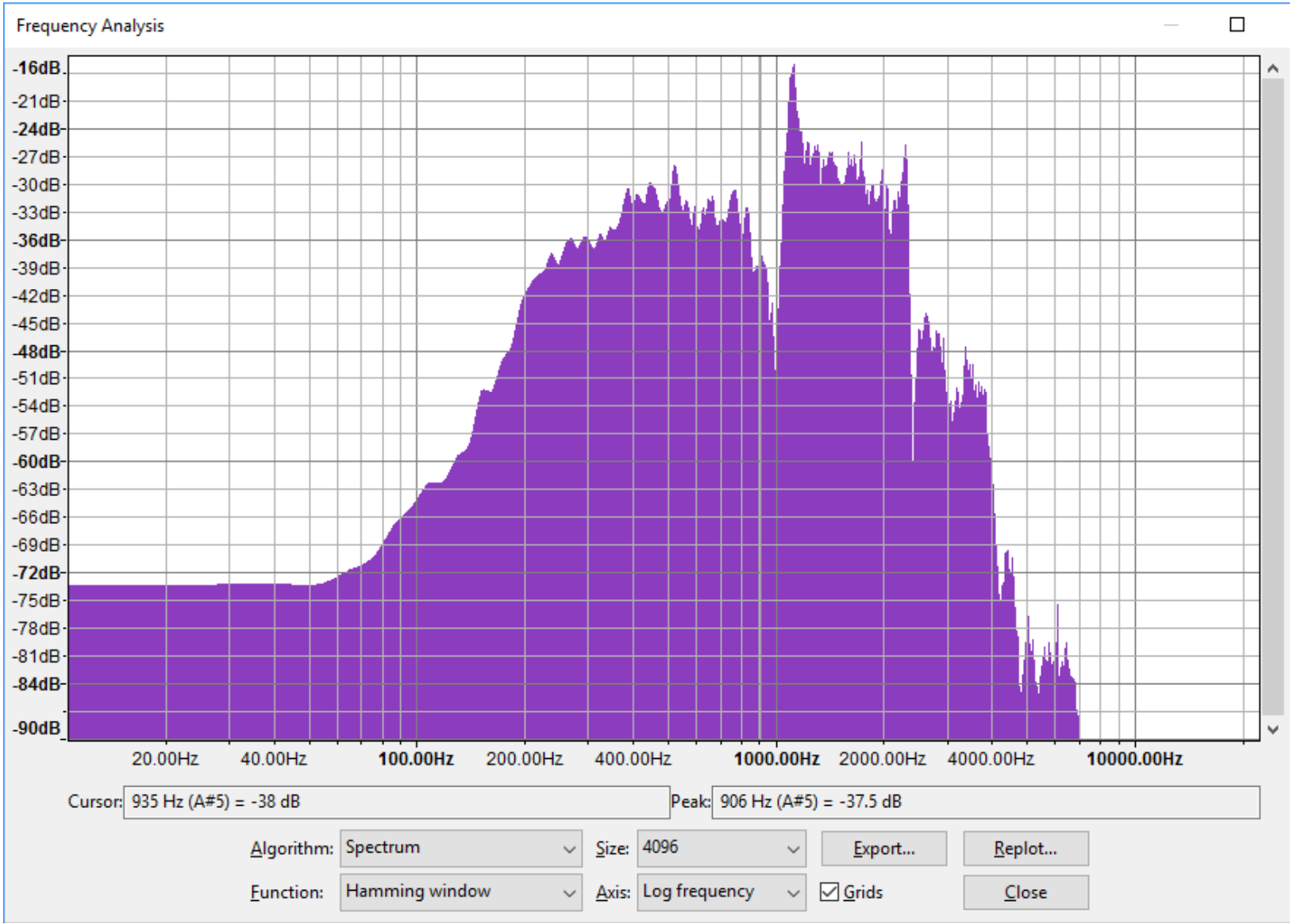
Si4463 with adjusted FIR filter – 1200 baud modem

Waveform of receiver output of FLEX 1500 and transverter



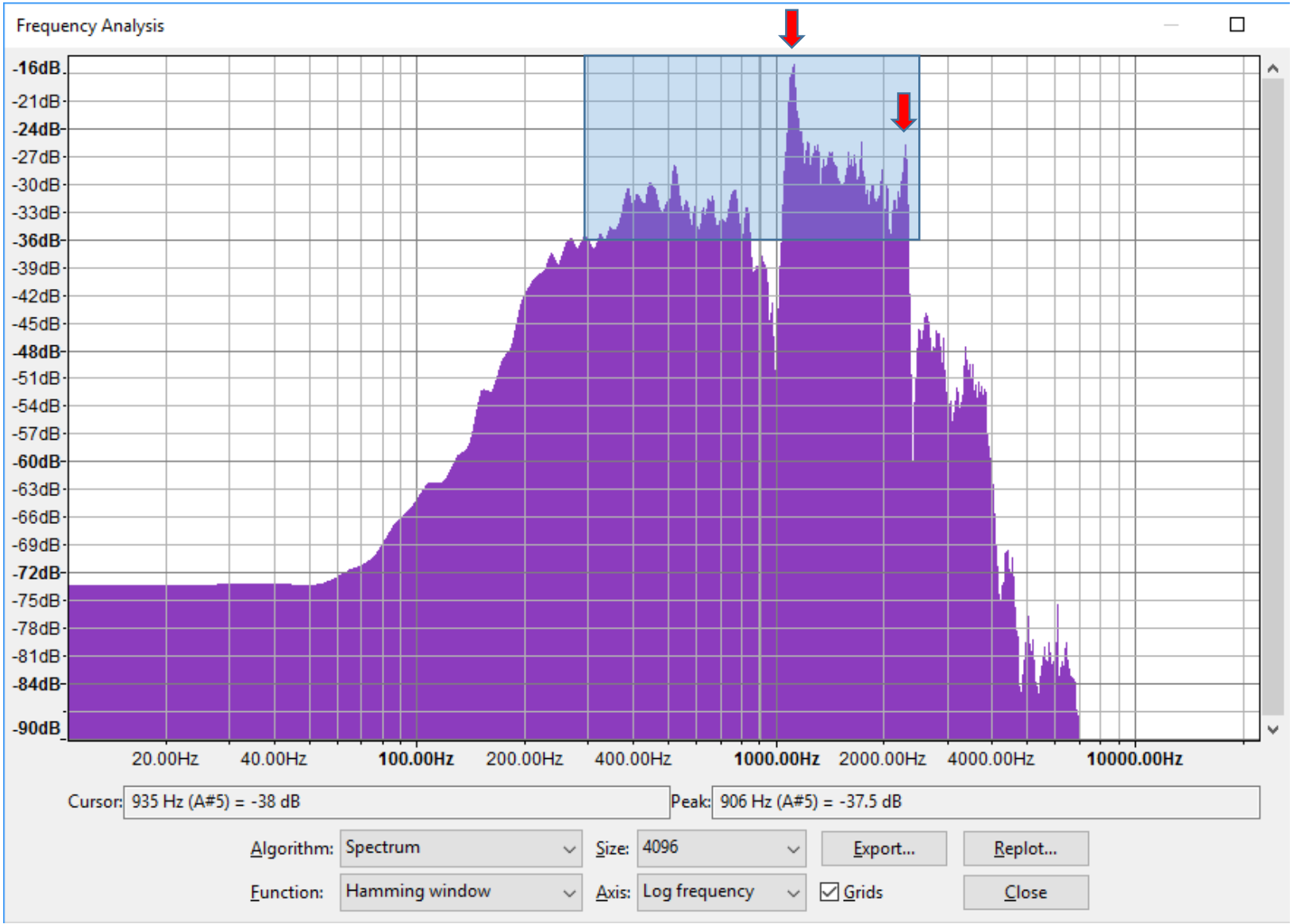
Si4463 with adjusted FIR filter – 1200 baud modem

Spectral analysis of receiver output of FLEX 1500 and transverter



Si4463 with adjusted FIR filter – 1200 baud modem

Spectral analysis of receiver output of FLEX 1500 and transverter



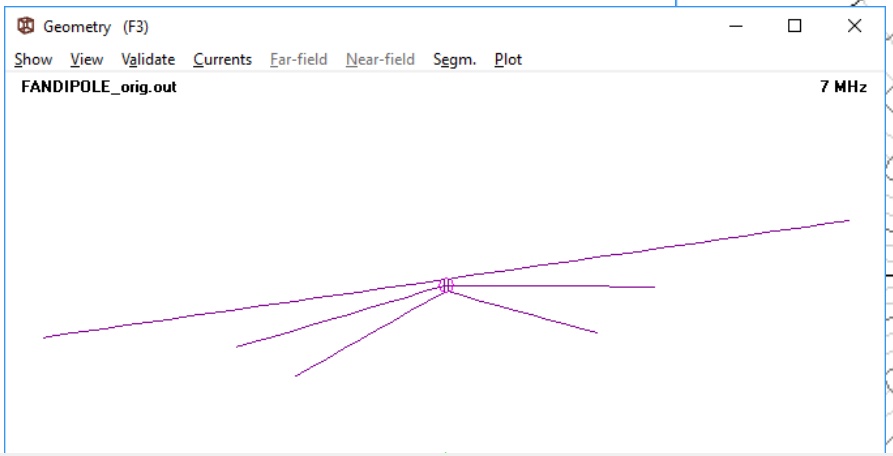
Software Tools for Ham Radio Electronics

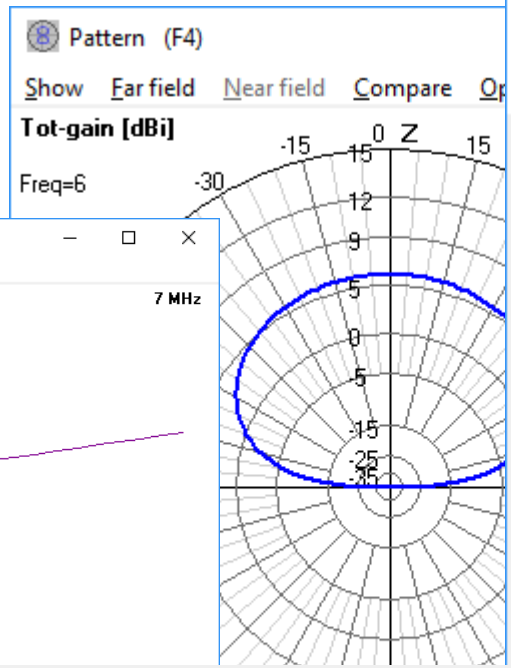
Antenna Design

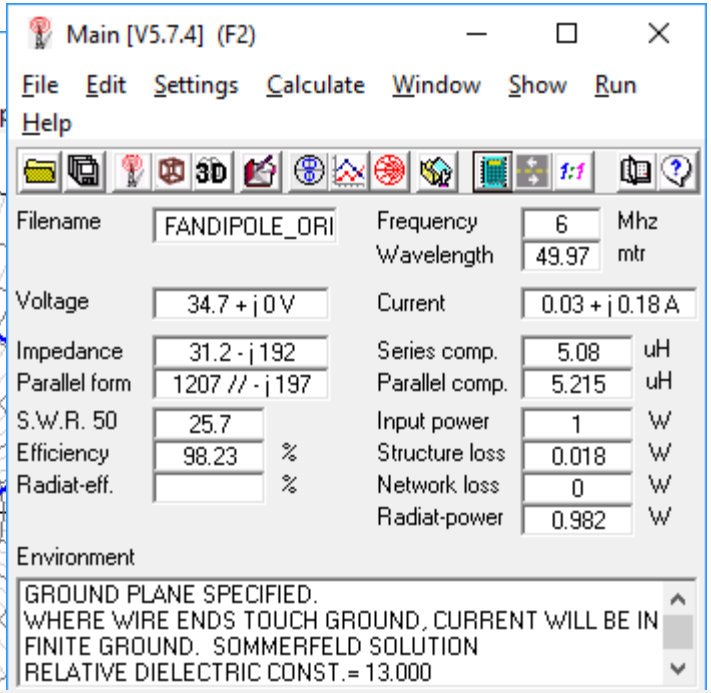
4nec2
Arie Voors
Windows, Linux-Wine

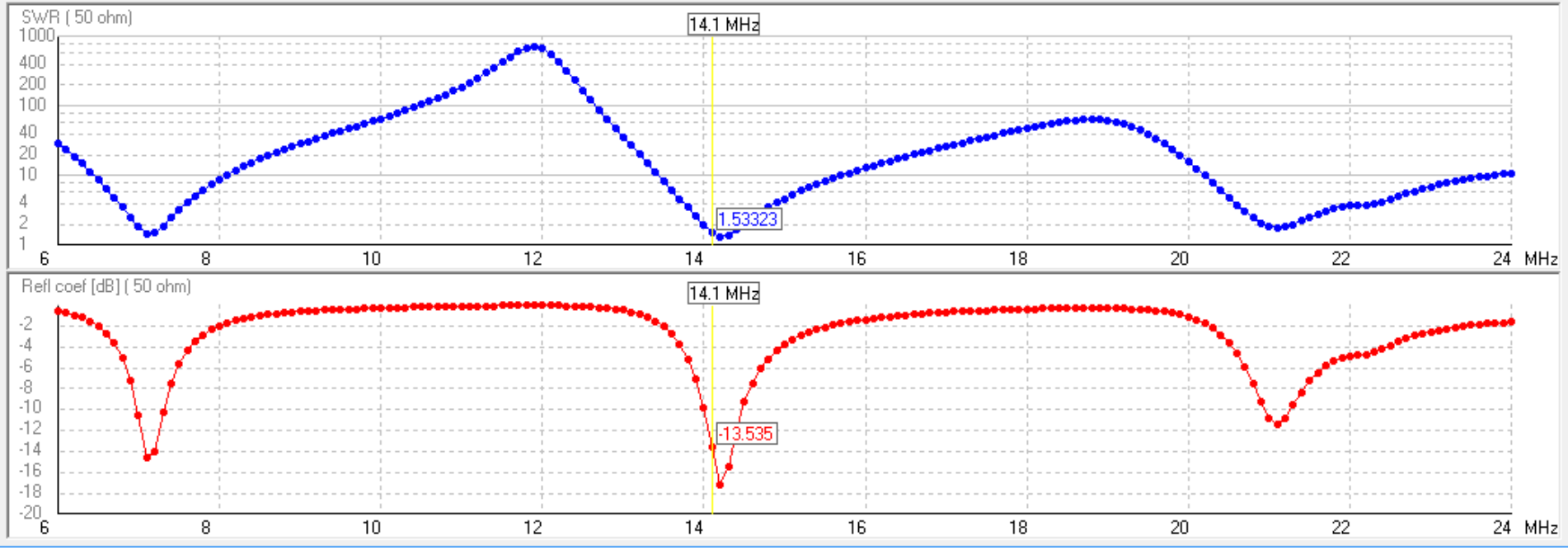
- Antenna Modeling
- Radiation Patterns
- Antenna Currents

4nec2
antenna modeling









Software Tools for Ham Radio Electronics

Toroid Inductors

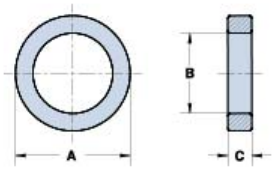
kitsandparts.com
Toroid Inductor Calculator

KitsAndParts.com -- toroid inductor calculator

Specs for **FT37-43** RF Toroids

FB-43-101	BLN1728-8	FT23-43	FT114-43	T25-2	T80-2
FB-43-2401	BN-43-2402	FT37-43	FT114-61	T25-6	T80-6
FB-73-2401	BN-61-2402	FT37-61	FT140-43	T30-2	T80-10
FB-43-4852	BN-43-1502	FT37-67	FT140-61	T30-6	T80-17
FB-43-7351	BN-61-1502	FT50-43	FT140-77	T30-10	T94-2
FB-31-1020	BN-43-302	FT50-61	FT240-31	T37-0	T94-6
	BN-61-302	FT50-75	FT240-43	T37-1	T94-10
	BN-43-202	FT50-J	FT240-52	T37-2	T106-0
	BN-61-202	FT82-43	FT240-K	T37-6	T106-2
	BN-73-202	FT82-61	FT240-61	T37-7	T106-6
	BN-43-3312		FT290-43	T37-10	T130-0
	BN-43-7051		XXX-XX	T37-17	T130-1
	BN-61-002			T44-2	T130-2
				T44-6	T130-6
				T50-1	T130-17
				T50-2	T157-2
				T50-3	T157-17
				T50-6	T184-17
				T50-7	T200-2
				T50-10	T200-6
				T50-17	T225-2B
				T68-1	
				T68-2	
				T68-6	
				T68-7	
				T68-10	

Physical Dimensions



OD(A) = 0.375 in / 9.5 mm +/- 0.25 mm
ID(B) = 0.187 in. / 4.75 mm +/- 0.10 mm
Ht(C) = 0.125 in. / 3.3 mm +/- 0.25 mm

A_L =350 +/- 20 % uH=(A_L *Turns^2)/1000
Actual measured AL using 10 turns #28 wire

Temperature Stability (ppm /°C) = 12500

Color Code = shiny black

Application Freq Range
Wideband Transformers 5 - 400 MHz
Power Transformers 0.5 - 30 MHz
RFI Suppression 5 - 500 MHz

Orders and Pricing
www.kitsandparts.com

Turns-Length Calculator for **FT37-43**
Includes 1 inch / 2.5 cm pig-tails

MHz	uH	pF	ohms	turns	inches - cm		
14.000	154.35	1	13577.3	21.0	12.5 - 31.8	Calc	Clear

enter uH to Calc number of turns, or
enter number of turns to Calc uH, or
enter two (2) items: MHz, uH, pF, ohms or turns to Calc all values.

Software Tools for Ham Radio Electronics

Software tools make ham radio design much easier
Many other tools available
Excellent design videos on YouTube (i.e., ZL2CTM, K7AGE, W2AEW)

Try some designs of your own:

1. Draft design (or start with someone else's design)
2. Simulate in software, tweak as necessary
3. Build and enjoy!