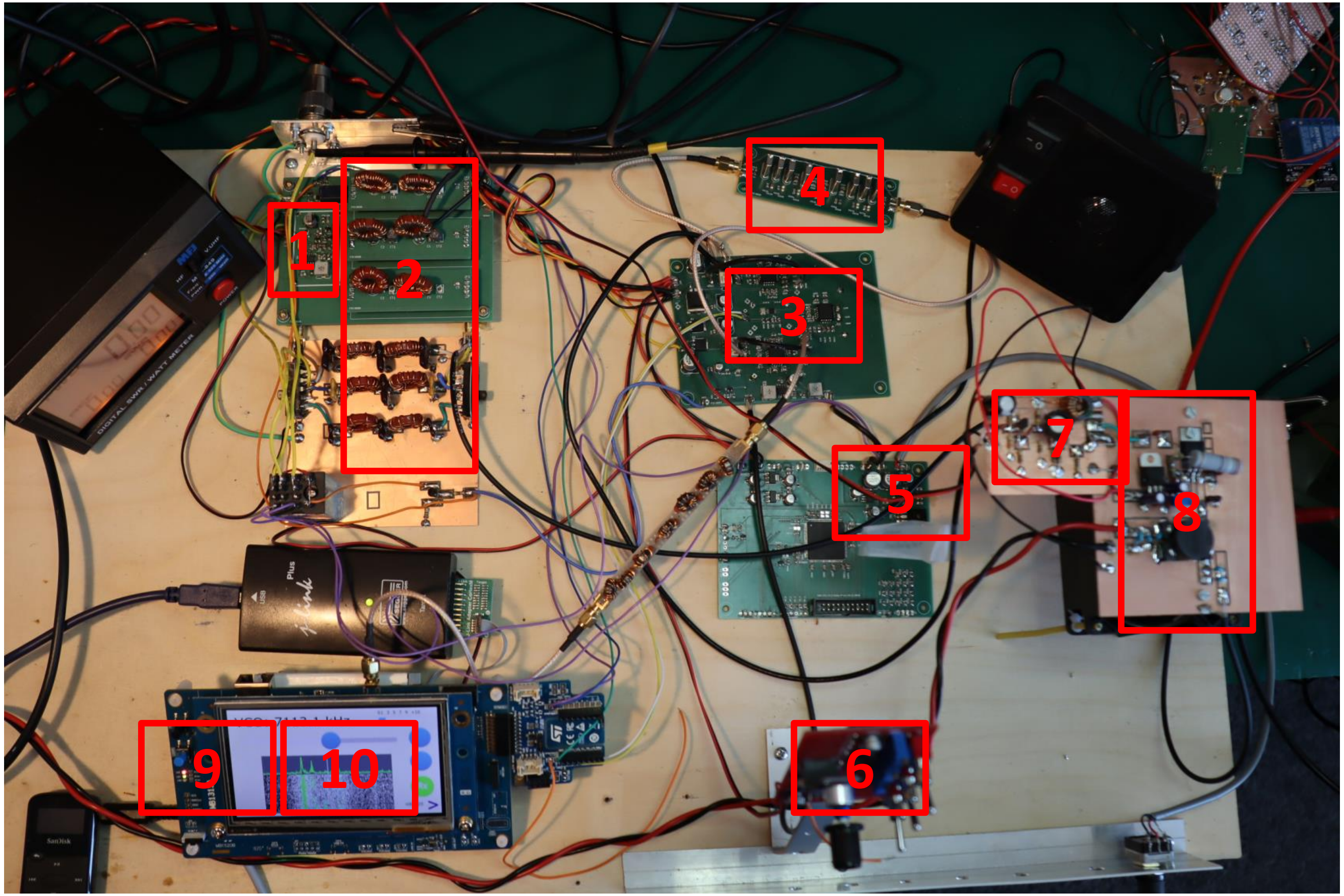
The DIY super-het transceiver



1. Antenna amp
2. BP and LP filters
3. DDS and mixers
4. Crystal ladder filter
5. AF amp
6. Microphone amp and 2-tone gen.
7. PWR pre amp
8. PWR amp
9. Touch GFX
10. FFT

Bandpass-Filter design

It is “wise” to select with a bandpass filter only the signals with frequencies of interest as input of the first mixer stage so reduce mirror frequencies and other ugly cross “mixed” signals (more when we discuss the mixer stage). In a heterodyne receiver mirror frequencies* are the things to beat (frequency plan, filtering, what not…).

So, after the antenna amp we use a bandpass filter for 20m, 40m and 80m.

The filter has been designed with the help of the Iowa Hills RF Filter Designer Version 2.2.

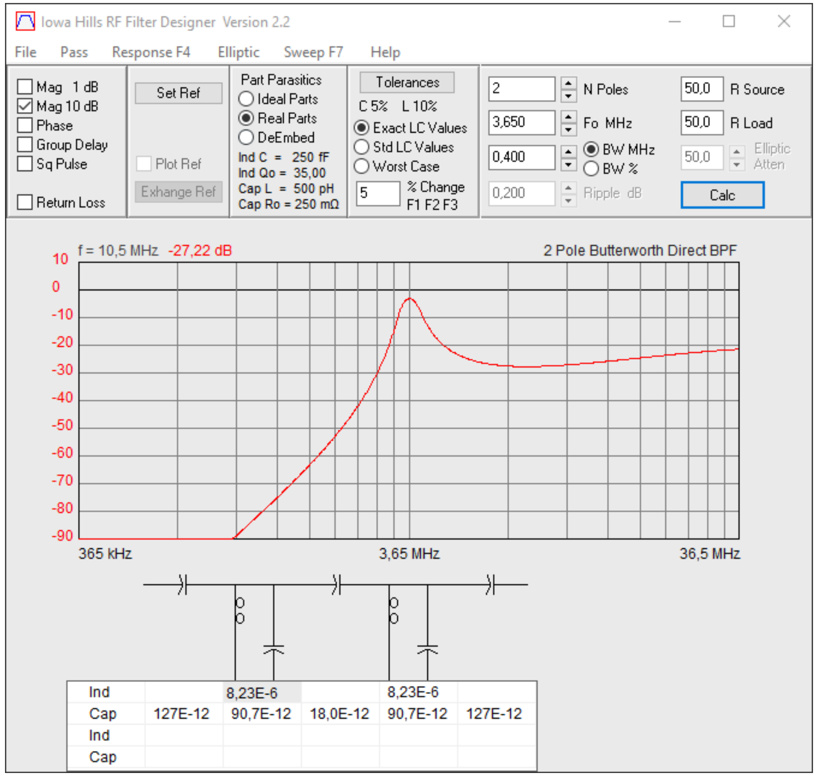
Design criterias:

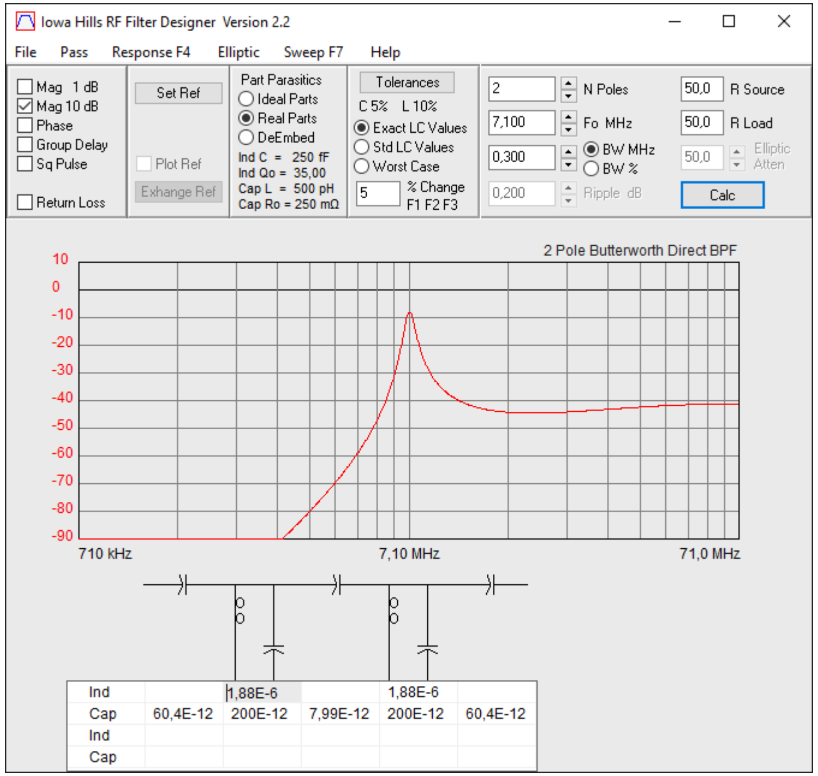
Poles: 2
Input / output impedance: 50 Ohm
Dielectric strength: 16V max
Additional BW: 0.1 MHz

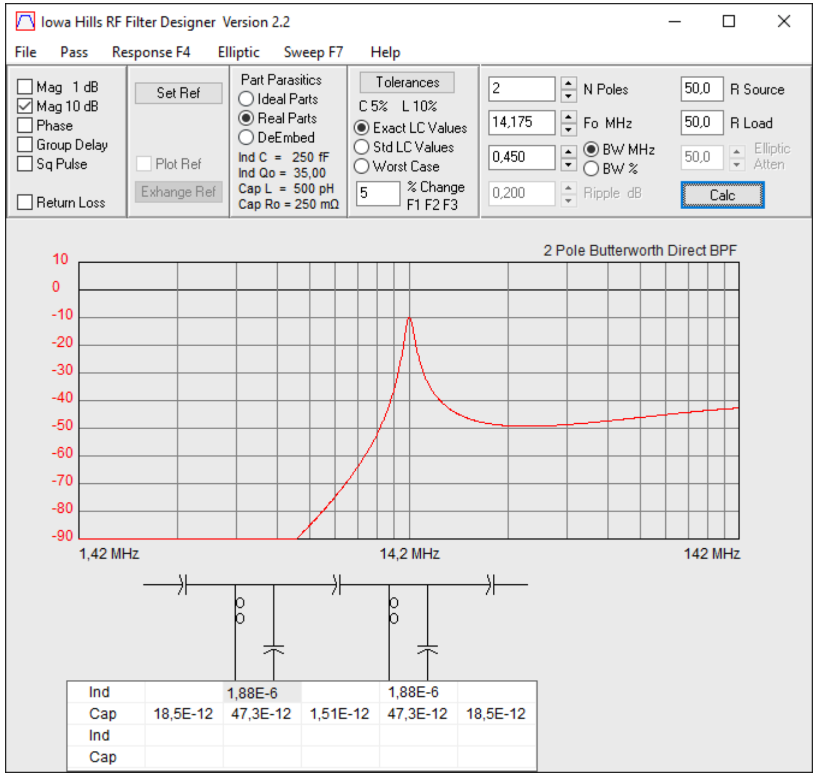
Band	**f_{min}**	**f_{max}**	**f_{center}**	**f_{BW}**
80m	3.5 MHz	3.8 MHz	3.65 MHz	0.3 MHz
40m	7.0 MHz	7.2 MHz	7.1 MHz	0.2 MHz
20m	14.0 MHz	14.35 MHz	14.175 MHz	0.35 MHz

* $f_{mirror} = f_{signal} +/- 2*f_{IF}$

Bandpass-filter design for HAM radio 80m, 40m and 20m

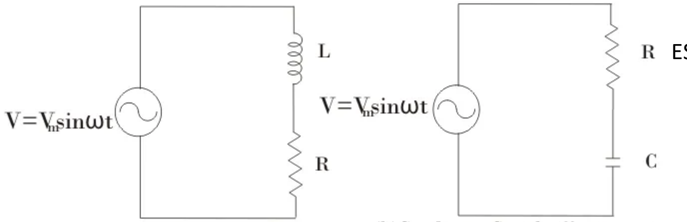






Bandpass-filter design 40m band 1/3

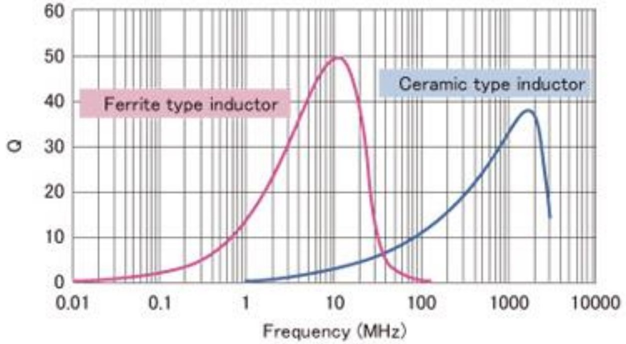
Real impedances L and C:



(a)Coil L with effective internal resistance R. (b)Condenser C with effective series resistance R.

High Q is your friend: $Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 RC}$

□Q value and frequency response of inductors with different substrate material



Q value changes depending on frequency and substrate material. In the frequency range of several hundred MHz and above, ferrite substrates cannot be used, and dielectric ceramics are used instead.

Capacitor Type	Dielectric	Relative permittivity	Dielectric strength (V/µm)	Minimum dielectric thickness (µm)	Typical range of values (µF)	Dissipation factor X 10^{-4}	Notes
Ceramic Class 1	Paraelectric (titanium dioxide)	12-90	<100	1	10^{-6} to 1	10 @1 MHz	Typical parts NPO, P100, N33
Ceramic Class 2	Ferroelectric (barium titanate)	200-14,000	<35	0.5	$10^{[illegible]}$ to 1	251 @1 MHz	Typical parts X7R, X5R, T5V
Film	Polypropylene (PP)	2.2	650/450	1.9 to 3.1	10^{-4} to 102	2-25 @100 kHz	
Film	Polyethylene terephthalate (PET)	3.3	470/220	0.7 to 0.9	10^{-4} to 10	170-300 @100 kHz	Aka: polyester or mylar
Film	Polyphenylene sulfide (PPS)	3.0	470/220	1.2	10^{-3} to 10	12-60 @100 kHz	
Film	Polyethylene naphthalate (PEN)	3.0	500/300	0.9 to 1.4	10^{-3} to 1	120-300 @100 kHz	
Film	Polytetrafluoroethylene (PTFE)	2.0	450/250	5.5	10^{-3} to 1	100 @100 kHz	Aka: teflon
Paper	Waxed paper	3.5-6.0	60	5 to 10	10^{-3} to 1	628 @1 MHz	
Aluminum electrolytic	Aluminum oxide	9.6	710	<0.01 (6.3 volt) <0.8 (450 volt)	1 to 47,000	100 @120 Hz	Polarized
Tantalum electrolytic	Tantalum pentoxide	26	625	<0.01 (6.3 volt) <0.08 (450 volt)	1 to 100	600 @120 Hz	Polarized
Niobium electrolytic	Niobium pentoxide	42	455	<0.01 (6.3 volt) <0.1 (40 volt)	10 to 1000	600 @120 Hz	Polarized
Glass	Glass	3.7-10	450	- - -	10^{-6} to 3 10^{-3}	10 @1 kHz	
Mica	Mica	5-8	118	4 to 50	10^{-6} to 3 10^{-3}	4 @1 MHz	

Relative permittivity = dielectric constant K

Dissipation Factor DF = 1/Q , Mica: 1/ 4*10-4 => Q = 2500, nice!

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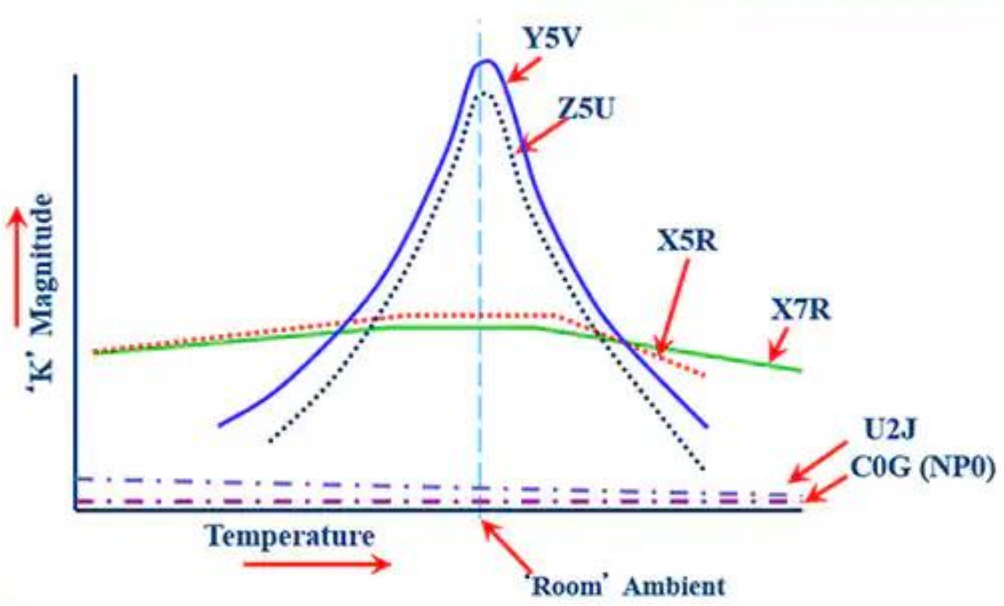
Bandpass-filter design 40m band 1/3

K = dielectric constant:



While Class I dielectric materials such as C0G and U2J offer more temperature-stable dielectrics, they have a lower dielectric constant (K). On the other hand, Class II materials like X7R and X5R feature mid-range stability as well as K value while offering much higher capacitance values.

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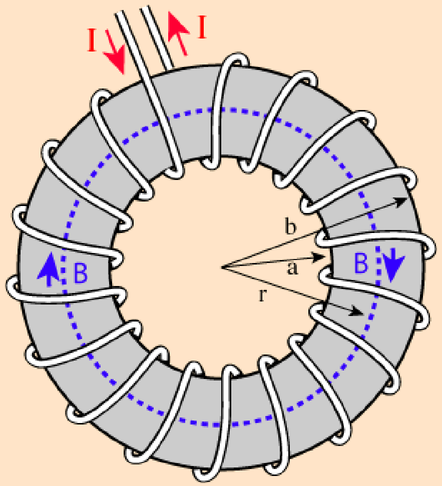
Bandpass-filter design 40m band 2/3

Approximate Inductance of a Toroid



Finding the magnetic field inside a toroid is a good example of the power of Ampere's law. The current enclosed by the dashed line is just the number of loops times the current in each loop. Amperes law then gives the magnetic field at the centerline of the toroid as

$$B2\pi r = \mu NI$$

$$B = \frac{\mu NI}{2\pi r}$$

The inductance can be calculated in a manner similar to that for any coil of wire.

The application of Faraday's law to calculate the voltage induced in the toroid is of the form

$$Emf = -N\frac{\Delta\Phi}{\Delta t} = -NA\frac{\Delta B}{\Delta t}$$

This can be used with the magnetic field expression above to obtain an expression for the inductance.

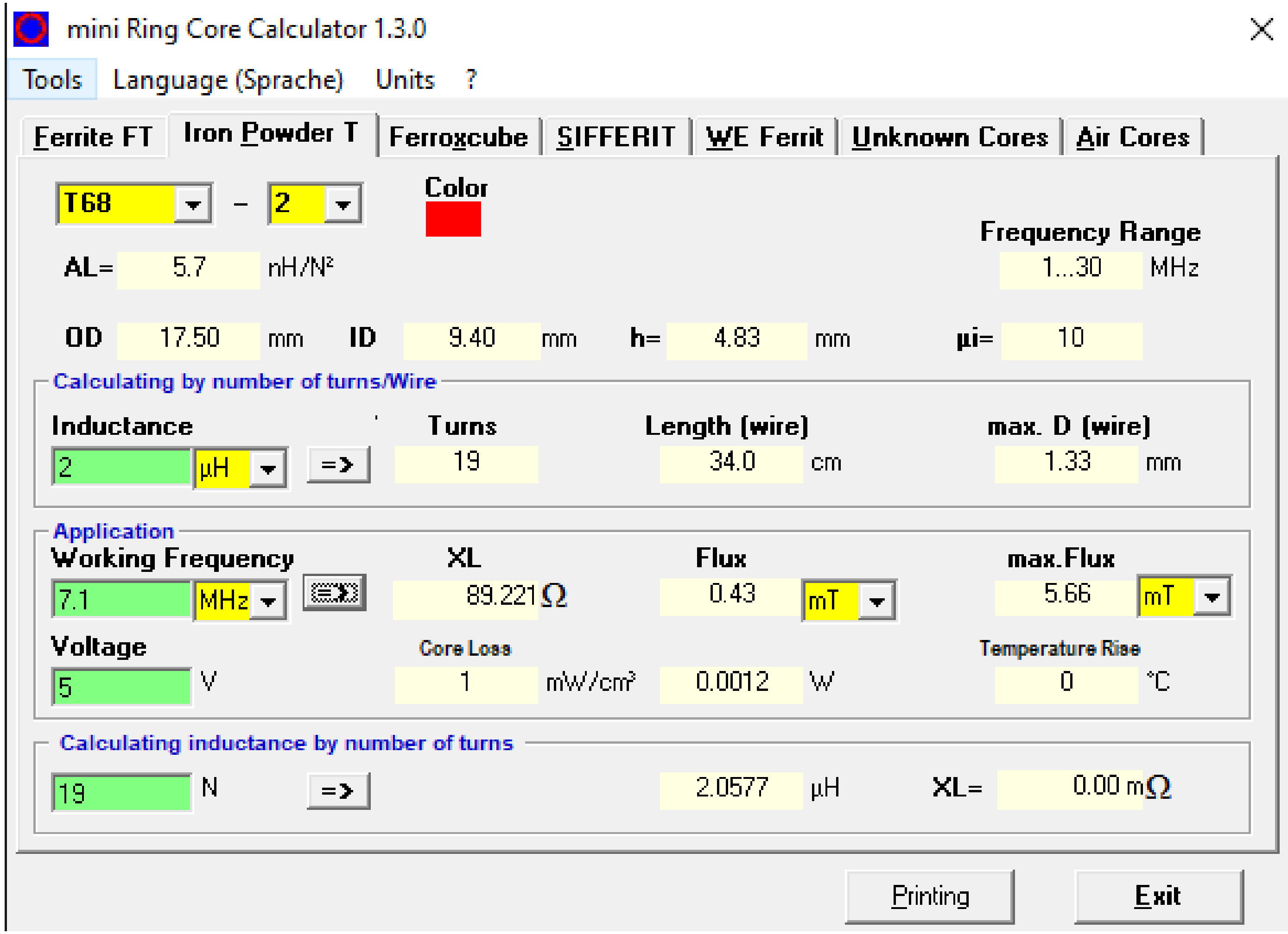
$$L \approx \frac{\mu N^2 A}{2\pi r}$$

A = cross-sectional area

r = toroid radius to centerline

B = magnetic induction
H = magnetic field

http://hyperphysics.phy-astr.gsu.edu/

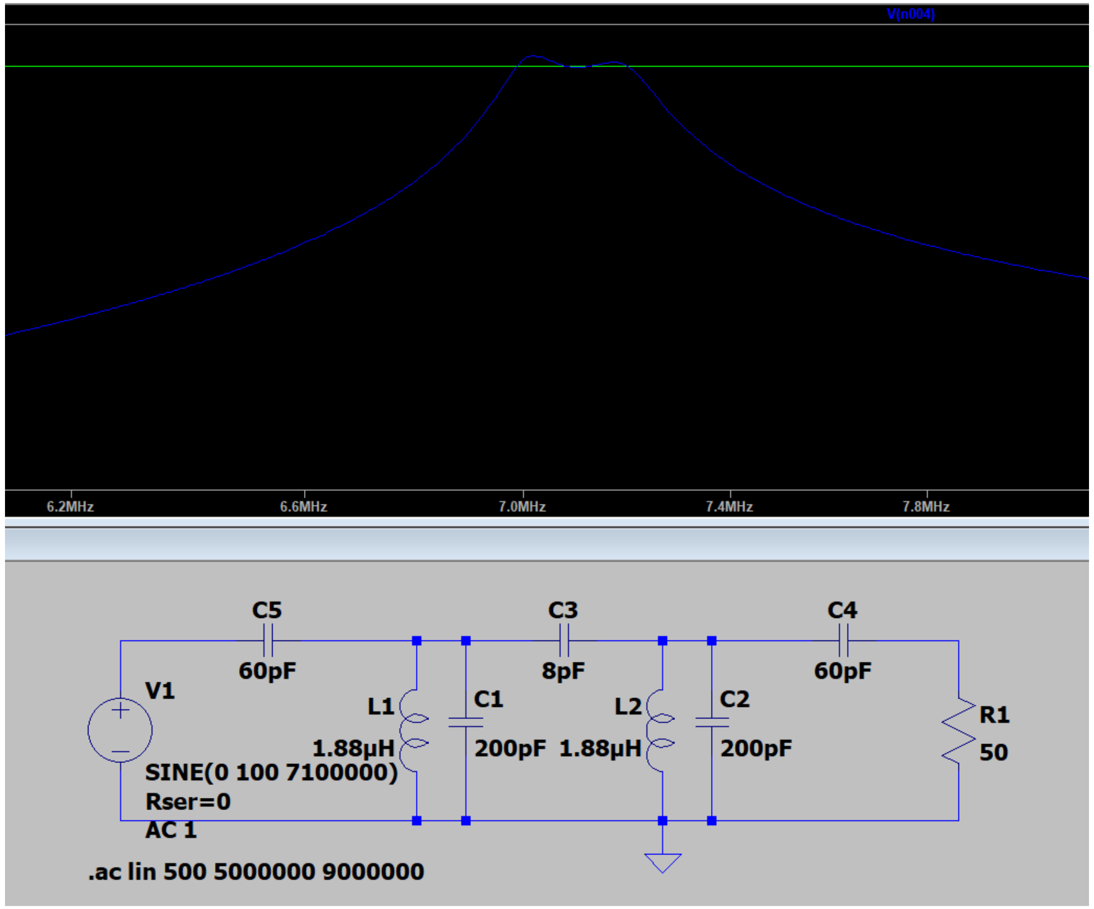


Characterizing your coils

Initial permeability is measured at 10kHz with a flux density of less than 10 gauss (sinusoidal excitation). Testing coil T68-2, 19 turns, 0.85mm wire, 2.0577 µH, X_L = 89.22 Ω

	Keysight UCU1733	RigExpert AA-55 Zoom	Siglent SVA1015X
L	2.28 µH @10kHz	2.0 µH @7.1MHz	1.98 µH @7.1 MHz
X_L		88	87
R		3.6	4
Q	6	24	21

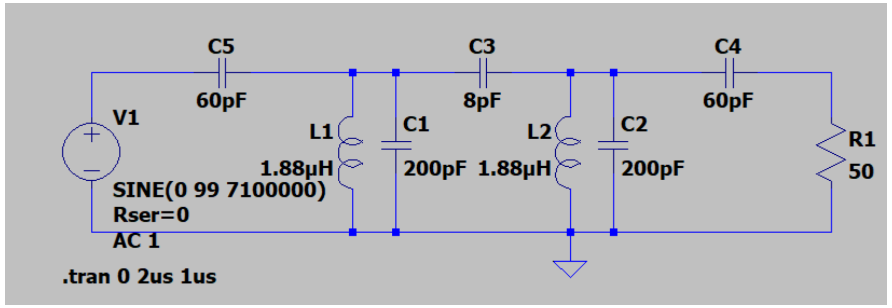
Bandpass-filter design 40m band



$$Q = \frac{f_C}{BW_{3\ dB}}$$

f_c = 7.1 MHz
BW_{3db} = 0.27 MHz
Q = 26

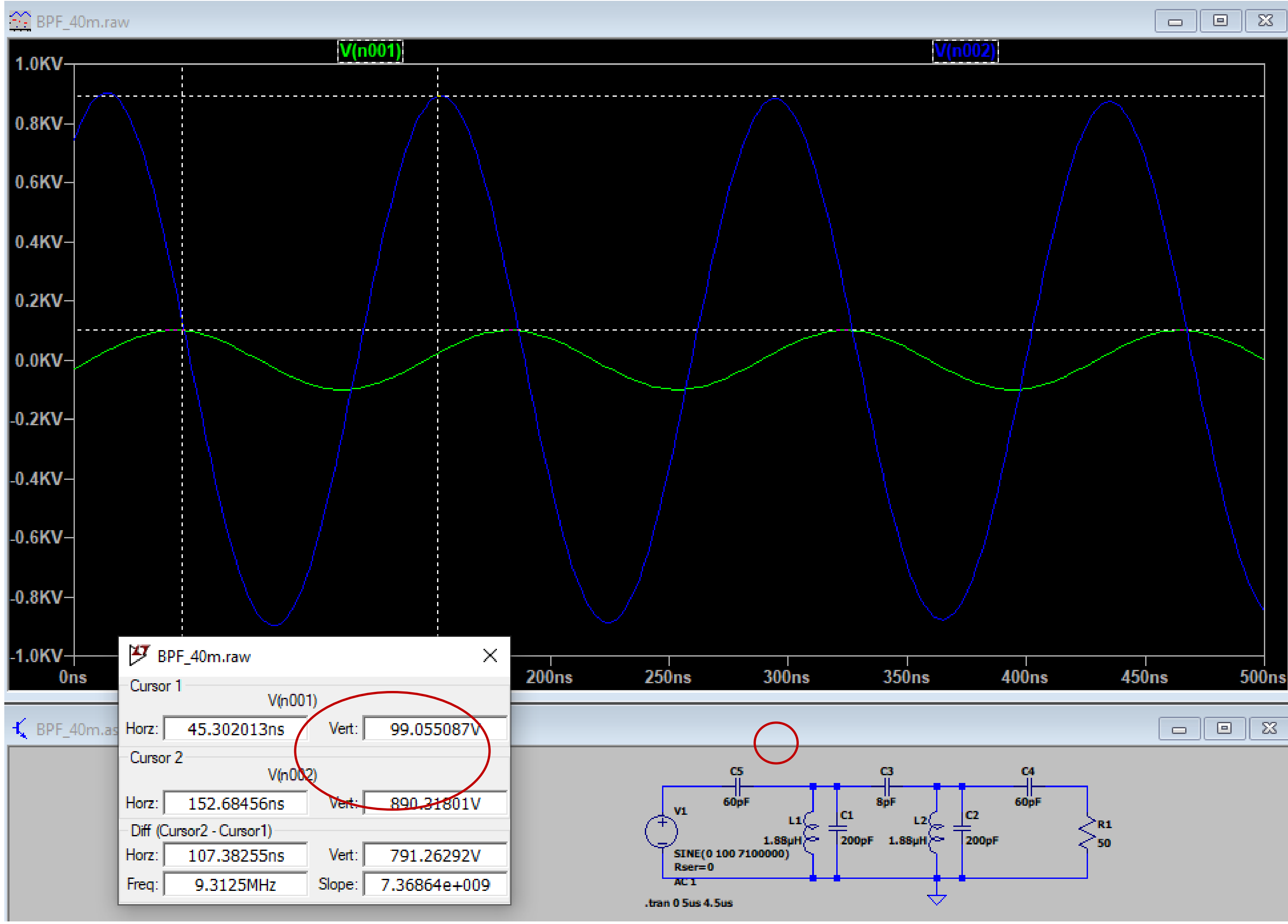
Choose proper voltage ratings



Pin @ 50Ω: 100W

Vin = $\sqrt{100W \ * 50\Omega} = 71Vrms$

	338-3138-ND	CDV19FF201JO3F	Cornell Dubilier Electronics (CDE)
CAP MICA 200PF 5% 1KV RADIAL	300 - Immediate	4,01000 Fr.	1



To the bench…

Lowpass-Filter design 1/3

Lowpass-Filter design

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