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Coil Calculator

Circuit calculations or mathematical simulations quickly come into conflict with reality if losses and parasitic effects of the components are not taken into account.
This is particularly evident in the case of inductors, because winding capacitances, skin effect and coil quality gain influence with increasing frequency.

In the interaction of the coil computer with a vector network analyzer (**NanoVNA**), however, these important parameters can be determined quite precisely in advance and thus protect against some unpleasant surprises.

Four values of L must be known to the calculator in advance:

- Low frequency inductance (µH)
- DC resistance (ohms)
- Frequency (MHz) of the first parallel resonance (measure with NVNA)
- Transmission loss (dB) at the first parallel resonance (measure with NVNA)

The frequency scale is logarithmically divided, with two ranges to choose from:

- While the first range (1MHz ... 100MHz) is mainly intended for KW chokes,
- can be used in the second range (1MHz ... 1GHz) also investigate smaller inductors, such as air coils, whose parallel resonance is usually a few hundred MHz.

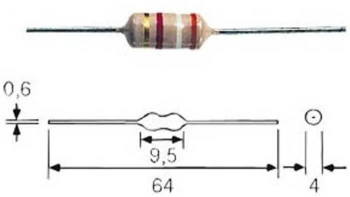
The most important difference between the current version of the coil computer and its predecessor is only the extended info file.
This now also contains examples for quality determination in cooperation with the NanoVNA (software *nanovna-saver*).

For the following introductory example, no VNA is required, so you can concentrate fully on the operation of the coil computer:

Example 1 - Fastron SMCC choke 47µH

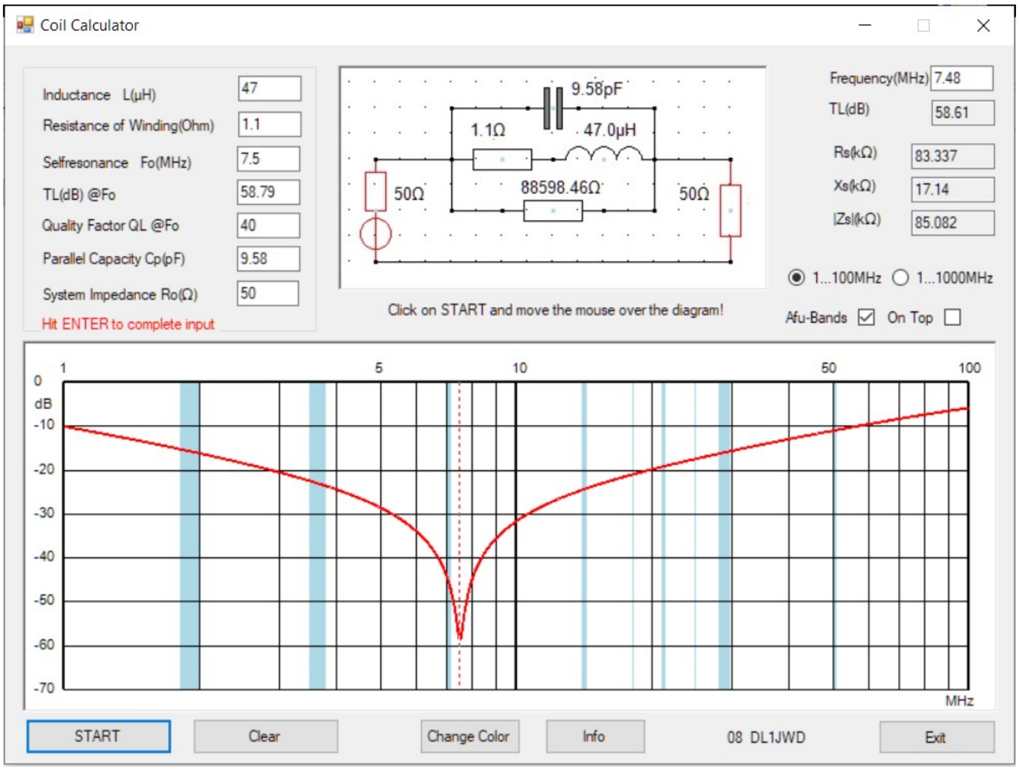
For broadband amplifiers you need RF chokes. As a rule, these must have a significantly increased blocking impedance compared to 50 ohms.

What is the apparent resistance and blocking damping of the Fastron 47µH choke on the classic amateur radio bands?



- Enter the values for the inductor L (47µH) and for the resonant frequency Fo (7.5MHz) according to the data sheet.

- The value for the parallel capacitance (9.6pF) is automatically added. But you could just as well enter Cp first (if known) and then display Fo.
- The DC resistance of the winding is 1.1Ohm according to the data sheet, but the exact size is usually negligible and therefore meaningless for our scenarios.
- For the quality factor, the manufacturer specifies the value 40.
- **All your entries must be completed with the ENTER key (the yellow colored fields should remind you of this).**
- For the blocking attenuation TL(dB) in case of resonance, the SR has already automatically calculated and entered the QL-dependent value (58.8dB).
- After clicking on the "START" button, the transmission frequency response appears, whereby the attenuation maximum at 7.5MHz immediately catches the eye.
- By setting the checkmark the position of the AFU bands can be highlighted by light blue vertical stripes.
- Using the mouse you can now move the frequency ruler, where the running values for frequency, blocking attenuation and impedance are displayed.
- A more precise setting than with the mouse succeeds if you enter the frequency directly (do not forget to finish with ENTER!). Then the frequency ruler automatically moves to the appropriate position in the diagram and all data can be read immediately.



Above the resonant frequency, the sign of Xs changes, because the coil then acts only as a lossy capacitance and the blocking attenuation TL is lost more and more as the frequency continues to grow.

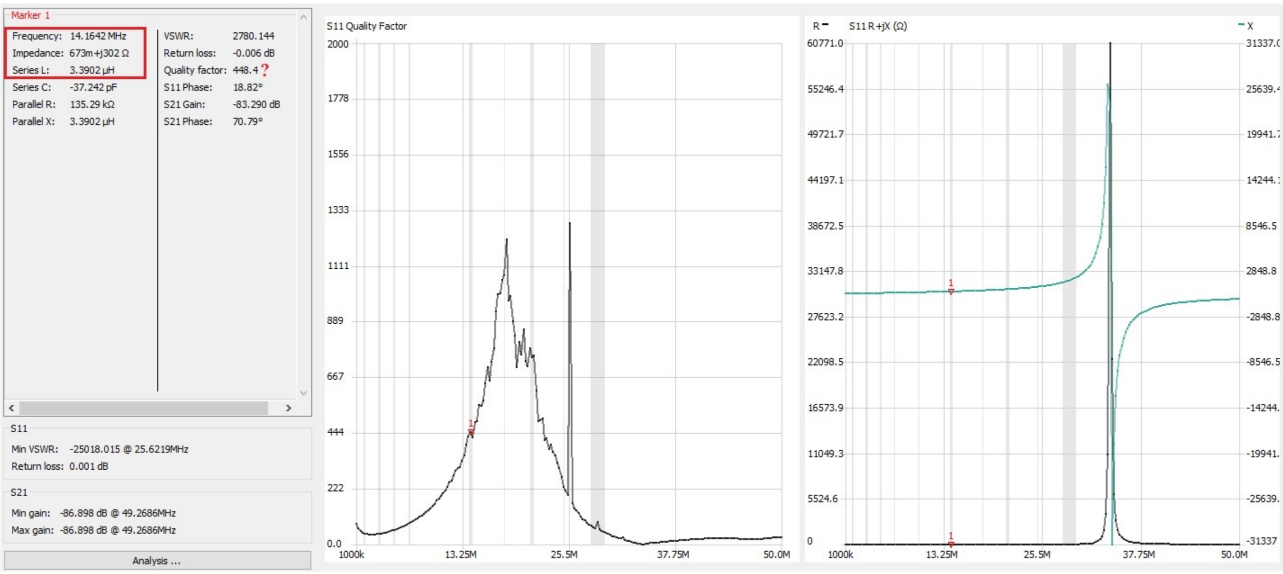
f (MHz)	1,8	3,65	7,1	14,1	21,5	28,5	50
|Z| (Ohm)	563	1400	20000	1600	878	625	340
TL (dB)	15	23	46	25	19	16	11

Example 2 - Quality measurement of an inductor

The quality of a coil, i.e. the ratio of reactance to loss resistance, is particularly important for oscillating circuit calculations.
This is especially true for filters that are also used in broadcast mode, because here you have to be stingy with every tenth of a DB (destruction by overheating).

What is the quality factor of a 3.4µH inductor wound with 15 Wdg CuL (d=1mm) on a powder iron ring core T 106-6 at 14.2MHz?

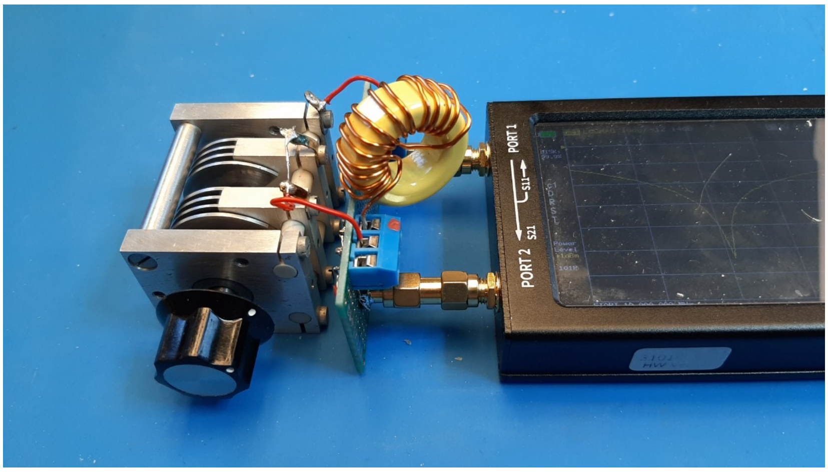
First, try measuring reflection using a NanoVNA (Port1):

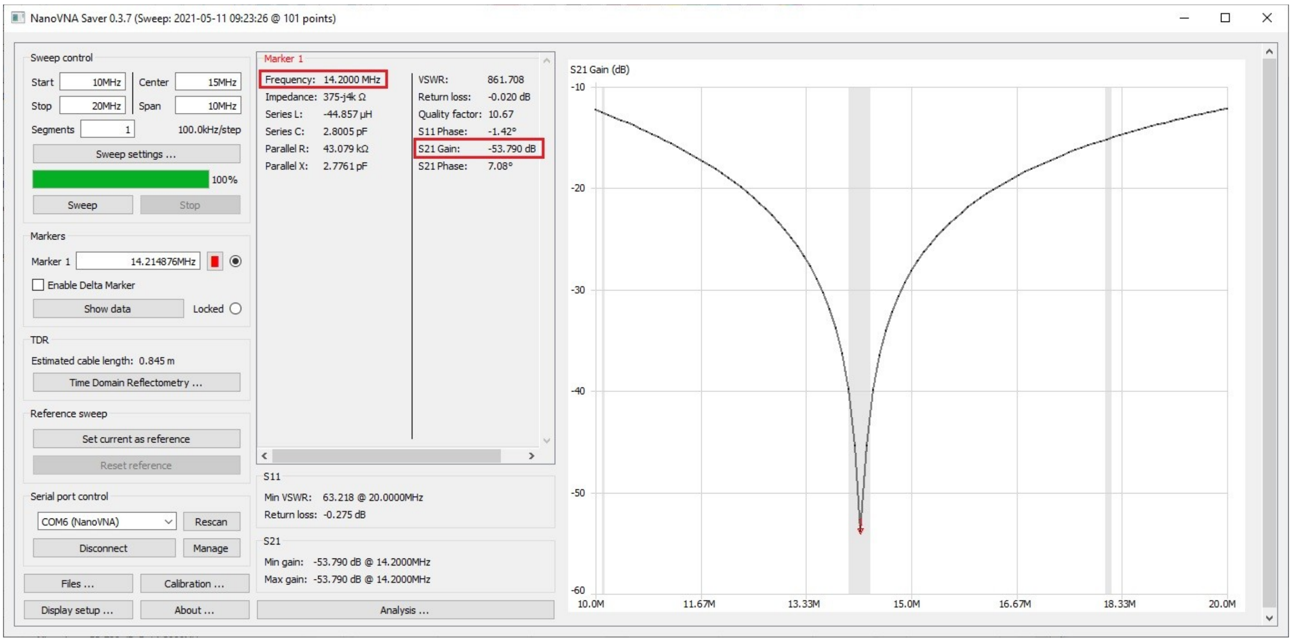


Although the impedance R+jX (L = 3.4µH) is displayed correctly, the frequency-dependent course of the coil quality (Quality Factor) does not contribute to enlightenment, since the capacitance of the short measuring lead totally falsifies the result.
A value greater than 400 for a powder iron ring core at 14MHz? Absolutely utopian!

The measurement of transmission attenuation (S21) promises more success than the quality determination via a reflection measurement (S11), since the supply lines no longer play a major role here.

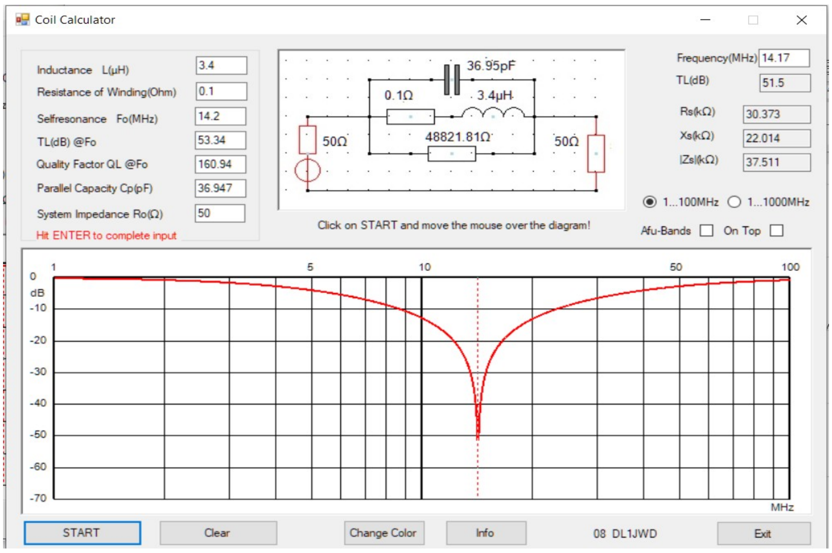
For this purpose, a 100pF air rotary unit is connected in parallel to the coil and tuned to resonance.





The subsequent quality determination is carried out by the coil Calculator which needs the measured values of the NanoVNA for resonance frequency (14.2MHz) and continuity attenuation (53.4dB).

As a result the truth comes out and a real quality factor of approx. 153 is displayed:

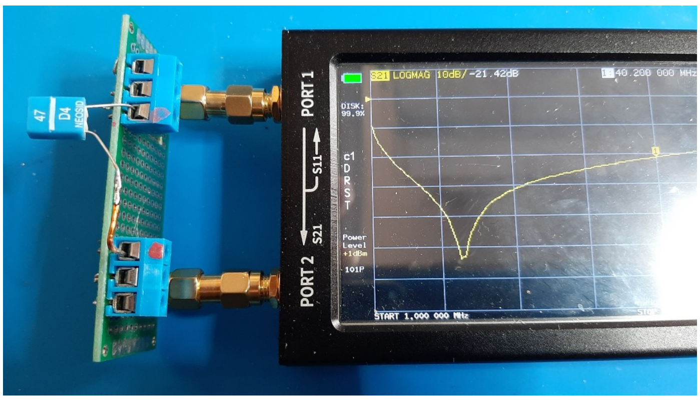


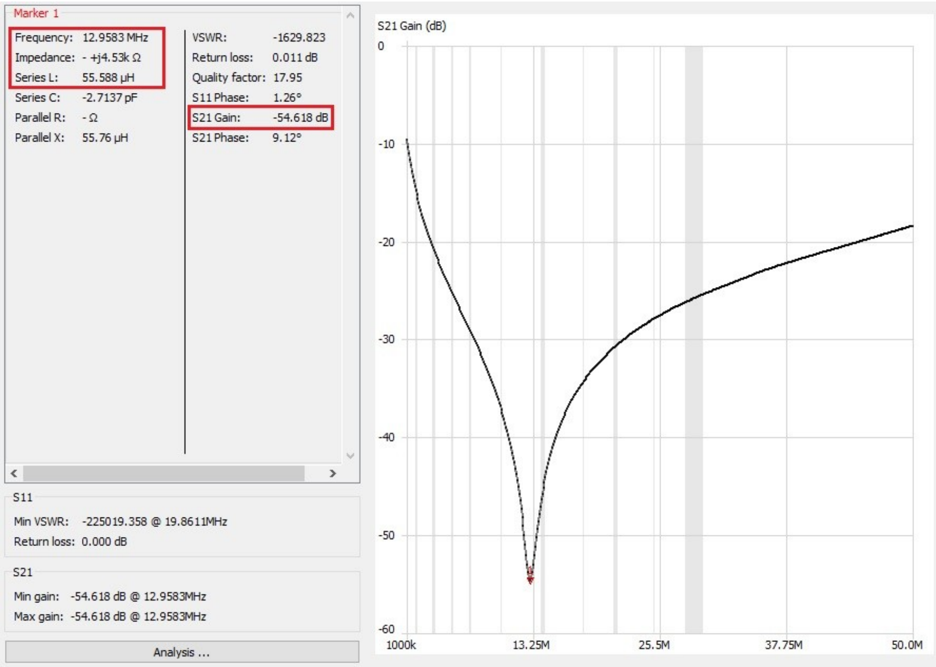
Example 3 - 47µH neoside SDS choke

On Ebay I came across this choke with a guaranteed parallel resonance of at least 12MHz and a unit price of only 10Cent. In order to determine that this could be a low-cost alternative to the Fastron choke (Example 1), the following question had to be answered:

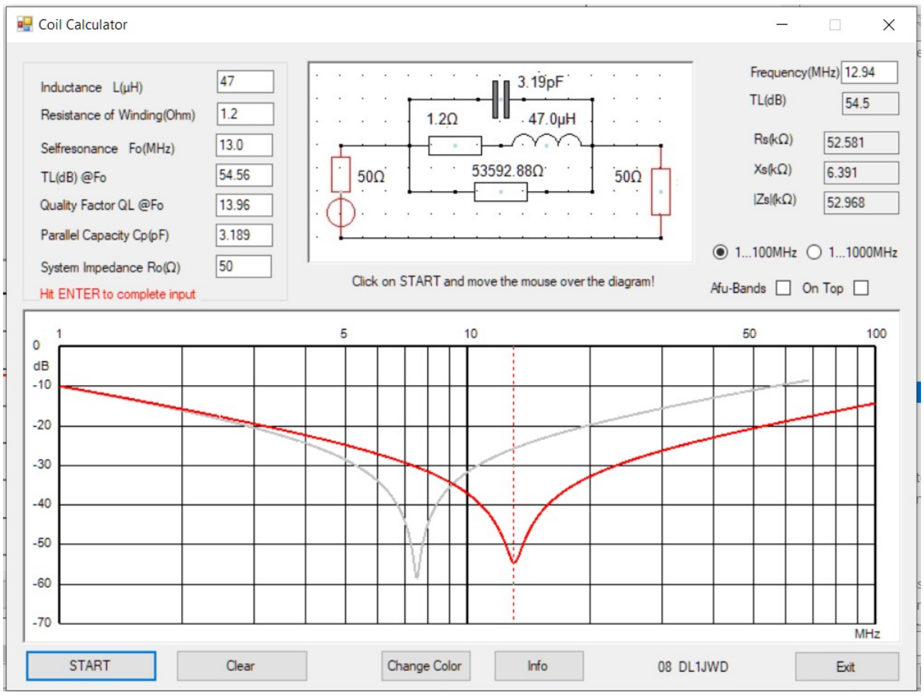
What is the apparent resistance and blocking loss of the 47µH Neosid SDS choke on the classic amateur radio bands?

The choke is connected in the shortest way between the center connections of the two SMA sockets of the NanoVNA and the attenuation curve (S21 gain) is recorded over the entire KW range:





The resonance frequency 13MHz can be read from the attenuation curve, at this point the transmission loss (S21 gain) is approx. 55dB.
I enter both values into the coil computer, the coil quality QL=13 is automatically added.



Compare the red curve with that of the gray curve of the Fastron choke (example 1) and you will see the clear superiority of the cheaper Neosid choke.

Hints:

• The SR allows you to overlay diagrams if you do not use "Clear". For better distinguishability, you can click the button "Change color" before recording another curve.

• For frequencies far above the first parallel resonance, the tool can only provide inaccurate or unusable values in many cases, since higher coil resonances are not taken into account.

Verification of the simulation using a VNA

I measured the transient attenuation of the Neosid choke with the **NanoVNA** for some important frequencies and compared it with the values determined by the coil computer:

F(MHz)	1,8	3,65	7,1	14,1	21,5	28,5	50
NanoVNA	14dB	20dB	27,5dB	45dB	32dB	27,5dB	21dB
Coil Calculator	14,9dB	21,4dB	29,1dB	46,5dB	33,3dB	28,5dB	21,5dB

As you can see, there are only small differences.

Example 4 - Sheath Shaft Lock

To suppress sheath waves and interference, it is customary to loop a 1:1 current balun into the 50Ohm antenna cable of the Trx.
Mine consists of 24Wdg thin coax cable RG316U, which I wound on the largest ferrite toroidal core (AD=56mm, ID=35mm, H=12mm) that can be found in the craft box.
The low-frequency inductance measurement results in 352µH, the DC resistance is less than 0.1Ohm.

With the NanoVNA I measure the first parallel resonance already at 7.37MHz, the corresponding transmission attenuation is 48dB.
The Coil Calculator confirms the measured attenuation curve (deviations less than 10%) and shows that in the KW range (1.8...30MHz) an acceptable value of better 30dB is achieved: