MEASUREMENTS WITH THE NANOVNA

part 3: Practical Measurement of Common Mode Chokes

By Arie Kleingeld PA3A

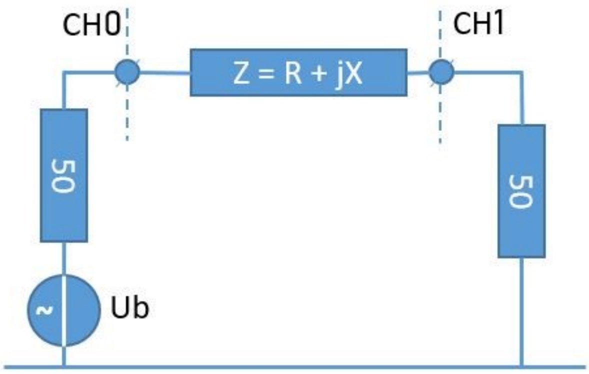
Preface

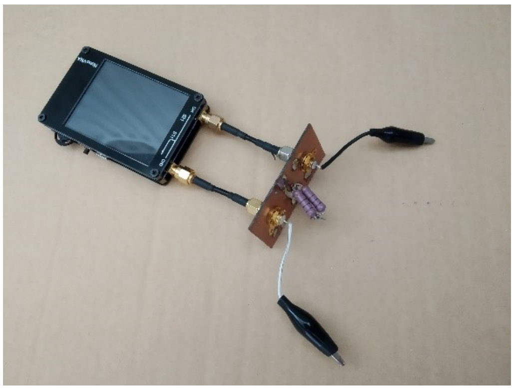
Common Mode Chokes (those are things that you need, for example, to avoid getting sheath current on your coax) are widely used. There is also a lot written and discussed about them. There are discussions about how to wind them, which core material is best, where should such a thing be, how much impedance (more than 5 kΩ) is needed, and so on.

We are not going to have that discussion now. We are just going to talk about measuring with the nanoVNA. I have been using various chokes for a long time. It is good to check your own chokes anyway. And we do that ourselves... with the nanoVNA, in my case version H3.2.

The measurement method has already been described in part 2 of this series of articles. This means that with the nanoVNA we will measure the S21 (the damping) and then convert the results in Excel to the impedance of the choke expressed in R + jX. To obtain the data, the "nano" is linked to the PC with the program nanoSAVER.

Measurement setup





Z = R + jX represents the choke. The trick is to measure it as simply as possible without influencing extra capacitance, resistance, or self-inductance. At the same time, I just want to leave the connections that are currently in place, as they are also there in practice. So it is, as it is. To measure the various chokes, I took a piece of printed circuit board and drilled holes in it. There are now two SMA females on one side and two strands with crocodile clips on the other. It is inspired by the approach in G3TXQ's article (see reference). On the side of the clips there is a 50-ohm resistor to simply go through the S11 calibration, before S21 is calibrated with the clips loose and the clips attached to each other.

Various chokes

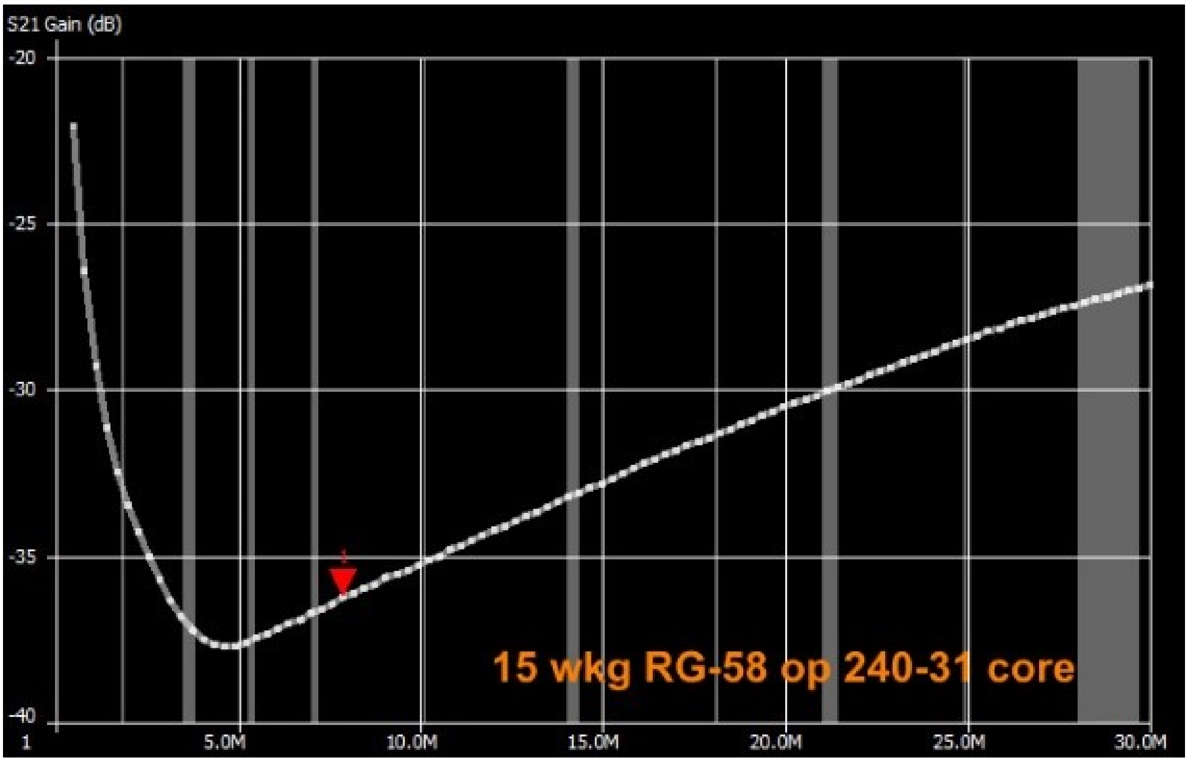
The chokes @ PA3A are made with the connectors already attached. I have chokes in RF coax, USB cables, audio cables, mains 230V, DC 12V, etc. and with various core materials. Nothing special for a simple ham shack. For the coaxial cables to the antennas, it is all possible to stop RF from the outside, both directly at the antenna (balun operation) and closer to the transceiver or between tuner and transceiver. In keeping with the power used, somewhat larger ring cores are used to easily obtain a good damping. For all other cables, the point is to attenuate RF currents in the shack as much as you can. The stress on the chokes is not that great there, so smaller toroid's can be used.

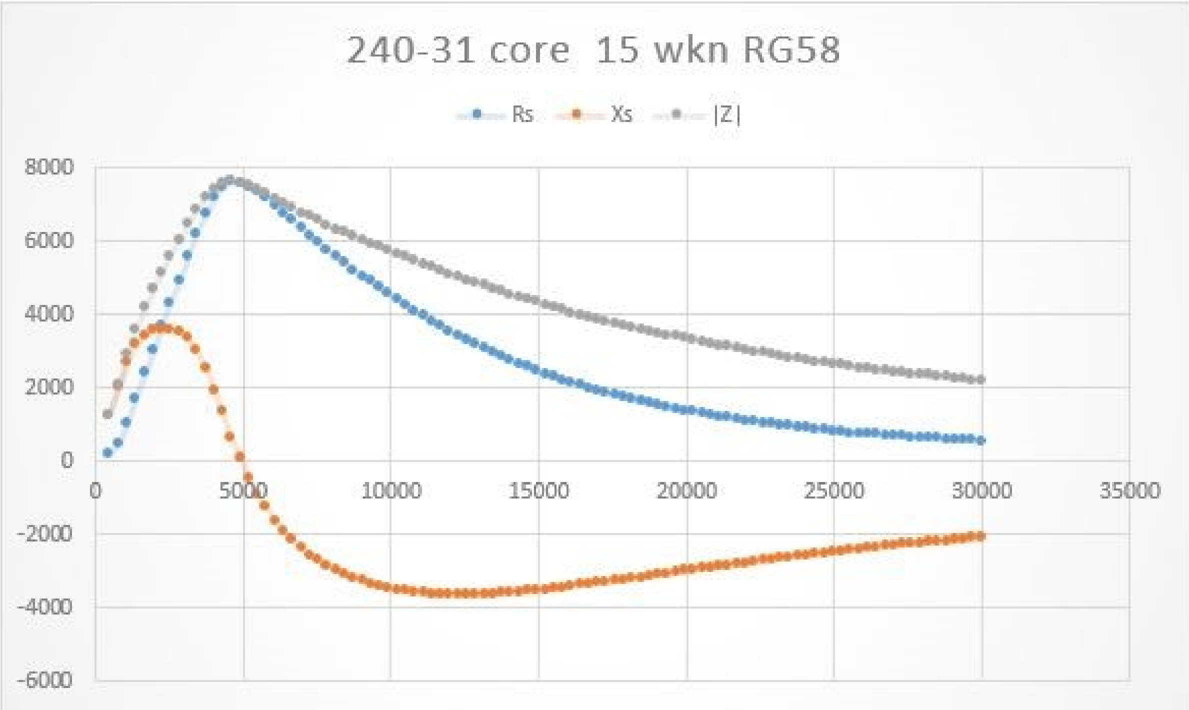
The core materials that I use here and there are of the well-known 31 and 43 type. I also use a lot of 3S4 cores. There is a lot of information available about the frequency range in which the different materials can be used. I will not go into that further now.

The measurements

We are going to measure 3 chokes. The first choke is used in the coax to dipole antenna for 3.5 - 10 MHz. It is a 15-winding 240-31 core with RG-58 coax, tightly wound around the core. This is very close to the transceiver and a same one is on the dipole as a balun *[photo right]*.

The nanoVNA is connected to the outer jacket via the clips. The attenuation reported by nanoSAVER is not disappointing: for the frequency range of 3.5 - 10 MHz it is 35 dB or more *[see graph below]*.

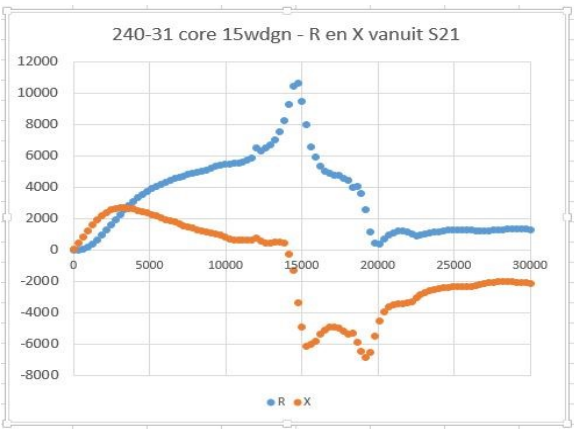




When the damping is decomposed to Z = R + jX with Excel, the above picture emerges. A number of things stand out here:

- The core shows a relatively large loss resistance Rs. According to experts, this is the desired behaviour of a sheath current choke coil. Rather a lot of resistance than a lot of reactance. Things are fine between 3.5 and 10 MHz.
- The Xs goes up well in the low frequencies (inductive behaviour) and then becomes lower and even capacitive. The fact that everything behaves in this way has on the one hand to do with the core material, but especially also with the capacity between the coax windings. Resonance point is just below 5 MHz.
- The total Z neatly follows the damping, the higher the Z, the more damping.

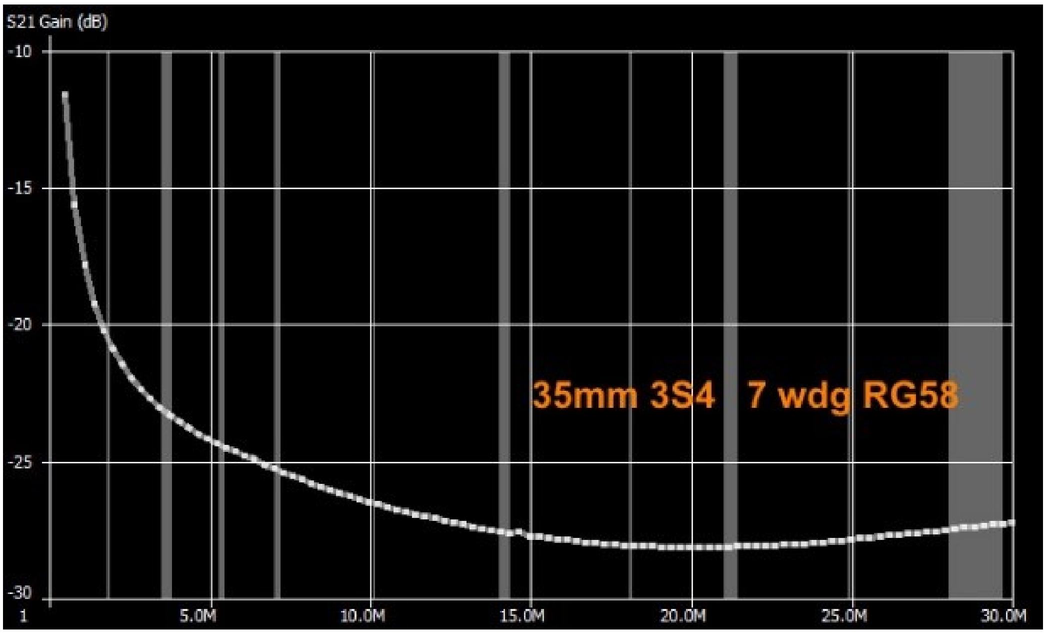
This attractive graph was not created just like that. During the first measurement attempts, it turned out that the connection with the PC caused all kinds of resonance effects that changed dramatically when you put your hand on the nanoVNA or held the USB cable [see the graph below left].

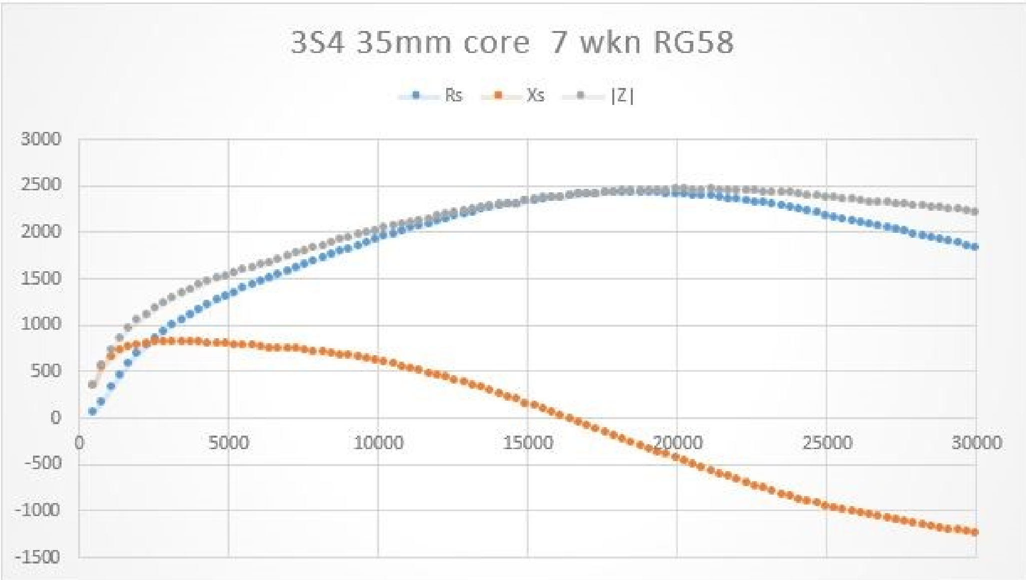


Apparently, the USB-C cable had to be RF disconnected for that. The "first aid" cores I had lying around were 43 and 3S4 material. Using two, stacked on top of each other with 7 wraps through the hole and the problem was gone *[photo next to graph on former page]*.

The second type of choke that I use in the shack is in the transmission line of my receiving antenna for 3.5 - 14 MHz. *[photo right]*

This consists of 7 windings of RG58 coax through a 35mm 3S4 core. Seven is the maximum number of windings because there is not enough space to insert the BNC connector. For a small core with 7 windings, there is quite a lot of attenuation over the HF area. Again, Rs is quite dominant. *[see the graphs below]*.



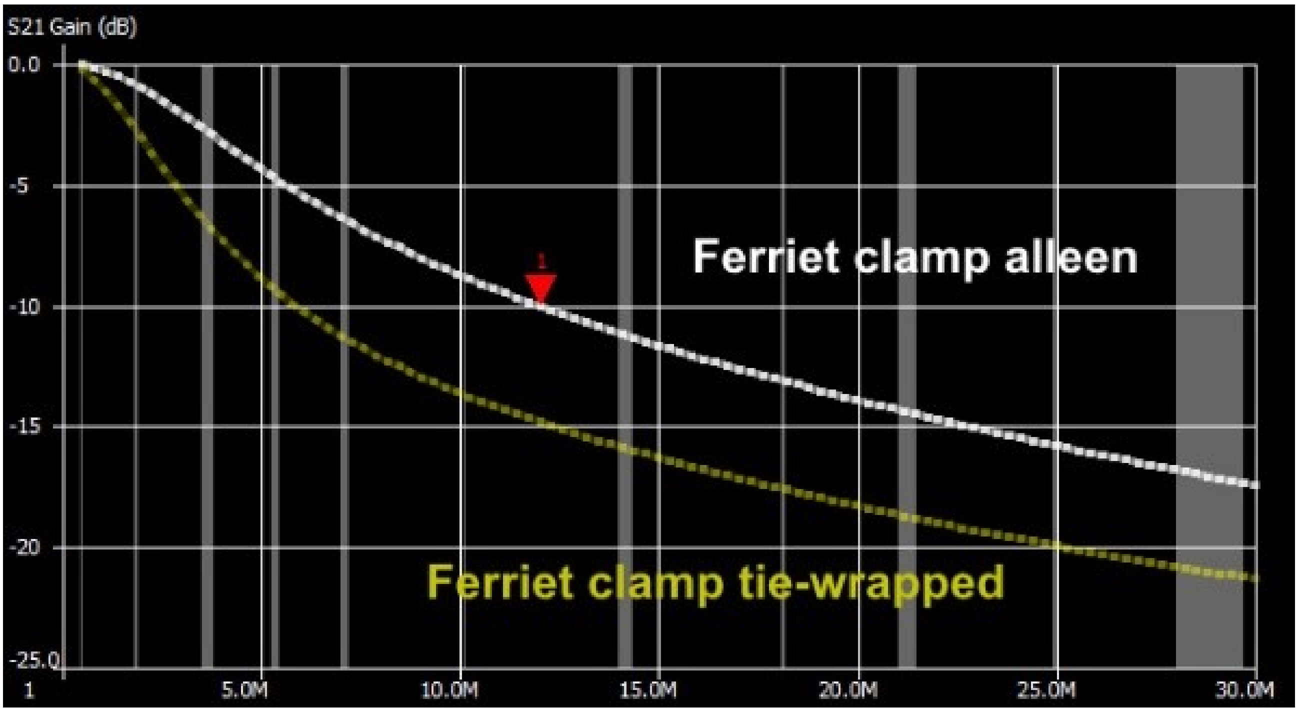


The last choke described in this article is what I call an "occasional choke." Occasionally you are somewhere in a place where there is some RF feedback or whatever. In my case this is usually during a field day, or during an improvised temporary contest station. Then you reach for those well-known and oh-so-handy ferrite clamp-ons and hope it helps.

You have to do something…

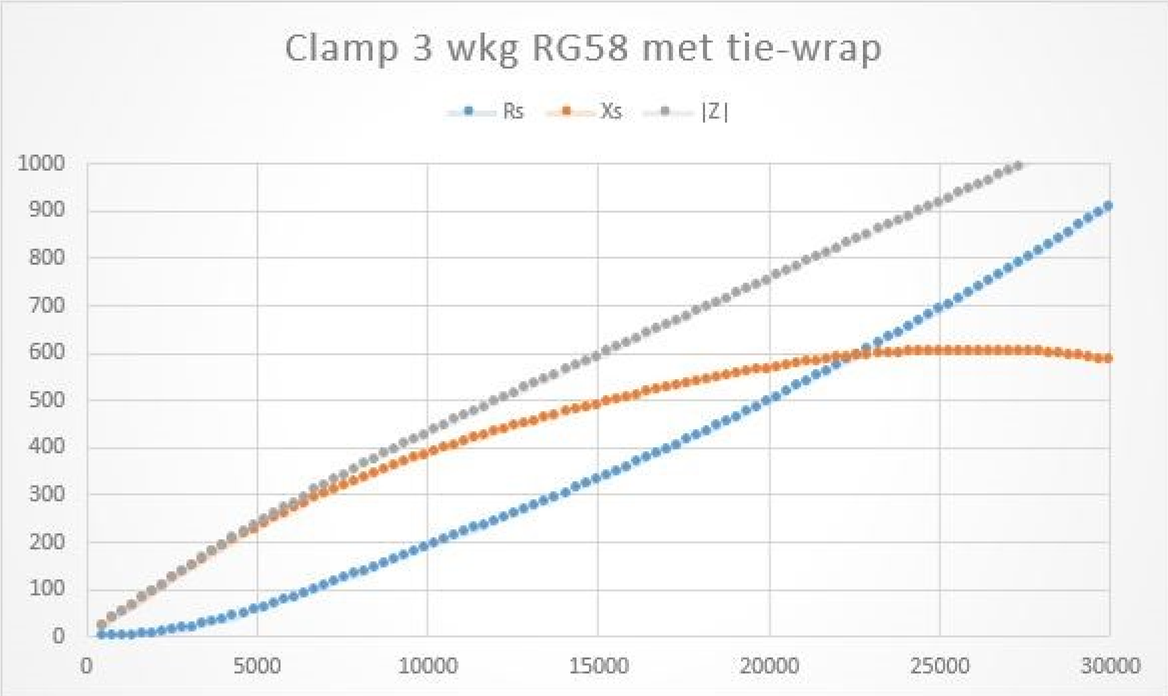
Here is such an example with 3 windings of RG58 (more is not possible) due to a heavy clamp-ons in terms of weight. So, this is a quick solution. The clamp is pressed on firmly and looks tight. Now the measurement..

A first measurement (white points) indicates that attenuation in the lower HF frequencies is not great. At 40m we only get to about 6 dB. Although it seems as if the clamp was properly closed after the wrapping (it has been properly snapped shut...) it was apparently not quite right. A tight tie-wrap around it provided 5 dB extra attenuation with a second measurement (the yellow points). This turned out to be reproducible with various measurements, so it is not an incident..



A good lesson for these clamps is therefore: ALWAYS put a tie-wrap (or rather two) around it, even if it looks so good without them.

Finally, the split of the impedance in ohms and reactive part $R_s + jX_s$ in the following graph. We see that the R_s is only rising slowly and is still rising in the higher HF range. Apparently, it is more suitable as a choke for higher frequencies than what we measured here. But hey, if it helps in the temporary situation, "who cares"?



After these measurements (the chokes have been in use for much longer than I have had the nanoVNA) it appears that the 240-31 core does an excellent job. In addition to RF in the shack, I also use the 240-31 core in the 230V mains. The clamp used is clearly less effective in my case, and we shouldn't expect miracles from it.

In the fourth part of the series "Measurements with the nanoVNA" we will identify different cores and find which material are we dealing with. The nanoVNA can also play a useful role in this.

For now, have fun measuring your chokes.

73,

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Reference:

G3TXQ: Amateur Radio (G3TXQ) - Common-mode chokes
(http://www.karinya.net/g3txq/chokes/#measurement)

PA3A: nanoVNA measurement articles: Measurement of high Impedances
(https://pa3a.nl/wp-content/uploads/2022/03/Measurements-With-The-NanoVNA-Part-2-Measurement-of-high-Impedances.pdf)