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The story of my Bandpass calculator

To avoid the contest turmoil I often use the 30m band, but here my IC-7300 regularly has to fight with the strong signals of an OM from the immediate vicinity, especially if it is traveling at 40m or 20m.

A narrow band filter in front of the receiver input was supposed to help, but this failed due to the lack of connection of the Trx for a separate receiving antenna and the tragic demise of my MFJ-1708 antenna switch in the middle of a cloud of smoke.
This left only the possibility to loop in a transmit/receive filter between PA and antenna coupler with the pleasant side effect of simultaneously reducing the own radiation of harmonics.

With regard to transmission loss and load capacity, there are of course much higher requirements for such a filter than would be the case for a pure receive filter.
In search of a solution, I came across the well-known filter kits from Wolfgang, DG0SA (r.i.p), which have already proven themselves hundreds of times in practice in multiband contest operation /1/.

Simulation of the original filter of DG0SA

The DG0SA circuit (Fig. 1) has the not to be underestimated advantage that all three resonant circuits must be uniformly tuned to the band center frequency, which considerably simplifies adjustment (and calculation!).

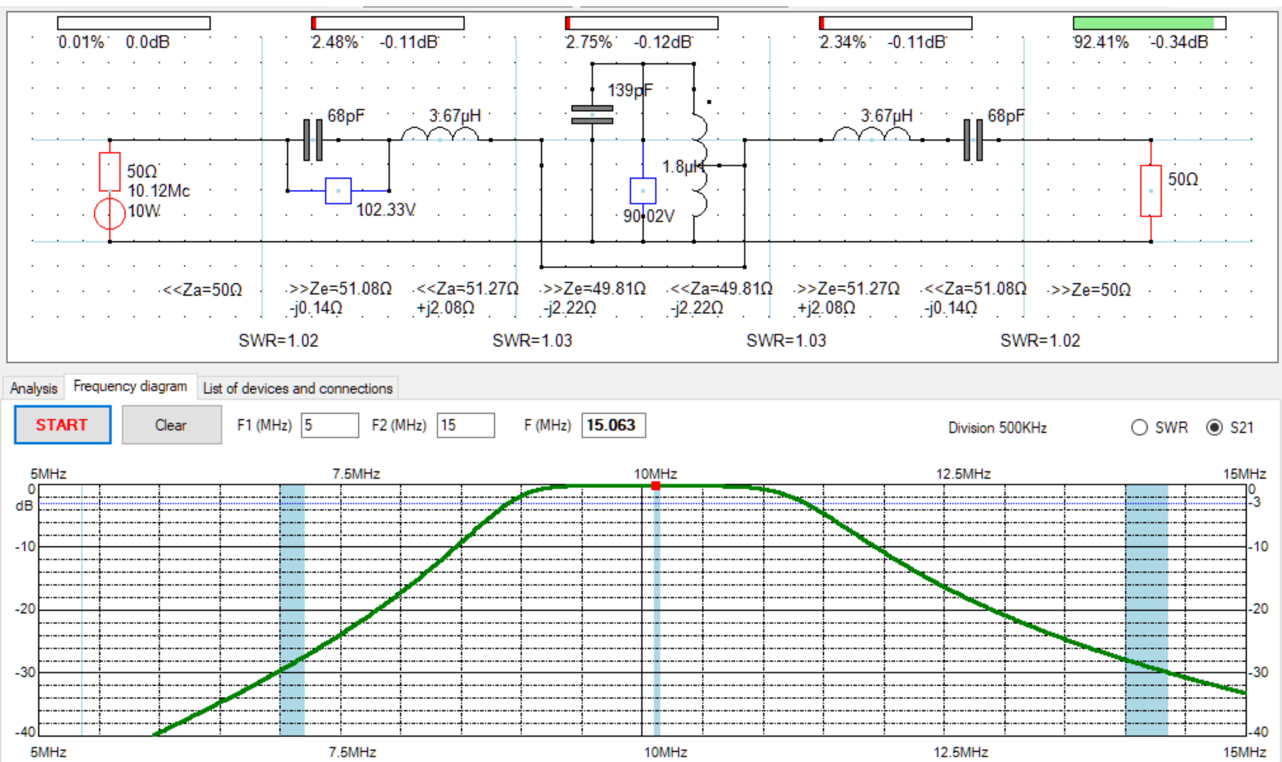

Fig. 1
Analysis of the 30m transmit/receive filter according to DG0SA with the *Special Network Analyzer* (SNWA); QL=225; QC=1000; Tap of the middle coil at 25%, coupling factor k = 0.95; Transmission loss 0.34dB;
Wide selection 40m or 20m band 28 ... 30 dB; Voltages at capacitances at 100W PA power 323.6V or 284.6V (RMS)

In the S21 plot, it is noticeable that the roof of the filter curve is considerably wider than would actually be necessary for the extremely narrow 30m band.
However, the insertion loss in the range between 9.5 and 10.5MHz remains constant below 0.34dB, i.e. in the transmission case only about 8% of the PA power in the filter is converted into heat (8Watt with a 100W PA).

The suppression of the immediately adjacent bands 40m and 20m only reaches the 30dB limit, which is of course unsatisfactory, it should be more than 40dB.

Optimization with the Bandpass Calculator

Is it possible to trim the DG0SA filter to a narrower bandwidth and thus higher wide selection by more optimal selection of components and shifting the tapping?

To answer this nagging question, experiments and measurements alone will not get you anywhere. And so I put together a "bandpass calculator" (BPC) from various building blocks of my JWD Tools (Fig. 2).

Input values are the system impedance Zo, the no-load qualities of the coils and capacitors, and the coupling factor between the coils of the tapped coil, which simulates the leakage inductance (0 < k <= 1).
This is followed by band center frequency Fm, bandwidth B and the maximum permissible insertion loss in the bandwidth range.
Furthermore, the two frequencies that are to be attenuated to the maximum must be entered, usually these are the two adjacent AFU bands.
en die maximal gedämpft werden sollen, i.d.R. sind das die beiden benachbarten Afu-Bänder.

The position of the coil tapping can initially be specified between (0 < az < 100%).

As tuning ranges of the capacitances, the BPC defines default values that depend on the system impedance Z0 and the band center frequency Mm, but these can also be changed.

As a result, the BPC provides two filter configurations, depending on whether the attenuation for F1 or F2 should be better.
Since the filter curve is symmetrical, however, both are usually identical, since the frequencies to be blocked are far enough away from the middle of the band.

After clicking on the START button, the value range of the three capacities is first released for editing.
Here you can, but do not have to, make adjustments, e.g. if you want to limit maximum or minimum sizes of L1/L2 (these depend on C1/C2).

All changes have to be confirmed with the ENTER key!

The NEXT button then initiates the iterative calculation.

As a first test, the BPC should first confirm the data of the 30m filter of DG0SA.
Fig. 2 shows that these are hit pretty well.

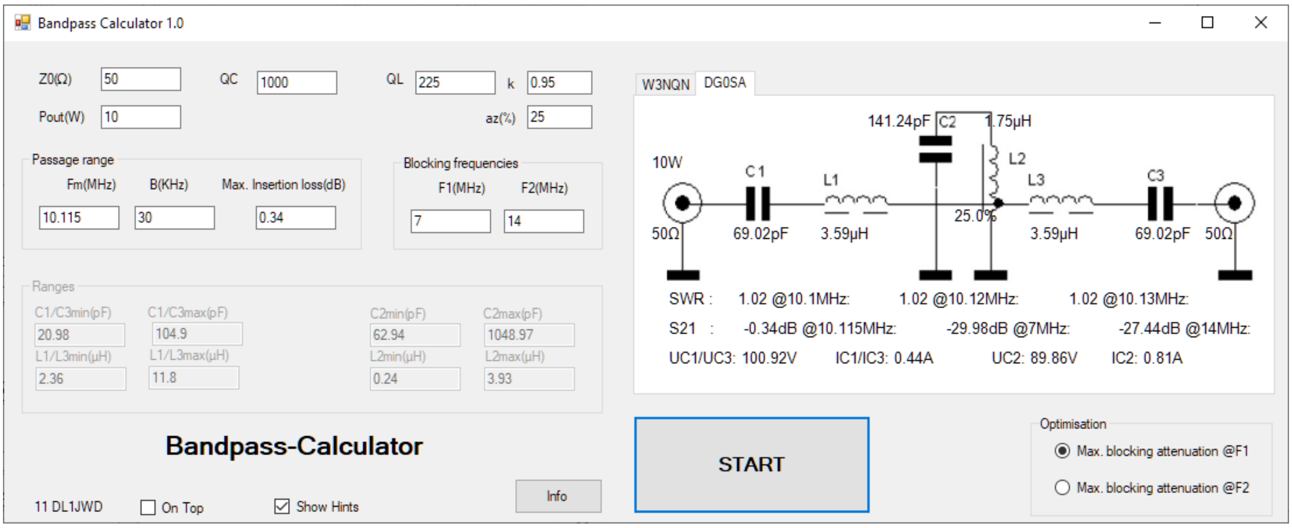

Fig. 2 The DG0SA filter is optimally dimensioned for tapping at 25% of the total number of turns of L2.
Currents and voltages are RMS values and apply to 10 watts (with a 100W PA they increase by a factor of 3.16).

Search for the optimal tapping

If the BPC itself is to search for the most favourable location of the tapping, the value 0 must be entered for az. However, this extends the computing time to about 15sec.

The result is a 30m filter, whose parallel oscillating circuit is much lower impedance, whereby the tap is about 50% of the total number of turns. Entsprechend höher ist auch der kritische Strom IC2 (und UC2 demzufolge niedriger).

With regard to the suppression of the adjacent tapes, however, there is unfortunately no hoped-for improvement compared to the DG0SA original version (Table 1).

	C1/C3 (pF)	L1/L3 [µH)	C2 (pF)	L2 (µH)	az (%)	UC1/UC3 (V)	IC1/IC3 (A)	UC2 (V)	IC2 (A)	TL (dB) @10,12 MHz	TL(dB) @7 MHz	TL(dB) @14 MHz	SWR 30m band
DG0SA original	68	3,67	139	1,8	25	102,33	0,44	90,02	0, 8	-0,34	-29	-29	1,02
DG0SA BPC	68,95	3,59	705,25	0,35	51	100,76	0,44	40,06	1,8	-0,34	-31,56	-28,47	1,02
DG0SA without tap	58,22	4,25	1030	0,24	100	118,41	0,44	22,16	1,45	-0,34	-25	-21,16	1,05

Table 1 Different DG0SA filters with the same 0.34dB insertion loss.
The versions with tapping at 25% and 51% respectively do not sufficiently block the 20 and 40m band with about 30dB.
Without tapping (az = 100%), the filter becomes completely inferior.
Currents and voltages refer to 10W PA power, at 100W multiply by 3.16.

Better selection only at the expense of insertion loss!

Unfortunately, the BPC had to confirm that if all variations of the DG0SA filter were exhausted, at least for the 30m band, the suppression of the adjacent bands could not be increased to over 30dB if the pain threshold of max. 0.4dB insertion loss was maintained.

But since you are usually on the 30m band with QRP on the way, you can slaughter in my opinion quite this "holy cow", here an increase to 0.6dB still seems tolerable, that would be about 13% losses in the filter (with a 10W PA so justifiable 1.3W).

After approx. 15sec, the BPC provides the desired configuration, which blocks the 40m and 20m bands at a maximum of 0.6dB (46dB and 43dB respectively). The BPC sees the most favourable position of the tapping at 45% of the total number of turns (seen from the cold end).

The SWR remains below 1.04. At 10W PA power, C1/C3 with 184V and 0.44A respectively. C2 loaded with 48V and 2.7A (effective values).
In the calculation, 5% leakage inductance of L2 is approximately taken into account by the coupling factor k = 0.95 (Fig. 3).

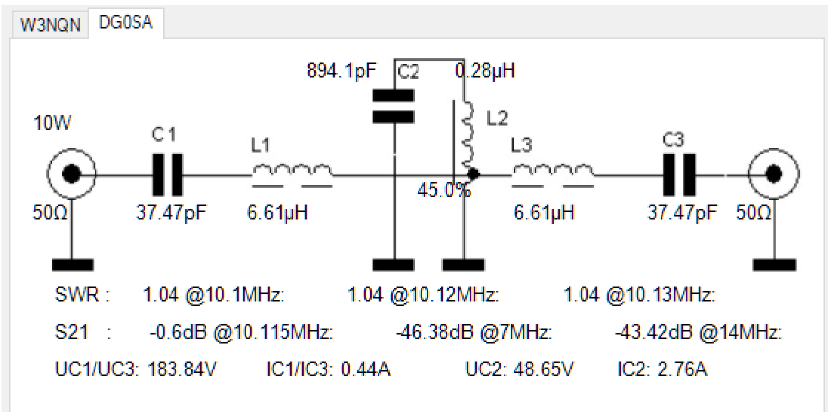

Fig. 3 Transmit/receive filter trimmed for QRP operation according to DG0SA for the 30m band with over 40dB suppression of the adjacent bands

Is it possible without a tapped coil?

If you want to do without coil tapping, enter the value 100% for az in the BPC. Unfortunately, the result is disappointing. As Fig. 4 shows, due to the decreasing operating quality of the parallel oscillating circuit, the attenuation of the adjacent bands can only reach values around 35dB (see also Table 1).

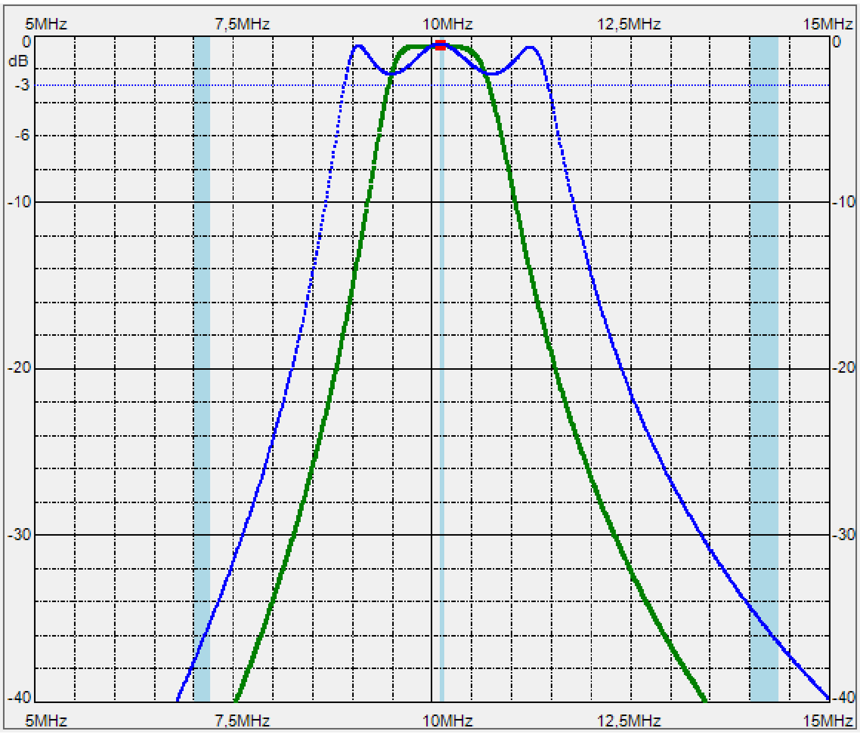

Fig. 4: Attenuation curve of the 30m transmit/receive filter recorded with HamVNAS with 45% tapping (green) and without tapping (blue). Both filters have been optimized by the BPC for the same insertion loss (0.6dB).

W3NQN transmit/receive filter

In addition to the DG0SA filters, the BPC can also optimize the classic filters according to W3NQN. In the latter, the positions of series and parallel oscillating circuits are reversed (Fig. 5). Surprisingly, in the case of the 30m transmit / receive filter, an approximately 4dB higher attenuation of the neighboring bands by the W3NQN structure is shown, which, however, is opposed by the greater effort (2 tapped coils) (Table 2).

	C1/C3 (pF)	L1/L3 (µH)	C2 (pF)	L2 (µH)	az (%)	UC1/UC3 (V)	IC1/IC3 (A)	UC2 (V)	IC2 (A)	TL (dB) @10,12 MHz	TL(dB) @7 MHz	TL(dB) @14 MHz	SWR 30m Band
DG0SA qrp	37,5	6,61	894	0,28	45	183,8	0,44	48,65	2,7	-0,6	-46,4	-43,4	1,04
W3NQN qrp	1032	0,24	35,9	6,89	50	44,8	2,93	191	0,44	-0,6	-50,5	-47,7	1,05

Table 2 Comparison of 30m transmit/receive filter data with DG0SA and W3NQN structure.
Both have the same insertion loss of 0.6dB but different wide selection.

Closing remarks

- A transmit/receive bandpass only works with 50Ohm termination on both sides, insertion into the antenna supply line can lead to destruction!
- Since the currents and voltages calculated by the BPC are output as RMS values, the components (capacitors!) should withstand three times the value for safety's sake.
- In order to ensure the required high coil quality (> 220), there is no way around powdered iron toroidal cores or air coils.

- For toroidal cores, the maximum permissible flux density must be observed (use mini toroidal core computer!)

- Detailed information on design and balancing can be found in the absolutely readable publications of DG0SA /1/.

- The BPC is of course also suitable for designing and optimizing bandpasses for any other frequency, as long as they correspond to the three-pole structure of DG0SA or W3NQN (Fig. 5).

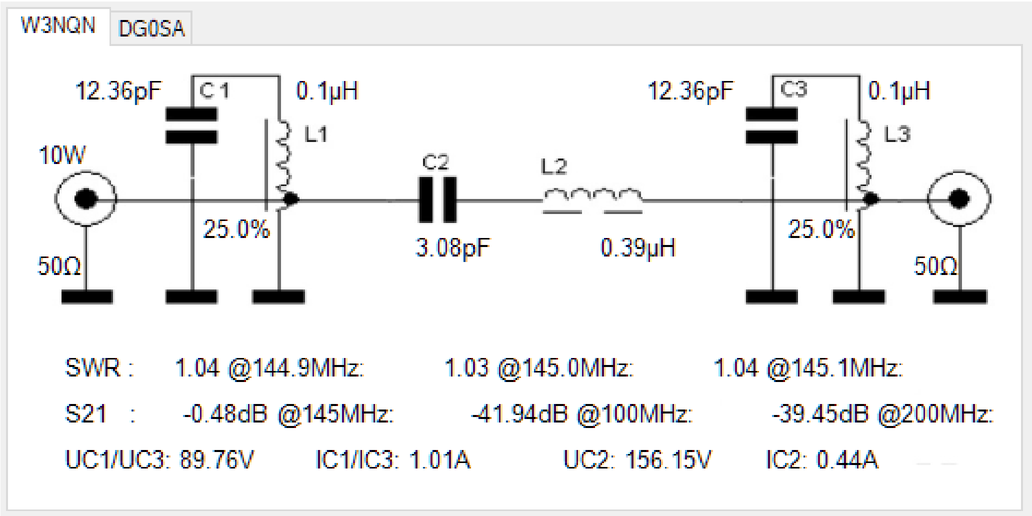

Fig. 5: Transmit / receive filter calculated with the BPR in W3NQN structure for the 2m band with an insertion loss of 0.48dB and a wide selection of approx. -40dB at 100 or 200MHz.
Currents and voltages refer to a PA power of 10W (RMS values).

Literature

[1] Wippermann, W., DG0SA: Sende/Empfangs-Bandpassfilter:
https://docplayer.org/62116069-Sende-empfangs-bandpassfilter.html

[2] Pfann,P., DL2NBU: 100 W - Bandpassfilter nach W3NQN: http://www.bavarian-contest-club.de/projects/bandpassfilter/100W-BP.pdf2002

[3] Doberenz,W., DL1JWD: Rechner für Sende/Empfangs-Bandpassfilter:
http:// www.dl1jwd.darc.de