HF/50MHz Receiving and Transmitting Band Pass Filters with 3 Equal Inductors –part2

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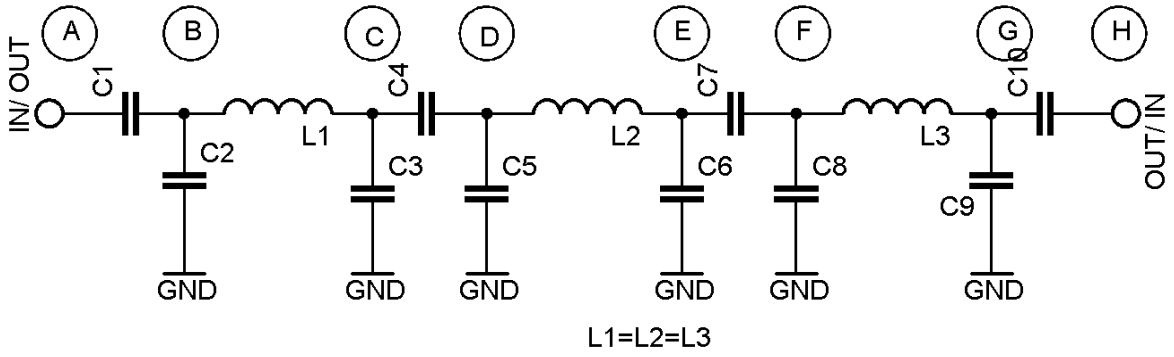
This is second part of HF/50MHz BP series with 3 equal inductors. I designed and realized a lot different types filters. Starting SDR design the new moments for me was that it is necessary to have band-pass (BP) filters which can be used in receiving and transmitting paths. This series of 4-5 articles are my research how to do and solve these requirements at the best and simple way. Different filters in other parts are results of some transformation delta to tee and vice versa and different schematics approach. I added some files from simulation in LT Spice [2] freeware software also to show voltage and current in all nodes to be aware capacitors component quality from break voltage and current point of view. All components are taken in analyses with real losses. The designer's target specification at the start was:

1. Filters have IL(insertion loss) lower than 0.5dB (~11% power loss with inductors Qo ~150-200)
2. All filter components values have to be standard values.
3. Coils are without taps!
4. Inductors can be changed with RF chokes than filter IL have to be smaller than 2dB.
5. Termination return loss S11, S22 are better than -20dB (VSWR=1.22).
6. Frequencies harmonically related to central frequency from lower and upper side are attenuated ~30dB or more.
7. BP filters have 50Ohms termination impedance and filters are symmetrical structure and it is not important what is input or output.
8. Calculated bandwidth -3dB 10-25% of central frequency
9. No tune design and design with low sensitivity to component tolerances

The second BP filter type is realized like it is proposed at picture 1 down. This BP design has very interesting history. First version with only one coil I saw 25 years ago as proposal for extremely low loss BP filter for 2m author was DL7VY[3]. First software which gave values for this type filter is ANSOFT AD [4] software as freeware student version. Initial values obtained from ANSOFT software for L and C weren't always good and I made changes which gave much better results than initial were. The calculation algorithm for good component values has to be changed to obtain better results. Optimizer must be with upper and higher limitations component values. At my site pages you can find filters which I published before BP for 160m, 6m and 2m.

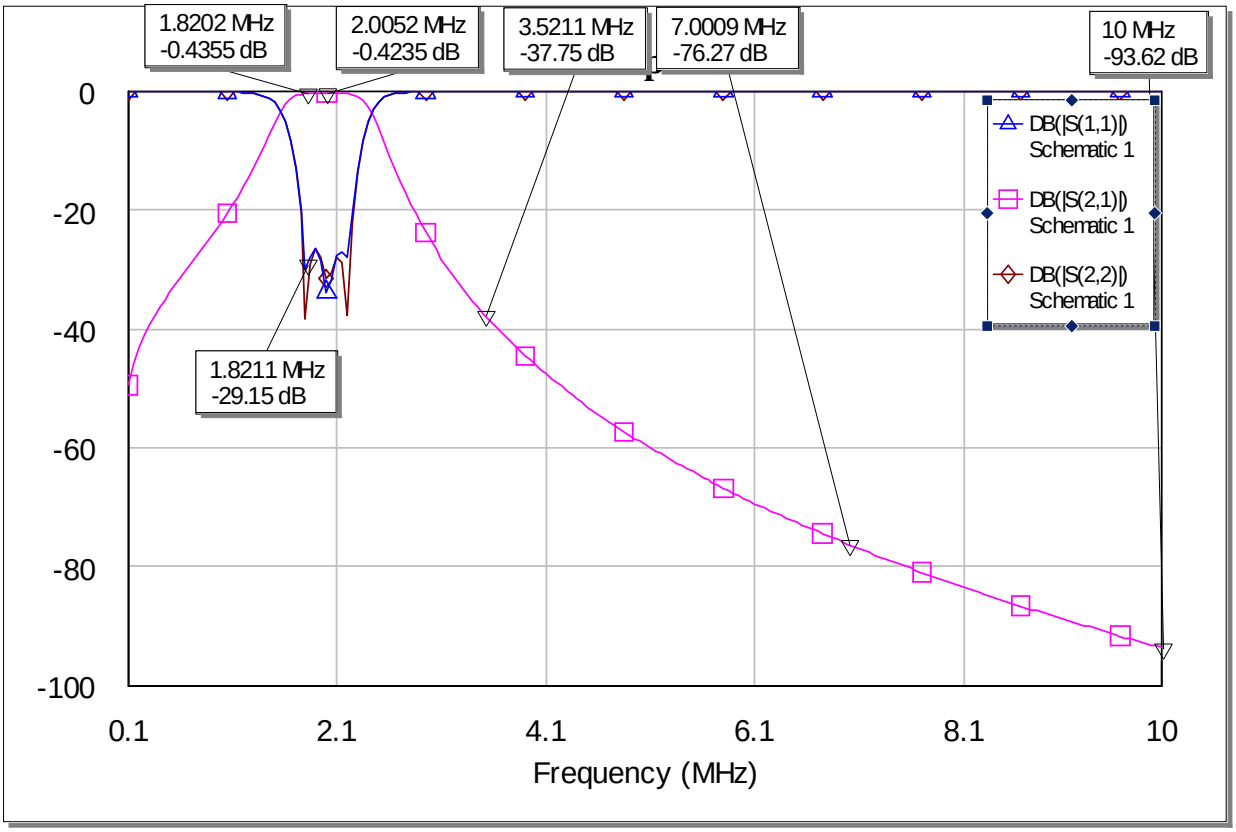


Picture1. HF/50 MHz BP (band-pass) filter version 2 BP-2.

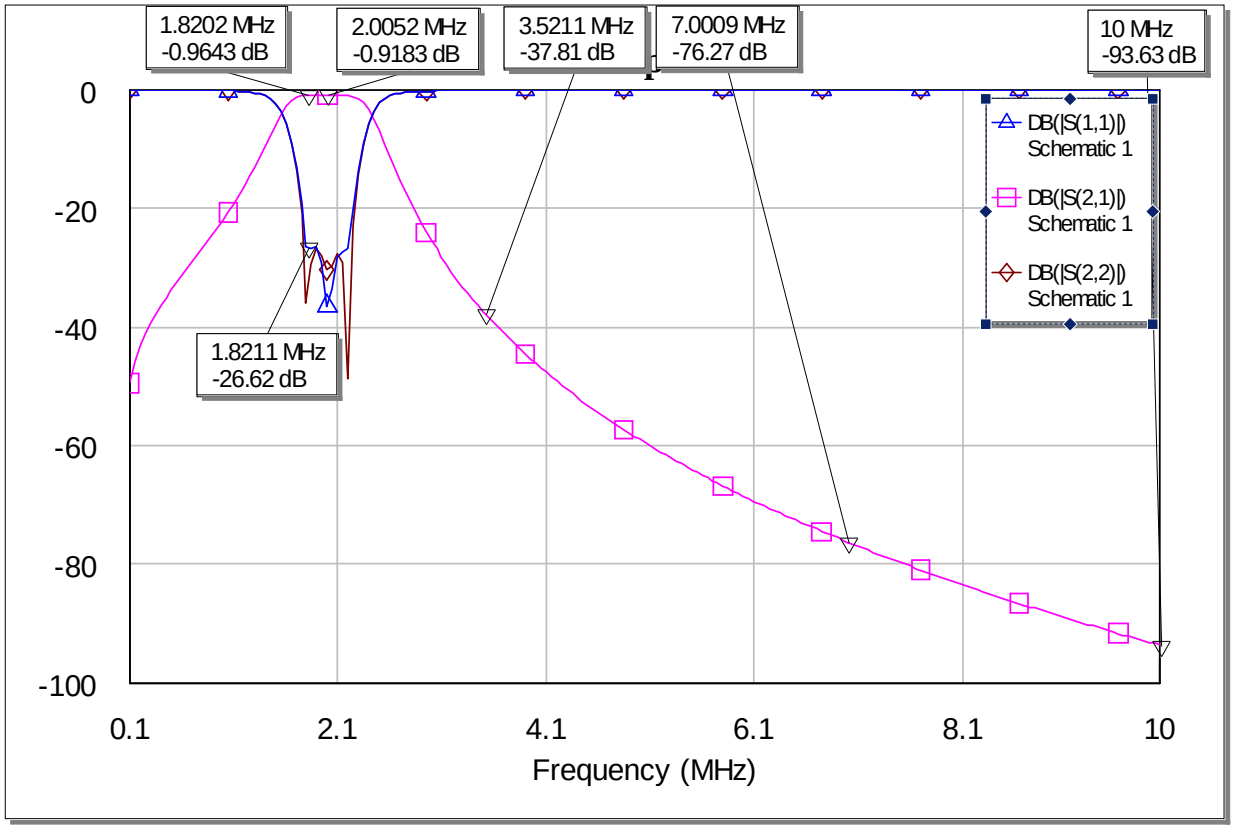
The component values for L and C are in table 1 and frequency response at other pictures down.

BAND	L[uH]	C1[pF]	C2[pF]	C3[pF]	C4[pF]	C5[pF]	C6[pF]	C7[pF]	C8[pF]	C9[pF]	C10[pF]
1.8MHz	8.2	1000	150	1800	2200	470	430	2200	1800	150	1000
3.5MHz	5.6	560	0	470	680	390	330	560	470	0	560
7MHz	3.3	270	22	220	150	220	220	220	220	15	270
10MHz	2.2	150	22	220	120	150	180	120	180	33	150
14MHz	1.5	120	8.2	180	150	82	82	150	180	8.2	120
10-14MHz	1.2	330		82	330	180	180	330	82		390
14-18MHz	1	150	10	150	270	82	82	270	150	10	150
18-21MHz	.82	150	27	100	100	100	100	100	120	39	120
21-24MHz	.68	120	27	82	120	100	68	120	100	10	120
24-28MHz	.56	91	33	82	82	82	56	150	100	15	91
24-28MHz*	.47	100	22	120	150	82	82	100	100	39	100
50MHz	.33	39	15	56	33	39	39	33	56	15	39

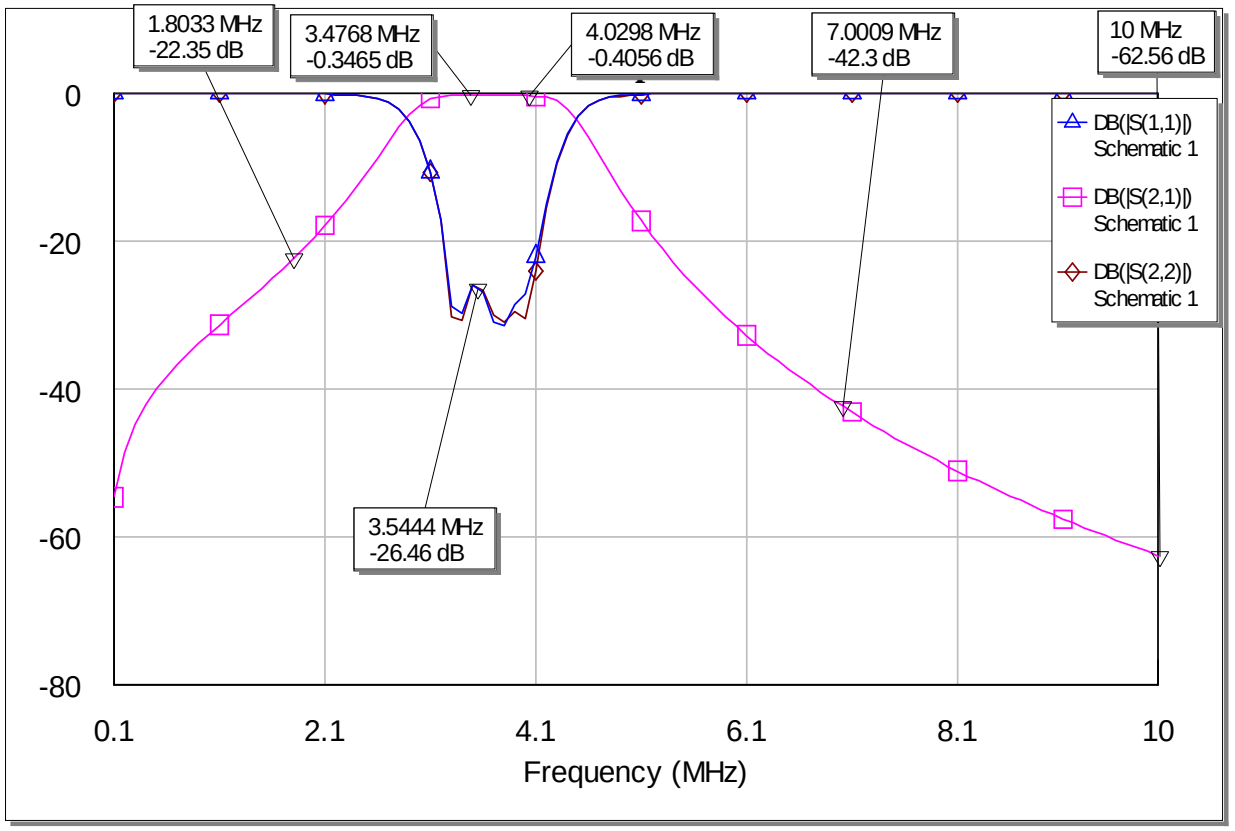
Table1. Element values for BP filters



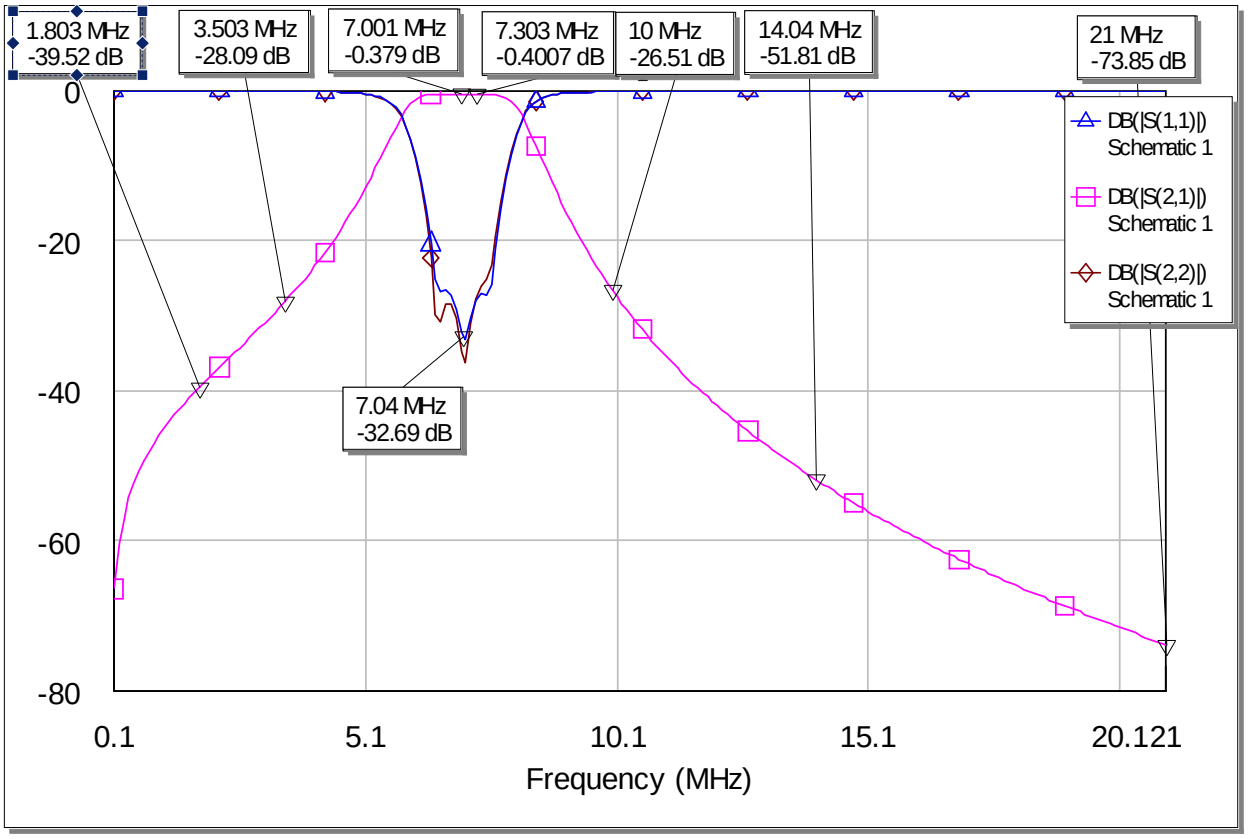
BP Filter for 1.8MHz



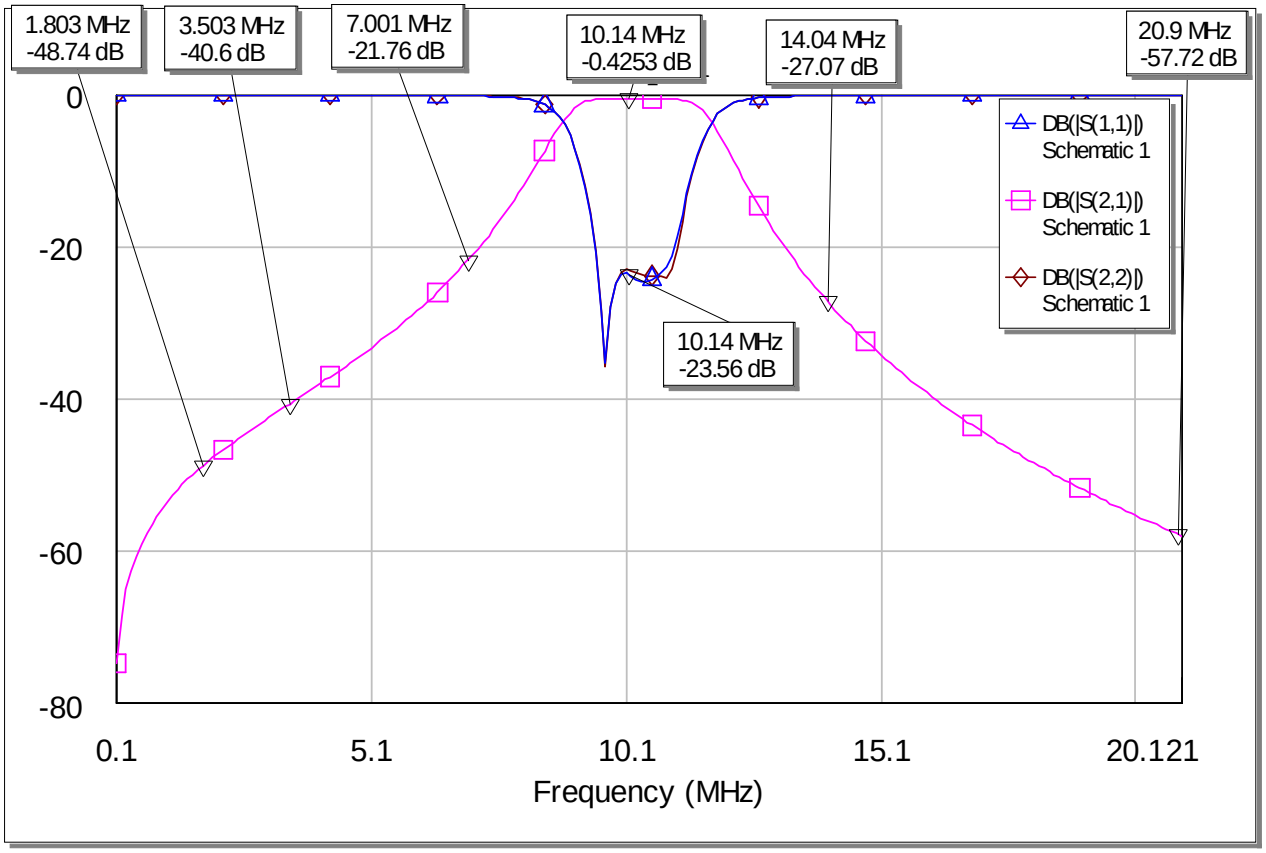
BP Filter for 1.8MHz high Q inductors were changed with choke Qo~60. BP IL is increasing for 0.5dB (use only in receiving part)



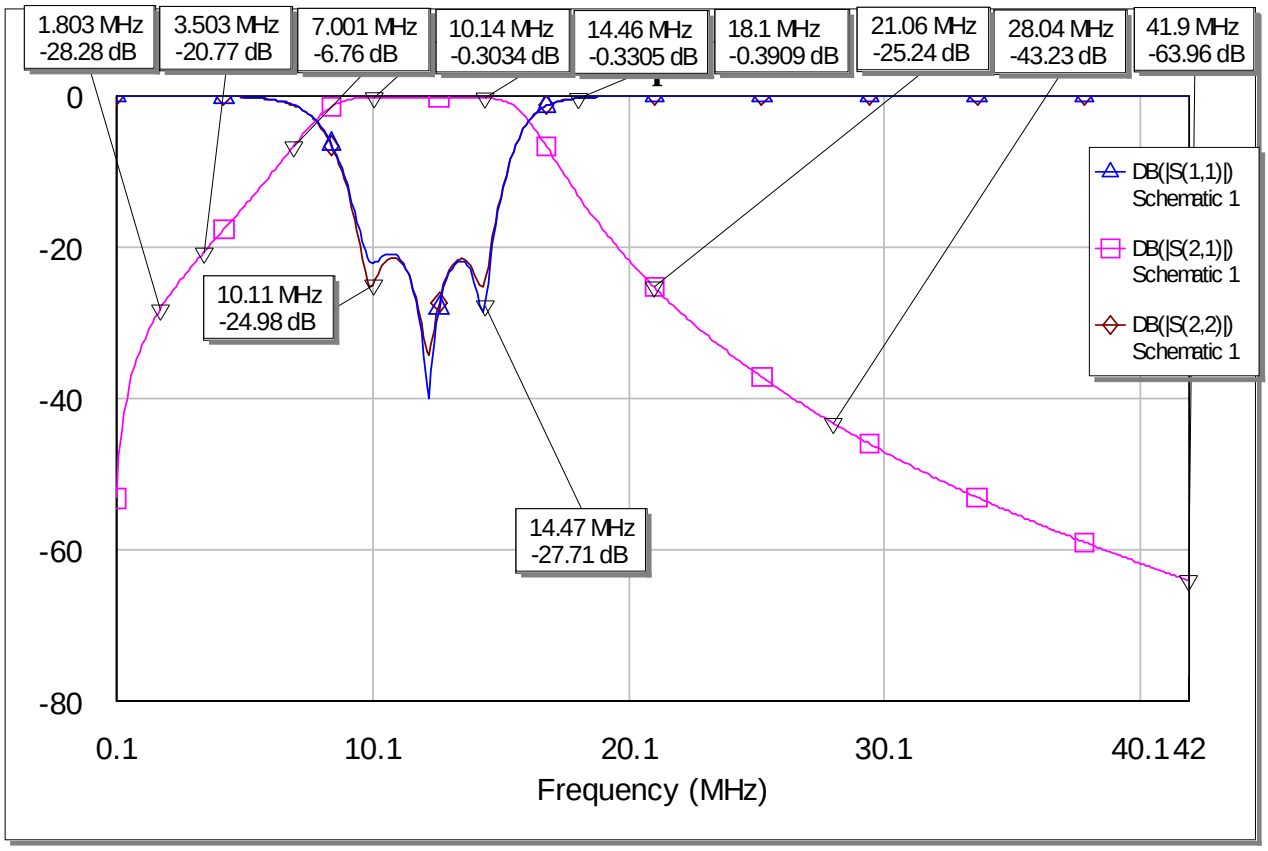
BP Filter for 3.5MHz



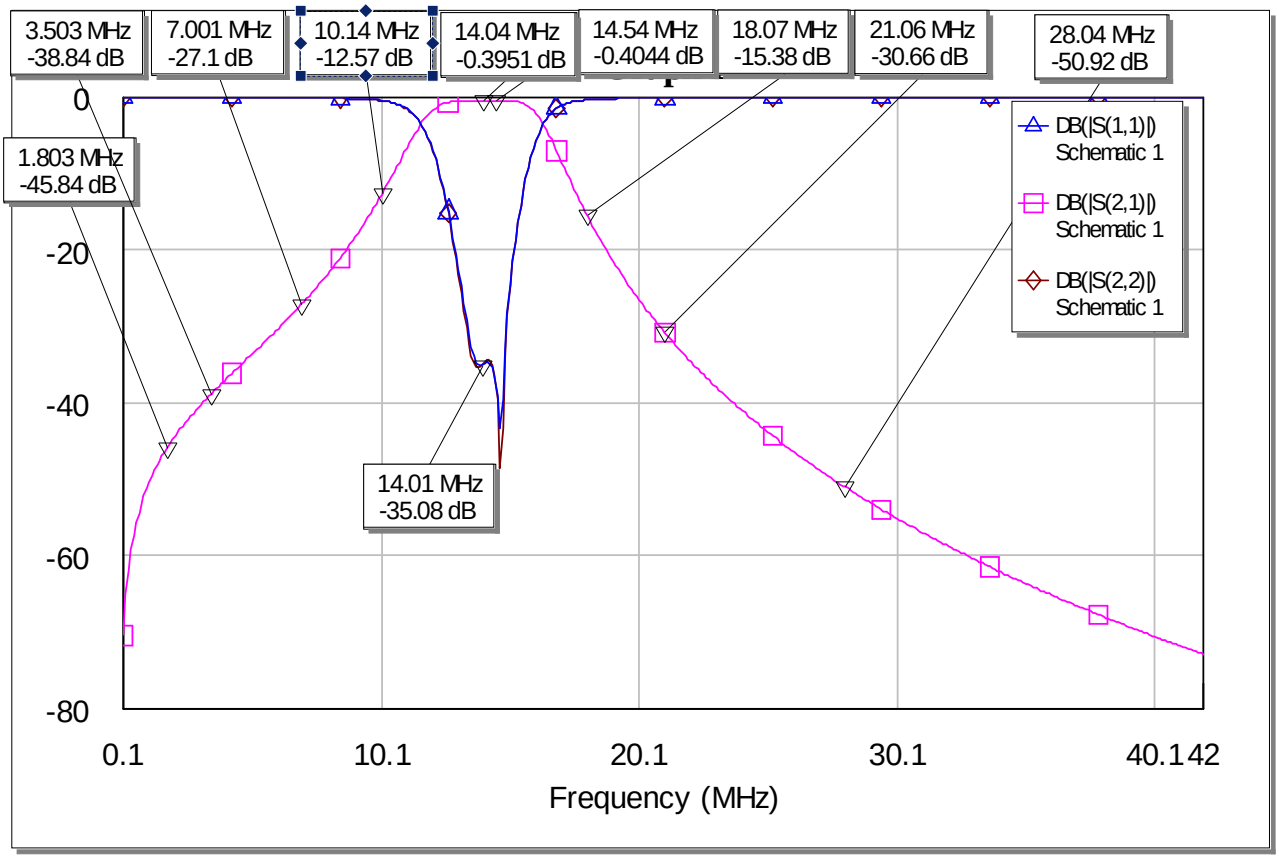
BP Filter for 7MHz



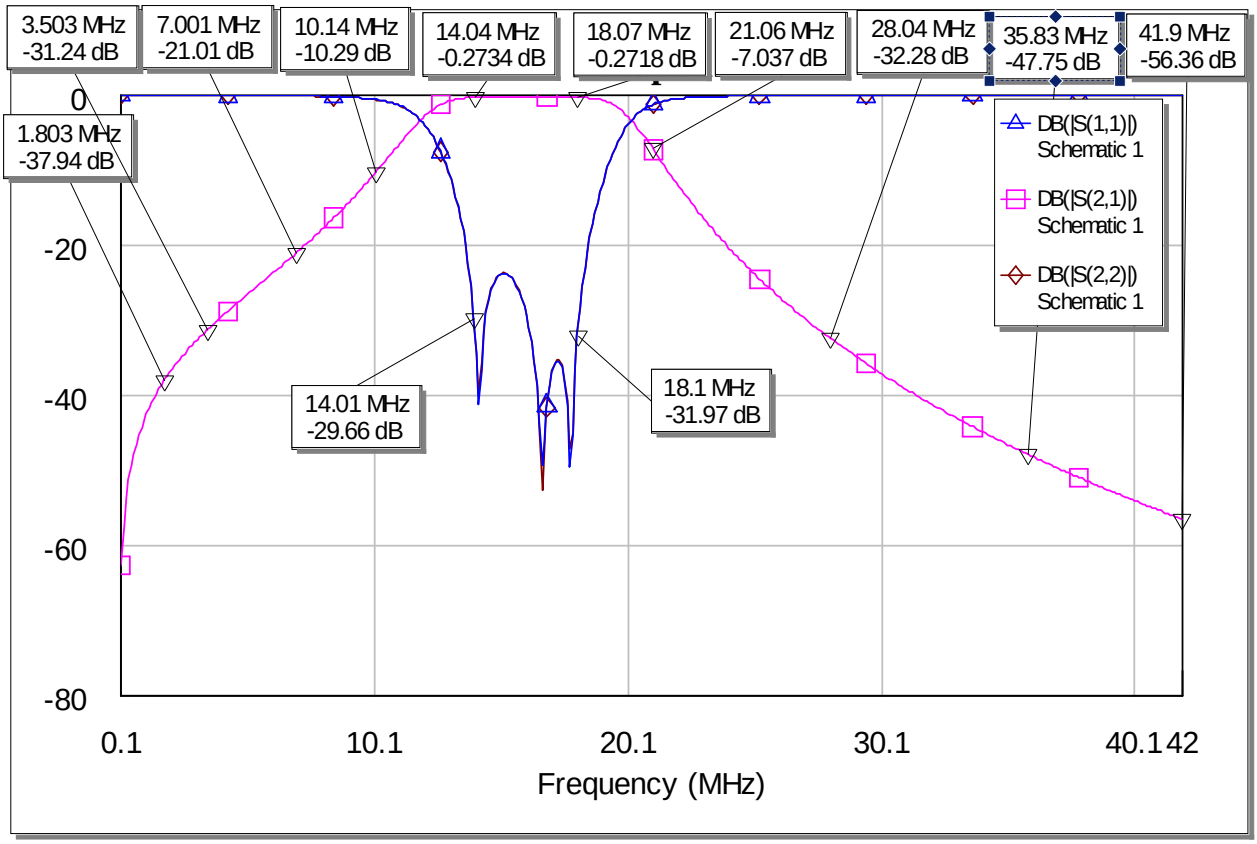
BP Filter for 10MHz



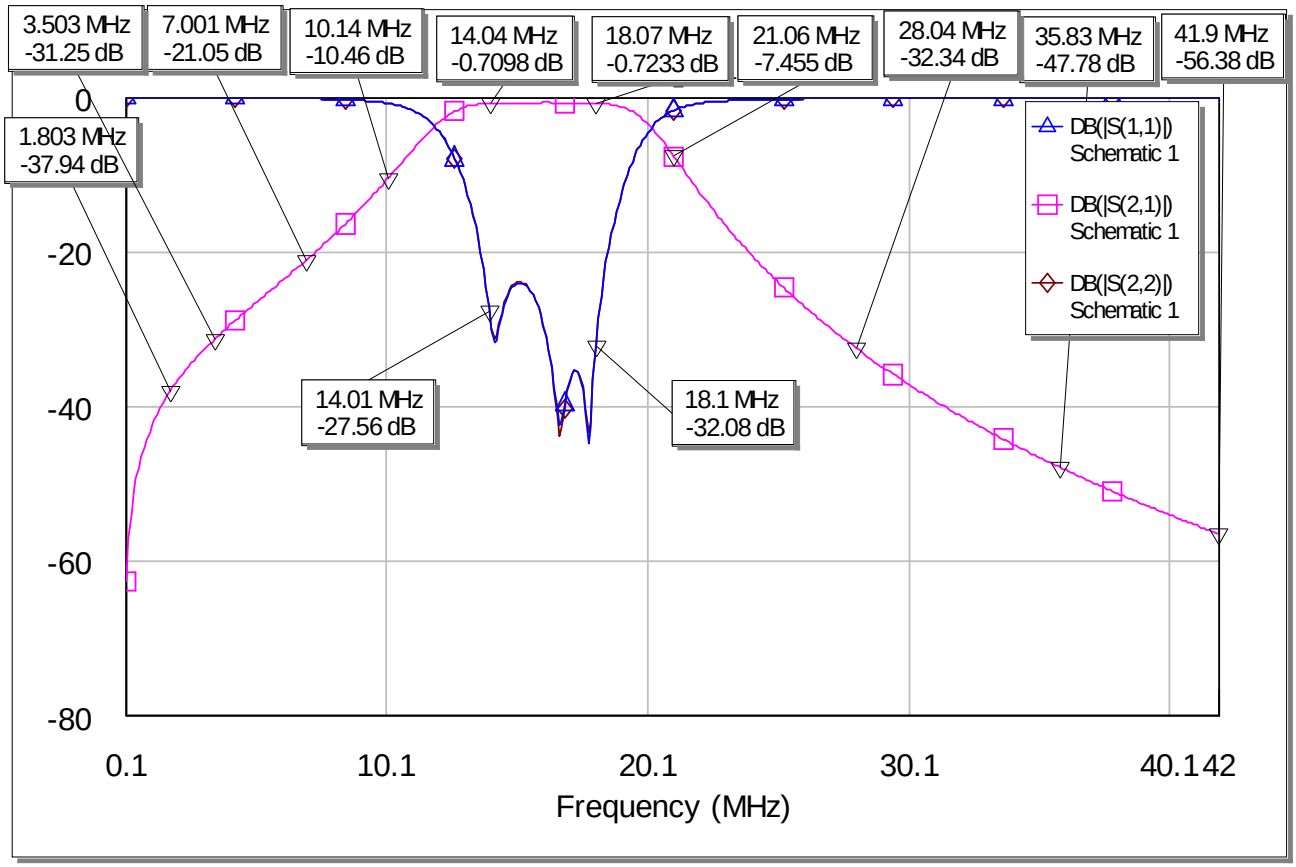
BP Filter for 10-14MHz



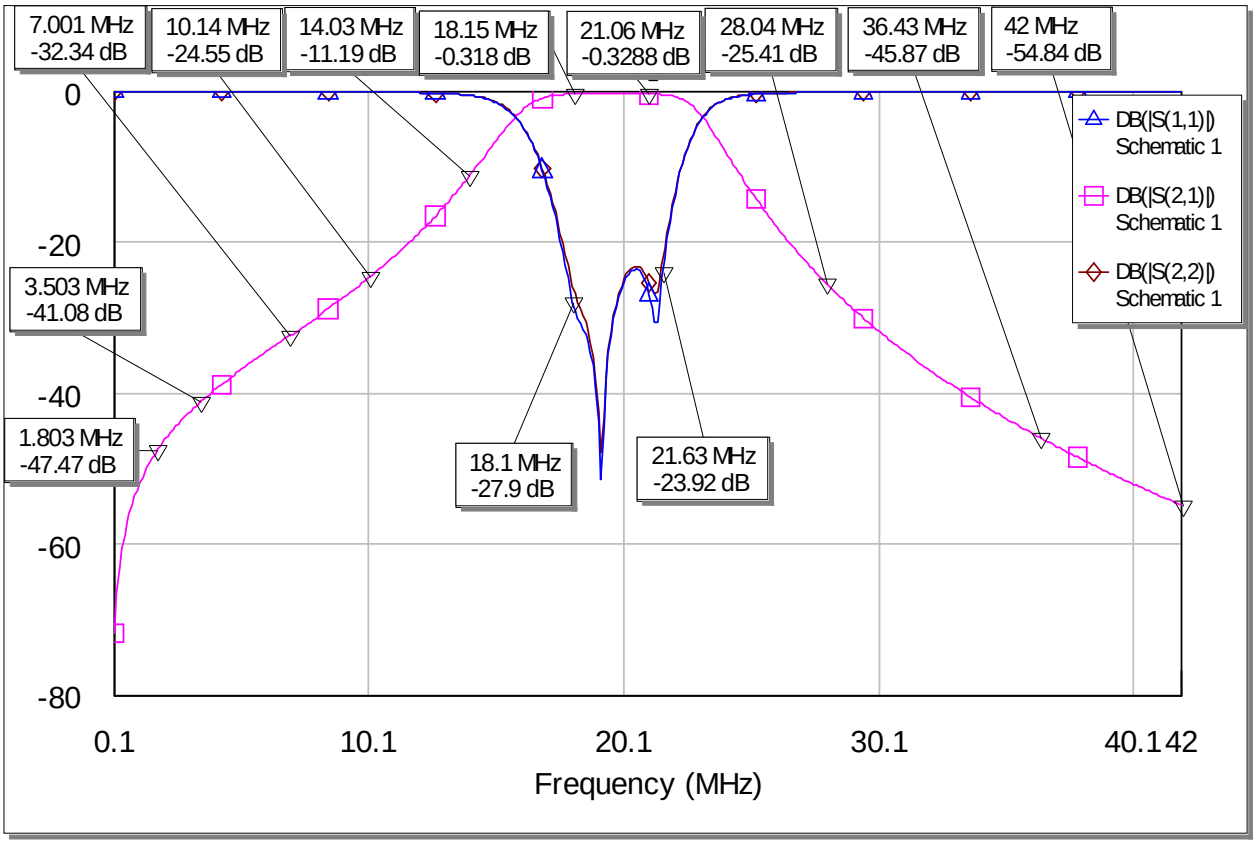
BP Filter for 14MHz



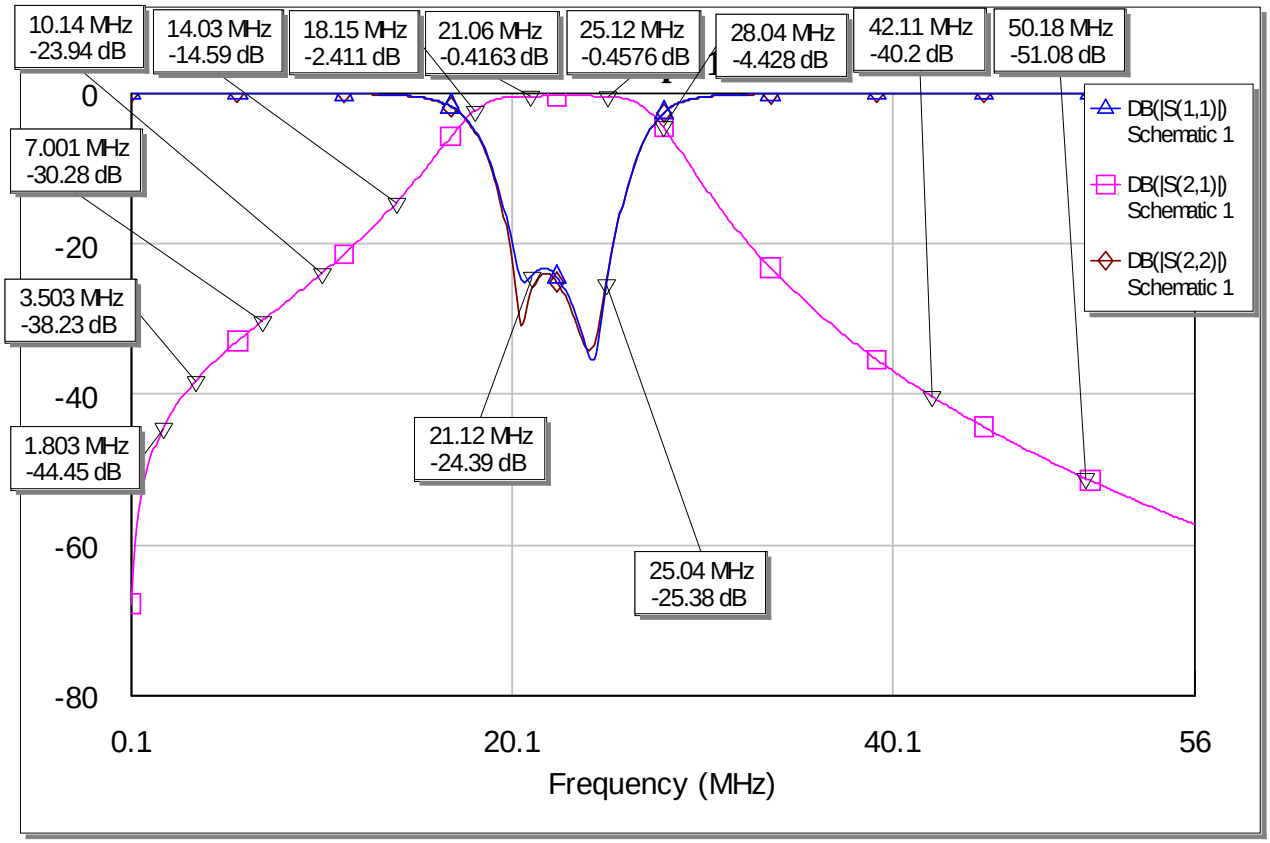
BP Filter for 14-18MHz



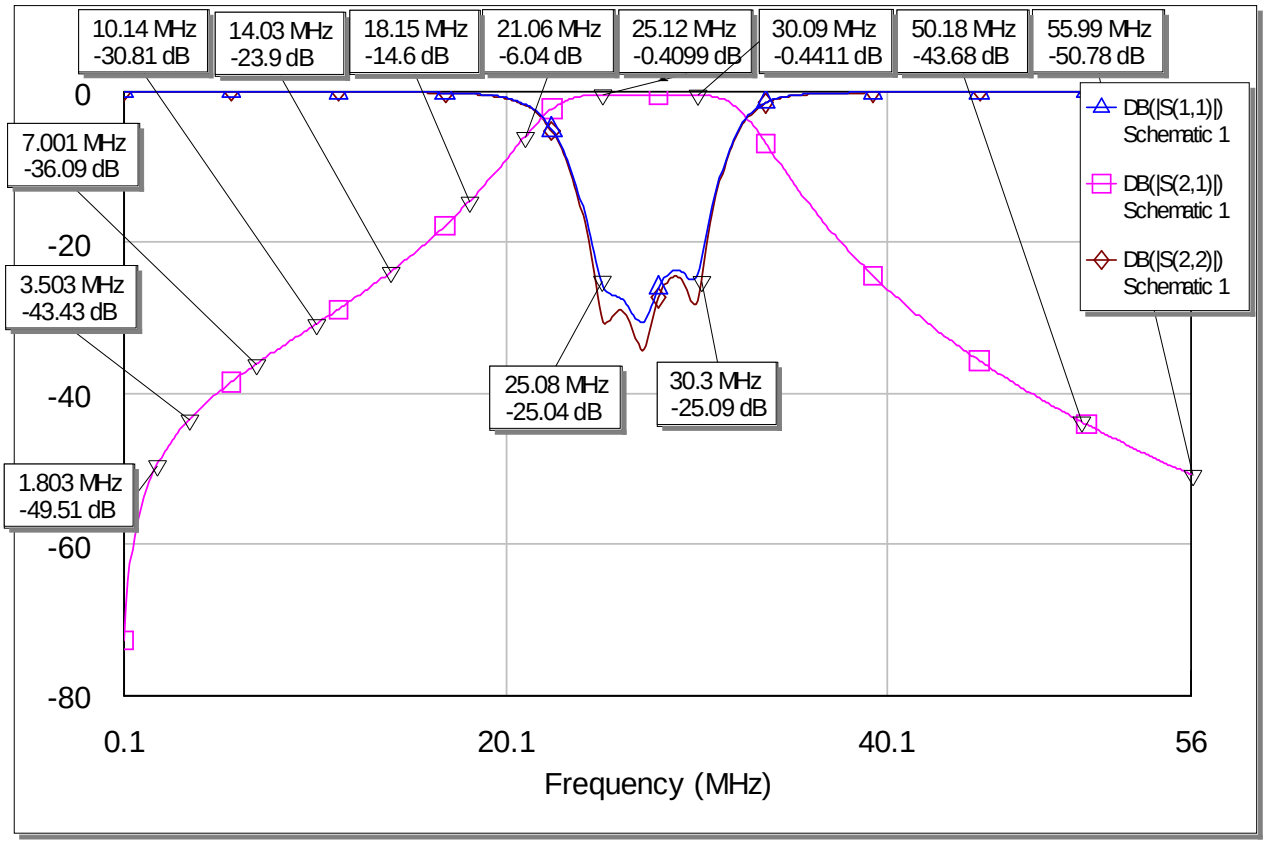
BP filter for 14-18MHz high Q inductor were changed with choke Qo~60. BP IL is increasing for 0.5dB (use only in receiving part)



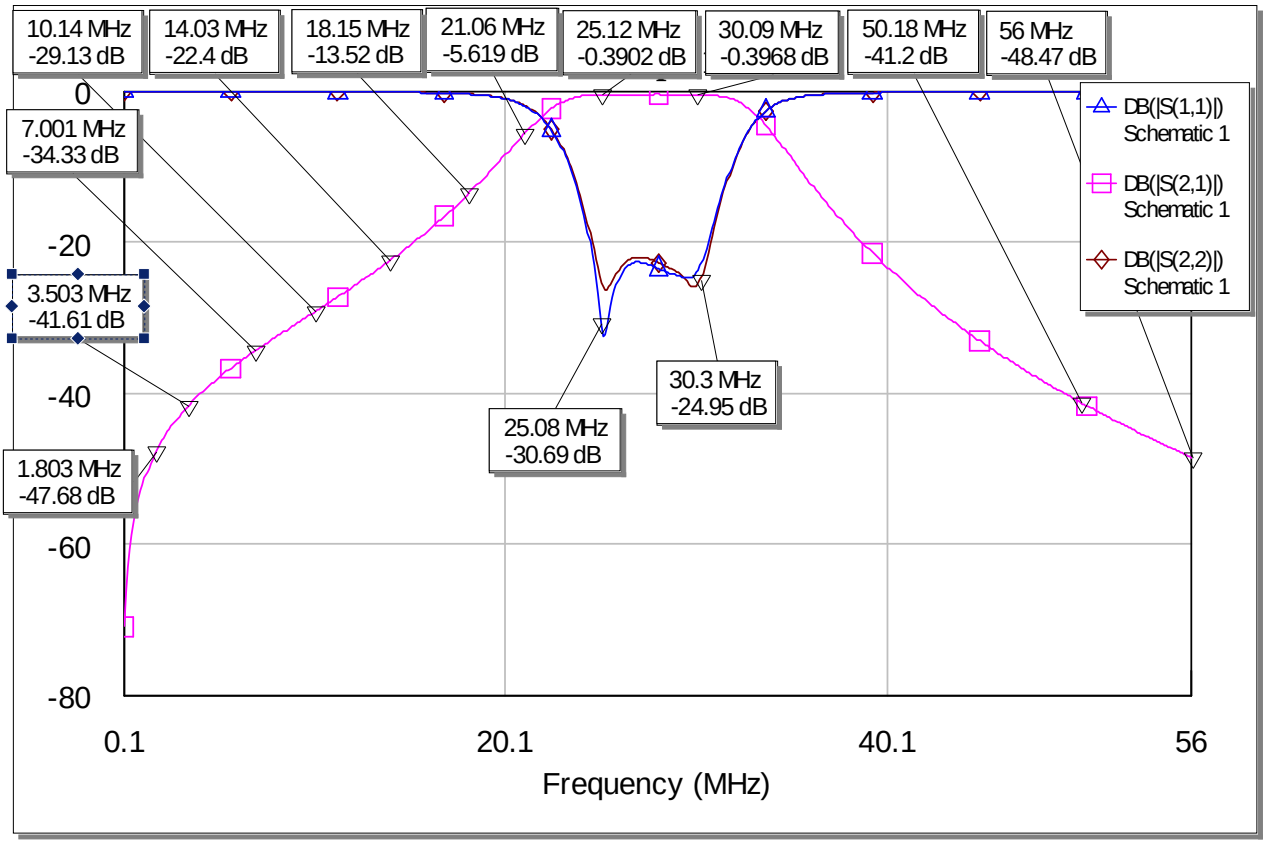
BP Filer for 18-21MHz



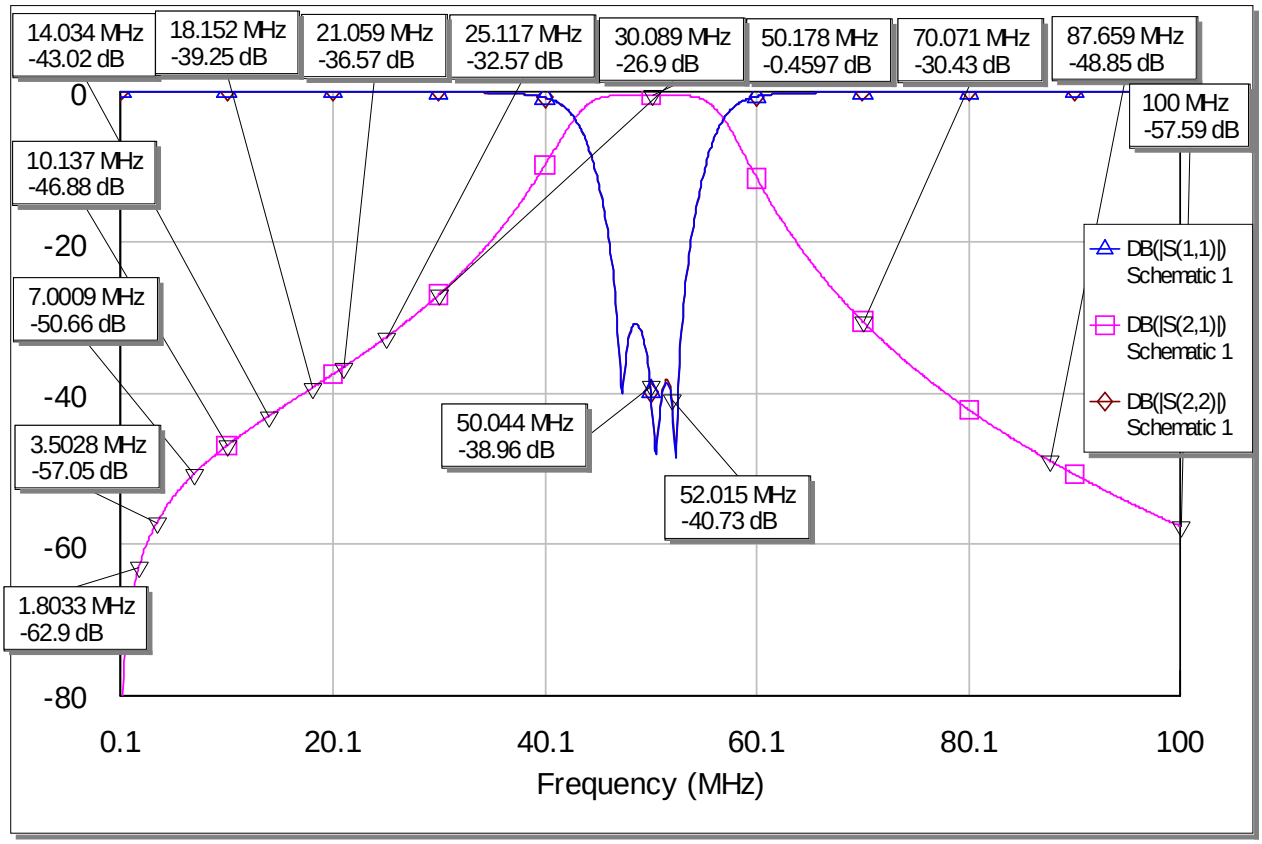
BP Filer for 21-25MHz



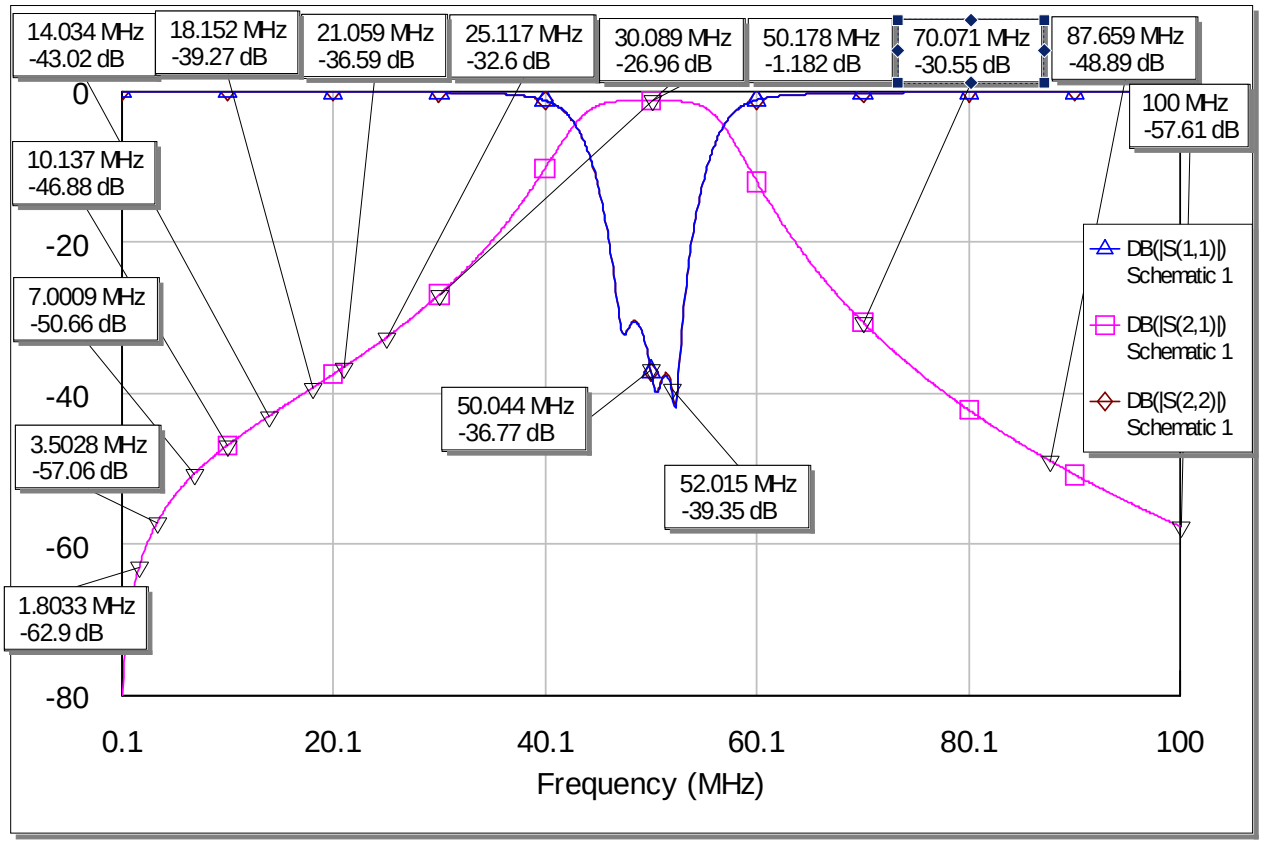
BP Filter for 25-28MHz ver1



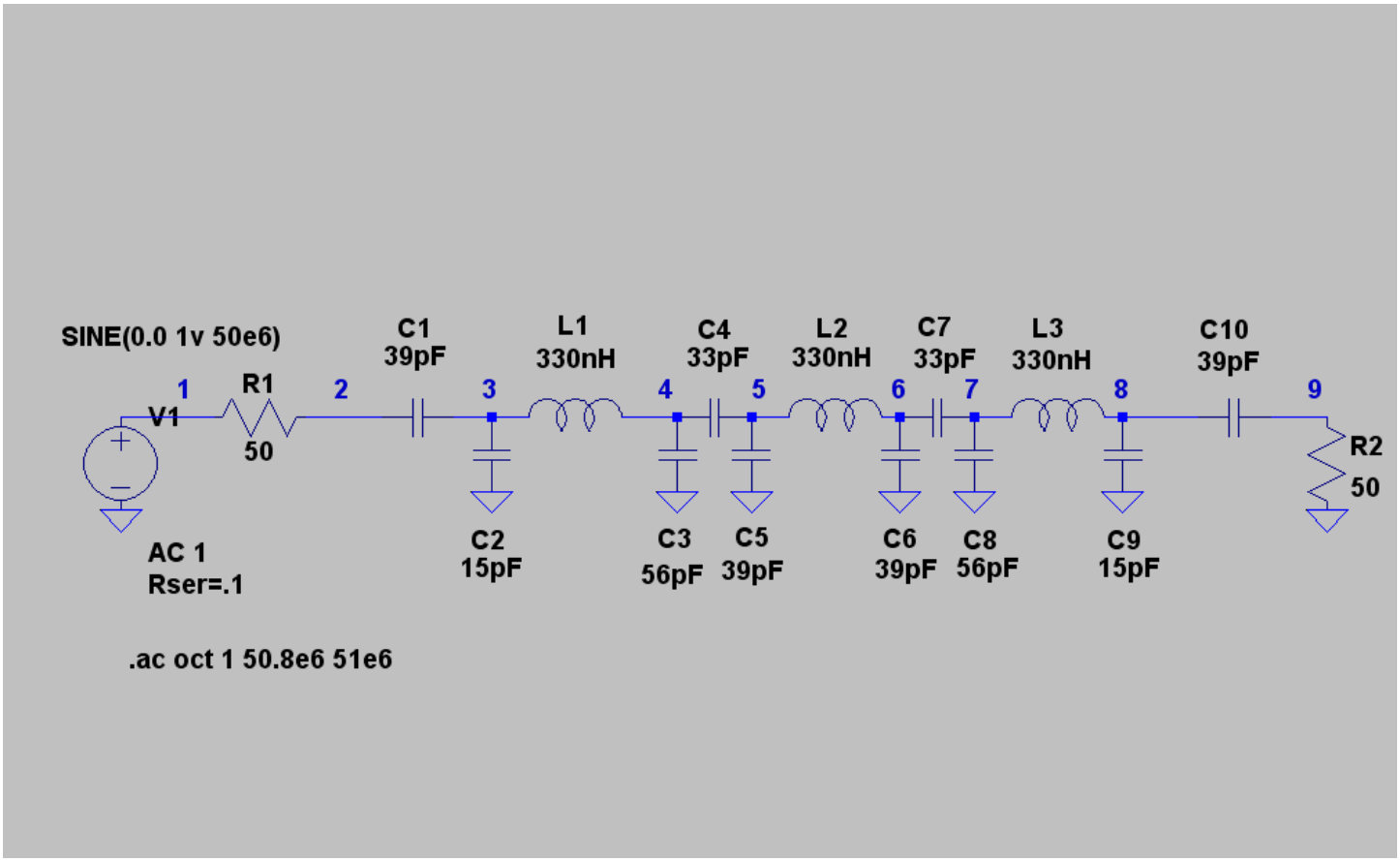
BP Filter for 25-28MHz* ver2



Filter for 50MHz



BP Filter for 50MHz high Q inductors were changed with chokes Qo~60. BP IL is increasing for 0.7dB (use only in receiving part)



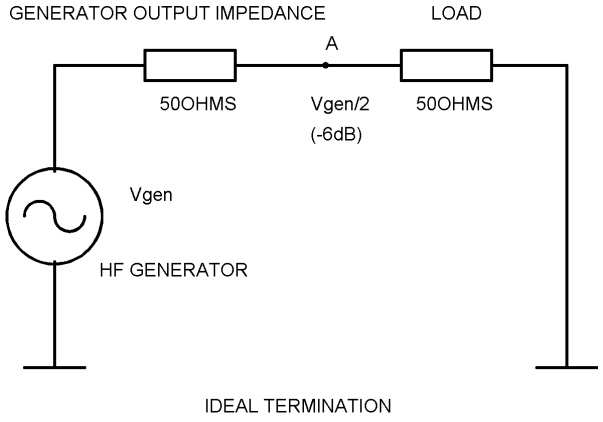
TX=100W VSWR=1.0 peak voltage magnitude in [V] and current in [A]

```
frequency:     5.1e+007      Hz
V(n001):       mag:     140.86 phase: 0.000394952°        voltage
V(n003):       mag:    133.545 phase:    57.6613°        voltage
V(n002):       mag:    70.6608 phase:   0.394451°        voltage
V(n004):       mag:    99.0413 phase:   -69.8623°        voltage
V(n005):       mag:    142.002 phase:   -28.0262°        voltage
V(n006):       mag:    142.563 phase:   -176.818°        voltage
V(n007):       mag:    99.7272 phase:   -135.537°        voltage
V(n008):       mag:    132.894 phase:    96.7819°        voltage
V(n009):       mag:    70.4226 phase:    154.782°        voltage
I(C10):        mag:    1.40845 phase:    154.782°        device_current
I(C9):         mag:   0.638773 phase:   -173.218°        device_current
I(C8):         mag:    1.78958 phase:   -45.5369°        device_current
I(C7):         mag:   0.997699 phase:   -131.035°        device_current
I(C6):         mag:    1.78165 phase:   -86.8185°        device_current
I(C5):         mag:    1.77463 phase:    61.9738°        device_current
I(C4):         mag:    1.00412 phase:   -73.9434°        device_current
I(C3):         mag:    1.77727 phase:   -159.862°        device_current
I(C2):         mag:     0.6419 phase:   -32.3387°        device_current
I(C1):         mag:    1.40404 phase:    179.604°        device_current
I(L3):         mag:    1.97932 phase:    164.629°        device_current
I(L2):         mag:    2.59184 phase:    -102.39°        device_current
I(L1):         mag:    1.97812 phase:   -10.2819°        device_current
I(R2):         mag:    1.40845 phase:    154.782°        device_current
I(R1):         mag:    1.40404 phase:  -0.396235°        device_current
I(V1):         mag:    1.40404 phase:    179.604°        device_current
```

TX=5W VSWR=1.0 peak voltage magnitude in [V] and current in [A]

```
frequency:     5.1e+007      Hz
V(n001):       mag:    31.9681 phase: 0.000394952°        voltage
V(n003):       mag:     30.308 phase:    57.6613°         voltage
V(n002):       mag:    16.0365 phase:   0.394451°         voltage
V(n004):       mag:    22.4775 phase:   -69.8623°         voltage
V(n005):       mag:    32.2273 phase:   -28.0262°         voltage
V(n006):       mag:    32.3547 phase:   -176.818°         voltage
V(n007):       mag:    22.6331 phase:   -135.537°         voltage
V(n008):       mag:    30.1604 phase:    96.7819°         voltage
V(n009):       mag:    15.9824 phase:    154.782°         voltage
I(C10):        mag:   0.319649 phase:    154.782°         device_current
I(C9):         mag:    0.14497 phase:   -173.218°         device_current
I(C8):         mag:   0.406146 phase:   -45.5369°         device_current
I(C7):         mag:   0.226428 phase:   -131.035°         device_current
I(C6):         mag:   0.404346 phase:   -86.8185°         device_current
I(C5):         mag:   0.402753 phase:    61.9738°         device_current
I(C4):         mag:   0.227886 phase:   -73.9434°         device_current
I(C3):         mag:   0.403353 phase:   -159.862°         device_current
I(C2):         mag:   0.145679 phase:   -32.3387°         device_current
I(C1):         mag:   0.318648 phase:    179.604°         device_current
I(L3):         mag:   0.449208 phase:    164.629°         device_current
I(L2):         mag:   0.588219 phase:    -102.39°         device_current
I(L1):         mag:   0.448935 phase:   -10.2819°         device_current
I(R2):         mag:   0.319649 phase:    154.782°         device_current
I(R1):         mag:   0.318648 phase:  -0.396235°         device_current
```

Pictures are taken from LTspice CAD simulation of BP filter for 50MHz. Little explanation of picture down ideal voltage generator have output impedance zero at HF systems output impedance is 50Ohms and load is also 50 Ohms in ideal case that mean that we are losing half voltage (-6dB) in transfer from ideal generator to ideal load VSWR=1.0 .



Notice at diagram that it is difference between input port 2 and critical nodes 3, (8 and 9) 2 time input voltage. In case normal HF/VHF RIG with power amplifier Pout=100W=50dBm Veff=70.1V and peak value is Vpeak =100V. Built in capacitors have to be with breaking voltage of min 200V. In the case QRP power amplifier Pout =5W =37dBm Veff=15.83V or Vpeak= 22.5V. Built in capacitors for QRP output power must be with minimum breaking voltage of 50V and this similar to the classic LP low pass in power amplifiers!!!!! For classic solution with LP and for QRP output power it is enough build in capacitors with breaking voltage of 50V!!! All this observations and calculations are OK if we have acceptable VSWR to VSWR=2. With VSWR over 3 capacitors must be with higher breaking voltage specification for 100W 500V and for QRP powers 100V!

WARNING!

All built in components have to be adequate quality very high Q. This mean that capacitors have adequate breaking voltages, high current and that ring cores are from adequate RF materials for used frequency and square surface for used output power to avoid filter destruction or equipment damages. About selection component for high power RF BP filters please read article [5, 6] from well known filter designer expert Ed W3NQN.

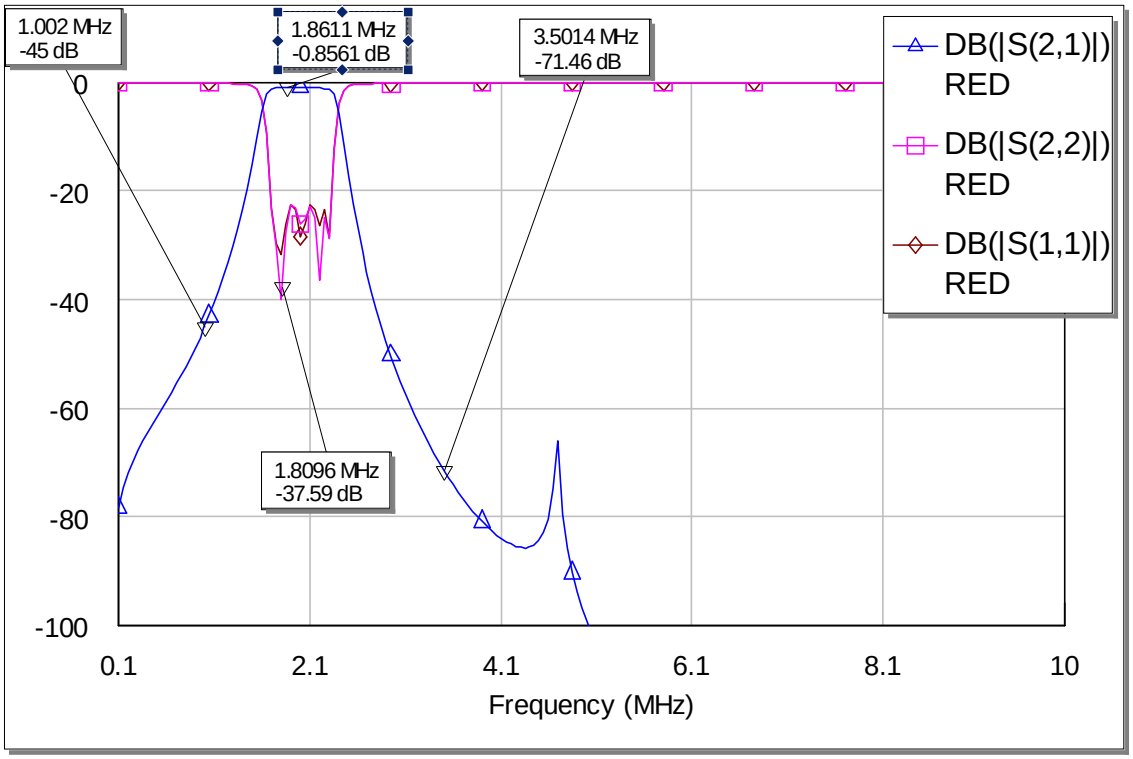
I am using very good freeware software from Wilfried DL5SWB for ring and air coils turns calculation [3]. Fine inductance adjustment for better SWR is possible with squeezing or unfolding wire turns on ring before fixing with small quantity of glue or silicon.

My proposal for BP realization is usage better SMD porcelain capacitors from ATC [8]. These capacitors have extremely good performances for HF /VHF /UHF bands high power filters/amplifiers. Only small disadvantage is price but all other things are better than with high performances classic capacitors. Also this capacitors enable calculation predictable realization at higher frequencies (21MHz and up) which isn't common case with capacitors with leads.

Summary:

The situation is for this type BP much better than it is in case BP in article number1. We have less stress extreme currents and voltages in built in components. The practical experiences with this BP type are very positive and they are one of the mine favorite practical solutions.

If we are cascading two equal filters for example filters for band 1,8MHz we can expect next frequency response from that new filter picture down. Additional hump in the amplitude frequency response is normal and it is expected from this type of filter. These types of filter are generally not good for the ideal cascading without parasitic pass bands.



Two equal BP for 1.8MHz cascaded

I wish you successful BP realization and I apologize for some possible mistakes. I made great effort to share my projects with all who are interesting for. Anyway, send me your comments positive or negative, results or photos of your realization please.

July 2008

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References:

1. ***www.yu1lm.qrpradio.com***
2. ***http://www.linear.com/designtools/software***
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6. ***Ed Wetherhold W3NQN – Clean Your Signal with Band-Pass Filter –part1), QST June 1998(pages 30-42),***
7. ***http://www.bavarian-contest-club.de/projects/bandpassfilter/100W-BP.pdf***
8. ***http://www.atceramics.com/***