HF/50MHz Receiving and Low Power Transmitting Band Pass-Low Pass Filters for SDR transceivers Genesis G****, AVALA**, ADTRX** and HF transceiver CER-01

By dipl. ing. Tasić Siniša –Tasa YU1LM/QRP

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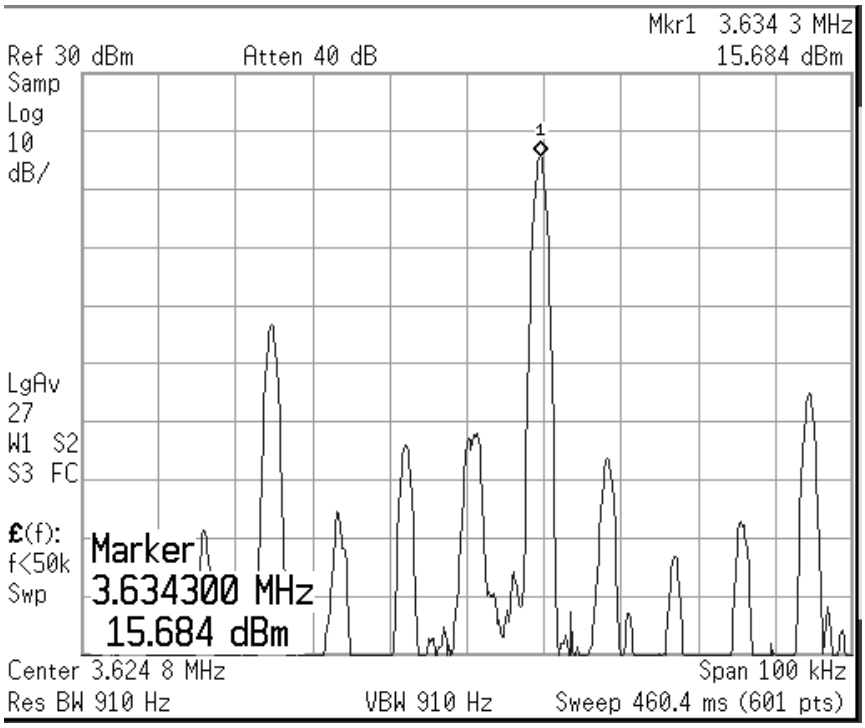
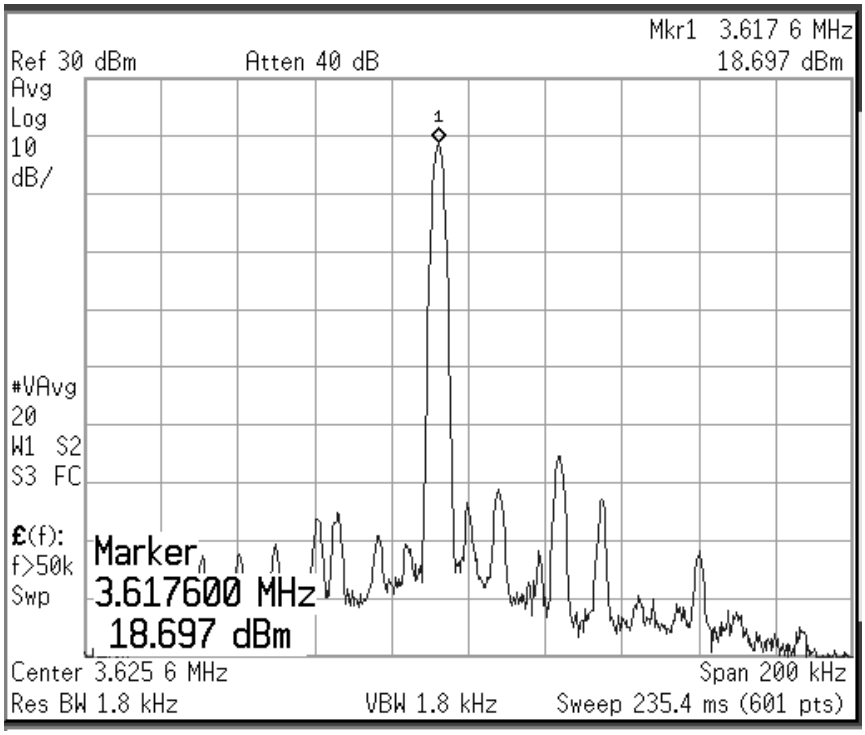
SDR subject has some specific requirements compared to classic RX/TX design. All SDR receivers as DC (direct conversion) receivers are sensitive more or less to the harmonic receiving. My SDR receivers including receivers built in SDR transceivers AVALA series have also sensitivity to harmonic receiving. I made this test at the very beginning but for the very low frequencies below 2MHz and results was good from my point of view 20-35 dB rejection odd harmonics and more than 35dB even harmonics, results are comparable with receivers with moderate input filters. I declare that it is possible receiving with my SDR receivers without input filters and practical experience confirm this but it is partly true. I received very interesting mail from Tim DJ4JM who told me that had been measured results little over 10 dB lower sensitivity for third harmonic for DR2A+ 7MHz receiver. I check these measurements again and obtain little better results but only 15dB for third and 34dB for second harmonic. My practical experiences with all my SDR RXs are that harmonic receiving exist and that it is negligible even with my big antenna such 84m delta loop is. Receiving at 1.8MHz band I can hardly detect in the evenings hours presents of very strong broadcast stations from 5 and 7MHz band. Only extremely strong carriers are visible and noticeable. Because of that some kind of filter LP (low pass) or better BP (band-pass) are welcome and they will improve overall characteristics of all previously published SDR RX. The second problem is in connection with SDR transmission. I published several transmitters/modulators with CMOS switches series 74HC4053, 74HC4066 [1] and all are working better than any other types I tested before when we are talking about linearity at fundamental frequency. This realization has specific that modulator is working digitally that mean it has a lot of odd harmonics also modulated of course lower level than wanted output signal. The problem becomes serious when this spectrum arrives to RF linear power amplifier. To keep on unchanged output spectrum it is necessary to attached amplifier with extremely wide working bandwidth what it is no true in case RF amplifier I am using. All used RF amplifiers have limited bandwidth to 60-80 MHz maximum. The final results we have even harmonics hardly noticeable in output modulator terminate with resistive termination 50Ohms.The bigger problem is products around output signal which is results this harmonics and unwanted phase shift in RF power amplifier at harmonic frequencies. It is interesting that odd harmonics not third only as we are expecting but higher order 5, 7 become problem (see spectrum at picture below). Builders who first assembled my mono-band SDR transceiver AVALA-01 Bodo DJ9CS noticed problems measuring output spectrum from power amplifier with IRF510. He proposed solution which LP filter which dramatically improve output spectrum see picture below also. I made changes in all my new designs and added LP as option for RX and necessary part for the transmitters section (see new version of AVALA-01 and new AVALA-02). Of course it is possible to add BP filters as best solution but also as most complicate for practically realization. Here down in article there are two proposals for LP and four for BP. All filters are possible solder at PCB layout ADTRX**AVALA** and Genesis*** transceivers or on separate board with RF power amplifier.

The filters target specification at start ware:

1. Filters are with maximum IL(insertion loss) lower than 2.5 dB with inductors Qo ~60
2. All filter components values have to be standard values.
3. Coils are without taps!
4. Termination return loss S11, S22 have to better as possible target value -20dB (VSWR=1.22).
5. Frequencies harmonically related to central frequency from upper side are attenuated ~20-30dB or more. For BP filters this target value is from the lower side fo/2 ~20-30dB.
6. BP/LP filters have 50Ohms termination impedance and filters are symmetrical structure and it is not important what is input or output.
7. Calculated bandwidth -3dB 5-25% of central frequency
8. All filter BP/LP variation is possible solder at the same PCB AVALA transceivers
9. No tune design with low sensitivity to the components tolerance.

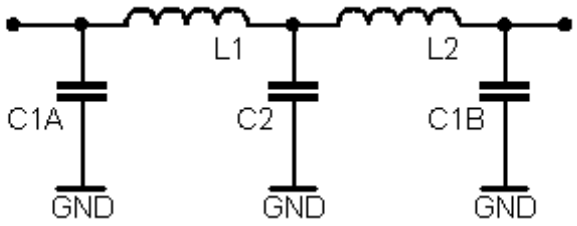


Output spectrum at output SDR transceiver AVALA-01 (Pout 35.67dBm (4.2W) without LP/BP at modulator output

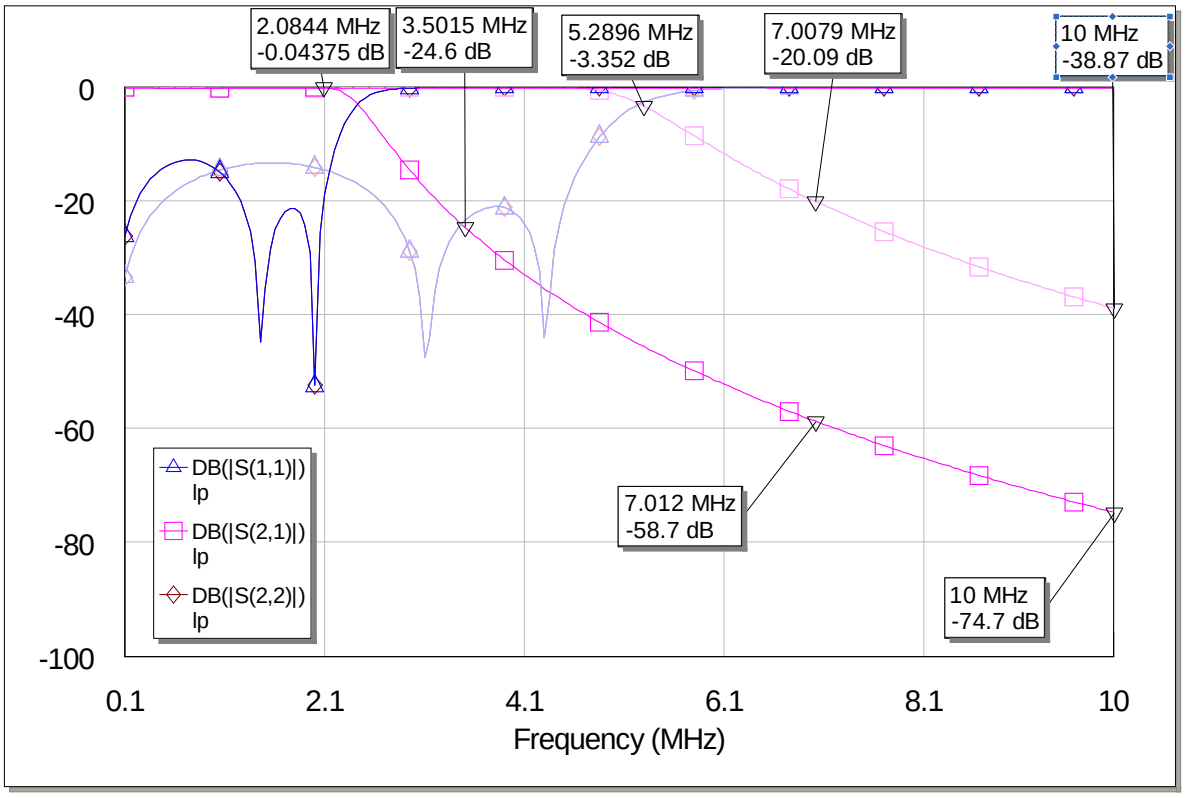


Output spectrum at output SDR transceiver AVALA-01 the same conditions as it is on picture up (Pout 38.6dBm (8.2W)) with 2 L section LP/BP at modulator output

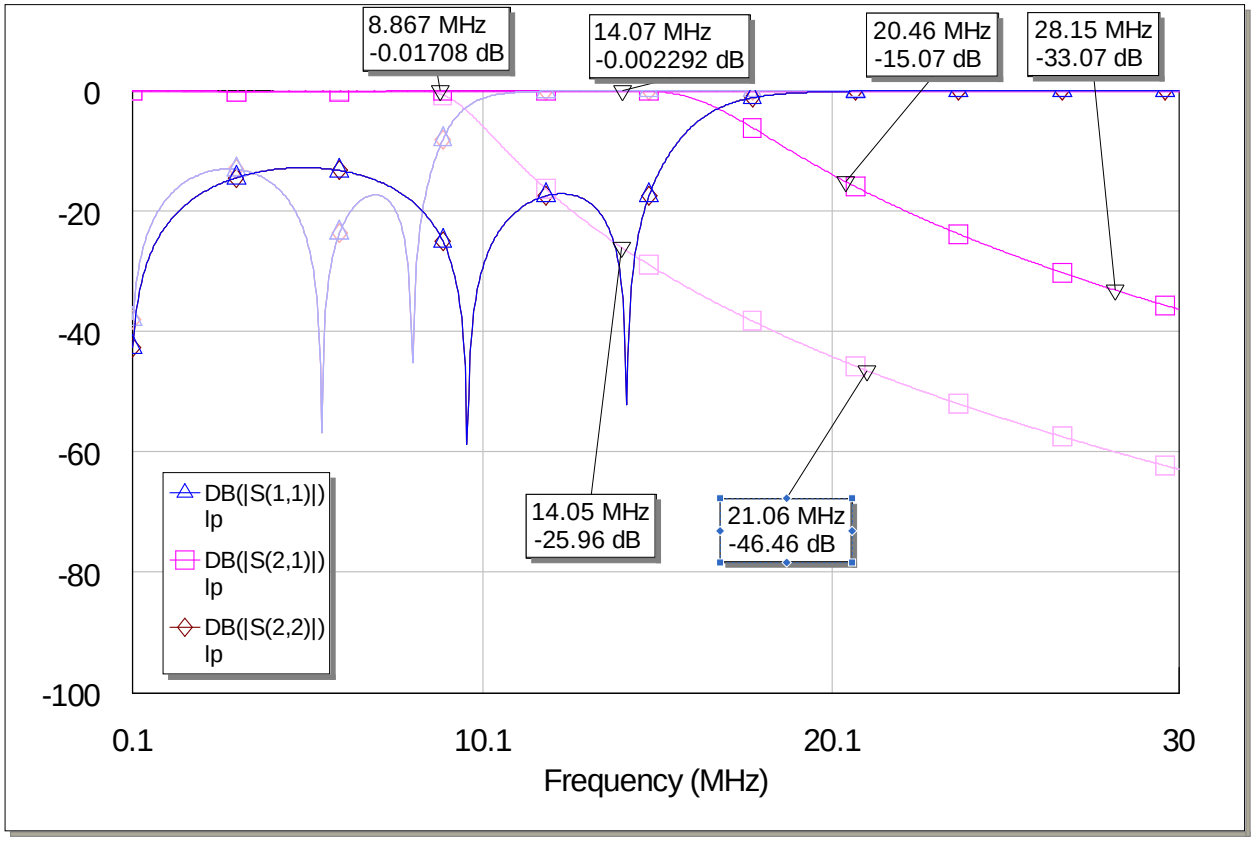
1. LP(low pass) with 2 coils



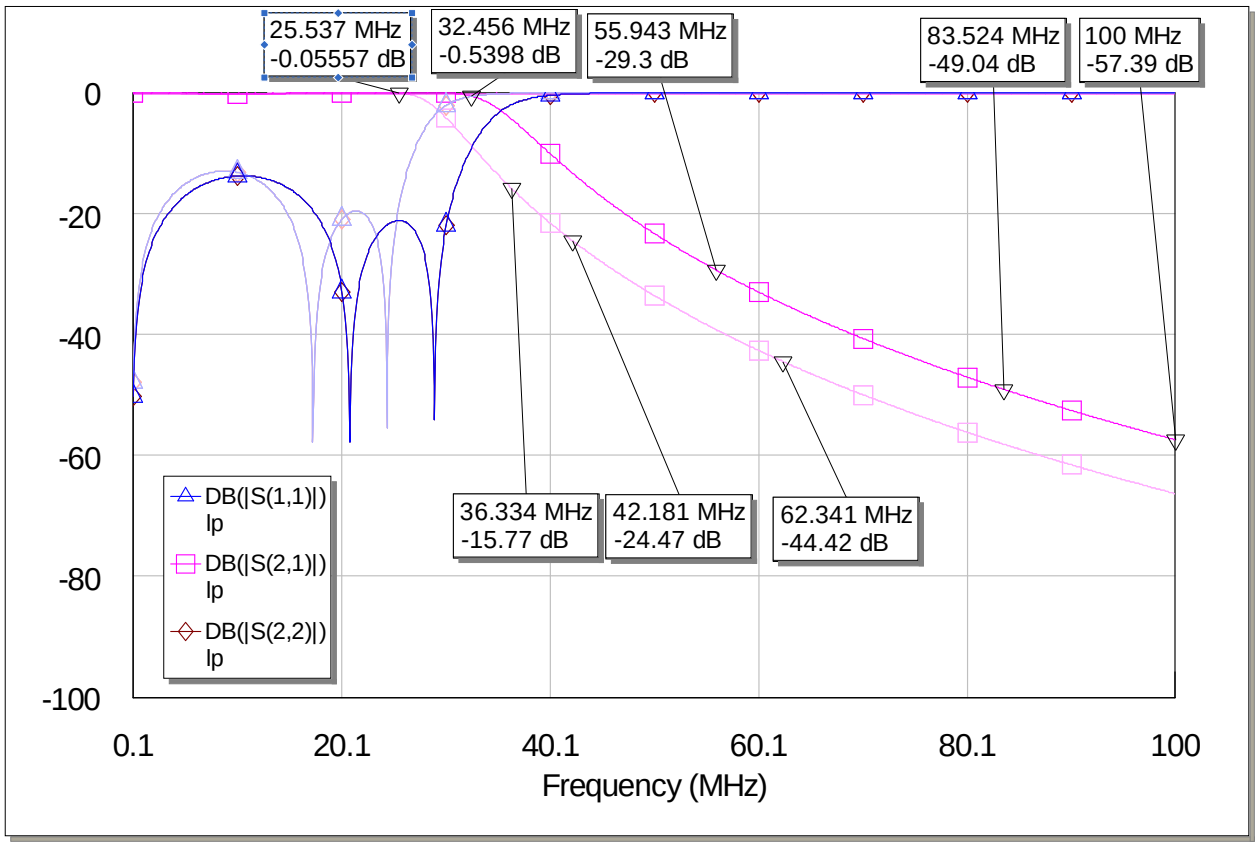
Fc -3dB [MHz][band]	**L1,L2[uH]**	**C1A,C1B[pF]**	**C2[pF]**
2.5 [1.8]	**4,7**	**1800**	**3300**
5.3 [3,5]	**2,2**	**820**	**1500**
8 [5,7]	**1,2**	**470**	**820**
15 [10.1,14]	**0,680**	**270**	**470**
25 [18,21]	**0,39**	**150**	**270**
35 [24,28]	**0,33**	**120**	**220**
57 [50]	**0,18**	**68**	**120**



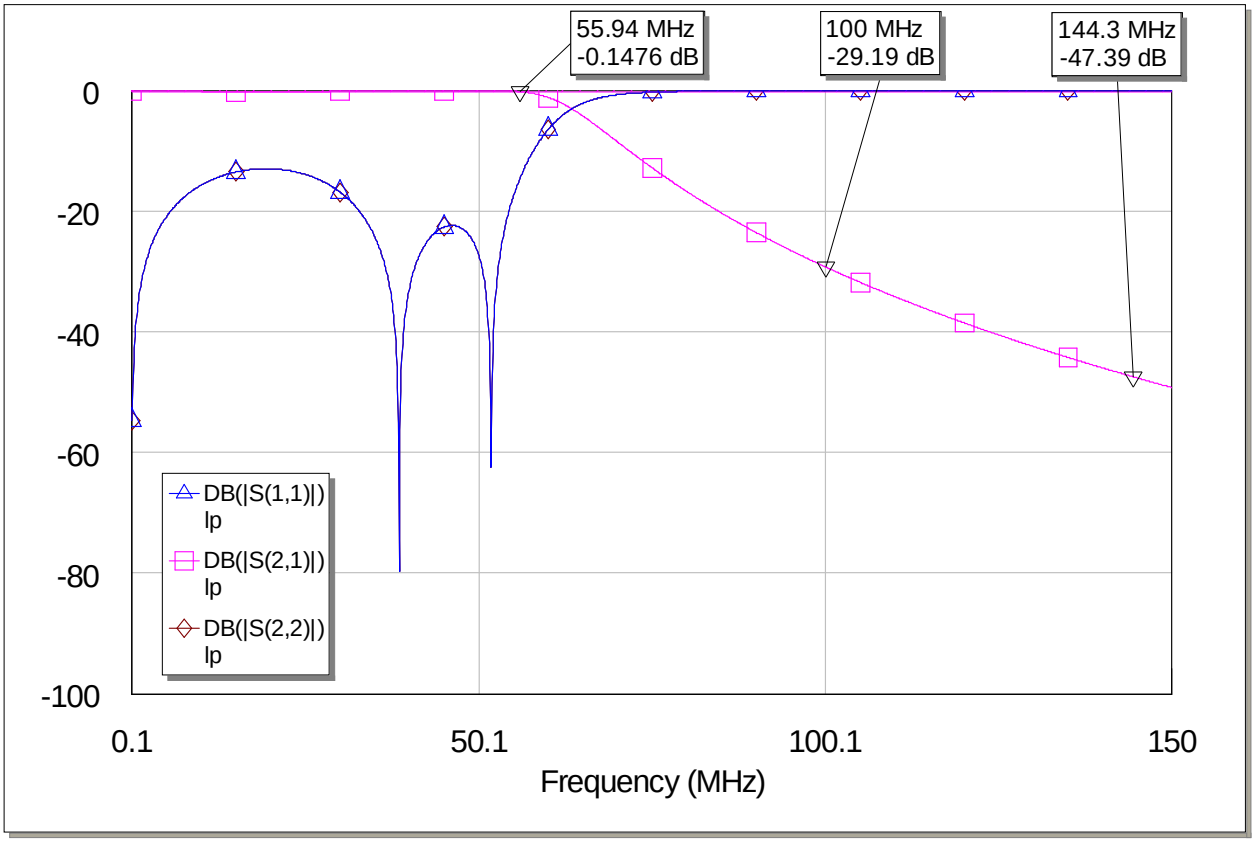
Picture1. LP (low pass) filter for 1.8MHz and 3.5(5.3) MHz



Picture2. LP (low pass) filter for 7MHz and 10(14) MHz

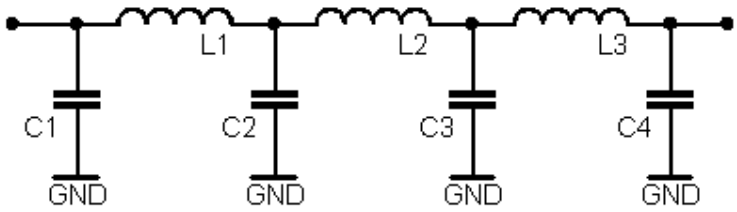


Picture3. LP (low pass) filter for 18MHz and 21,25,28 MHz

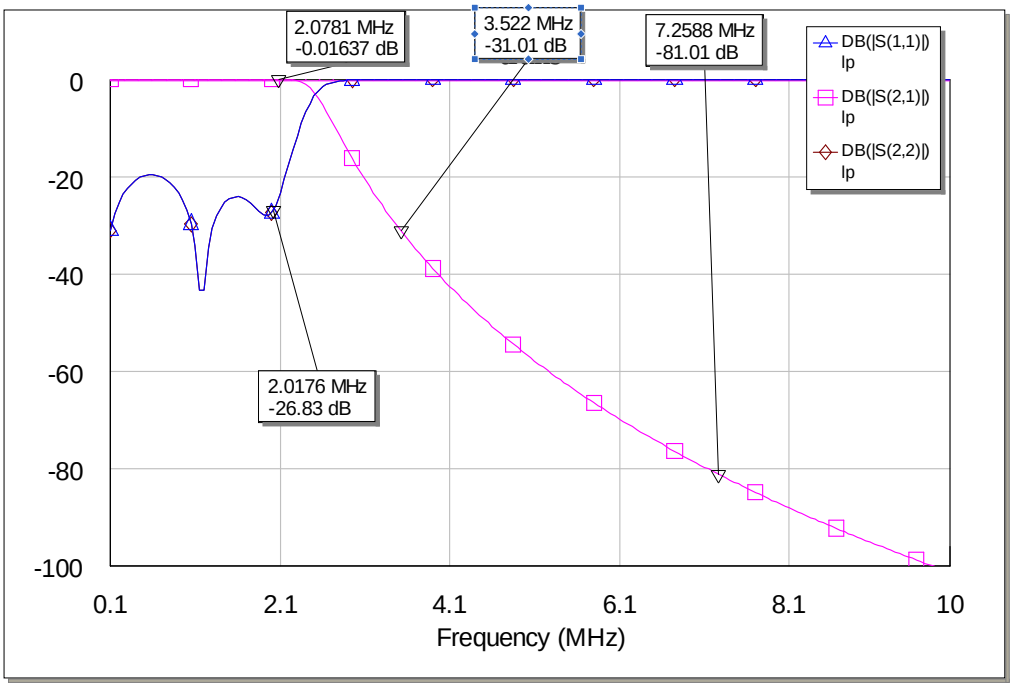


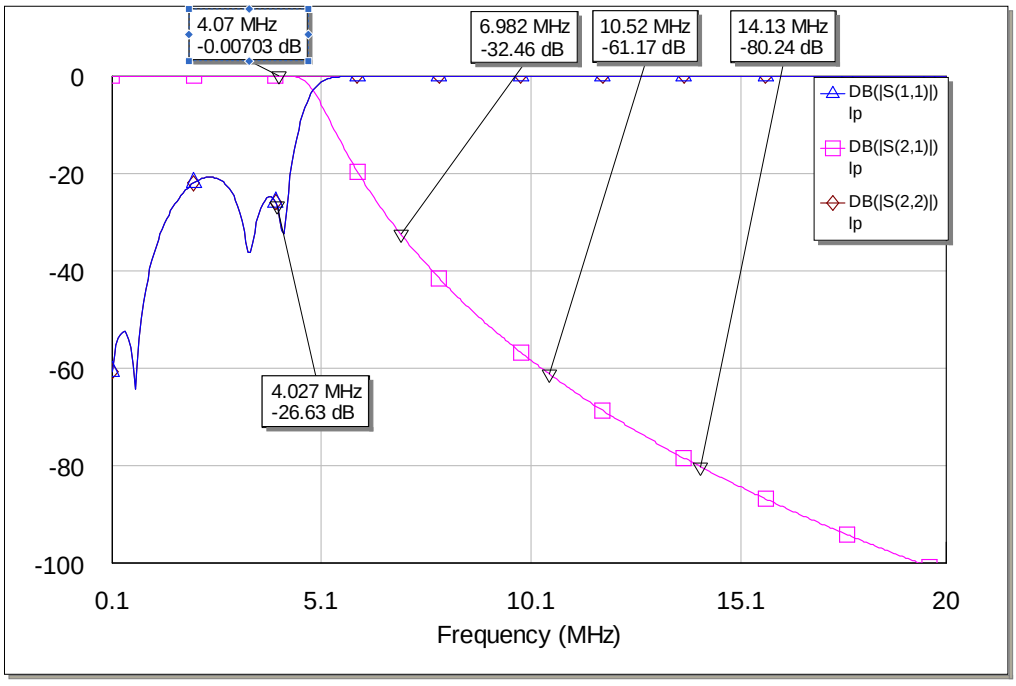
Picture4. LP (low pass) filter for 50MHz

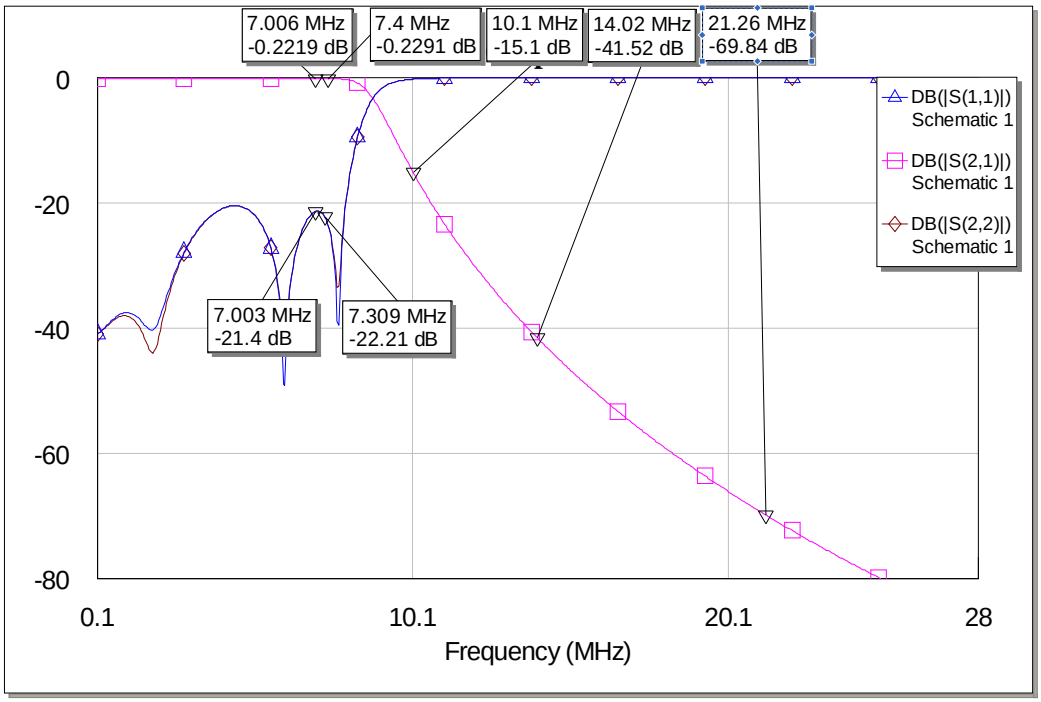
2. *LP(low pass) with 3 coils*

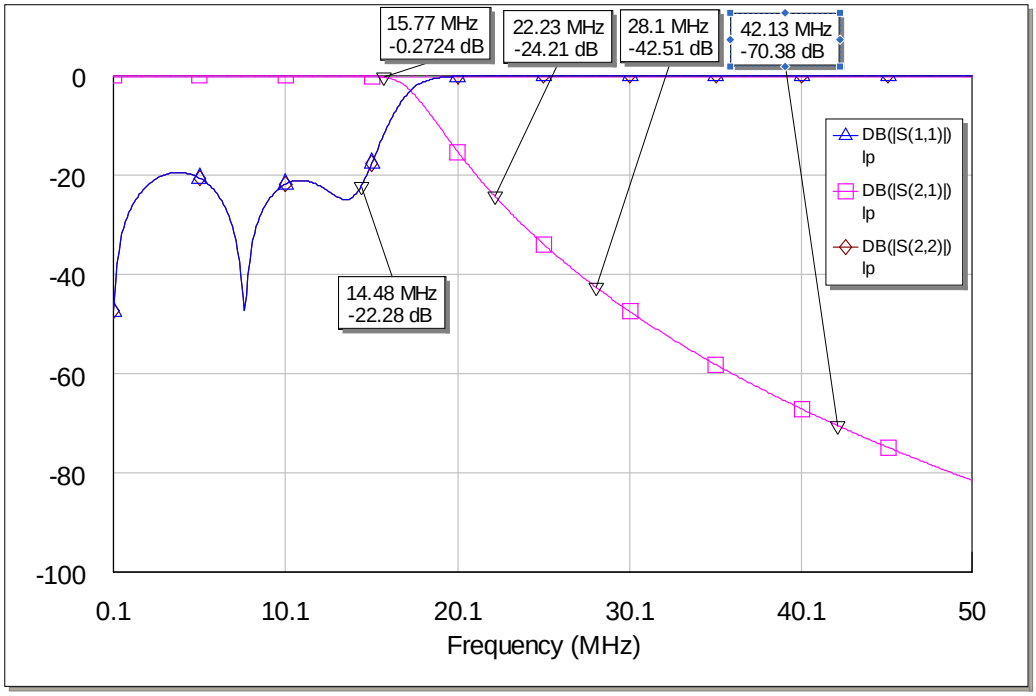


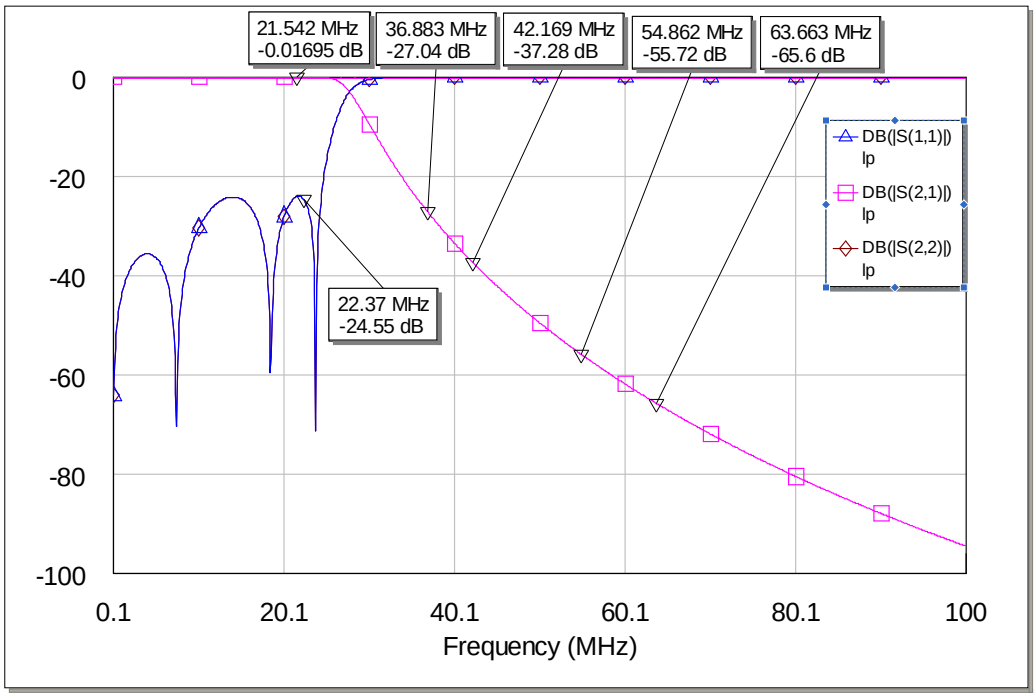
Fc -3dB [MHz][band]	L1 [uH]	L2 [uH]	L3 [uH]	C1pF]	C2[pF]	C3[pF]	C4 pF]
2.5 [1.8]	4,7	5,6	4,7	1200	2700	2700	1200
5.3 [3,5]	2,7	3,3	2,7	560	1200	1200	560
8 [5,7]	1,5	1,8	1,5	330	680	680	330
15 [10.1,14]	0,680	0,820	0,680	180	390	390	180
25 [18,21]	0,47	0,56	0,47	100	220	220	100
35 [24,28]	0,33	0,43	0,33	47	150	150	47
57 [50]	0,22	0,27	0,22	39	100	100	39

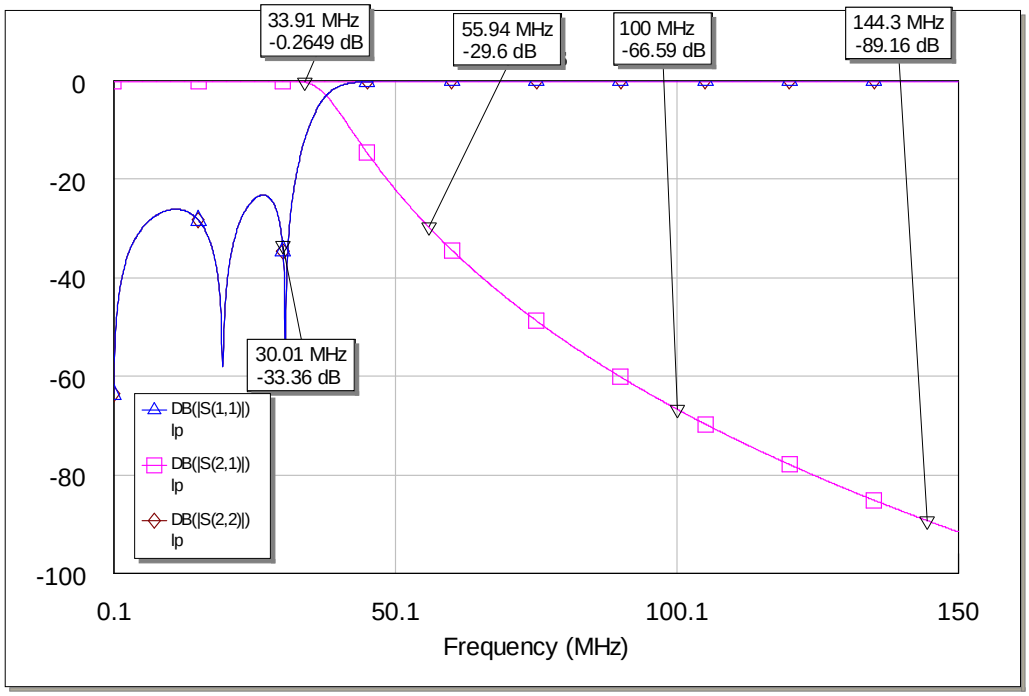

2.0781 MHz
-0.01637 dB
3.522 MHz
-31.01 dB
7.2588 MHz
-81.01 dB
2.0176 MHz
-26.83 dB
DB(|S(1,1)|)
lp
DB(|S(2,1)|)
lp
DB(|S(2,2)|)
lp
0
-20
-40
-60
-80
-100
0.1
2.1
4.1
6.1
8.1
10
Frequency (MHz)

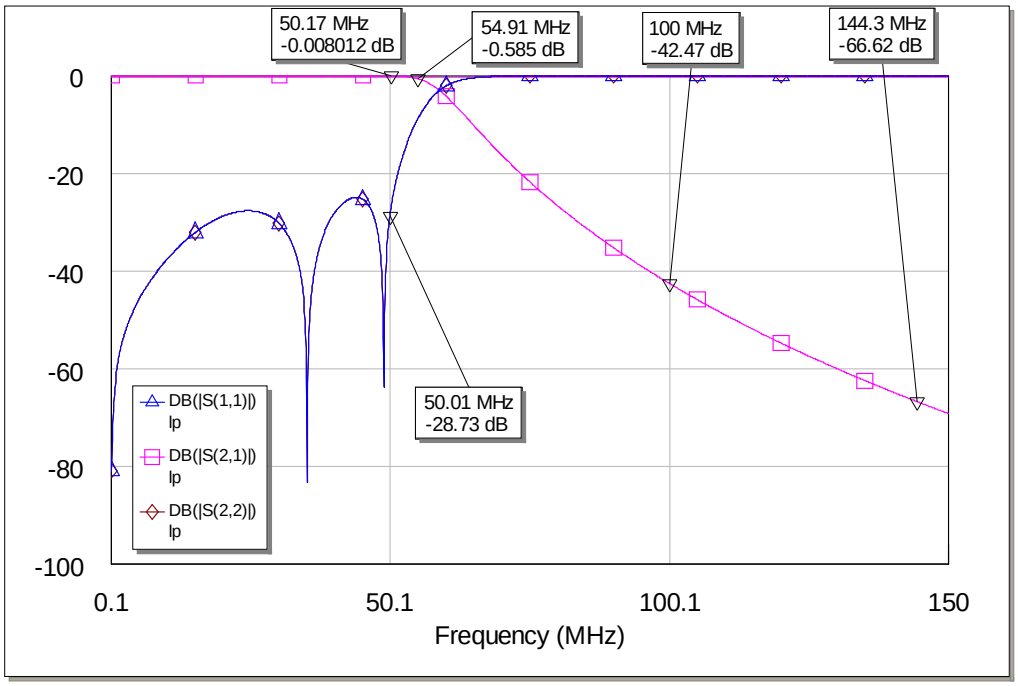

4.07 MHz
-0.00703 dB
6.982 MHz
-32.46 dB
10.52 MHz
-61.17 dB
14.13 MHz
-80.24 dB
4.027 MHz
-26.63 dB
DB(|S(1,1)|)
lp
DB(|S(2,1)|)
lp
DB(|S(2,2)|)
lp
0
-20
-40
-60
-80
-100
0.1
5.1
10.1
15.1
20
Frequency (MHz)


7.006 MHz
-0.2219 dB
7.4 MHz
-0.2291 dB
10.1 MHz
-15.1 dB
14.02 MHz
-41.52 dB
21.26 MHz
-69.84 dB
0
-20
-40
-60
-80
7.003 MHz
-21.4 dB
7.309 MHz
-22.21 dB
DB(|S(1,1)|)
Schematic 1
DB(|S(2,1)|)
Schematic 1
DB(|S(2,2)|)
Schematic 1
0.1
10.1
20.1
28
Frequency (MHz)


15.77 MHz
-0.2724 dB
22.23 MHz
-24.21 dB
28.1 MHz
-42.51 dB
42.13 MHz
-70.38 dB
0
-20
-40
-60
-80
-100
14.48 MHz
-22.28 dB
DB(|S(1,1)|)
lp
DB(|S(2,1)|)
lp
DB(|S(2,2)|)
lp
0.1
10.1
20.1
30.1
40.1
50
Frequency (MHz)

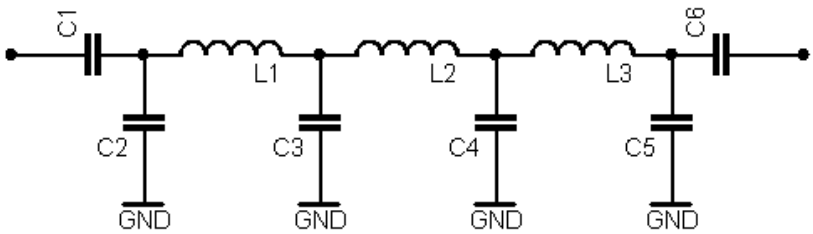

21.542 MHz
-0.01695 dB
36.883 MHz
-27.04 dB
42.169 MHz
-37.28 dB
54.862 MHz
-55.72 dB
63.663 MHz
-65.6 dB
22.37 MHz
-24.55 dB
DB(|S(1,1)|)
lp
DB(|S(2,1)|)
lp
DB(|S(2,2)|)
lp
0
-20
-40
-60
-80
-100
0.1
20.1
40.1
60.1
80.1
100
Frequency (MHz)


33.91 MHz
-0.2649 dB
55.94 MHz
-29.6 dB
100 MHz
-66.59 dB
144.3 MHz
-89.16 dB
30.01 MHz
-33.36 dB
DB(|S(1,1)|)
lp
DB(|S(2,1)|)
lp
DB(|S(2,2)|)
lp
0
-20
-40
-60
-80
-100
0.1
50.1
100.1
150
Frequency (MHz)



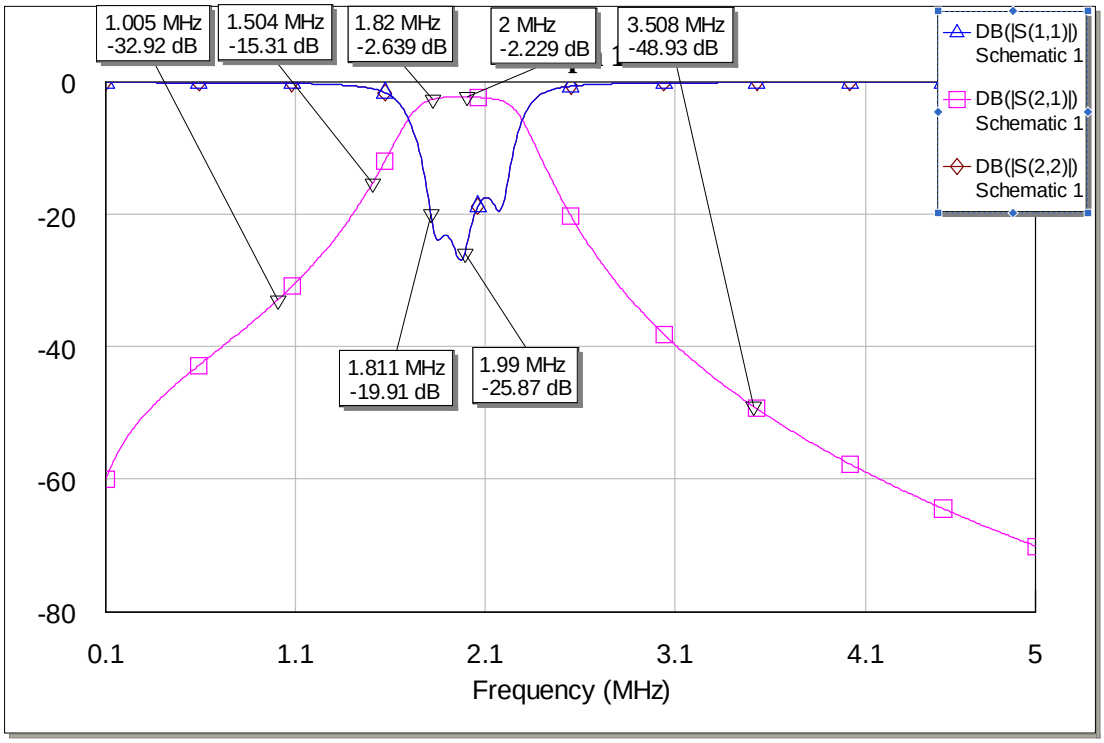
3. A New BP(band pass) filter with 3 coils BP-LP YU1LM

This band pass filter realization is something new. I didn't see something similar in literature ever before. This filter offers very good performances but it is sensitive to component variation if we like to build very narrow filters. This statement is related to precise values of C3 and C4 capacitors. Filter is ideal for SMT component use especially for critical components.

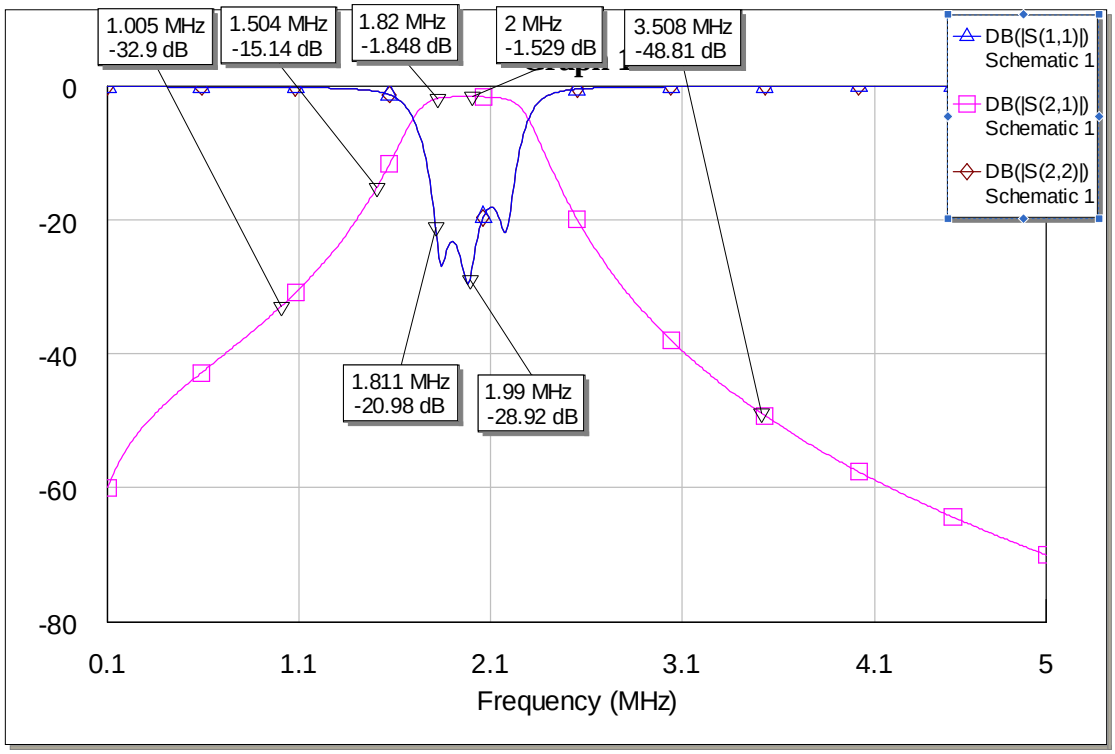


BAND	L[uH]	L2[uH]	L3[uH]	C1[pF]	C2[pF]	C3[pF]	C4[pF]	C5[pF]	C6[pF]
1.8MHz	**12**	**1.8**	**12**	**470**	**100**	**6800**	**6800**	**100**	**470**
3.5MHz	**4.7**	**1**	**4.7**	**330**	**82**	**3300**	**3300**	**82**	**330**
7MHz	**2.2**	**0.27**	**2.2**	**180**	**82**	**3900**	**3900**	**82**	**180**
10MHz	**1.2**	**0.15**	**1.2**	**150**	**82**	**3300**	**3300**	**82**	**150**
14MHz	**1**	**0.091**	**1**	**82**	**33+18**	**2700**	**2700**	**33+18**	**82**
10-14MHz	**0.82**	**0.43**	**0.82**	**220**	**56**	**680**	**680**	**56**	**220**
14-18MHz	**0.56**	**0.22**	**0.56**	**150**	**68**	**820**	**820**	**68**	**150**
18-21MHz	**0.39**	**0.12**	**0.39**	**120**	**82**	**1000**	**1000**	**82**	**120+15**
21-24MHz	**0.33**	**0.1**	**0.33**	**100**	**68**	**820**	**820**	**68**	**100**
24-28MHz	**0.33**	**68nH**	**0.33**	**68**	**47**	**910**	**910**	**47**	**68**
50MHz	**0.15**	**33nH**	**0.15**	**47**	**33**	**560**	**560**	**33**	**47**
50MHz*	**0.1**	**6,8nH**	**0.1**	**33**	**68**	**2700**	**2700**	**68**	**33**

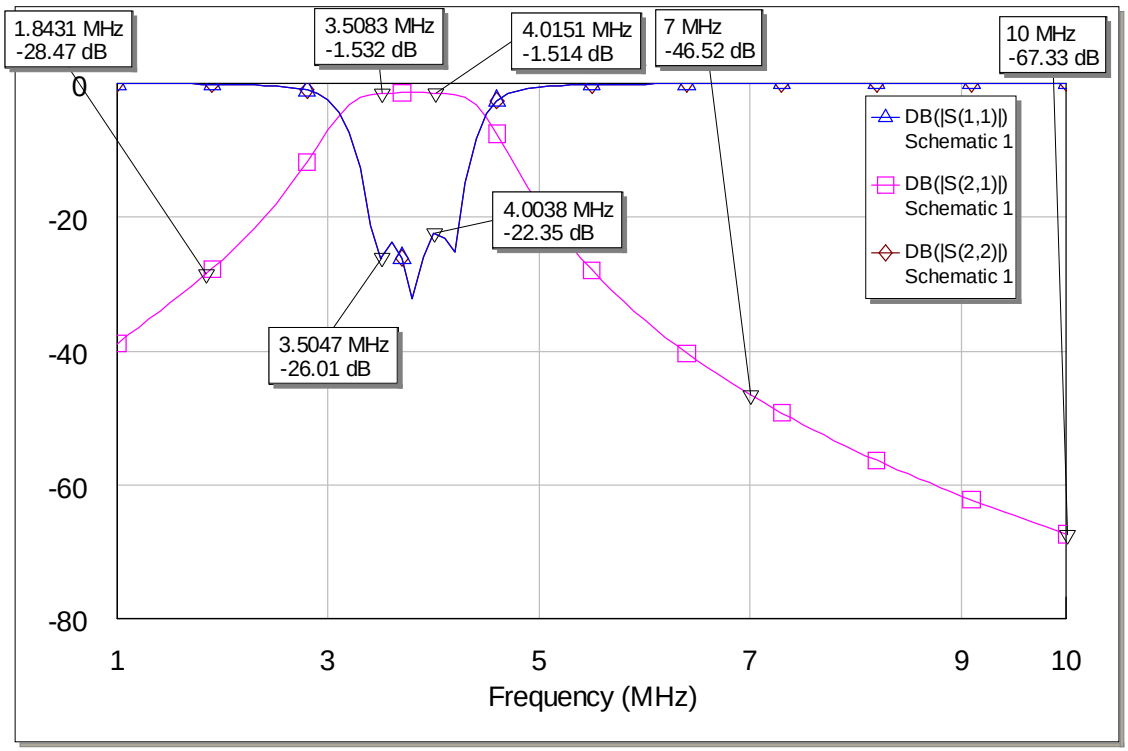
Table1. Element values for BP filters with 3coils BP-LP-YU1LM (*Super-selective BP)



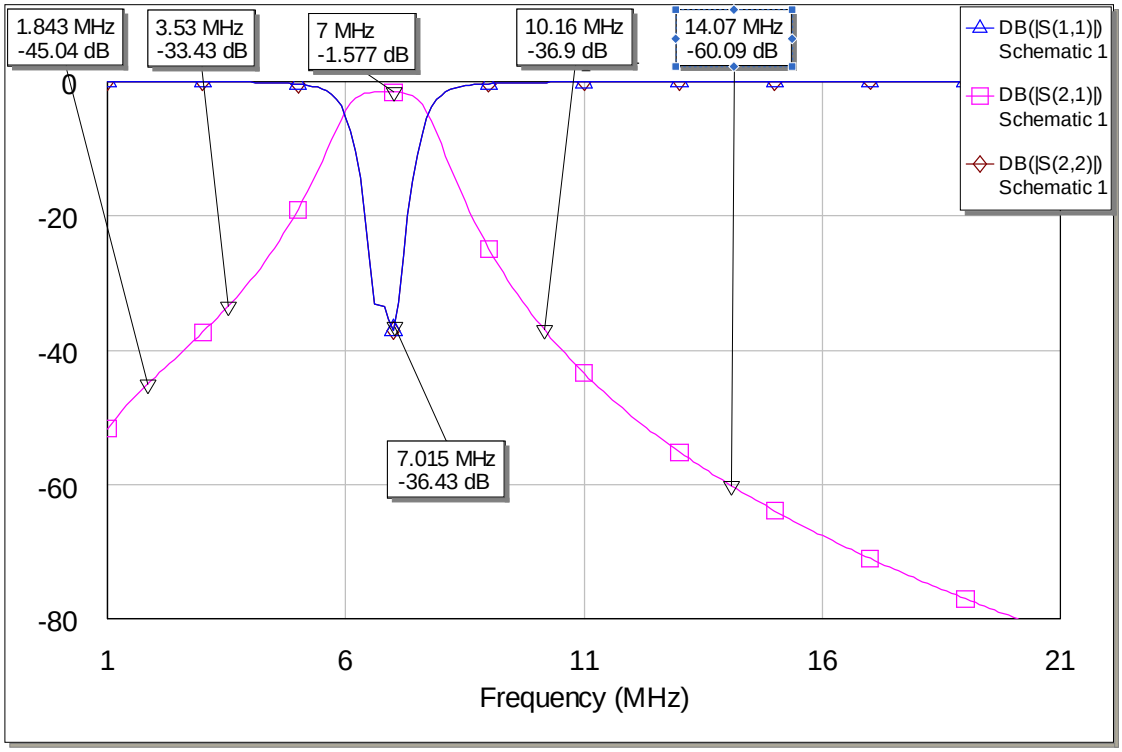
BP for 1.8MHz with molded chokes Qo~60



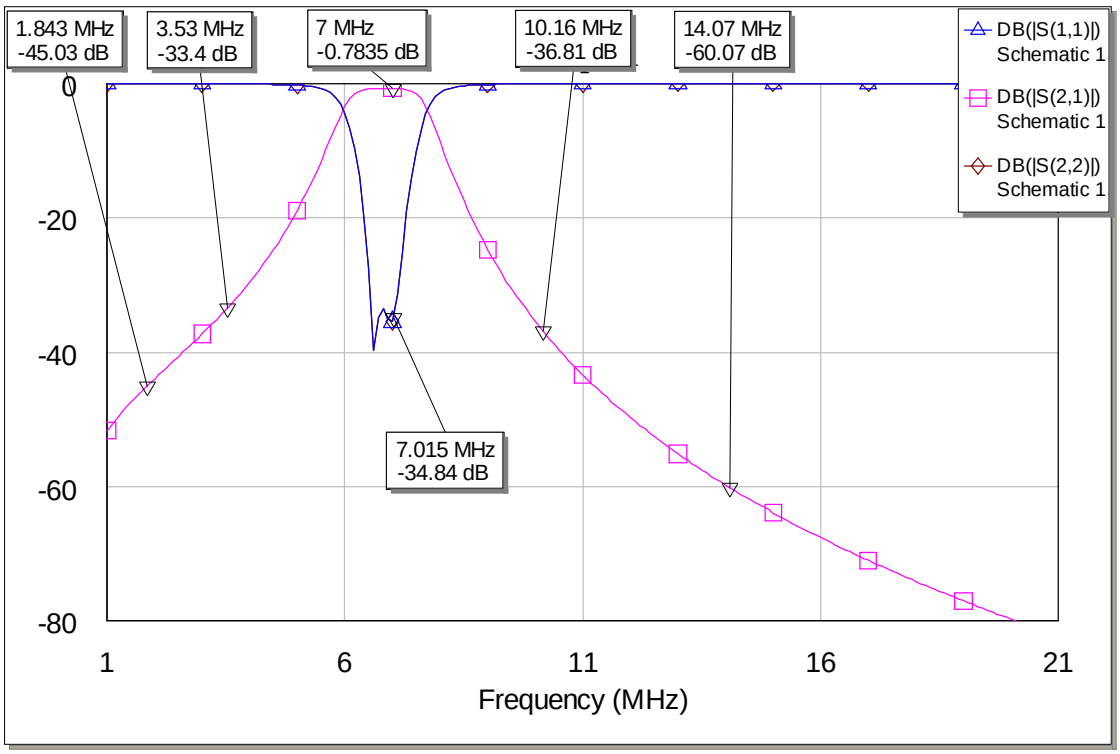
BP for 1.8MHz with ring core Qo~180



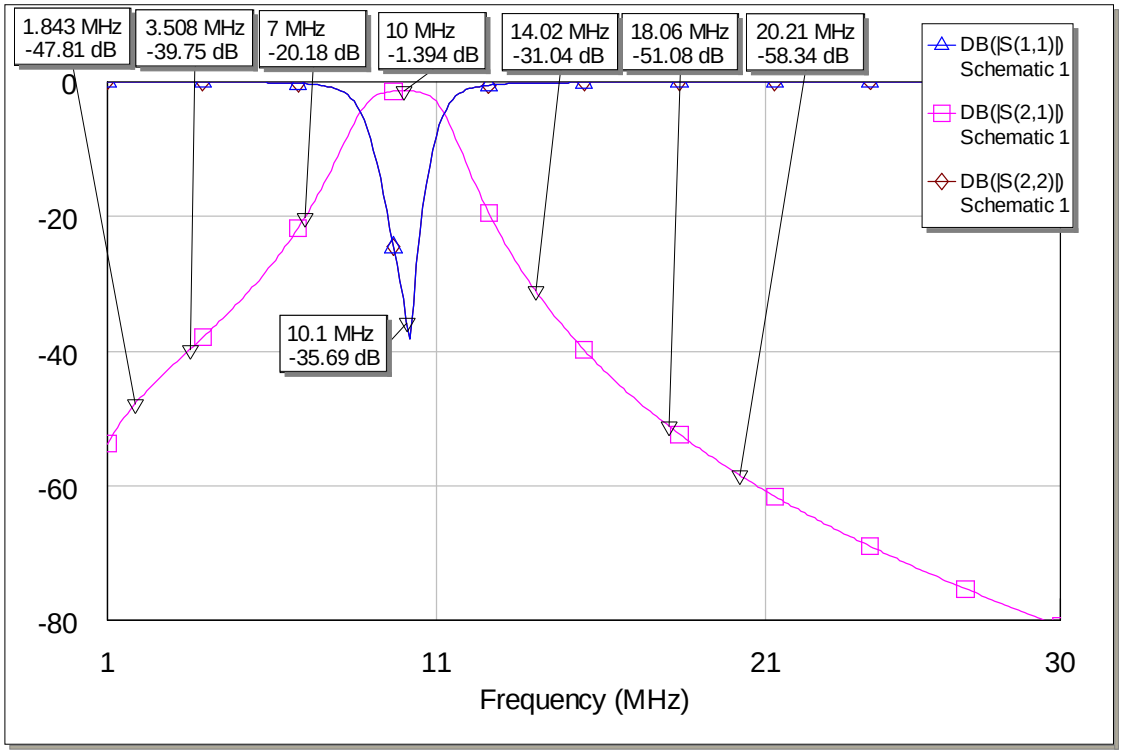
BP for 3,5MHz with molded chokes Qo~60



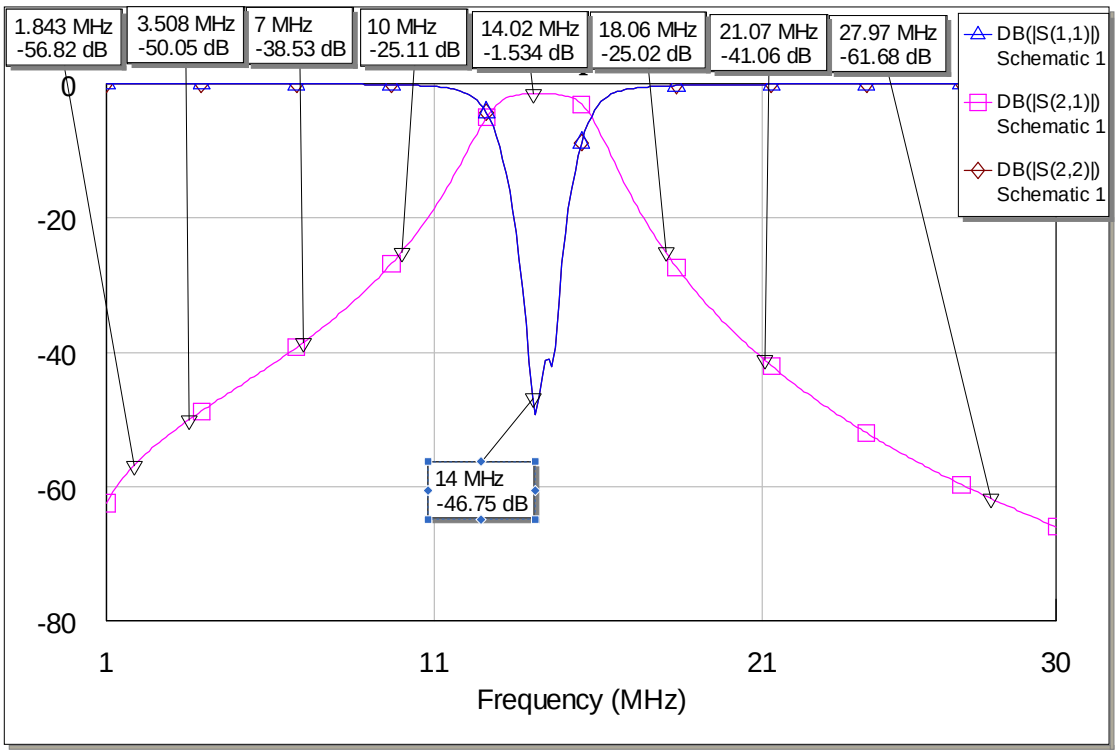
BP for 7MHz with molded chokes Qo~60



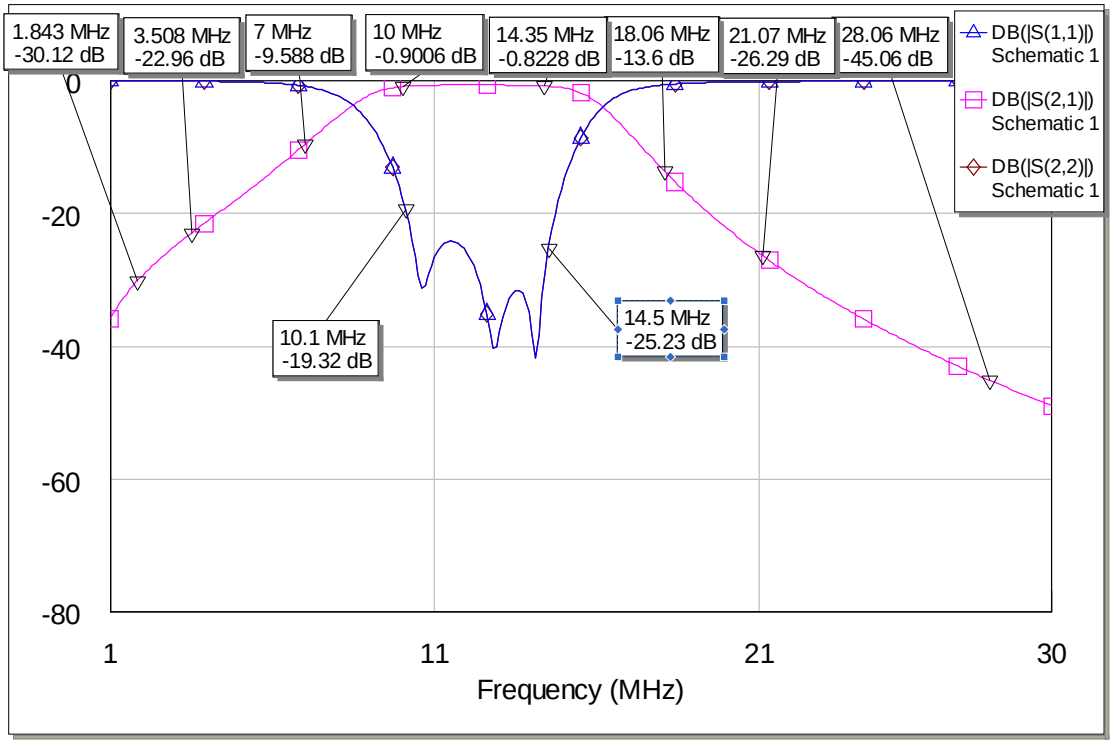
BP for 7MHz with ring core Qo~180



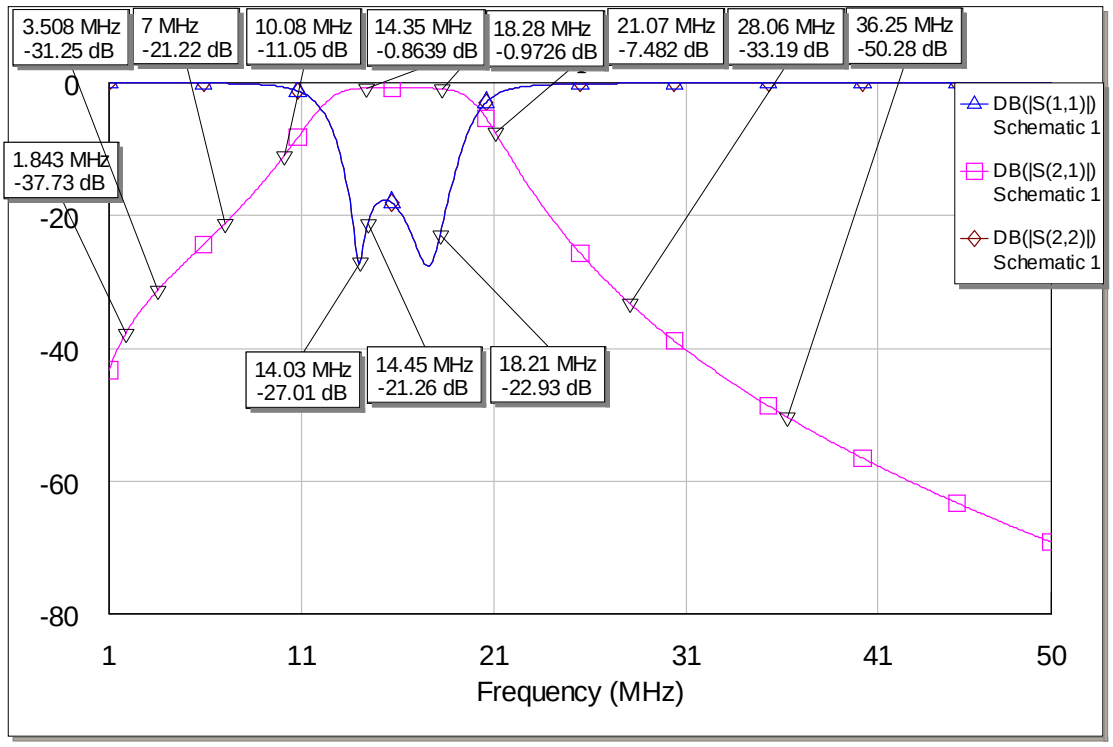
BP for 10.1MHz with molded chokes Qo~60



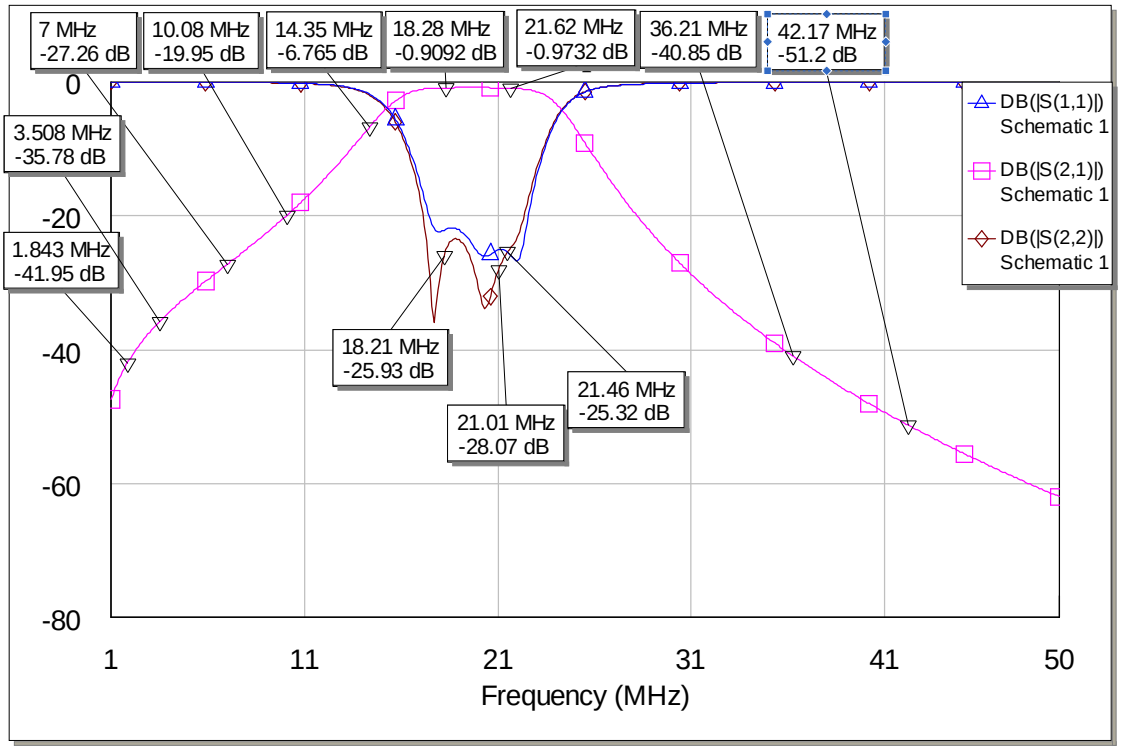
BP for 14MHz with molded chokes Qo~60



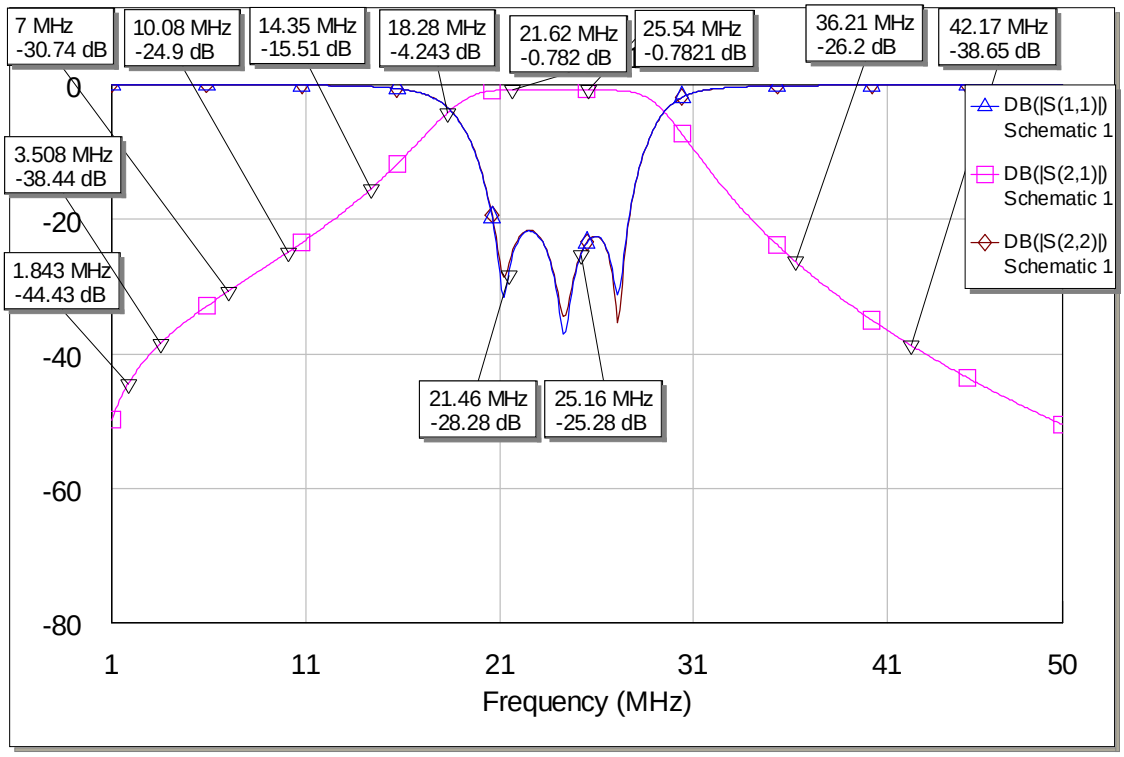
BP for 10-14MHz with molded chokes Qo~60



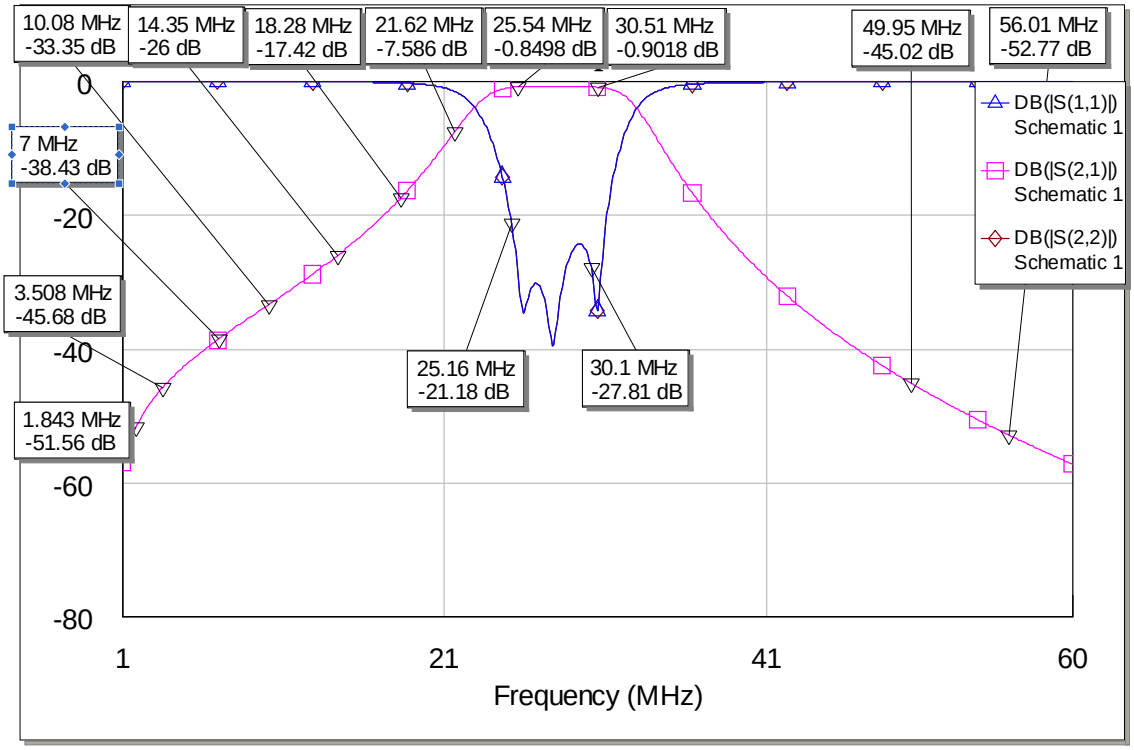
BP for 14-18MHz with molded chokes Qo~60



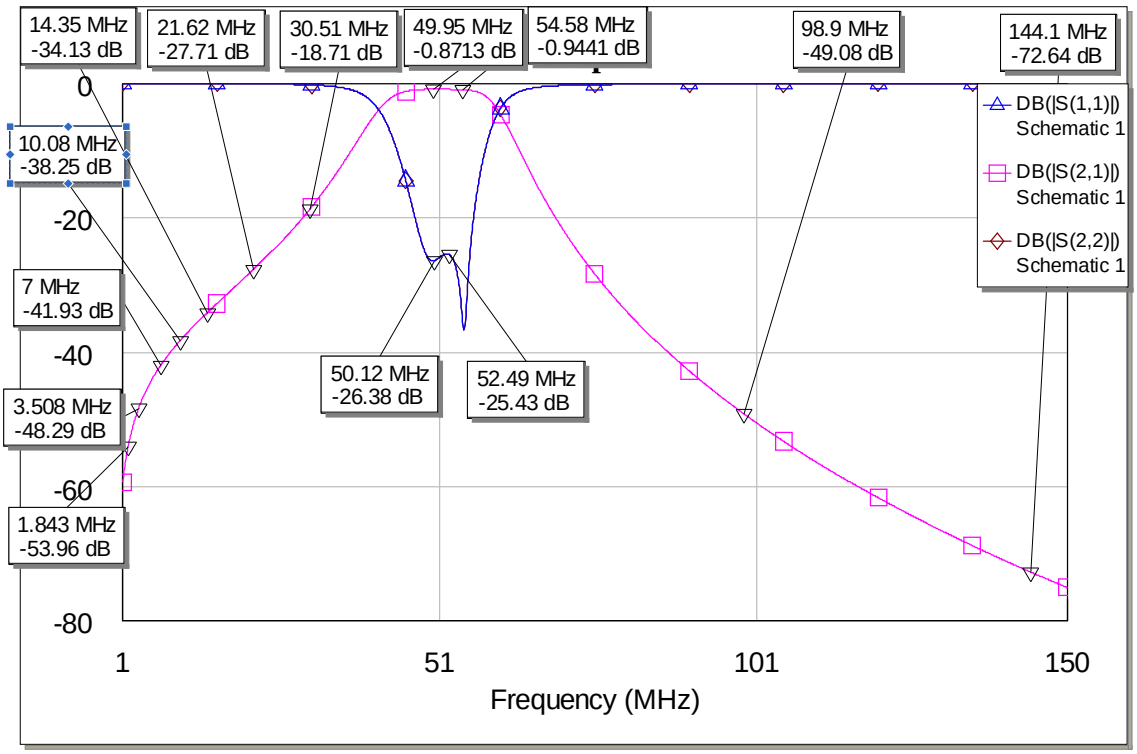
BP for 18- 21MHz with molded chokes Qo~60



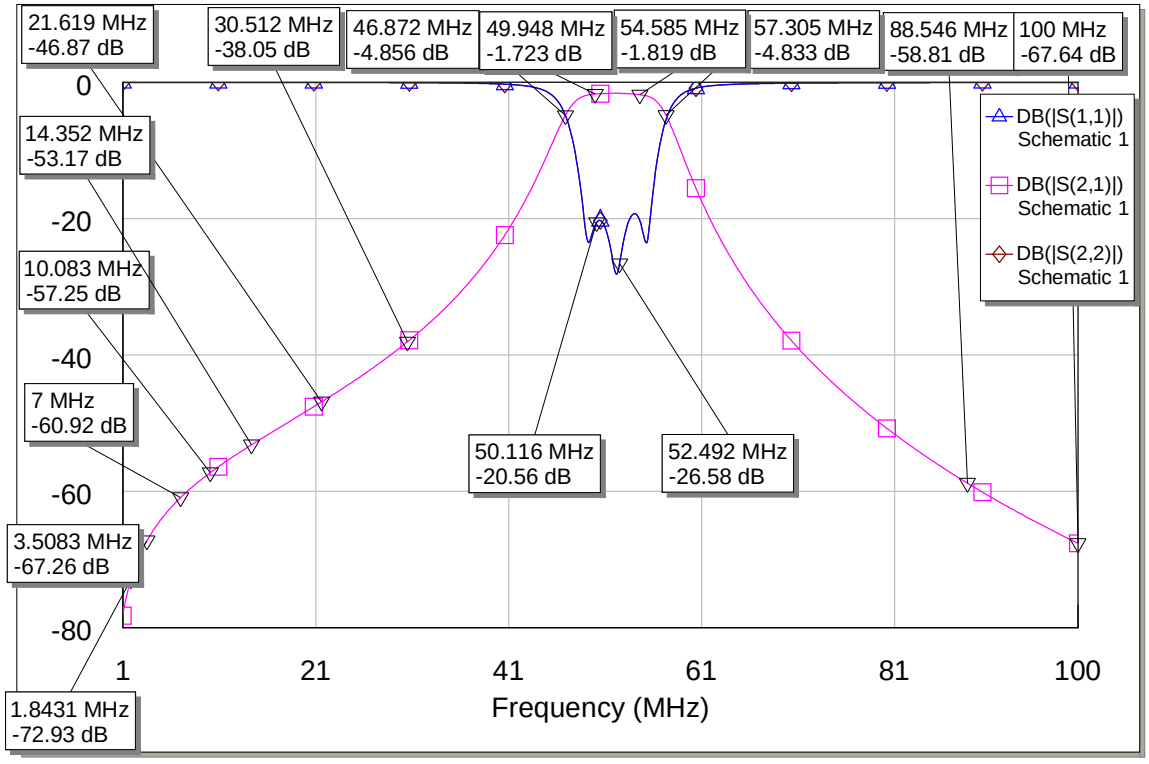
BP for 21- 24MHz with molded chokes Qo~60



BP for 24- 28MHz with molded chokes Qo~60



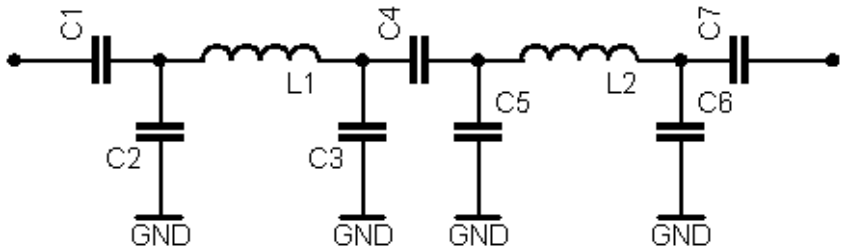
BP for 50-52MHz with molded chokes Qo~60



BP for 50-52MHz with molded chokes Qo~60, super-selective realization is very ‘touchy” to the component variation!

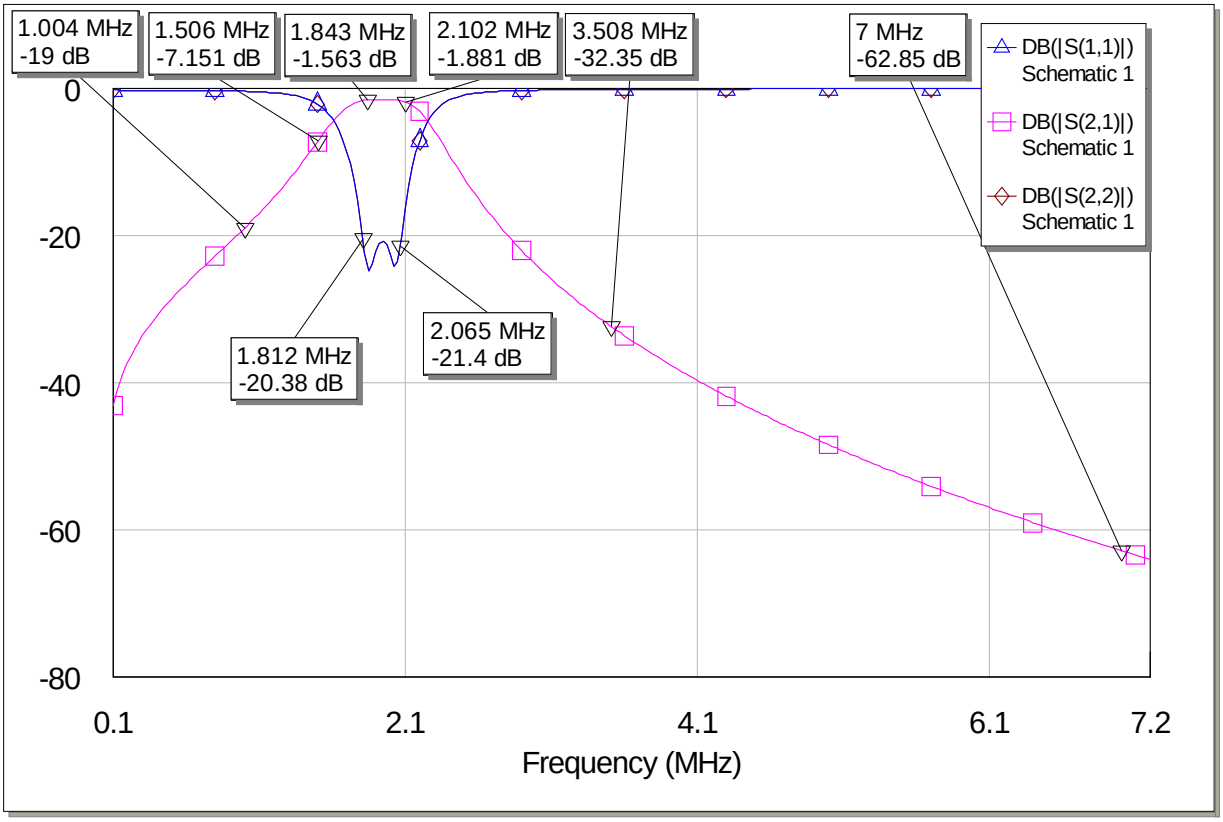
4. BP with 2 coils

This type of filters I published in several articles at WEB pages. Published BP filters were with 3 coils which offer much more freedom in design than with 2 coils especially if want obtain wider BP this type is very good for narrow BP type. These filters for wide bandwidth are not so good they have moderate selectivity. It is hard expect more from 2 coils only.

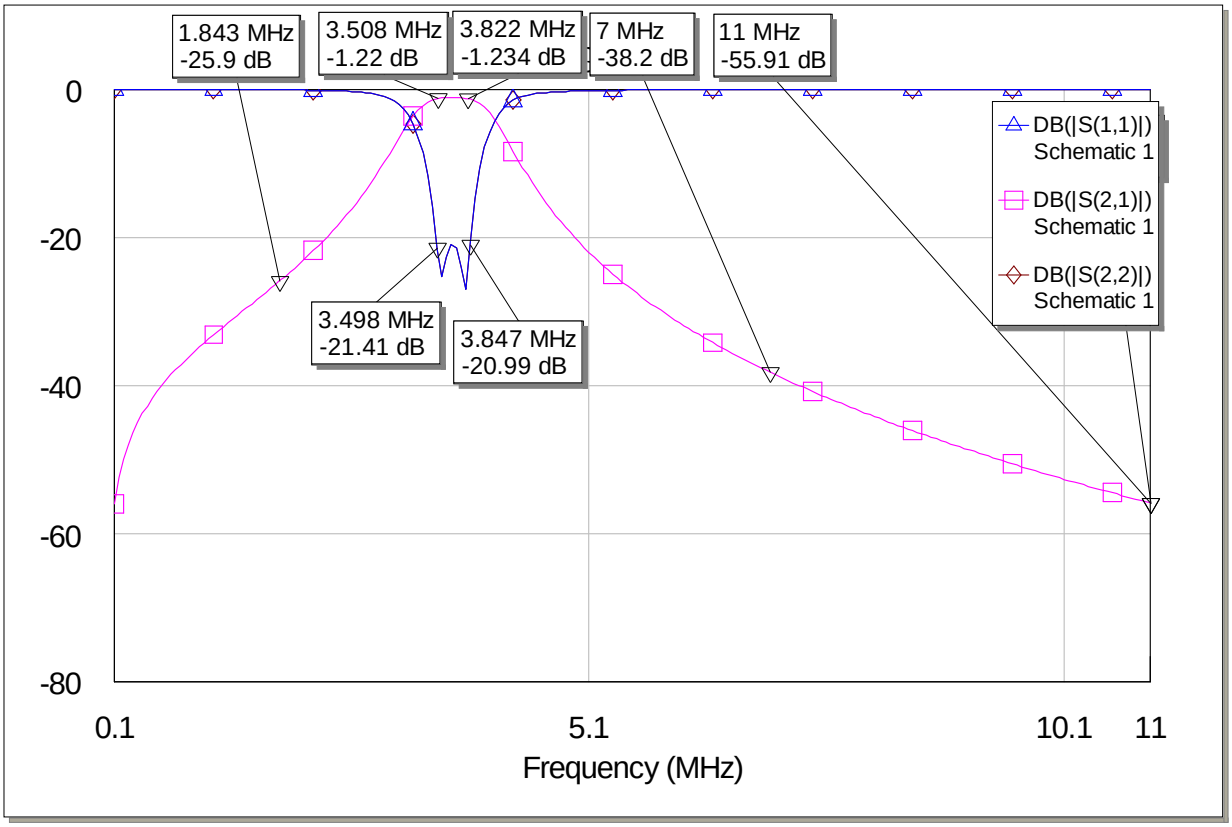


BP filter with 2 coils

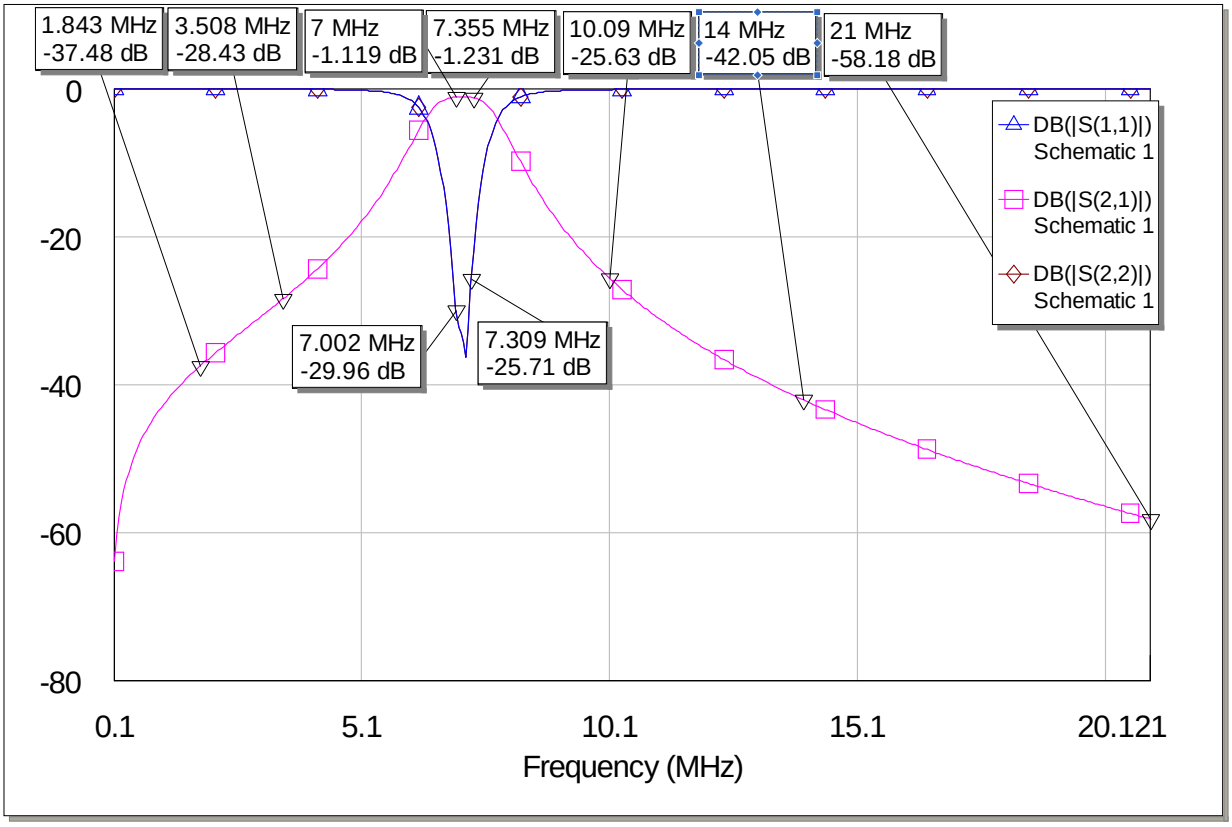
BAND	L1[uH]	L2[uH]	C1[pF]	C2[pF]	C3[pF]	C4[pF]	C5[pF]	C6[pF]	C7[pF]
1.8MHz	**10**	**10**	**3300**	**1000**	**680**	**270**	**680**	**1000**	**3300**
3.5MHz	**4.7**	**4.7**	**560**	**390**	**560**	**240**	**560**	**390**	**560**
7MHz	**2.7**	**2.7**	**330**	**220**	**240**	**68**	**240**	**220**	**330**
10MHz	**1.5**	**1.5**	**220**	**220**	**220**	**56**	**220**	**220**	**220**
14MHz	**1**	**1**	**150**	**150**	**180**	**56**	**180**	**150**	**150**
18-21MHz	**0.68**	**0.68**	**470**	**150**	**100**	**56**	**100**	**150**	**470**
21-24MHz	**0.33**	**0.68**	**0.33**	**100**	**68**	**820**	**820**	**68**	**100**
24-28MHz	**0.47**	**0.47**	**560**	**91**	**68**	**56**	**68**	**100**	**560**
28MHz	**0.33**	**0.33**	**180**	**150**	**120**	**47**	**120**	**150**	**180**
50MHz	**0.22**	**0.22**	**68**	**68**	**56**	**18**	**56**	**68**	**68**



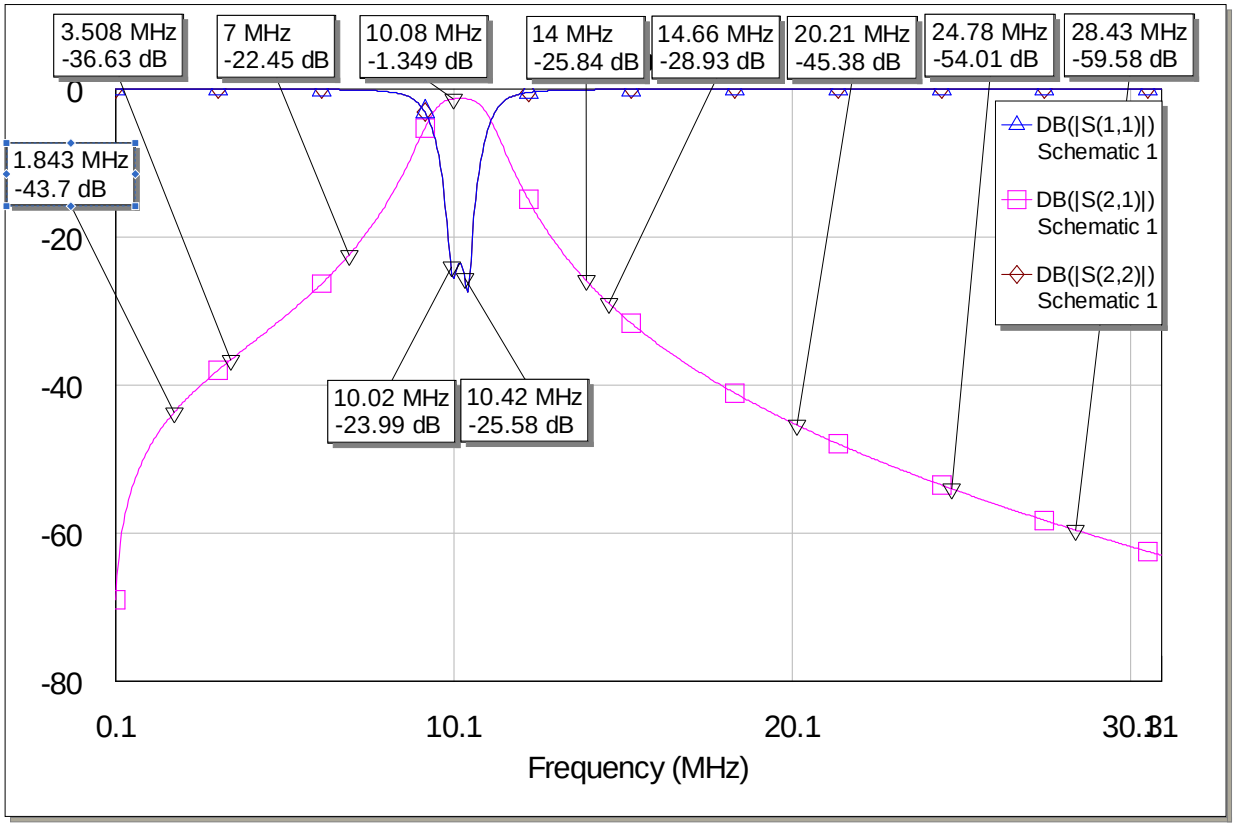
BP for 1.8MHz with molded chokes Qo~60



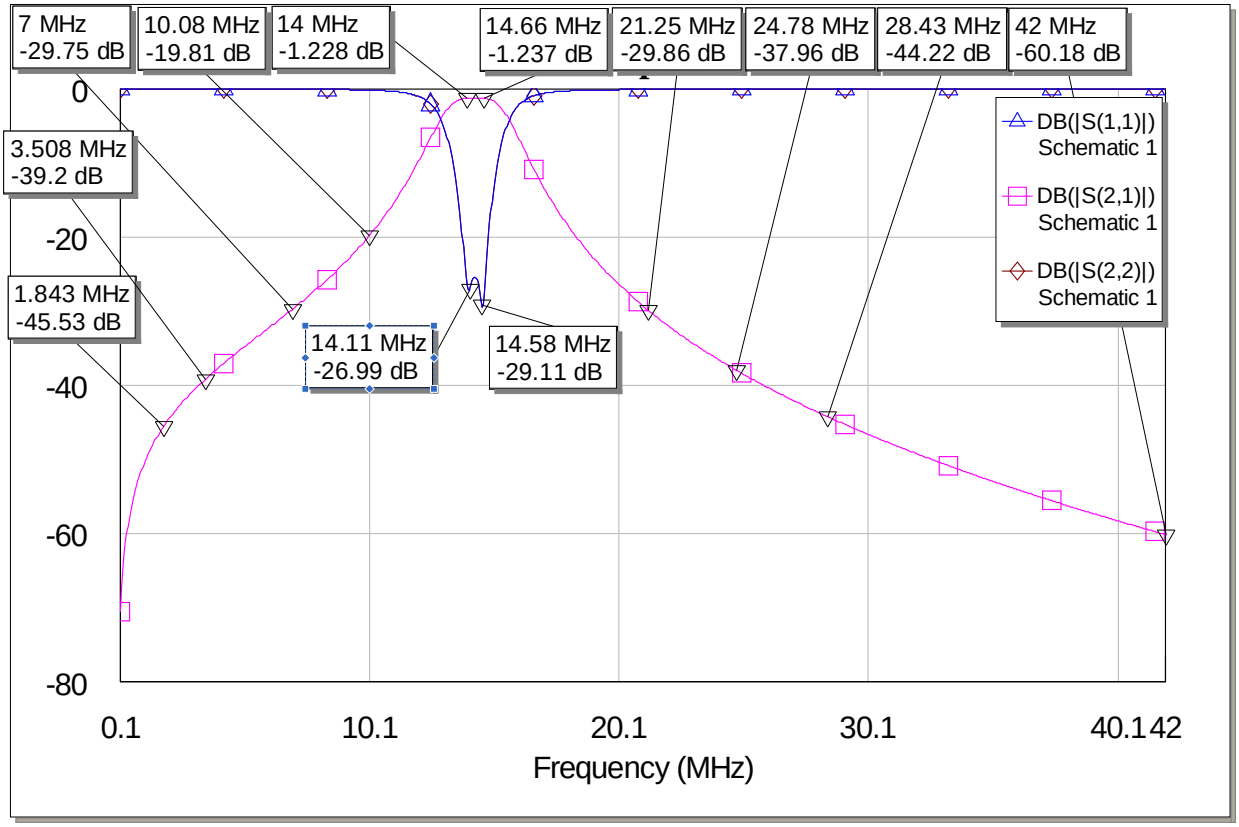
BP for 3.5MHz with molded chokes Qo~60



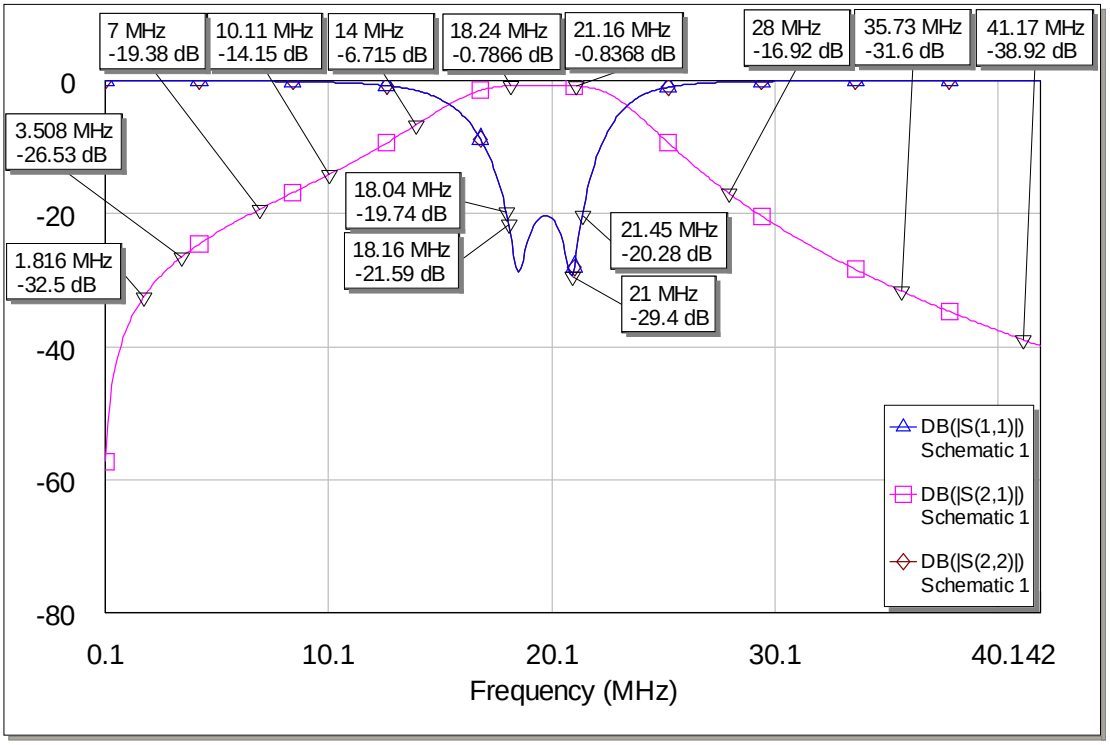
BP for 7MHz with molded chokes Qo~60



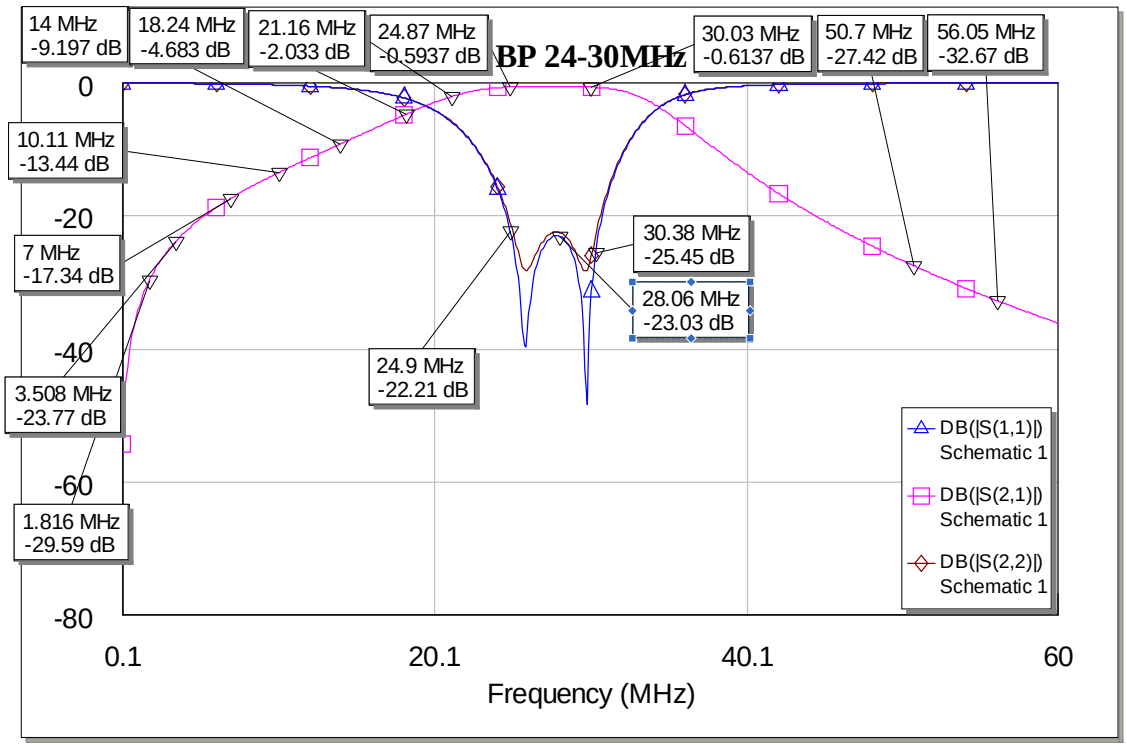
BP for 10MHz with molded chokes Qo~60



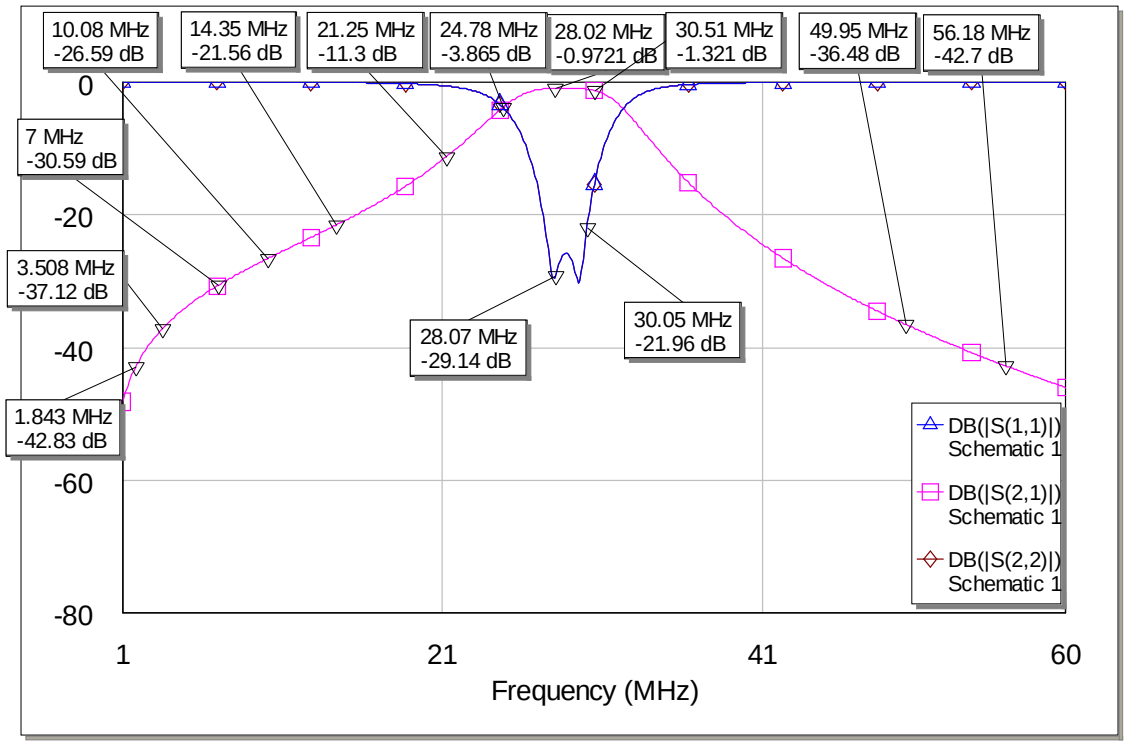
BP for 14MHz with molded chokes Qo~60



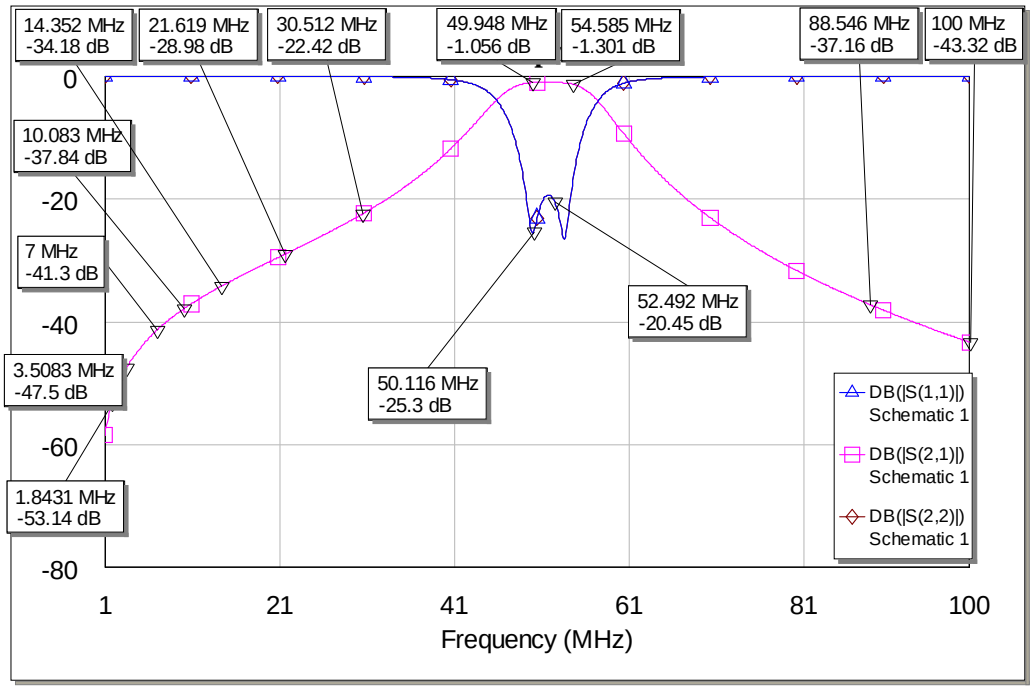
BP for 18-21MHz with molded chokes Qo~60



BP for 24-30MHz with molded chokes Qo~60



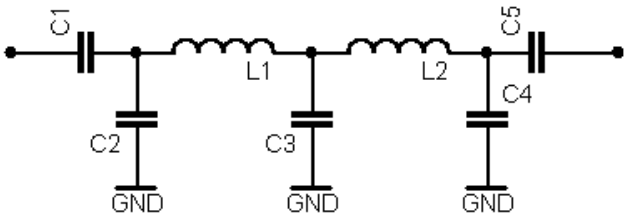
BP for 28-30MHz with molded chokes Qo~60



BP for 50-52MHz with molded chokes Qo~60

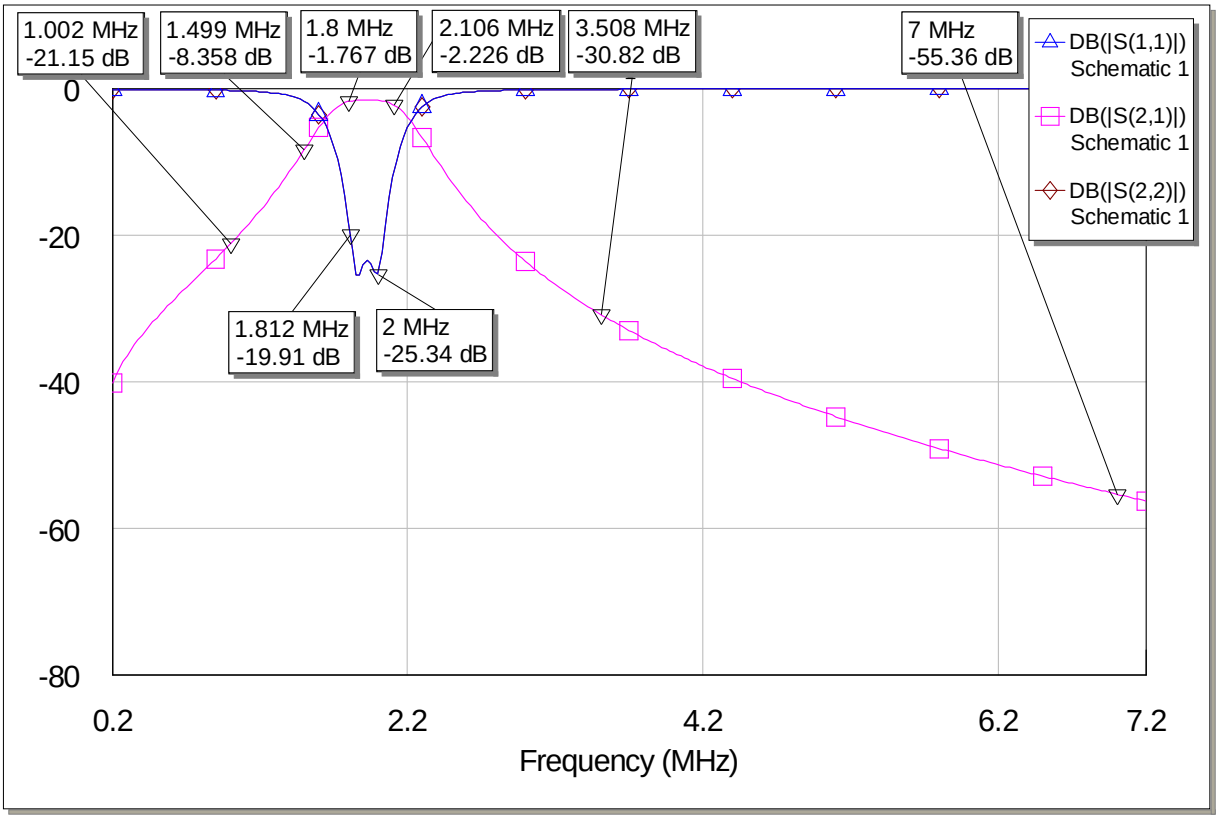
5. BP with 2 coils the simplest solution ver1

This type BP filters I used several times it simple as possible solution for BP with minimum components but still very useful realization. These filters for wide bandwidth are not so good they have moderate selectivity. It is hard expect more selectivity from 2 coils and few capacitors only.

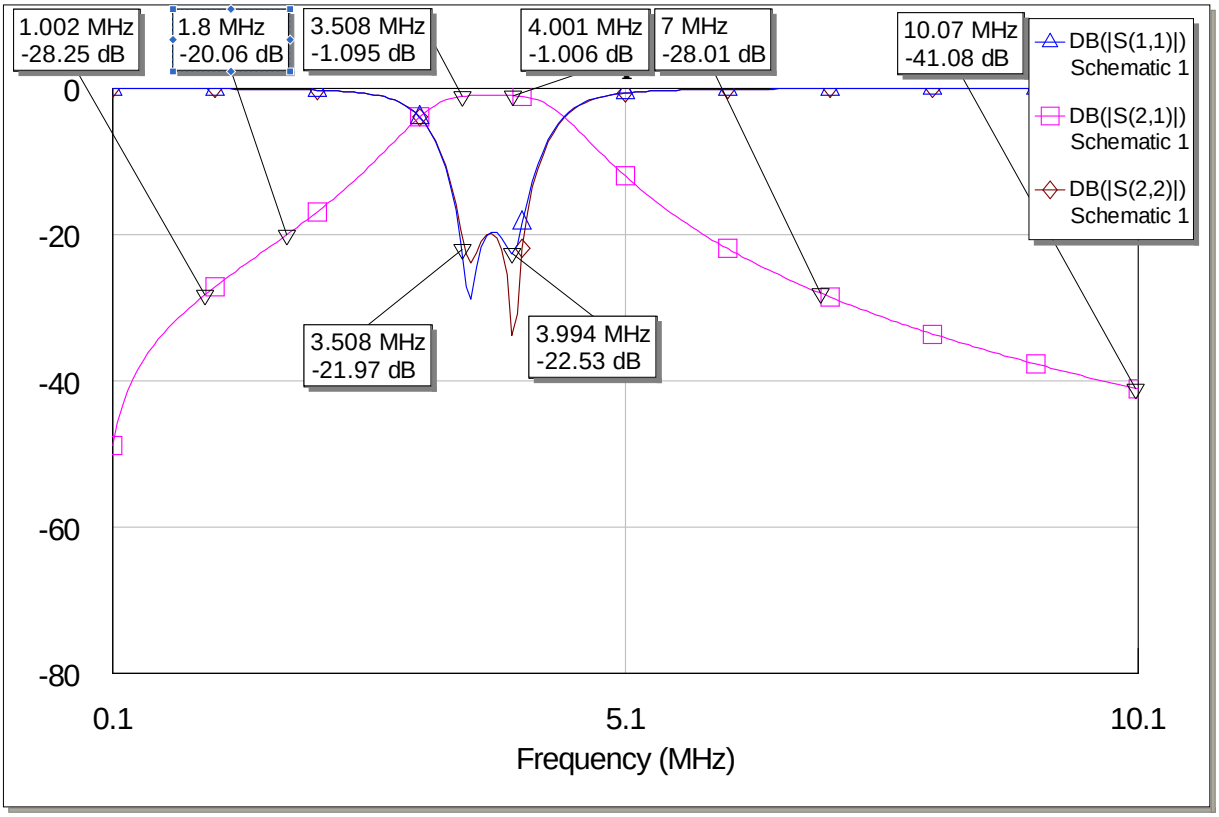


BP with 2 coils ver1

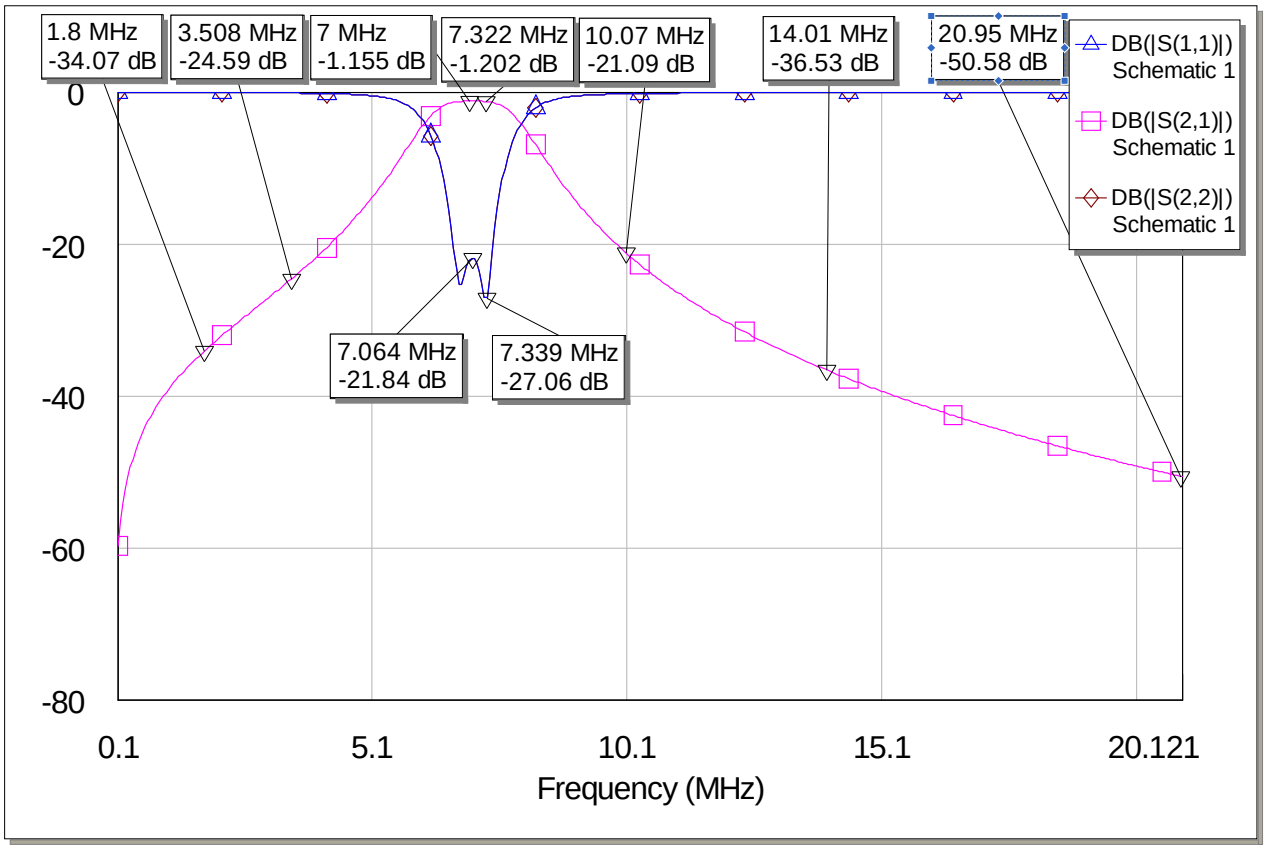
BAND	L1[uH]	L2[uH]	C1[pF]	C2[pF]	C3[pF]	C4[pF]	C5[pF]
1.8MHz	**8.2**	**8.2**	**680**	**390**	**3900**	**390**	**680**
3.5MHz	**5.6**	**5.6**	**330**	**91**	**1200**	**82**	**330**
7MHz	**2.7**	**2.7**	**150**	**82**	**1000**	**82**	**150**
10MHz	**2.2**	**2.2**	**100**	**39**	**560**	**39**	**100**
14MHz	**1.5**	**1.5**	**68**	**33**	**470**	**33**	**68**
10-14MHz	**1.2**	**1.5**	**220**	**47**	**270**	**10**	**150**
14-18MHz	**0.68**	**0.82**	**180**	**82**	**330**	**47**	**150**
18-21MHz	**0.47**	**0.47**	**120**	**82**	**470**	**91**	**120**
21-24MHz	**0.43**	**0.43**	**100**	**68**	**390**	**68**	**91**
24-28MHz	**0.39**	**0.39**	**82**	**47**	**270**	**47**	**82**
28MHz	**0.39**	**0.39**	**56**	**47**	**390**	**47**	**56**
50MHz	**0.18**	**0.18**	**39**	**33**	**220**	**33**	**39**



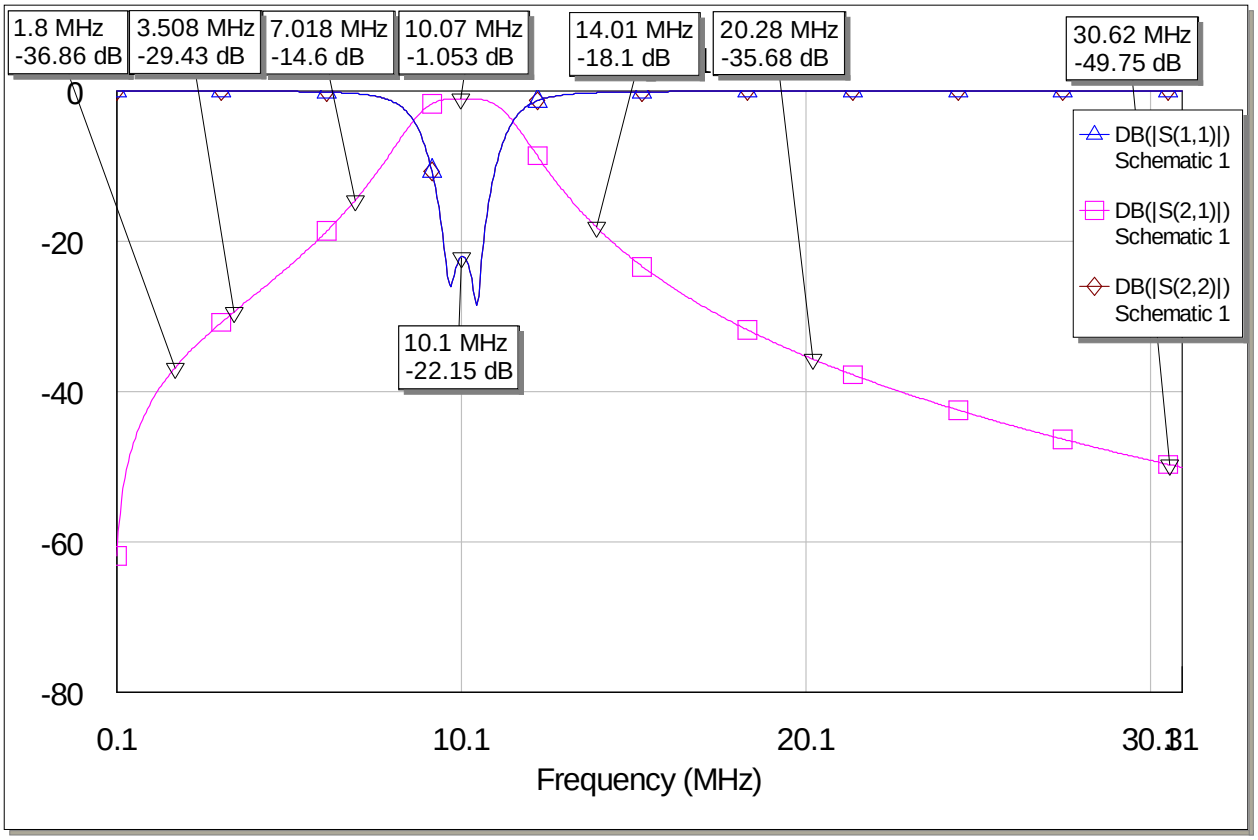
BP for 1.8-2MHz with molded chokes Qo~60



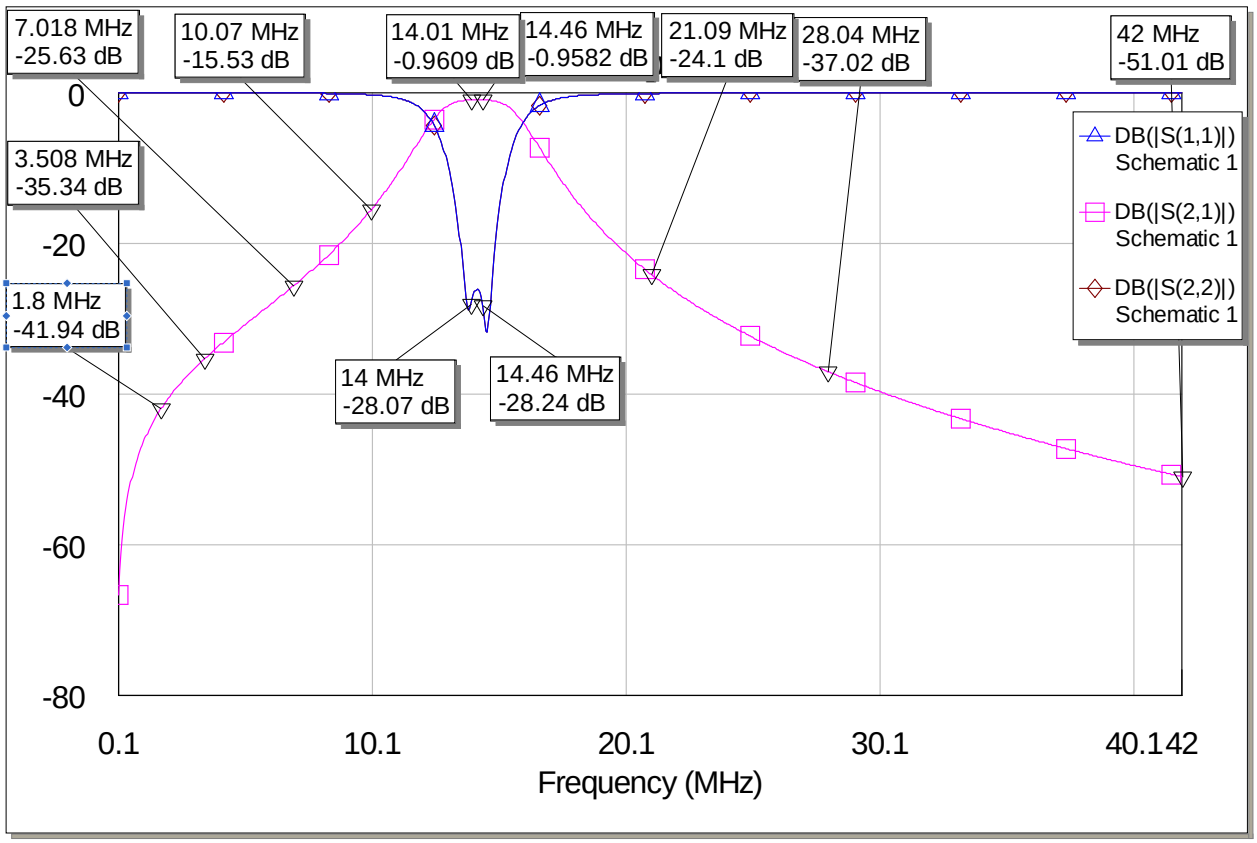
BP for 3.5-4MHz with molded chokes Qo~60



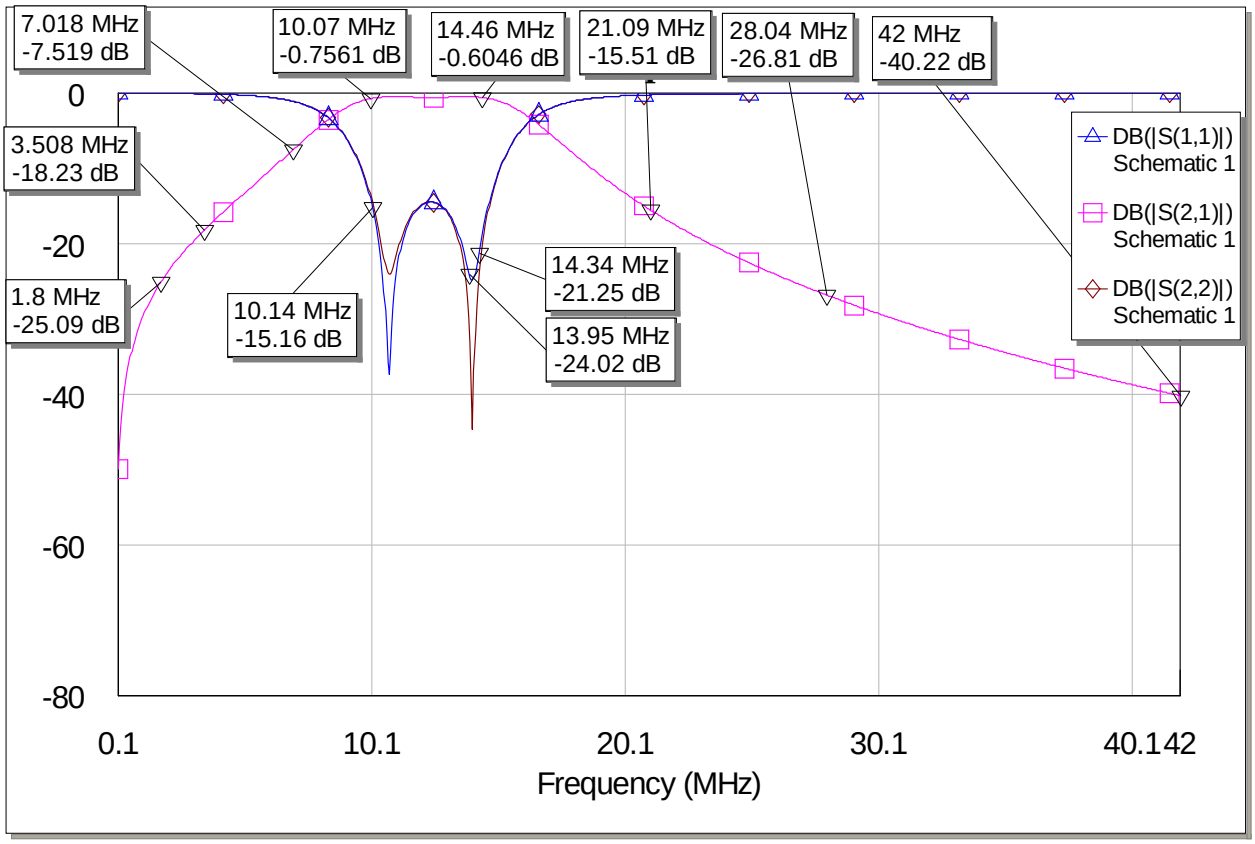
BP for 7-7.3MHz with molded chokes Qo~60



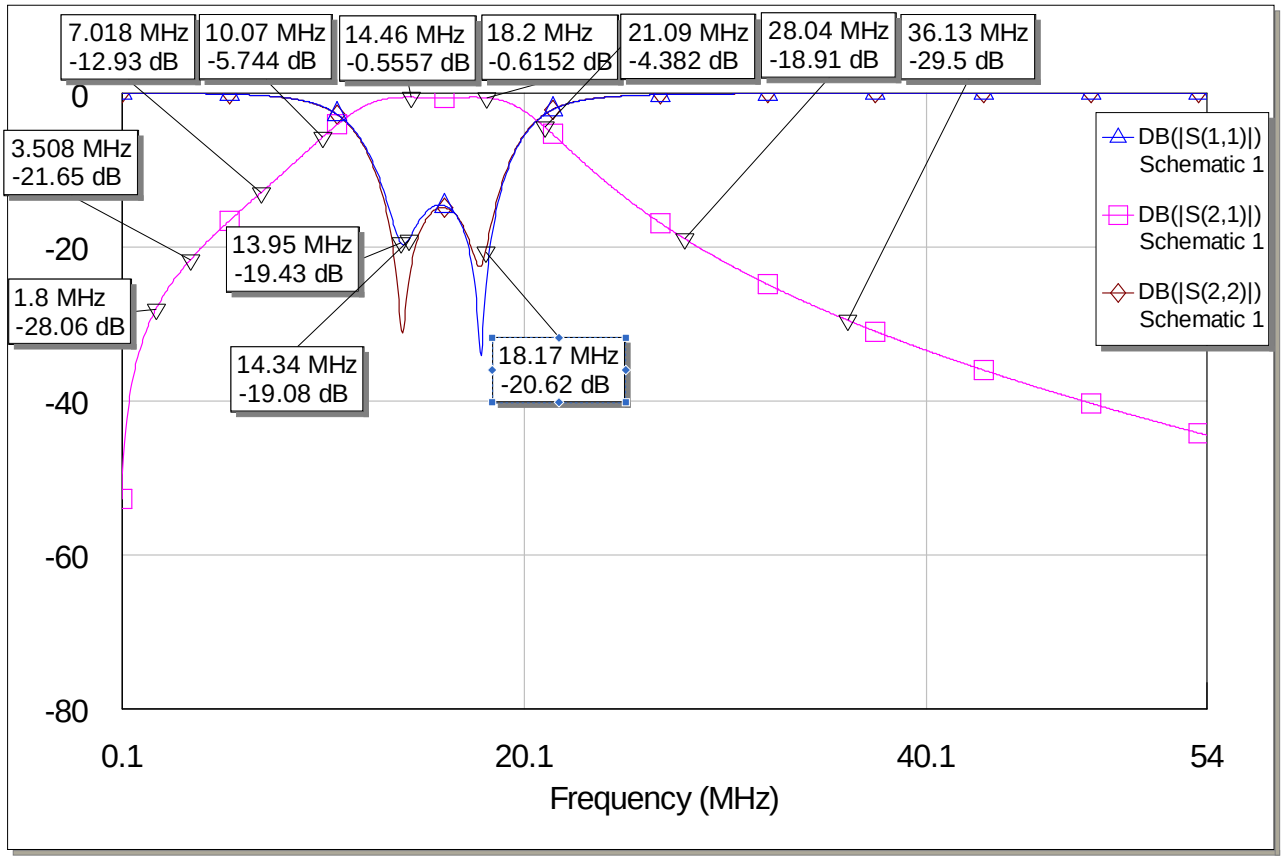
BP for 10MHz with molded chokes Qo~60



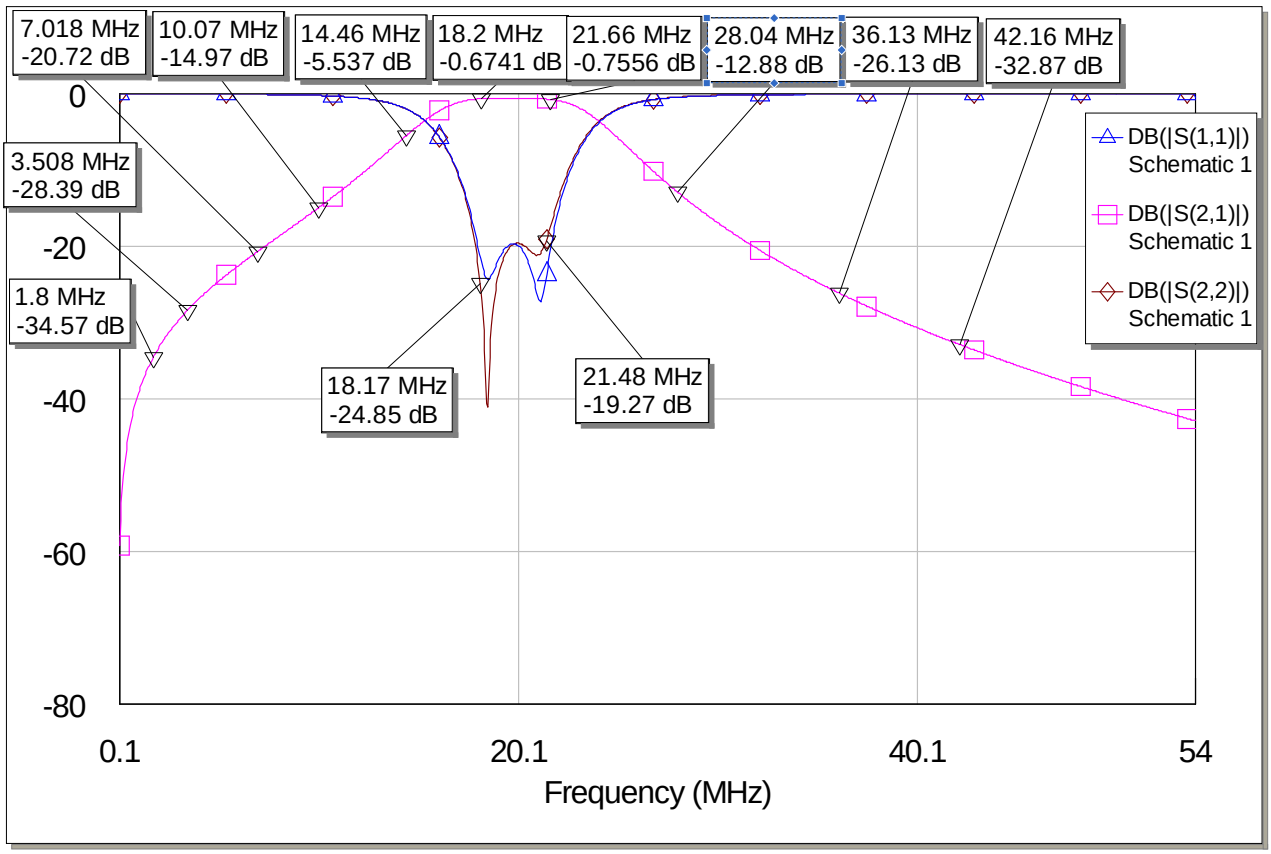
BP for 14-14.5MHz with molded chokes Qo~60



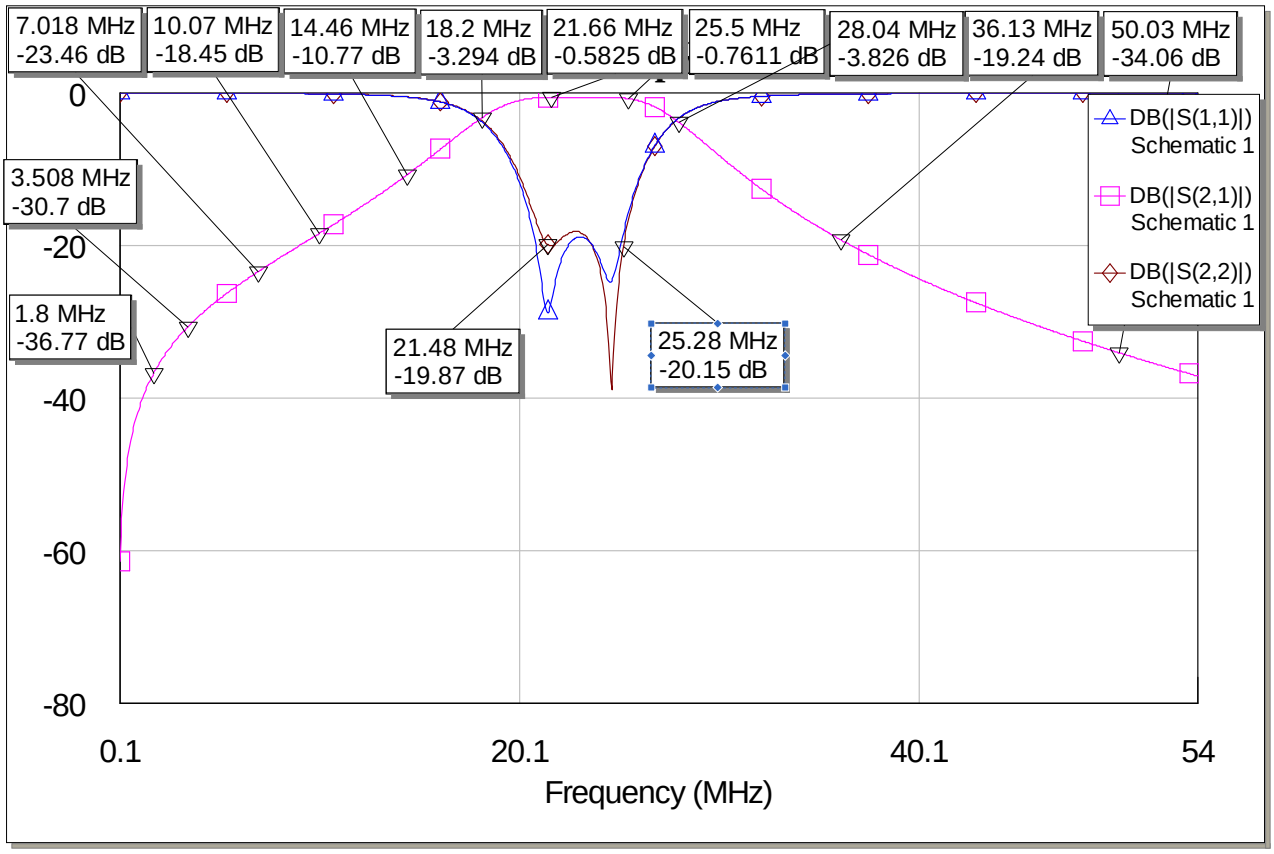
BP for 10-14.5MHz with molded chokes Qo~60



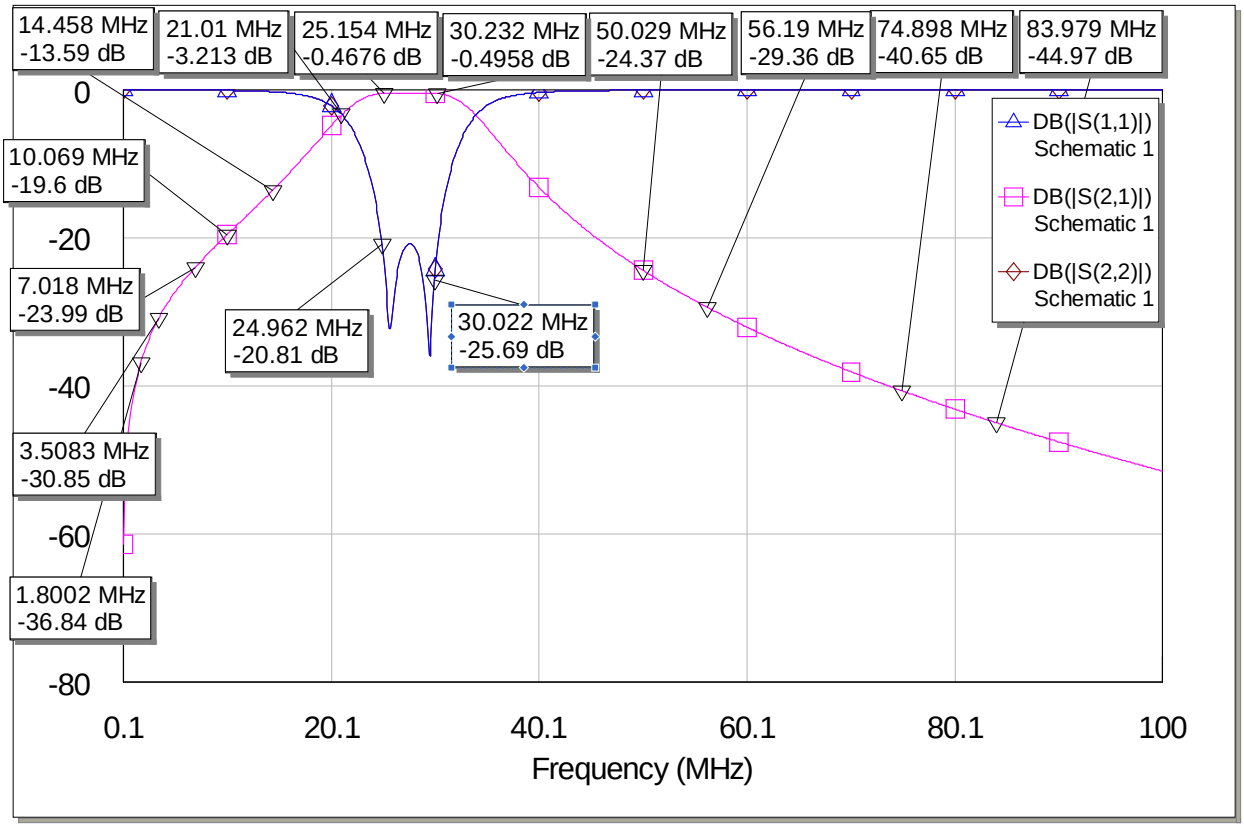
BP for 14-18.5MHz with molded chokes Qo~60



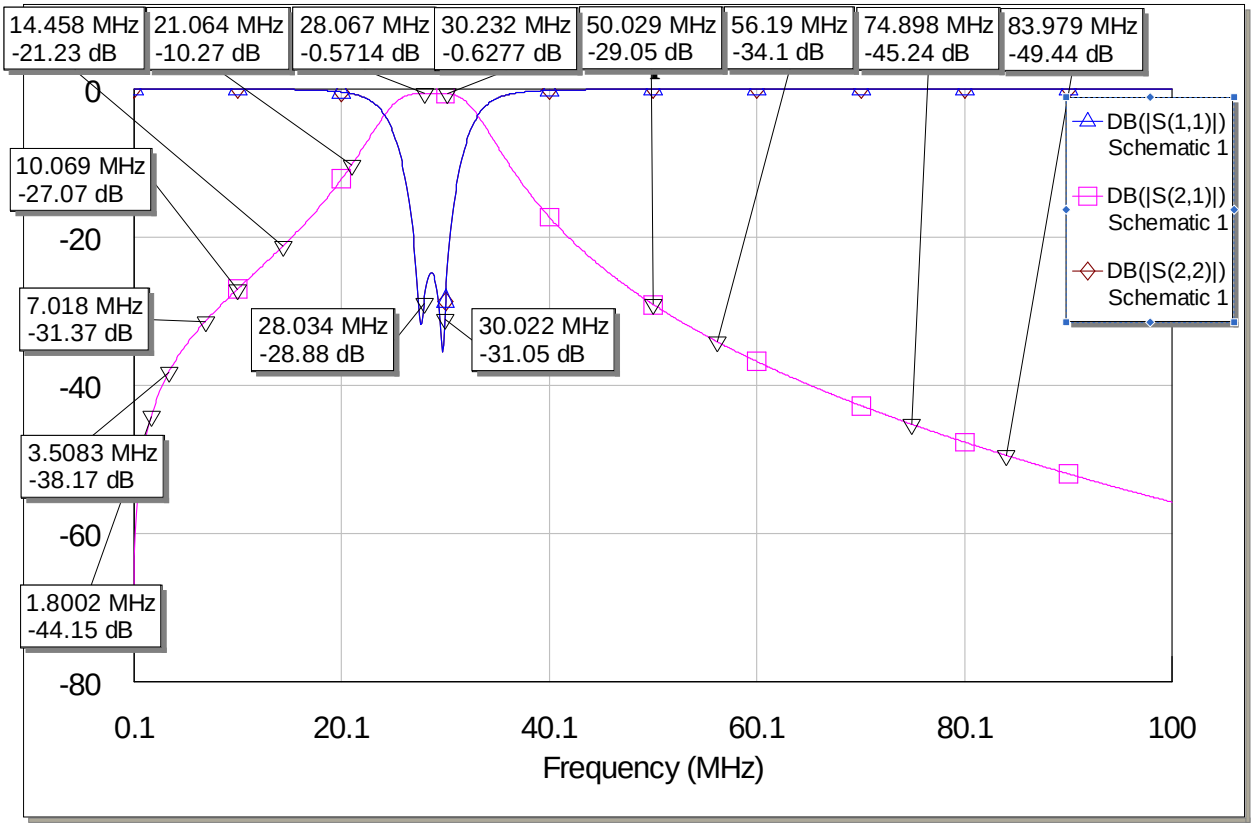
BP for 18-21.5MHz with molded chokes Qo~60c



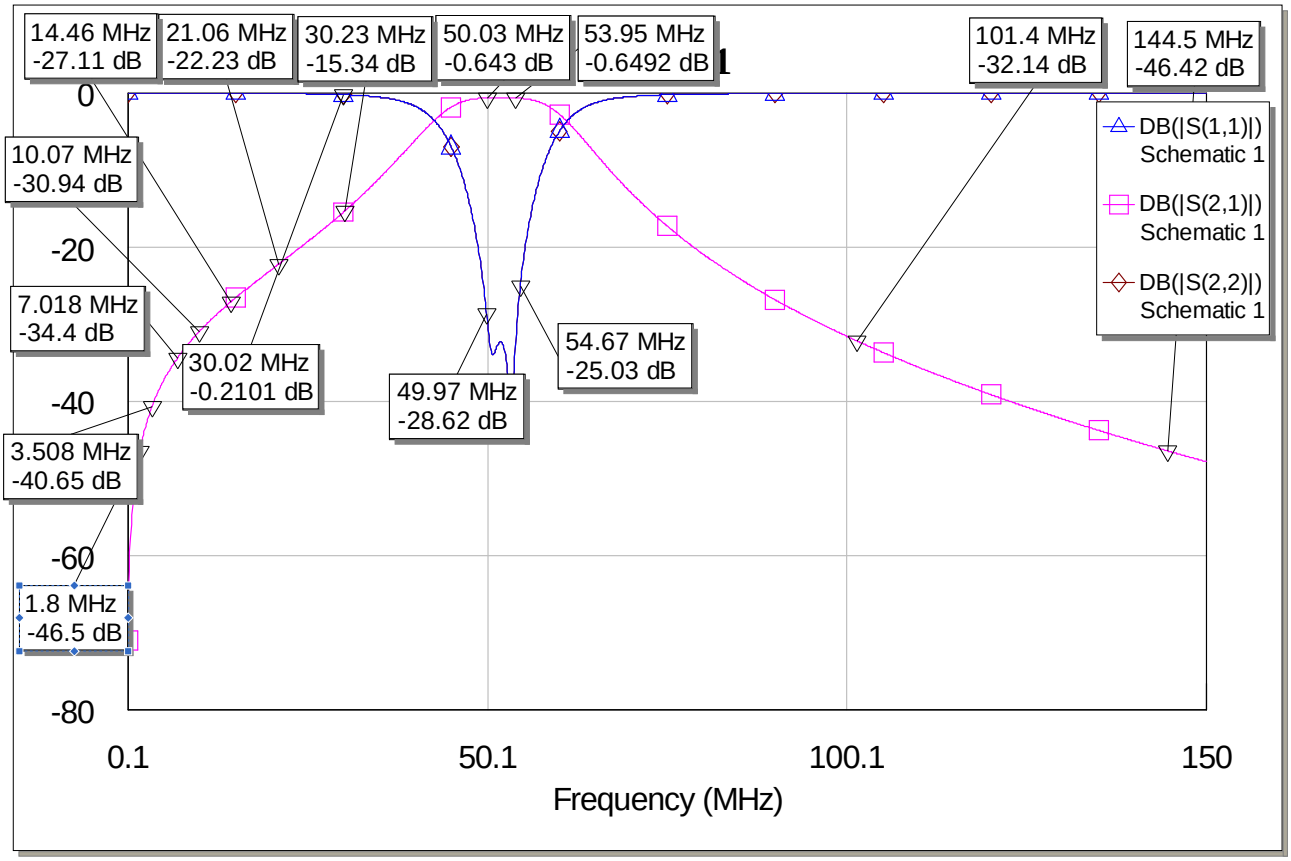
BP for 21-25MHz with molded chokes Qo~60



BP for 24-30MHz with molded chokes Qo~60



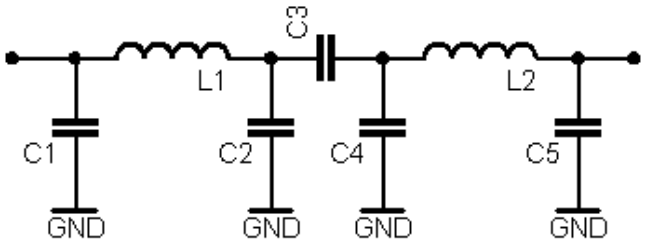
BP for 28-30MHz with molded chokes Qo~60



BP for 50-54MHz with molded chokes Qo~60

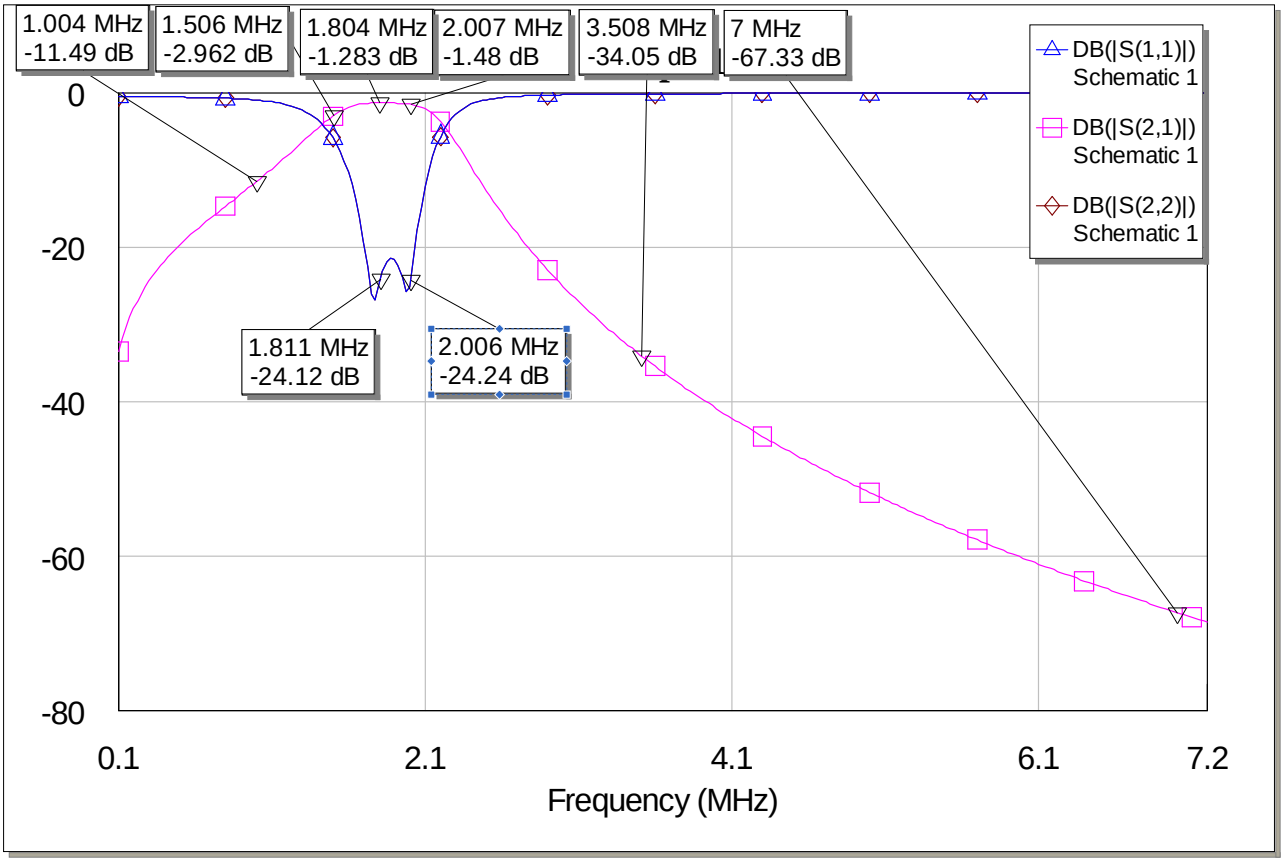
5. BP with 2 coils the simplest solution ver2

This type BP filters I used several times it is simple as possible solution for BP with minimum components but still very useful realization. This solution is similar to BP ver1 original idea for design going from 2m LP-BP from DJ8ES. These filters for wide bandwidth are not so good they have moderate selectivity. It is hard expect more selectivity from 2 coils and few capacitors only.

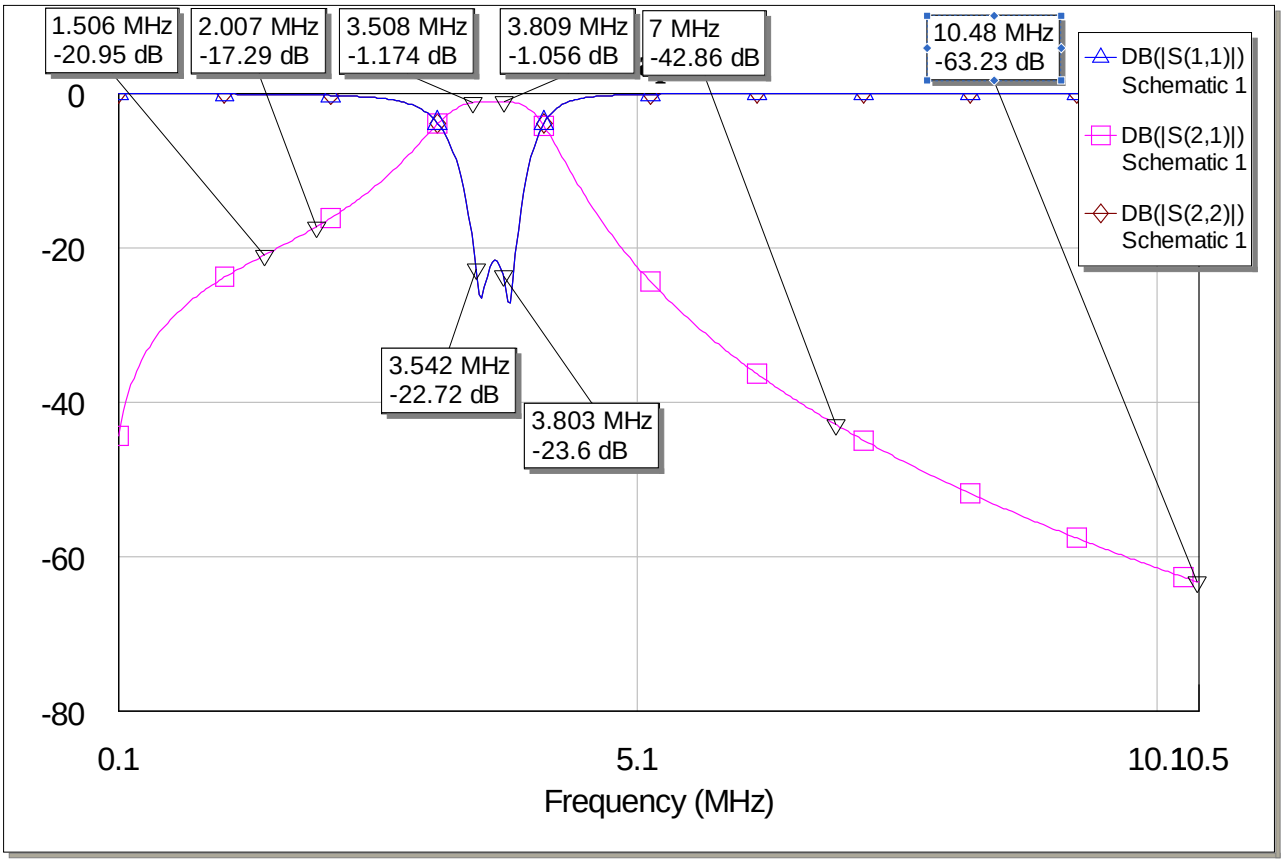


BP filter with 2 coils ver2

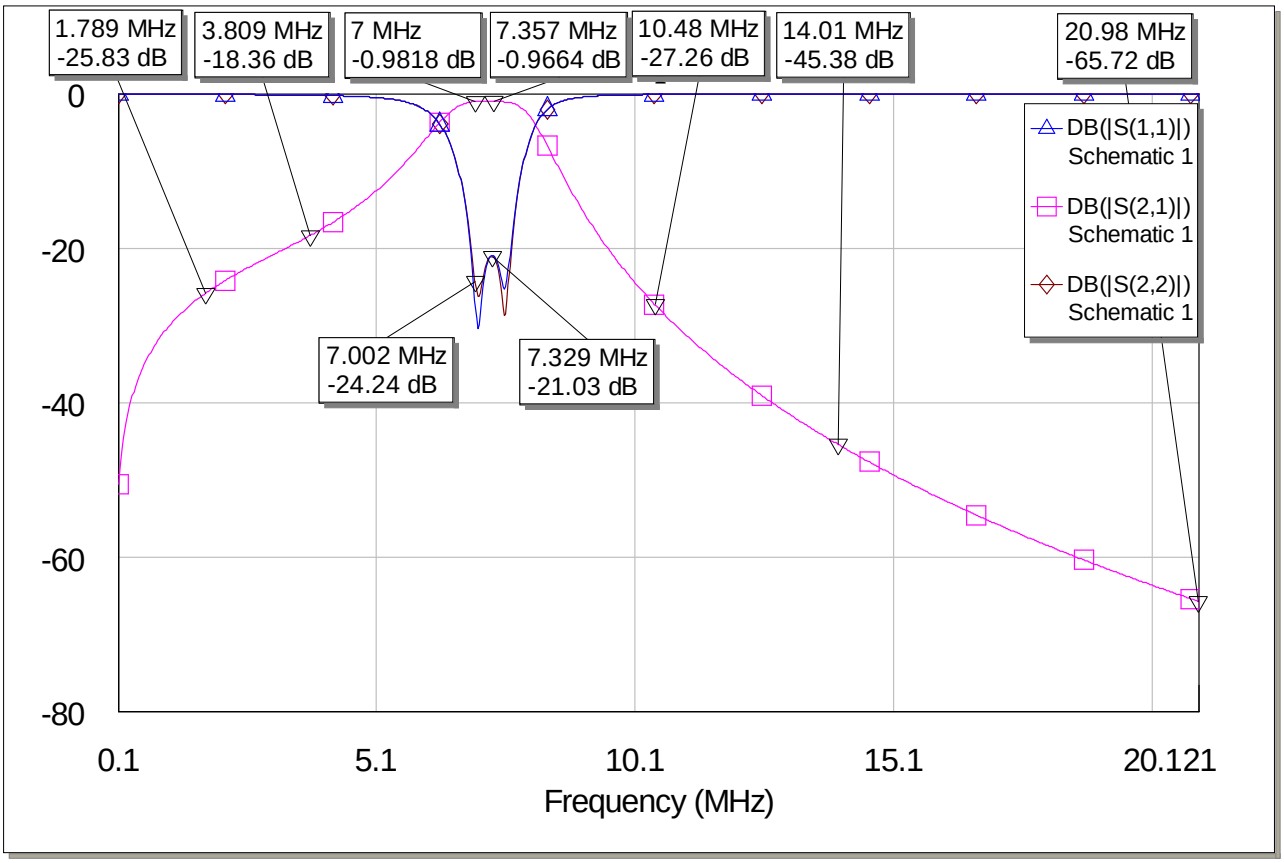
BAND	L1[uH]	L2[uH]	C1[pF]	C2[pF]	C3[pF]	C4[pF]	C5[pF]
1.8MHz	**10**	**10**	**1500**	**680**	**330**	**680**	**1500**
3.5MHz	**5.6**	**5.6**	**1000**	**330**	**91**	**330**	**1000**
7MHz	**2.7**	**2.7**	**560**	**180**	**47**	**180**	**560**
10MHz	**2.7**	**2.7**	**240**	**82**	**22**	**82**	**240**
14MHz	**1.5**	**1.5**	**240**	**82**	**22**	**82**	**240**
14MHz ver1	**1.5**	**1.5**	**270**	**82**	**18**	**82**	**270**
18-21MHz	**1**	**1**	**100**	**56**	**33**	**56**	**100**
24-28MHz	**0.68**	**0.68**	**82**	**47**	**27**	**43**	**82**
50MHz	**0.43**	**0.43**	**82**	**22**	**4.7**	**22**	**33+39**



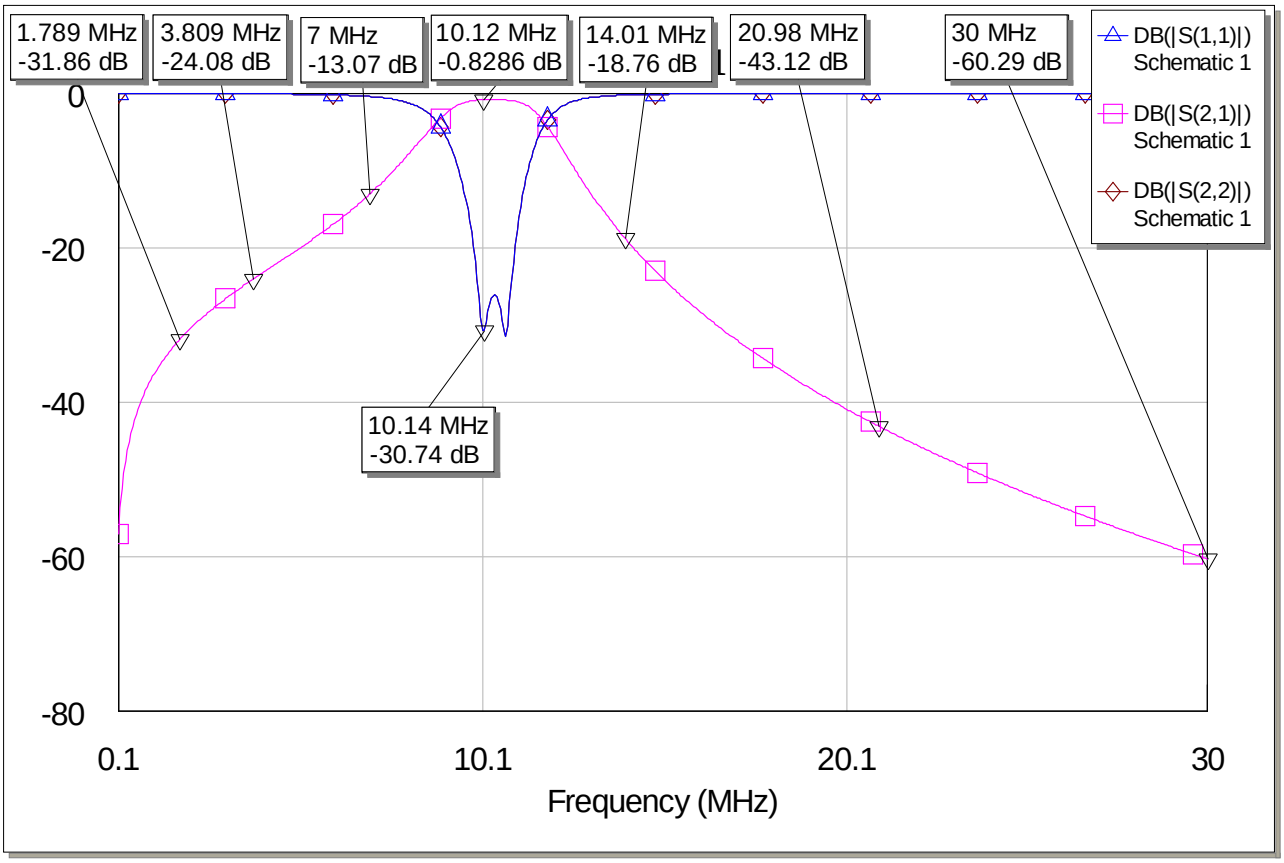
BP for 1.8MHz with molded chokes Qo~60



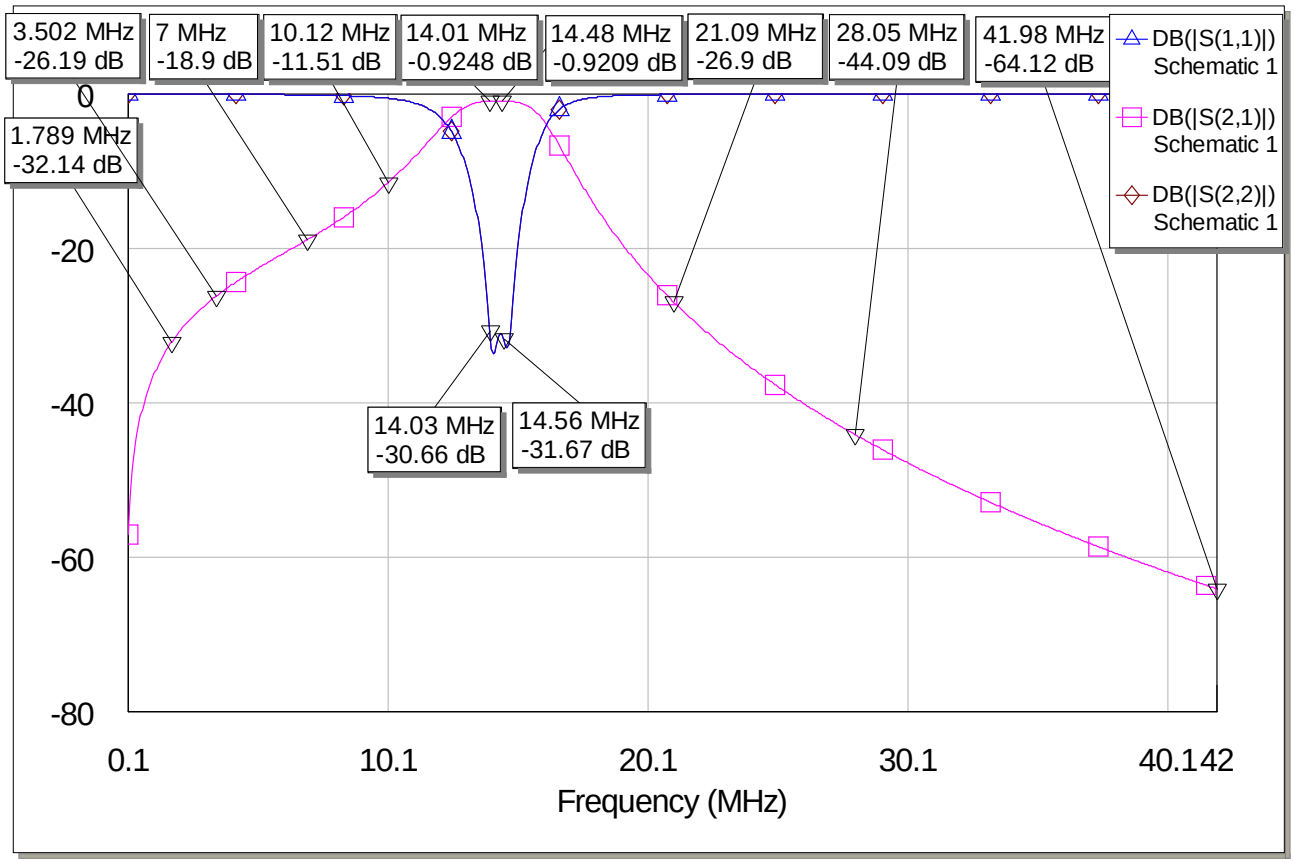
BP for 3.5MHz with molded chokes Qo~60



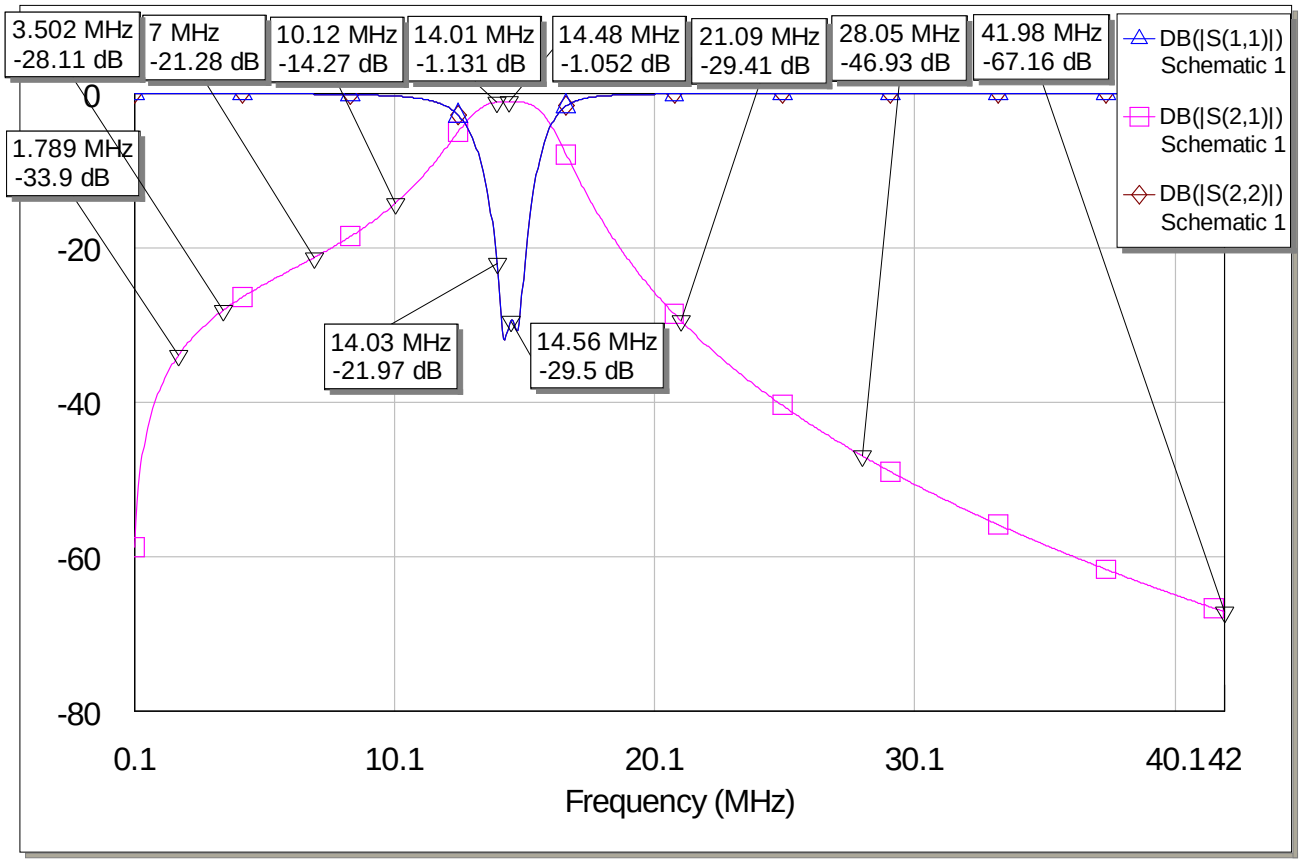
BP for 7MHz with molded chokes Qo~60



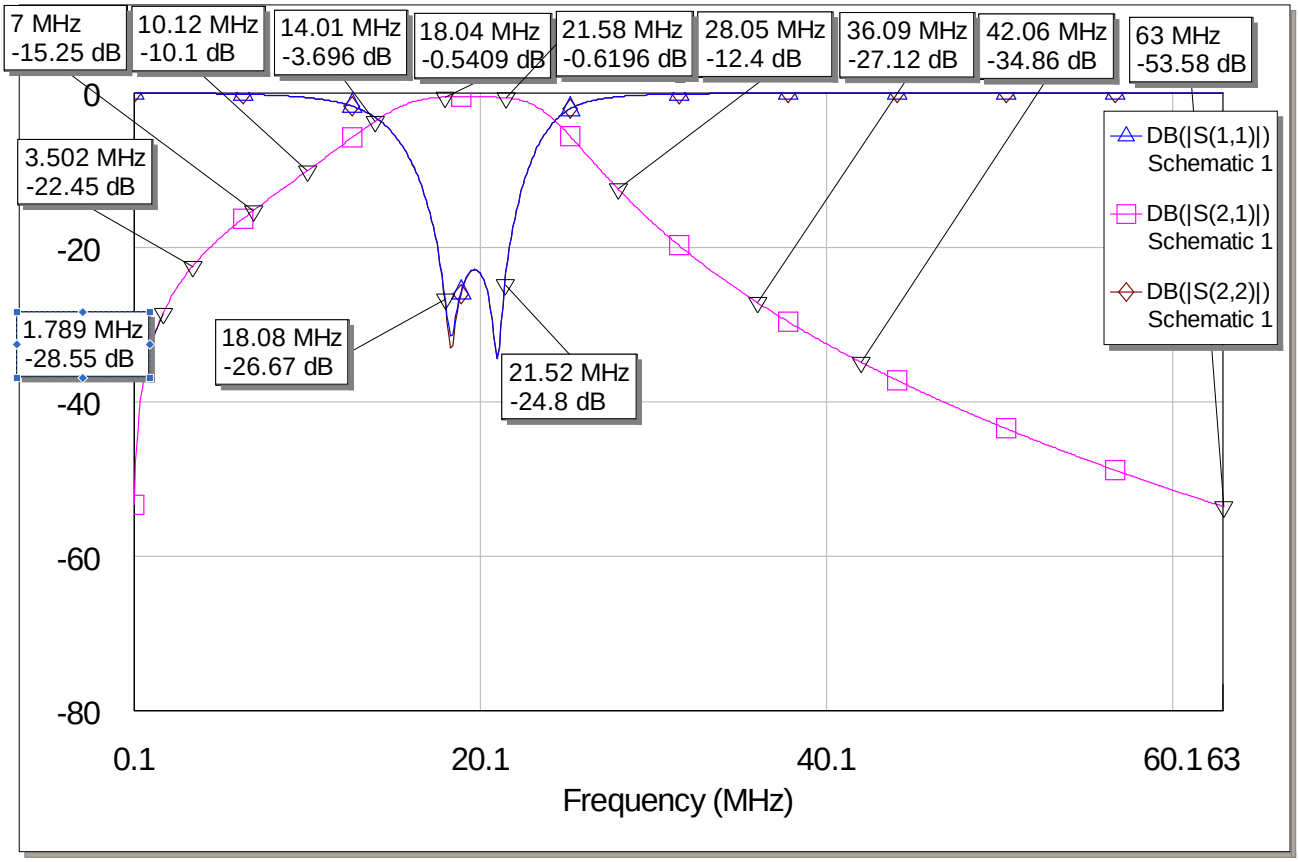
BP for 10MHz with molded chokes Qo~60



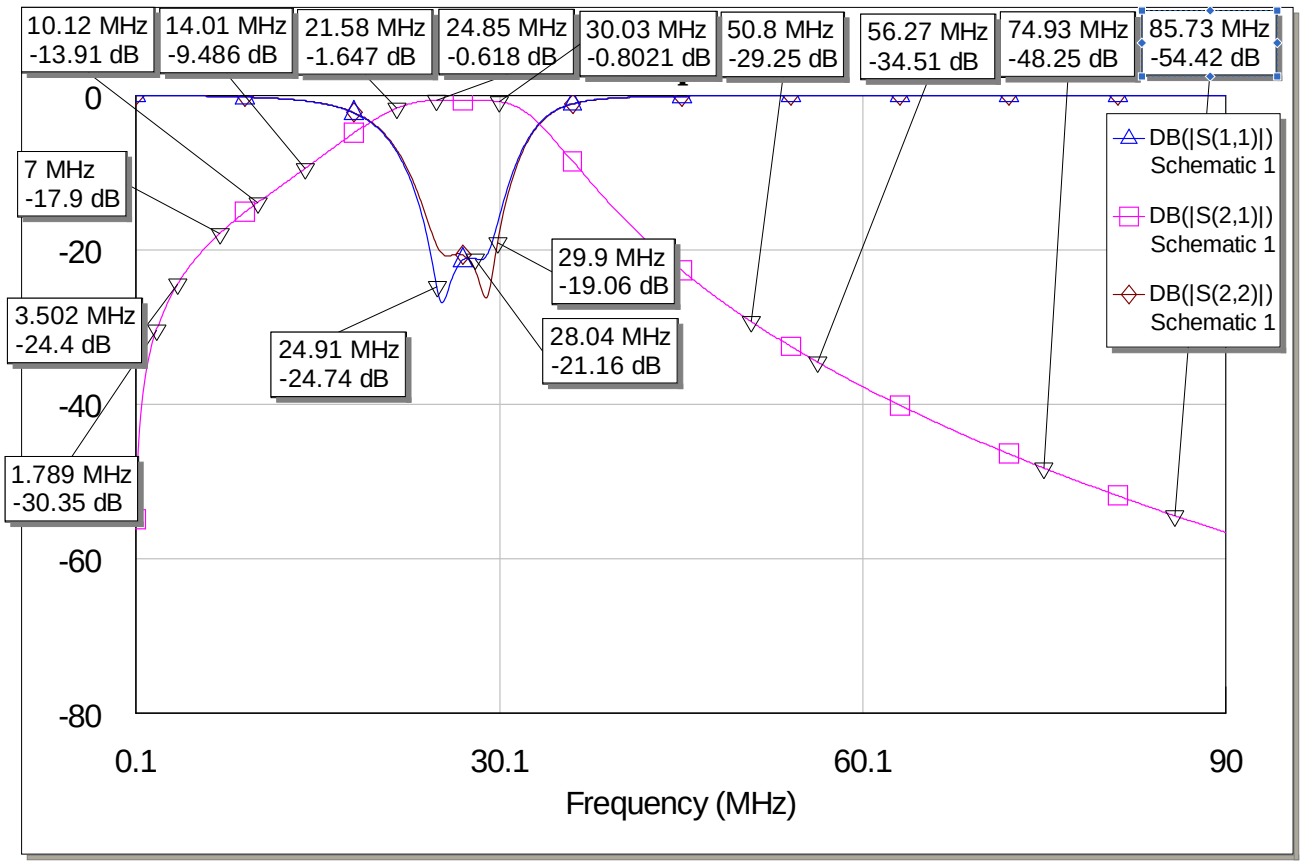
BP for 14MHz with molded chokes Qo~60



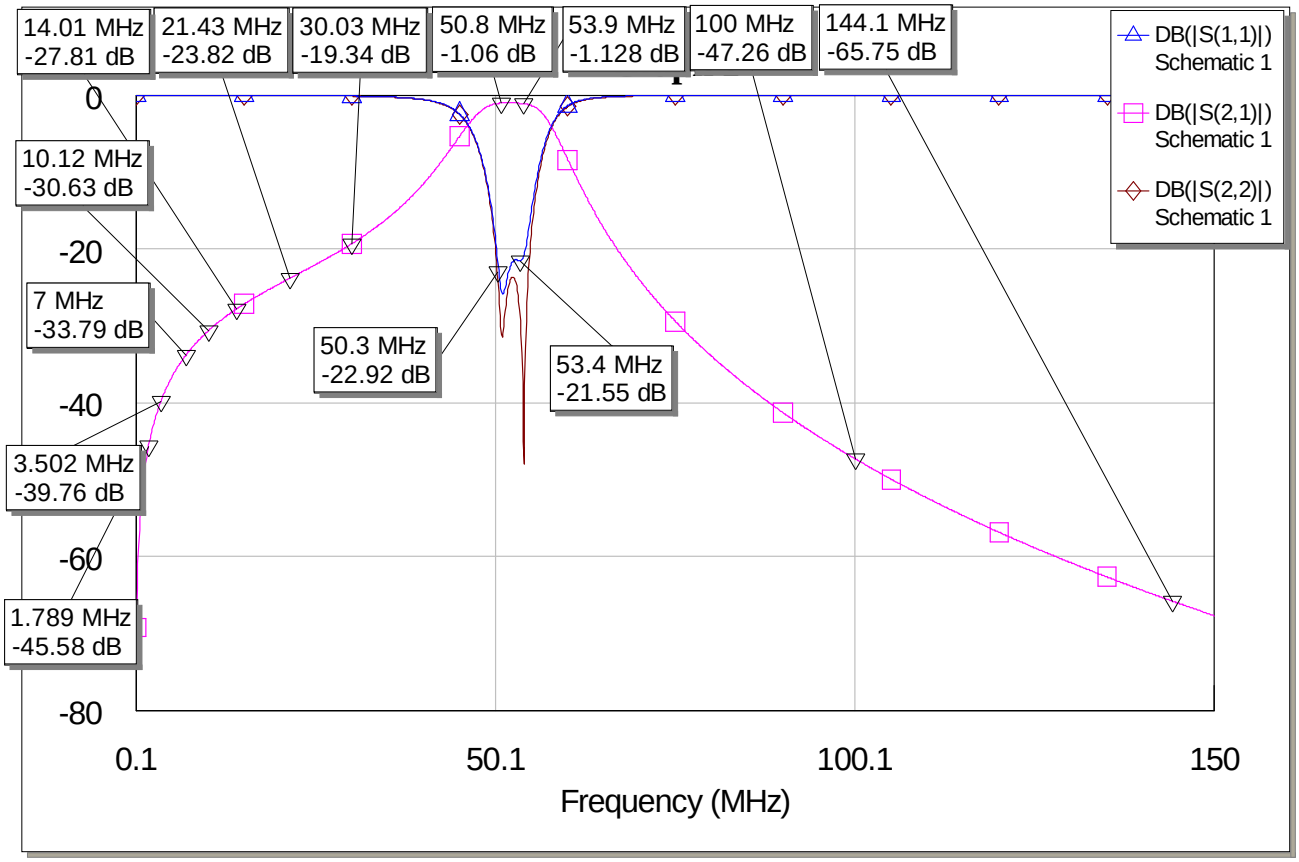
BP for 14MHz with molded chokes Qo~60 ver1



BP for 18-21MHz with molded chokes Qo~60



BP for 24-30MHz with molded chokes Qo~60



BP for 50-52MHz with molded chokes Qo~60

August 2008, rewritten September 2009

VY 73/72 and GL in homebrew Tasa YU1LM/QRP
tasayu1lm@gmail.com

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